

# **Significant Properties of E-learning Objects (SPeLOs)**

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Draft Version: 0.91  
March 2008

A report commissioned by the JISC Information Environment Committee under the Information Environment strategic theme.

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# 1 Introduction

## 1.1 Overview

The purpose of this study is to examine the nature of Learning Objects (LOs) in the context of digital preservation, in order to identify the Significant Properties (SPs) of those objects which it is essential to retain, over time, if preservation is to be successful.

This study considers one question to which answers are essential if we are to successfully preserve Learning Objects for any significant period of time. There are some who wonder whether such questions are even worth asking (Tompsett). However, as Jorum have noted in their own preservation watch reports (Jorum, 2006) there are arguments that Learning Objects need to be retained for at least as long as a course exists. It is not unusual for this to be ten years or more (Harvey, 2002), and ten years is a long enough period to be of concern when preserving digital material. It is not forever, it is not even a lifetime, and it is a very different period than that being considered by bodies such as national libraries and archives when talking about digital preservation. But as anyone who has tried to access older digital material can attest, ten years is a long time for digital material, much as a week can be a long time in politics. A tape created on a VAX, a word-processor file from an Atari, or even a presentation created with Powerpoint for Windows 95 may all be only ten years old, but would require specialist knowledge and equipment to deal with today, unless active steps had been taken to preserve them in the intervening years.

In other words, Learning Objects will often be intended to last longer than the three-year period which might be considered a safe period of neglect for most digital objects. That is enough to make consideration of how we can best preserve them worthy of some thought. Doing so is likely to make the preservation task simpler and cheaper, and to ease the burden on object creators who wish to put material into repositories. Understanding what properties need to be preserved during software or format migrations also allows us to understand what does not need to be preserved. This can simplify the preservation task, and result in significant savings,

It will be apparent in the text that follows that it can be difficult to separate the properties that something has as an E-learning object from the properties it possesses even when taken out of that context. A digital still image has Significant Properties that have already been identified elsewhere. These will generally still be significant if that image is used in a learning context; but that use will result in the object acquiring additional Significant Properties.

It may also result in it losing some Significant Properties. Some images may still be able to meet a learning intention even if colour or resolution is not maintained. If a

migration results in loss of resolution of such an image, it is not a well-preserved image but may be a well-preserved Learning Object.

The study has attempted to concentrate on those properties that are specific to the e-learning domain. The illustration above reminds us that domain considerations may cause us to revisit non-domain-specific properties.

## **1.2 Audience for this document**

This document is written both for those concerned with the maintenance and management of Learning Objects and the digital preservation community. It is assumed that the former are familiar with the types of Learning Objects that exist, their uses and the means by which they are created and re-used, and that the latter community understand the general principles of digital preservation and the reasons why they are of concern.

We do not expect each community to be familiar with the other's area of expertise and for this reason, the following section outlines the broad principles of each specialism in sufficient detail to inform each community of the other's concerns. It is also undoubtedly true that each section is sufficiently brief to require readers to pursue some of the cited references if they wish to gain a deeper understanding of the issues described.

The document is not primarily aimed at those who create and use E-learning objects. Their views, however, are valuable to us. Creators and primary users of digital objects are those who are typically best-informed about what they consider to be Significant Properties of the objects that they create and use, although they may often take these properties for granted. Comment from these groups will be welcome in refining the thinking expressed in this study.

## **1.3 Acknowledgements**

We would particularly like to acknowledge the assistance of Martin Sepion and Will Pickford at the JISC Regional Support Centre for E-learning, who kindly took the time to review a draft and confirm that our broad understanding of the use and management of LOs and VLEs was sufficiently accurate for the purposes of this study.

Naturally the fault for any errors or omissions lies with us.

## 2 Background

### 2.1 Preservation and archives

#### 2.1.1 Digital preservation

Digital preservation has been defined as the managed activities necessary:

- 1) For the long term maintenance of a byte stream (including metadata) sufficient to reproduce an acceptable facsimile of the original document; and
- 2) For the continued accessibility of the document contents through time and changing technology. (RLG, 2002)

For this study (as indeed in the NAA's 'performance' model) we recognise that the concept of a 'document' must be recognised as encompassing objects with more complexity and modes of behaviour than traditional documents, either digital or paper-based. ELOs may be complex and multi-part, may not have a traditional narrative structure with beginnings and ends, and may possess interactivity, amongst other properties.

Many strategies for digital preservation have been developed and discussed in recent years. The three most widely recognised methods are:

- *Migration*: the process of transferring digital information from one hardware and software setting to another or from one generation of computer technology to subsequent generations. For example, moving files from an HP-based system to a SUN-based system involves accommodating the difference in the two operating environments. Migration can also be format-based, to move image files from an obsolete file format or to increase their functionality.
- *Emulation*: this involves the re-creation of the technical environment required to view and use a digital collection. This is achieved by maintaining information about the hardware and software requirements so that the system can be reengineered on subsequent generations of computing platform. Examples abound, such as programs which can simulate old Atari games machines or early DOS-based PCs, and thus run software created for them without modification.
- *Technology preservation*: this is based on preserving the actual technical environment that runs the system, including software and hardware such as operating systems, original application software, media drives, and the like. (Cornell)

Whilst anyone attempting to preserve Learning Objects will need to make a decision at some point on which of these approaches they intend to use, their existence is not important to the problems which this study attempts to address. Whichever mechanism is chosen, one test of its appropriateness is the extent to which it preserves the Significant Properties of the objects it is applied to.

### 2.1.2 OAIS Model

The Open Archival Information Systems (OAIS) Reference Model (ISO 14721) is the major international standard addressing the issue of long-term preservation of information.

The OAIS Model is now widely accepted as a sound model for thinking about the implementation of digital preservation. Rather than a set of instructions or procedures, it is simply a common reference model, a common terminology and a common conceptual framework. Its strength is the detailed descriptions of functional entities and data models. It offers the possibility of a unified approach to process design, tools, and metadata specifications. This study does not concern itself explicitly with whether or not repositories can be considered to conform to the OAIS model and it does not see such conformance as a pre-requisite. The model, however, provides essential language and abstract concepts which will prove particularly valuable when we try to consider the question of what (if anything) distinguishes a Learning Object repository from any other digital object repository, and what elements such a repository shares with other repositories. The model has already gained ground among those in the HFE Community seeking to build an effective repository:

"The establishment of the OAIS (Open Archival Information System) reference model offered the AHDS a framework upon which to base its repository. Layered upon this the AHDS has a range of Preservation Handbooks, Ingest Manuals and metadata tools to assist AHDS staff." (Dunning, 2006)

The OAIS Reference Model addresses and describes a full range of archival functions including Ingest, Archival Storage, Data Management, Access, and Administration. It speaks in terms of data models used to represent digital information, held in archives, from a preservation perspective.

"The OAIS defines an Information Object as a Data Object interpreted using its Representation Information. In order for this Information Object to be successfully pre-served, it is critical for an OAIS to clearly identify and understand the Data Object (the bits) and its associated Representation Information (implicitly hidden in the interpreting/rendering software)". (NEDLIB, 2000)

Information transmissions internal and external to the OAIS archive functions occur by way of Information Packages, which contain the information object that needs to be preserved for future access. OAIS defines three different types of Information Package: the Submission Information Package (SIP), the Archival Information Package (AIP) and the Dissemination Information Package (DIP).

This concept of Information Object is central to the OAIS model: it explicitly distinguishes between the Data Object (the actual bit-stream) and the Representation Information, which enables the bit-stream to be interpreted as meaningful information. Preservation of both bit-stream and Representation Information through time are essential for successful digital preservation.

In terms of the Access function, OAIS describes Designated User Communities. They are users of the Dissemination Information Package or DIP. The atom unit here is the Consumer, which is defined in the Model (1.7.2) as “those persons or client systems who inter-act with OAIS services to find preserved information of interest and to access that information in detail. This can include other OAISes as well as internal OAIS persons or systems.” We need to understand something about the differences between user communities and consumers in the ELO context, about which more below.

For this project, we believe that the operation of the OAIS model will be crucial to managing preservation of LOs. But we also need to be clear on the following: LOs are not preserved merely by being stored or managed in a Virtual Learning Environment (VLE) or any other online storage and retrieval system (such as JORUM or COLEG). There is a strong argument that, like any other digital object, LOs can only be deemed to be being preserved when held in a digital archive which accepts and discharges the key responsibilities identified in the OAIS model - whether implicitly or explicitly. This may mean that there will be a migration stage to take the objects out of the operational system and into a preservation repository. It is, however, equally possible that an operational VLE or other system can also perform a preservation function. (JORUM has conducted work which suggests that it does meet the bulk of the OAIS responsibilities, for instance.)

### **2.1.3 Designated Communities**

Another key concept in OAIS is that of Designated Communities: "the subset of Consumers expected to independently understand the archived information" (Lavoie 2004). In the con-text of this research we expected the Designated Communities for Learning Object types might be diverse, some associated with particular classes of LO, with not all Designated Communities having an equal interest in all object types. But we also wanted to give consideration to the extent to which the potential Consumers of DIPs (to use OAIS terminology) are distinct, or have distinct needs, from the Designated Community. This is of tremendous relevance to the consideration of Significant Properties. Although a digital archive is really only required to serve the needs of its Designated Community, it may wish to give consideration to the wider needs of others who wish to use its holdings, even if it is not obliged to do so.

Thus a Designated Community (academics, tutors, students, administrators) who manage and use Learning Objects can be seen as distinct from Consumers (researchers, historians, scholars) of objects stored in a digital archive. This will be discussed in more detail else-where, but it seems clear that academics and students

will have a very particular set of requirements for what constitutes Significant Properties. They will be thinking of properties such as metadata for discovery; audit trails; rights management metadata; interactiveness; and the things that will enable them to reuse the object.

#### **2.1.4 Records Management**

In the pre-digital age, it was always understood that archival preservation of historical documents was one possible outcome of a good Records Management (RM) system. Paper files would be retained by an organisation for as long as there was a business need to refer to them and reuse them, and for as long as there were legal requirements to retain them. The efficiency of any business or organisation would always be improved by a properly functioning RM system which enabled storage and retrieval of these business documents for work purposes or legal compliance.

If the life cycle of the record were properly managed, a document would reach the disposition stage where it could either be destroyed (because its usefulness for business purposes had expired), or retained permanently in the archive (because it had potential historical value for future study or research).

These principles transferred successfully to electronic records management systems in the 1990s. The formats, storage methods, and means of retrieval of the documents may have changed, but the principles remained the same, resulting in electronic (digital) records being managed through ERM and EDRM systems, disposed and destroyed according to agreed timed schedules or (where appropriate) selected for permanent preservation and transferred into a digital archive. The operation of this model is clearly visible in The National Archives' concept of 'Seamless Flow'. "Over the next few years, we expect that the volume of electronic records transferred to The National Archives will increase dramatically. The only way we can manage this is by automating as many of the processes as possible and ensuring that others (selection, exemption identification, redaction) take place at creation in the government departments or as soon as possible after creation." (National Archives).

It seems likely that success in the management and preservation of LOs is most likely if an Electronic Records Management approach is followed, one that completely integrates operational systems and LO repositories with an archival approach.

Proposals which fit this RM-based suggestion have already been suggested in the 2004 JISC study, Long-Term Retention and Reuse of Learning Objects and Materials. This report made a clear case for the longer-term value of Learning Objects; and it has proposed retention periods, in line with the 'business requirements' of the University. The authors have also discussed the technological infrastructure that would be needed for retaining E-learning Materials and Objects, and they have expounded on the relations between Digital Repositories, Archives and Libraries.

While not strictly in scope of the remit of this project, it would clearly be of value to under-stand better the workflow patterns used in VLEs and LO Repositories across a section of Universities and HFE Institutions. A study of the workflow may reveal patterns that help us think of LOs in terms of their lifecycle (rather than focusing exclusively on their Significant Properties). Such a lifecycle might include stages such as these:

- i. LOs are created
- ii. They are stored in a VLE where they are managed for the duration of business need
- iii. They are accessed, reused and copied, thus creating audit trails
- iv. They might result in managed outputs - such as assessed students, exam results, tests passed, lectures attended
- v. They are migrated to a digital archive where they are preserved
- vi. Potentially, they are re-used or re-purposed within other Learning Objects

Later on we will describe the Significant Properties we have identified, and how they might apply in these stages. There will be SPs of value to the designated community, and SPs needed for preservation.

### **2.1.5 Repositories**

LO Repositories, while they clearly succeed as a means of keeping digital material safely and in one place, should not be considered to be the same as digital preservation repositories.

An LO repository may not meet the mandatory responsibilities that a preservation repository must meet. Even if it deals well with long-term preservation for its host institution, it may not succeed in making material independently understandable to people other than the creators. ELO repositories that function like personal safe-deposit boxes for the object creators are not performing preservation in the sense that we need to address.

It's also worthwhile remarking that Significant Properties are not the same things as mandatory properties or metadata elements. Some Significant Properties are expressed as meta-data elements, and some of these metadata elements are mandatory (such as a unique ID, or perhaps a title.) But some properties aren't associated with metadata (although we may choose to create metadata elements to record their presence) and many will not be mandatory. Some properties are significant in preservation terms only if they appear, whereas others are significant because they must appear if we are to make a good job of preserving the object.

### 2.1.6 Performance Model

In their 2002 paper, *An Approach to the Preservation of Digital Records*, the National Archives of Australia defined the concept of “essence” of a digital record – whence Significant Properties – and also of “performance”. What differentiates the interaction of a researcher with a paper object in the real world and a digital object in the electronic world is that in the electronic environment this interaction is brokered by hardware and software, which has the effect of coaxing a “performance” out of the stream of otherwise inanimate bits and bytes.

“The source of a record is a fixed message that interacts with technology. This message provides the record’s unique meaning, but by itself is meaningless to researchers since it needs to be combined with technology in order to be rendered as its creator in-tended. The process is the technology required to render meaning from the source. When a source is combined with a process, a performance is created and it is this per-formance that provides meaning to a researcher. [...] A source may be mediated by many different software platforms, and each combination of source and specific proc-ess platform may produce a slightly different performance.” (Heslop et al., 2002)

It is therefore the fidelity of the performance that must be preserved over time and changes in technology, if the record is to be meaningfully preserved, so that future performances continue to convey the “essence” of the record. An example given is that of a movie on cine-film: it is not the rapidly decaying nitrate film per se that is of interest to researchers, but the moving image one is able to view when the film is used in conjunction with screen and projector. If that film is copied to a newer, more stable and accessible medium, be it polyester film or video tape, it can be considered “preserved” at that point if its essence – the moving image, at the same frame rate and resolution – is still accessible, and the performance “equivalent”.

It's worth noting that these valuable considerations and models is developed in the context of "records", in its archival sense of "evidence of business activity" (ibid). "The characteristics that are not essential to the meaning of a document’s message are not essential to the document’s meaning as a record." The extent, therefore, to which this model is universally applicable to any digital objects created outside this context is something that we will have to consider further with regard to Learning Objects that are not intended as "records". Nevertheless, for the purpose of preservation, we must be aware that any class of Learning Object will have its own “essence” no less than any other digital object or record.

## **2.2 What are Learning Objects?**

### **2.2.1 Definitions**

According to the most common definition, E-learning is "learning facilitated and supported through the use of information and communications technology (ICT)" (widely quoted without citation). Analysis of the process of delivering E-learning has yielded a number of models, the most compelling being that an E-learning experience is made up of the interaction of a number of components that we recognise from their real world analogues: courses, assessments, teaching materials, study materials, etc.

Learning Objects are a relatively new way of presenting learning content. They are digital entities designed to facilitate reuse. Instructional designers can build small (relative to the course) instructional components that can be reused in different con-texts. The term Assessment Learning Object (ALO) is used to describe an object de-signed to provide a summative or formative assessment of the learning. (Adams & Williams, 2006)

Perhaps inevitably, interpretations and analysis of the processes involved in the delivery and experience of electronically facilitated learning have come to be influenced by the terminology of computing, therefore the tendency to think of these components as some kind of object is irresistible. The e-Tools Report (Miller et al, 2004, p. 21-22) notes the OO-origins of the concept of reusable Learning Objects, and the potential efficiency gains that a skilled teacher can make from reuse of the many rich types of high-level data objects currently available. (Reuse will usually involve adaptation, resulting in new or derived objects.)

The holy grail of this approach is the idea of creating E-learning courses by combining reusable Learning Objects (LOs), stored in some kind of retrieval and management system. There is, however, no one definition of what constitutes an Learning Object or of what size such an object should be to maximise its reusability capability.

e-Tools notes an IEEE definition of Learning Objects as "any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning":

A Learning Object is usually a small digital or non-digital file (like text, images, audio, and video) or module that when integrated with other Learning Objects make up course content. Learning Objects are a re-usable resource that can be used in a variety of contexts, across disciplines and institutions. It is a resource that can be modified to suit the academics teaching style and method and further enhance the objectives of the course. (Miller, 2004)

The concept of reusability is therefore also key. The term Reusable Learning Object (RLO) has gained currency, alongside E-learning Object (ELO) and Learning Object (LO). We can see no useful distinction between the terms for the purposes of this report, or any reason to re-iterate the electronicness or reusability of the class of digital objects under discussion, and will therefore use the term Learning Object and LO throughout.

### **2.2.2 When is an LO not an LO?**

One critical thing to understand is the scope and scale of the Learning Object domain. An analysis of the entire educational field – using object-oriented, relational or any other data modelling techniques – will yield an enormous variety of objects, classes, or entities, each with their own associated attributes and inter-relationships; from such overarching things as a national framework and curriculum, to an individual lesson (see Section 3.3, Typology), examination or a single multiple-choice question. "[T]he Learning Technology Standards Committee's definition leaves room for an entire curriculum to be viewed as a Learning Object, but such a large object view diminishes the possibility of Learning Object reuse" (Wiley). For the purpose and scope of this report we must therefore work within more manageable definitions, such as that of Clive Shephard:

A Learning Object is a relatively small, reusable digital entity that can be selectively applied – alone or in combination – by computer software, learning facilitators or learners themselves, to meet individual needs for learning or performance support. (Shepard, 2000)

### **2.2.3 What types of LO are there?**

We will see in the Typology (Section 3.3) that there are many ways to classify LOs. It is worth outlining the most common approaches here, to better understand the field.

The main approaches to classifying LOs appear to be:

- *Scale or size*: for example the scheme proposed by Stephen Jeyes to CETIS in 2001, which yields five levels of object:
  1. Course
  2. Learning Episode
  3. Learning Assembly
  4. Information Object
  5. Digital Asset
  
- *Content*: The current IEEE web page for the Learning Object Metadata standards project lists the following as examples of Learning Objects:

- multimedia content
  - instructional content
  - Learning Objectives
  - instructional software and software tools
  - persons, organizations, or events referenced during technology supported learning
- Purpose or intent: SmartForce's Learning Object Framework, for example, is based on a definition of four, very high-level Learning Object classes:
    - Instruction objects (e.g. interactive learning tools, coursework, online seminars and lectures).
    - Collaborative objects (anything supporting human interaction online).
    - Application objects (e.g. simulated real-world tasks).
    - Assessment objects

Each of these aspects adds a dimension to classification, but many can be conveyed through descriptive and contextual metadata, and may not prove significant for digital preservation purposes. Many of the items in JORUM fall into common categories of computer file in general use, such as Powerpoint or Flash presentations (the latter often interactive), Word documents, graphics (static and animated) and web page assemblies (HTML files and images). The class of LO that seems most unique to the domain is the assessment object - multiple-choice and other types of question, or assemblies thereof.

#### **2.2.4 SCORM**

Of particular significance in the field of LOs is the Shareable Content Object Reference Model (SCORM), published by the Advanced Distributed Learning Initiative (ADL). SCORM is a set of standards designed to facilitate interoperability, accessibility and reusability of web-based learning content.

SCORM provides a standardised approach to managing heterogeneous Learning Objects, by defining a way to specify both a packaging manifest (a list of all the files that an object might comprise) and metadata. For example, to package an object SCORM-wise, one would combine the original object file or files (e.g. a Powerpoint file, or several linked HTML files) with an XML encoded list of the files, and XML encoded metadata file, and create a Zip file containing all these files. SCORM-compliant applications – usually VLEs – can depend on this standard format to import objects reliably, with all their metadata intact.

Not all Learning Objects are SCORM objects, nevertheless it is a very useful starting point for consideration of LOs, as we can reliably expect a SCORM package to contain both the file bitstreams and standardised metadata in a way that is easy to

unpack and understand. The SCORM packaging technique has many affinities with approaches adopted by digital archives.

## **2.3 Significant Properties**

### **2.3.1 Definitions**

The JISC ITT provided the following definition of Significant Properties:

Significant Properties, also referred to as “significant characteristics” or “essence”, are essential attributes of a digital object which affect its appearance, behaviour, quality and usability. They can be grouped into categories such as content, context (meta-data), appearance (e.g. layout, colour), behaviour (e.g. interaction, functionality) and structure (e.g. pagination, sections). Significant Properties must be preserved over time for the digital object to remain accessible and meaningful.

The InSPECT Report (Wilson, 2007) identified five categories of Significant Property, in line with the JISC ITT definition.

- Content, e.g. text, image, slides, etc.
- Context, e.g. who, when, why.
- Appearance, e.g. font and size, colour, layout, etc.
- Structure, e.g. embedded files, pagination, headings, etc.
- Behaviour, e.g. hypertext links, updating calculations, active links, etc.

The same team working for SHERPA DP arrived at broadly similar terms and definitions when considering the Significant Properties of an e-print. This time, the four categories were:

- Text
- Images
- Layout
- Descriptive metadata

"The Significant Properties of a resource may be identified as the intellectual content that must be retained in subsequent migrations," this report stated. "The objective of digital preservation is to retain the four properties outlined above in a format that is sustainable in the long-term." (Knight, 2007)

### **2.3.2 Limitations of InSPECT**

Valuable as they are, the InSPECT and SHERPA categories above restrict themselves largely to de-scribing the static properties of a resource and its readability. "Content" and "Appearance" allude to certain features of a document, and the stated aim of digital preservation is to en-sure we can still read the document in the future. When considering these two categories, the curator may make a decision that the colour of

the font, for example, is an important part of the reading experience. But does this express all the inherent properties of the digital object?

"Context", as defined by InSPECT, is certainly applicable to Learning Objects managed in a VLE and used by their intended audience (see Section 2.1.4). Contextual properties could presumably cover such things as authorship and delivery of tutorials, audit trails of re-use and repurposing, as objects are moved in and out of the repository, and records of student assessments.

Of these five InSPECT categories, "Structure" and "Behaviour" are particularly significant in describing the actual inherent "digitalness" of a digital object.

The InSPECT definition of "Structure" deals with the structure of such things as a Word document or PowerPoint slide show, as stand-alone texts which communicate something and are heavily dependent on an internal file structure in order to keep on communicating. Put simply, if our preservation actions somehow remove the tables from a Word document, or result in lines from a two-column layout being unintentionally interleaved, then the text will cease to communicate effectively. For the purposes of Learning Objects, we would hope "Structure" to also include the structure of complex or compound Learning Objects, or relationships of one Learning Object to another, such as sequence or encapsulation.

The definition of "Behaviour" refers to the performance of a digital file or object when it's dependent on scripts, programs, links and so forth. These are undoubtedly Significant Properties and are also inherently digital.

### **2.3.3 CEDARS and CAMILEON**

Both of these projects are well documented elsewhere. They acknowledged (among other things) the extent to which it is necessary for digital archivists to know what the Significant Properties of digital objects were, when it came to migration of the object for preservation purposes. CEDARS in particular coined the term "Significant Properties", and first discussed its importance. It also examined what the term meant in the context of a number of object types. Neither project, however, appears to have defined a comprehensive set of Significant Properties.

The CEDARS approach, like that of InSPECT, seems to have focussed predominantly on the unit of the static digital document, and what was needed to be retained in order to keep on reading it. Significant properties were discussed as an approach to understanding an object's "text-ness" or "PDF-ness".

The 2002 *CEDARS Guide to Technical Strategies*, although limited mainly to the area of academic resources, suggested, as potential Significant Properties:

- File Names in UNIX systems - i.e. the case of the letters in the filename, deemed to be significant in UNIX systems but not in Windows systems.
- The packaging of a CD.
- Text, fonts, tables and diagrams.
- The layout of text, fonts, tables and diagrams in relation to each other.

Other caveats for the digital archivist proposed by CEDARS were:

- State any assumptions about significance upfront (i.e. before migration).
- Don't assess Significant Properties based simply on a file format.
- Don't preserve a resource with the wrong assumptions about what is significant.
- In some cases the resource may be missing a vital part of information.

This Guide proposed assessing these Significant Properties at the level of author, publisher and software. For long-term preservation, they concluded, "the Significant Properties as perceived by the *reader* are clearly paramount" (CEDARS, 2002; italics ours). Again, this suggests that legibility of the object was the prime concern of the project.

One way to assess success was to "imagine that the original hardware is still available and to ask if one could, in principle, recreate a working copy of the preserved object from data as represented in the putative abstract form". (CEDARS 2002, Section 13).

Although the CAMILEON project was largely focused on the innovative notion of "migration on request" - in other words, that a digital object should only be migrated when someone wants to access it - it did posit that all such migrations have to be carried out in such ways as to cause minimum loss of the Significant Properties of the object.

At the DLM-Forum in 2002, Hedstrom and Lee emphasised how difficult this was going to be because we now have so many "options available for creating surrogates, facsimiles and derivatives", clearly concerned that each generation of copying and migration might be losing something significant in the process. The conclusion they reached was that "digital documents have many features and exhibit behaviours that may or may not be important to preserve." (Hedstrom and Lee, 2002)

The methodology of CAMILEON was very thorough, drawing on examples outside of the digital realm. It researched legal admissibility and authenticity of documents, as well as colours, text, layouts and annotations in books. It thought about different ways of rendering and accessing objects (browsing, viewing, annotating, visualising). The micro-units of MIME types, format-specific specifications and style sheets were taken into account, and many metadata and technical standards were consulted. The resulting conceptual model for expressing Significant Properties proposed coverage of the following aspects:

- Complex digital objects (composed of more than one component)
- Common components of digital objects (text, graphics)
- Internal composition of complex objects (methods used to assemble a complex object)
- The explicit external relationships between objects (hyperlinks)
- The attributes of these external relations (e.g. semantic, cardinality, direction)
- Low-level properties (basic data unit, byte-level encoding, data type)

The model revealed that: "certain properties apply to all types of components, some properties are unique to particular component types, and some properties are applicable to multiple components but not necessarily to all types."

But it still didn't inform as to what these Significant Properties are. Instead, the model offered "a basis for breaking down the functions and behaviours of hyperlinks and pointers so that collection managers can decide which properties of the external relations are important to preserve." In other words, the digital curator still had to make a decision about significance; it's just that the conceptual model made the problem a lot clearer.

### **2.3.4 Significant Properties of E-learning Objects (SPeLOs)**

To the above observations we would add those of Hedstrom and Lee:

"...decisions about which Significant Properties to maintain will depend on institutional priorities, anticipated use, knowledge of the designated community, the types of materials involved, and the financial and technical resources available to the repository." (op. cit.)

We note also the similar conclusion of Gareth Knight in SHERPA-DP's consideration of E-prints repositories:

"...it is unlikely that different users will require access to this information in its entirety. The researcher, who is accessing the institutional repository, is likely to be concerned that the dissemination version provides an accurate rendition of the text, images and layout of the authors' or published paper; the publisher will be concerned that the lay-out of their original has been retained; while the preservation service is likely to re-quire information on all five properties, in order to construct a new dissemination version of the e-print." (op. cit.).

For the purposes of this report, we therefore begin with two main observations about the Significant Properties of Learning Objects:

1. The five InSPECT categories are not sufficient to express the complexity and richness of Learning Objects.

- 
2. The categories are not fixed values, and will mean different things depending on who is using the Learning Object and for what purpose.

## 3 Analysis

### 3.1 Scope of the study

The aim of this study was to complement the original InSPECT project and expand the port-folio of digital object types to include Learning Objects. Through identifying and analysing the Significant Properties of these digital object types (and the sub-types within them), the project intended to gain a deeper understanding of their complexity and characteristics. The report we have prepared will lead to additional focused research and development work to establish best practices for the long-term preservation of Learning Objects.

We discuss and analyse how the concept of “Significant Properties” applies to each of the object types, and we have assessed the working definition of “Significant Properties” produced by the InSPECT project.

We have built a simple model for expressing and describing the Significant Properties for each of the object types we have identified. The model helps to describe the relationship between Significant Properties and designated community, and some of the factors that impact the level of significance.

Three main elements were in the scope of the study:

- *Learning objects*: We needed a means of identifying them simply and soon realised there was no single standardised 'list' for doing this. Our starting point was to work instead with agreed sets of metadata terms used to describe LOs, and consolidate a new typology from it. We examined actual Learning Objects held in the JORUM repository. We did not examine objects in the context of a VLE.
- *Significant properties*: our Significant Property groups (ultimately what became the SPeLOs schema) were derived from intensive desk research using available literature and sorted by us into a new a coherent taxonomy. See 2.4 below for development of this process.
- *Designated communities*: different categories of these were identified, associated with different sets of LOs.

## **3.2 Methodology / Approach**

### **3.2.1 Identifying properties**

Learning Objects are typically single digital objects or aggregations of simple digital objects, sometimes within a specific packaging or framework (e.g. SCORM). From the start, our project approach assumed that there are two types of Significant Properties that would be relevant to the work:

1. Properties inherent to the object type (e.g. document, presentation, audio, video)
2. Properties specific to Learning Objects

We determined to focus on properties present in actual Learning Objects (such as those in JORUM), as opposed to the potentially vast array of properties which might theoretically be attributed to digital objects.

Working through desk research, we gathered information and ideas from a range of LO standardisation efforts and from the academic literature, in order to understand the range of Learning Object types and the formats in which they are generally expressed. Taking In-SPECT as a starting point, we compared our understanding with other work to define Significant Properties in general, and identify them for specific digital object types.

### **3.2.2 Designated communities and consumers**

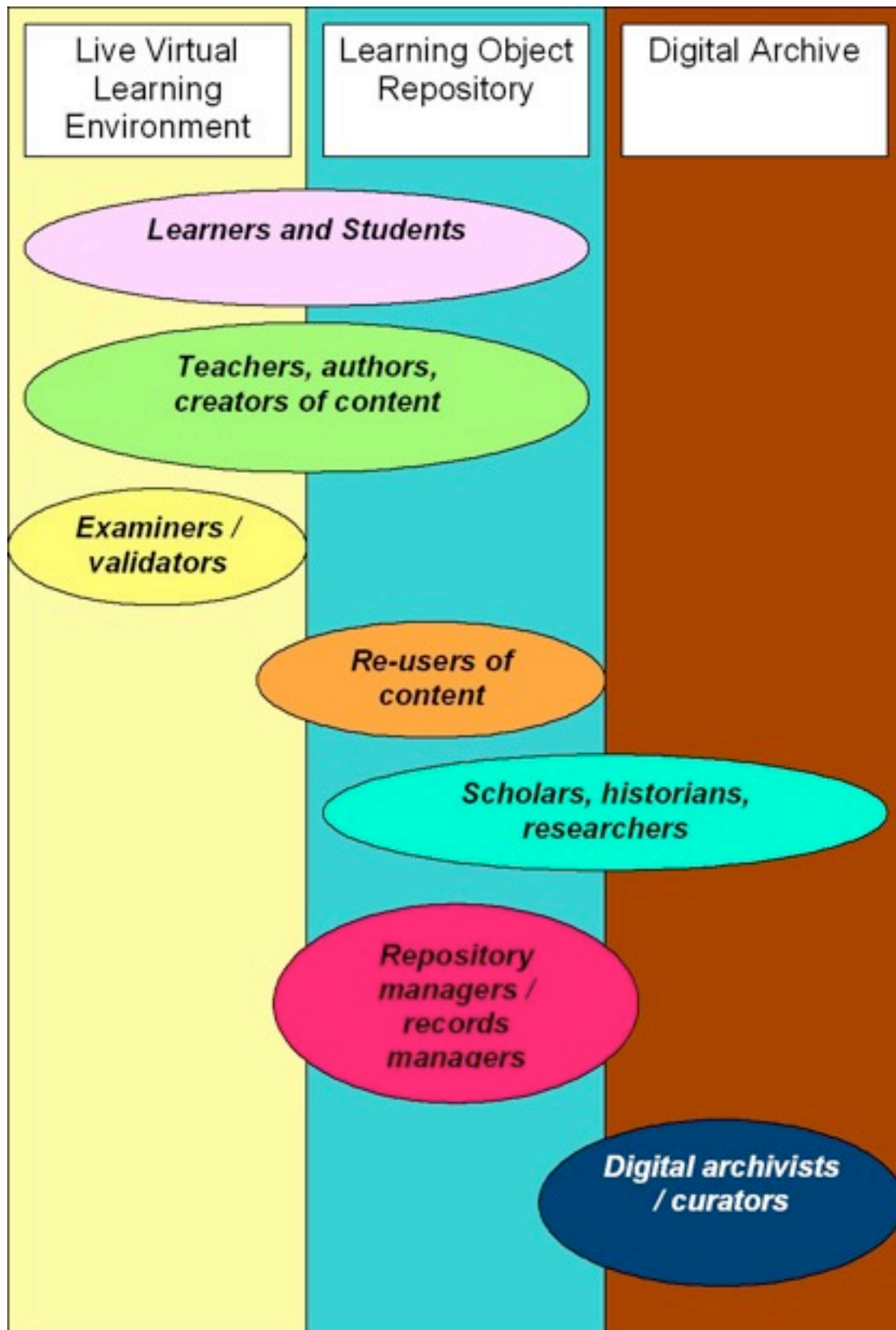
We understood there would be potential Designated Communities for Learning Object types, which could be associated with different categories of object, and that not all objects are of interest to all Designated Communities. But we also wanted to give consideration to the extent to which other potential Consumers (in OAIIS terminology) are distinct, or have distinct needs, from the Designated Community. This is of tremendous relevance to the consideration of Significant Properties. Although a digital archive is really only required to serve the needs of its Designated Community, it may wish to give consideration to the wider needs of others who wish to use its holdings, even if it is not obliged to do so.

Thus a Designated Community (academics, tutors, students, administrators) who manage and use Learning Objects can be seen as distinct from other Consumers (researchers, historians, scholars) of objects stored in a digital archive.

We took this aspect into consideration when examining JORUM and studying some of the objects stored in it.

The diagram on the following page gives an indication of our view of the seven discrete designated communities, and where their requirements intersect with

Learning Objects in the three main environments that an LO will encounter during its lifecycle (VLE, LOR and Digital Archive).



### **3.2.3 Survey**

Having been provided with access to the contents of JORUM, we thus surveyed a number of objects in their repository to determine which properties identified as potentially significant were actually present in a representative sample of objects in a repository. This was necessary because some properties (such as rights or licences) may be significant, but may not appear in many objects because the object's format makes their inclusion optional.

### **3.2.4 Typology and classification scheme for Learning Objects**

The project's approach to building a typology started with the document UK Learning Object Metadata Core Draft 0.2 (CETIS 2004), which we will sometimes identify as LOM. Appendix 2 of this document comprises a useful compilation list of UK and European Learning Re-source Types, and a compendium of preferred vocabularies used by various organisations for each one.

The schemas were taken from Resource Discovery Network (RDN), Further Education Resources for Learning (FERL), National Learning Network (NLN), Curriculum Online (CO), Higher Level Skills for Industry, Facilitating Access and Information to Learning and Teaching Resources in Engineering (FAILTE), Edinburgh Engineering Virtual Library (EEVL) and CELEBRATE. The e-Government metadata standard type encoding schema was also examined, although it was soon eliminated.

We consolidated the detail of these schemas into a single spreadsheet, noting the sources (there were nine different providers). This resulted in a list of 204 LO types. However we decided the RDN/LTSN LOM application profile (CETIS 2004), appeared to be the most comprehensive typology, and most immediately applicable to this project's aims. We located further descriptive information on each of the types (Barker et al. 2007) which was added to the spreadsheet.

This gave us 26 distinct LO types as a good starting point.

Next, we began a simple process of consolidation to align the schemas of the other organisations with the RDN schema. This was mostly an exercise of putting like with like, identifying cases where one schema called the same thing by a slightly different name (or the exact same name). For example, a large number of types can be usefully brought together under the RDN heading of 'Activity / Exercise / Fieldwork', including the terms Activity, Exercise, Experiment, Open activity, Experiment, and Assignment/task. Likewise, such diverse terms as 'Exam', 'Questionnaire' and 'Assessment/Test' all clearly denoted the same thing as RDN's 'Examination Test'.

Reference numbers were assigned to bring related terms together.

From this consolidation exercise, it became clear that the e-Government metadata types were the least useful of all for this project. The terms used did not appear to have any potential for learning and were more specific to use in central government administration than an academic context.

This process also revealed a number of Learning Objects which, in some schemas, were being managed at a micro-level; including for example individual images, or sets of images; datasets and tables; software tools; sound files; and animations. We decided to try and classify these appropriately. This resulted in a set of 11 LO sub-types. This part of the exercise rescued and incorporated a few selections from the e-Government list which looked likely to be of use. The 'image' classification was one of the most comprehensive, including diverse units such as Diagram, Figure, Graph, Plan drawing and Slide.

The results of this exercise were:

- A comprehensive list of discrete Learning Object types as used in the HFE community
- A naming scheme that would be recognised by that community, and which adhered to published standards
- An assurance that the list offered wide coverage of object types from across a range of varying naming schemes, meaning that we were unlikely to miss any important LO type from our considerations

This was a strong starting point to begin our next step of discovering and assigning Significant Properties to each discrete type.

### **3.3 Development of the Property Groups**

The project worked using desk research, gathering information from standards and from the academic literature to learn as much as possible about Learning Objects and their proper-ties. This initial brainstorming was followed by a taxonomic process where numerous diverse properties were sorted into discrete groups.

We arrived at the following 'Property Groups': function, context, reusability, delivery, rights management, digital object and look-and-feel. Each group had a provisional set of proper-ties assigned to it. (Another group, 'Content', contained only five properties which were soon identified as duplicate properties already assigned elsewhere in the scheme, and eliminated.)

The original sources for these Property Groups, and their lists of properties with definitions, are described below. Each table is followed by a brief discussion of the significance of the properties.

The original arrangement of our groups was hierarchical, in that it tried to distinguish between high-level properties which applied at the functional-context levels, down to proper-ties of actual digital objects at the lower depths. This approach was revised later in the project.

The next step was to consider ways of expressing each property in terms of a structured Ontology. We considered developing a comprehensive OWL ontology, but concluded that this was beyond our present remit and capabilities. Nevertheless, through some early experiments using Protégé, the Ontology Editor developed by Stanford University School of Medicine (<http://protege.stanford.edu>), we found it useful to express the properties in the ontological style, and began to think of them in terms of simple statements, expressing simple boolean properties (e.g. isInteractive) or functional relationships (e.g. IsPartOf, HasPart).

Although we have resisted mining this seam further, we feel that it offers an attractive way to expressing Significant Properties, particularly given the power offered by tools like Protégé to generate structural models, logical tests and visual aids.

We then did an initial comparison of our properties with Learning Objects in the JORUM repository. A fuller description of this process is in the next section. It became clear early on, however, that many examples actually corresponded to two or more of the 26 types in our initial classification scheme. The typology element was emerging as one of the most subjective parts of the model. We decided at this juncture to make 'types' into another form of 'properties'.

The model thus became something that was less of a strict hierarchical model. It did not work to strict inherited characteristics, and properties could be assigned to individual Learning Objects on a basis that didn't involve some form of exclusivity.

We also found that the schema works very well if we allow some of the elements to be repeatable. (This approach is in line with the Dublin Core standard for descriptive metadata.) In particular, Group E properties may benefit from that degree of flexibility if we want to recognise, for example, the different roles of authors and technical contributors using the E4 property.

### **Group A: Functional**

<b>Reference</b>	<b>Property</b>	<b>Description</b>
A1	isInstructional	Examples include interactive guided learning, coursework, streamed audio and video based online seminars, and demonstrations.
A2	isCollaborative	Examples include one-to-one, expert-led, and peer-to-peer human interaction in a media rich online environment.
A3	isAssessment	Examples include prescriptive, validated, and compliance testing.
A4	isApplication / Task	Examples include hands-on experience with real job tasks in a controlled environment.
A5	isInteractive	Requires or supports interaction with the user, for example, by entering text or using the mouse to manipulate objects or widgets on-screen.

#### ***Source***

The source for this property group is a description of the Learning Object Framework developed by Smartforce - now part of Skillsoft (BNET, 2000).

#### ***Discussion of the properties and their significance***

The intention here is to establish some very high-level functional properties to classify the diverse objects. There is no clear consensus within the HFE community on what these functions are, nor what to call them. The SmartForce framework may not be recognised as a standard, and its definitions are not completely stable. The only one that is completely unambiguous is 'Assessment'. Unsurprisingly, in our initial matching of Functions to LO Classifications, many of the objects tended to be 'Instructional'.

'isInteractive' was added by the Project as a separate functional property. Although Interaction is incorporated in two of the SmartForce definitions, we wanted to bring it out to make it stronger and bring it into line with our ontological approach. It is not the same as 'isCollaborative'. It refers to interaction between the user and the LOs, commonly found in objects like multiple-choice tests and exercises, and often confirmed by the 'isInteractiveResource' property of the object at the digital level.

Having determined these functions, the temptation was to use them at the very top position of a hierarchy, so that they could cascade down and govern the classification of the objects; for example, B4, B5 and B6 (see below) could all be confidently assigned as subdivisions of A3. This would in turn tend to govern aspects of the behaviour and performance of the objects at the lower end of the scheme.

However, this approach was found not to work very early on in the testing of the schema. For example, we found in JSTOR instructional objects that also contain an assessment on the material covered. Collaboration is also key in many online educational applications. In order to preserve the richness and diversity of the objects, it seemed sensible to avoid imposing disjunction and the rigidities of a hierarchical dependency-type schema.

With the Performance Model in mind, interactivity is an aspect of functionality that it is essential to preserve in a reusable LO. Other properties would seem more an expression of intention about the object's usage, therefore in terms of significance for digital preservation, only 'isInteractive' is of any interest to us.

### Group B: Learning Object Classification

Reference	Property	Description
B1	isActivity / Exercise / Fieldwork	A task that students are asked to do to help them develop particular skills, knowledge, or habits of mind.
B2	isActivity / Exercise / Fieldwork Notes	A set of notes or instructions associated with an activity, exercise or piece of fieldwork.
B3	isSimulation Model	A representation of a process, activity, organisation or object.
B4	isExamination Test	Materials, typically made up of several assessment items, that are designed to measure student learning (exams, questionnaires, quizzes) or to support educator design or development of such materials (rubrics).
B5	isQuestion Bank	A collection of assessment items and associated software to enable the storing of content to support the assessment of student learning.
B6	isAssessment Item	An item (e.g. a question/answer pair) that is designed to measure student learning. A complex object, consisting of a question together with its associated data such as score, feedback and either any media files required or links to those files.
B7	isComputer-based Tutorial	A computer-based resource that provides guided, practical information about a specific subject.

B8	isEvaluation Form	A form (computer-based or hardcopy) designed to solicit feedback with the intention of evaluating an activity or process.
B9	isCourse / Module / Unit / Programme	A sequence of instructional activities designed by an educator (or a faculty or other group of educators) to advance significantly student skills, knowledge, and habits of mind significantly in a particular discipline and to help students meet specified requirements (as set forth in curricula or government policy).
B10	isResource Pack	A complete package for a course, module or unit, including learning resources of several types, and possibly including supporting documentation such as tutors' instructions and Learning Objectives specified.
B11	isCase Study	A learning resource which is a detailed account of a process or activity.
B12	isProject Outline	A description of a set of activities organized around a particular academic topic.
B13	isStudy Guide	A guide created to provide students with hints, techniques, or management ideas in a particular area.
B14	isLecture Presentation	A video or audio recording or a transcript of a lecture, presentation, speech or classroom session.
B15	isGlossary	A collection of specialized terms and their meanings.
B16	isCourse / Lecture / Presentation Notes	A set of notes or overhead slides that accompany a course, lecture, presentation, speech or classroom session.
B17	isWorked Example	A written problem or exercise designed to illustrate a rule.
B18	isTextbook	A book with an explicit goal of explaining a field of inquiry to students.
B19	isDemonstration	A video or audio recording or a transcript of a practical exhibition of a process, activity or object.
B20	isReading List	A list of resources that accompany a course, module, unit or other activity.
B21	isTeaching Tip	A piece of practical advice primarily intended for an educator.
B22	isCurriculum Syllabus	Outlines of courses and modules and their contents. General material describing a course or unit of study.
B23	isEducator Guide	A guide intended for use by educators.

B24	isEducational Policy	A document containing statements or series of steps for particular way of accomplishing an activity related to education.
B25	isEducational Report	Detailed account or statement, often outlining the results or events of a meeting, endeavor, activity or study (e.g. review, evaluation) related to education.
B26	isLesson Plan	A plan for helping students learn a particular set of skills, knowledge, or habits of mind. Often includes student activities as well as teaching ideas, instructional materials, and other resources. Is shorter (in duration) than, and often part of, a unit of instruction. Goals and outcomes are focused.

### ***Source***

The typology of 26 Learning Objects produced by this project's exercise (see above) to render down the terms in the LOM schema and combine them with the other schemas. See Appendix A for a fuller version in table form.

### ***Discussion of the properties and their significance***

As noted before, these terms have the principal benefit of being widely accepted and recognised within the HFE Community, and have the authority of agreed naming and metadata schemes to back this up. That said, there remain some ambiguities about different objects being called by different names. The project's challenge was to reconcile overlap and similarities.

The classification is extremely useful in helping us to identify users' assumptions about the format that a certain class of LO might take. Notice that it is assumed that a Lecture Presentation (B14) is most likely to take the shape of a video or audio presentation, and hence its digital manifestation will often be rendered as an audio-visual file.

Nevertheless, this typology element is one of the most subjective parts of the model. Comparisons with actual LOs in JORUM revealed to us that there is rarely a one-to-one match between a single object and a single classification type. Quite often a deposited object is associated with two or three of these terms in the metadata. If that object is subsequently removed from the repository for re-use and repurposing within another learning assembly, there are potential additional complications of multiple classifications.

For these reasons it has been decided to express the LO Classification as another form of properties. Given our basic non-hierarchical approach, it allows each object to be 'tagged' with one or many classifications.

Significance: While all of these classifications mean something in the context of a VLE, and are crucial for teachers and students to understand their work, they are probably less meaningful for preservation purposes. It does, however, help to identify objects that are potentially (a) complex aggregations and (b) possess additional interactive elements not fully expressed using A5.

### Group C: Learning Unit Classification

Reference	Property	Description
C1	isPhysicalObject	Also called an 'Artefact' or 'Realia'.
C2	isCatalogueRecord	
C3	isDataset/Dataset table	Structured data in lists, tables, charts, databases, etc., normally in a format for direct machine processing. Data may be numeric, spatial, statistical or structured text.
C4	isImage/Diagram/Figure/Graph/Slide	Visual representation of a person, object, scene or process. Includes diagrams, icons, drawings, graphics, illustrations, logos, paintings, pictures, photographs, etc.
C5	isVideo/Movie/Animation	
C6	isTool/Software	
C7	isNarrative/Story	
C8	isMap/Geospatial	A geospatial representation, for example of a geographical area or road network. Includes navigational charts.
C9	isSound	
C10	isIndex	
C11	isOrganisationChart	

#### *Source*

The typology of 11 learning units produced by this project's exercise (see above) to render down the terms in the LOM schema and combine them with the other schemas. A 'learning unit' will be smaller than a 'Learning Object'; however, not all Learning Objects need be made up one or more of these units. See Appendix A for a fuller version in table form.

#### *Discussion of the properties and their significance*

As with Property Group B, these terms have the principal benefit of being widely accepted and recognised. Many of them are used by FERL and NLN, although mostly

lack precise definitions as to what the unit of learning is. Many of the definitions in the table above are taken from the e-Government standard.

The Physical Object property has been included for sake of completeness, although it is unlikely to apply in the digital world.

The Property Group is useful insofar as it can be used to identify certain specific objects, or their properties, which are missed out by Property Group B.

Significance: While all of these classifications mean something in the context of a VLE, and are crucial for teachers and students to understand their work, they are probably less meaningful for preservation purposes. To a certain extent, some of the terms are replicated in Property Group J, for example 'isSound' and 'isAudio', but the 'isDataset' property is useful.

### Group D: Contextual

Reference	Property	Description
D1	isPartOfCourse	Object is used (most likely along with other objects) to build up a Course
D2	isPartOfVLE	Object is not necessarily part of a course, but is available as a resource or research tool within the Virtual Learning Environment
D3	isPartOfCurriculum	Object is not bound to a single course, but does take its place in the University curriculum.
D4	isPartOfLearningEpisode	Object is used by a student as part of their learning episode; a Course may contain many episodes.
D5	isPartOfLearningAssembly	Object is used by a tutor as part of their learning assembly.
D6	isPartOfLearningObjectives	Object is not necessarily part of the episode-assembly sequence, but may constitute 'background reading' or research in support of the Learning Objective
D7	isPartOfSequence	This refers to a very specific step in the learning assembly.
D8	hasPlaceInSequence	This refers to a very specific step in the learning assembly.
D9	isPartOfAccreditation	Object forms part of a student's accreditation. Probably includes assessments.

**Source**

The source for this set of properties was Steven Jeyes' presentation (Jeyes, 2001).

**Discussion of the properties and their significance**

This contextual property group refers exclusively to use of Learning Objects inside a teaching and learning context. It tries to view Learning Objects in terms of where they sit on a presumed hierarchy. In the original CETIS slide, the hierarchy runs from the largest unit (Course) to the smallest (Digital Asset). It is a helpful model in so far as each unit is associated with a person who is actually doing something (eg tutor, student, author), a concept which we used to create the next property group.

- COURSE (Validator)
- LEARNING EPISODE (Student)
- LEARNING ASSEMBLY (Tutor)
- INFORMATION OBJECT (Author)
- DIGITAL ASSET (Curator)

We added Accreditation from the JORUM metadata. We also added VLE, Curriculum, and Learning Objectives as other contextual terms which seemed to have wide use and meaning in the HFE world. At one stage, the context was also going to include the wider external world of the public sector and commercial publishing.

Properties in this group are only likely to have any significance when applied to Learning Objects stored in a VLE. They are significant for expressing and recording the stages that take place when, for example, a tutor is assembling a learning package. The properties will also, to a certain extent, work in synergy with the reusability property group (see H below). These properties will also have implications for the production of complex Learning Objects, especially when it comes to issues of aggregation and disaggregation. We make this assumption based on other assumptions about what a VLE is capable of doing in terms of recording and storing metadata about object use, and the needs of the academic community.

It may also be of interest to note that this contextual metadata - assuming it was available when an object was used in a VLE - is not kept for objects in JORUM.

Significance: this Property Group may have no significance at all for the performance model. It will be significant for other purposes, mostly academic use, reuse and aggregation, but not for preservation/performance. See for example 'Learners and students' and 'Teachers, authors and creators of content' in our Designated Communities chart (Appendix B).

**Group E: People/Roles**

Reference	Properties	Description
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E1	isCheckedbyValidator	Object has been checked by a Validator to ensure its value as part of a Course. (See D1)
E2	isUsedbyStudent	Object is used by a Student to learn something. (See D4)
E3	isAssembledbyTutor	Object has been assembled by a Tutor to form a Learning Assembly.
E4	isWrittenbyAuthor	Object has been written by a named individual (and see H5 in Rights Management).

### ***Source***

The source for this group was the CETIS presentation on interoperability given in 2001.

### ***Discussion of the properties and their significance***

These properties seem to be attractive as they correspond to the real world of tutors and students using Learning Objects. Unfortunately, each property could apply with equal ease to almost any Learning Object found in a VLE. None of them are particularly significant for preservation purposes.

Significance: as with Property Group D, this Property Group may have no significance at all for the performance model. It may be significant for other purposes, mostly academic use, but not for preservation/performance.

### **Group F: Reusability**

<b>Reference</b>	<b>Property</b>	<b>Description</b>
F1	isSearchable	The content of the resource can be searched (for example a text search can retrieve specific words or phrases in the resource)
F2	isDiscoverable	Object or resource can be found or accessed by its high-level metadata
F3	isInteroperable	Object is stored in an interoperable format. See section 8 of the JISC Report: "there is an extremely important distinction to be made between the internal operation of a Learning Object and its external interoperability. E-learning specifications and standards will facilitate the latter, but not the former."

F4	isAccessible	This refers to 'controlled access' within the context of a VLE, where the curriculum and its objects have been mapped to certain elements which can be separately assessed or recorded.
F5	isCapableofWorkinginDifferentApplications	See Section 7.1.2 of the JISC Report, which exposed particular problems among Assessment applications. "There are noticeable differences between applications in how they import, render and export question and test content."
F6	isApplicableToOtherLearningEnvironments	Object can be removed from one VLE and made to function / behave correctly in another
F7	isApplicableToOtherSubjectAreas	Object is associated with a certain discipline (eg Geography) but could feasibly be repurposed in another (eg Mathematics)
F8	isCustomisable	Content and look and feel of the object could be changed by an author to suit their purposes; also the object could be disaggregated to be reaggregated with other objects
F9	isCapableOfGeneratingLessons	"IMS CP metadata separates data about the internal file structure from the various views/ applications/aggregations of it. Through the concepts of packages and manifests and the following of certain rules, chunks of data can be recombined into new e-learning resources without, say, hypertext links being compromised. New resources, such as an entire course or individual lessons, can be put together so that they are completely self-contained and can stand alone. This is the special contribution of IMS CP."
F10	isModular	All LOs have to be modular to some extent if they are going to be reused. This may not be a useful SP.

F11	isFlexible	See JISC Report section 5.2.1 on Granularity. "If a Learning Object is too large or conceptually complex it may be difficult to reuse it in different contexts. Ensuring that Learning Objects are created at an appropriate level of granularity is therefore seen as a key requirement for reusability."
F12	isKeptInALORepository	Object is stored, along with descriptive metadata, in a specialist repository such as JORUM.

**Source**

Long-Term Retention and Reuse of Learning Objects and Materials (JISC, 2004).

**Discussion of the properties and their significance**

Reusability is a term highly specific to Learning Objects in the context of a VLE or LO Repository. The 2004 JISC Project team wanted "to avoid tying the report to any one view on how best to promote reusability in e-learning. Many different approaches are currently being used to develop e-learning materials for reuse, and they are dependent on the aims of the creators and the audience they are designing for."

This Property Group is largely a set of properties which can be used by an institution to help to verify whether their VLE is actually supporting reusability successfully. Properties F4, F5, F6, F8, F9, F10 and F11 refer to specific functions of a VLE. However, some of the properties are also highly significant in the way they impact on and can affect preservation and performance.

**Group G: Delivery**

Reference	Property	Description
G1	isSoftwareDependent	Object is dependent on the software that created it in order to perform
G2	isHardwareDependent	Object is dependent on hardware in order to perform
G3	isFormatDependent	Object is dependent on a certain format in order to perform
G4	isDeliveredbyVLEpackage	The object is delivered by VLE packaging standard such as SCORM, COLA or Moodle.

G5	isDeliveredbyAssessmentpackage	The object is delivered by an assessment package such as TOIA (online assessment) or IBIS (Item Banks - banks of questions for exams)
G6	isDeliveredbyZIP	Object is zipped up inside a repository
G7	isDeliveredwithXMLSchema	Object has an XML Schema associated with it

### ***Source***

The software, hardware and format dependencies are based on common assumptions about digital preservation, which we have derived from the OAIS model. The properties G4 and G5 derive from assumptions about the specific VLE systems which work as tools for delivering or managing LOs. As these are functions specific to a VLE, the project has not been able to test them in the case studies. The properties G6 and G7 refer to specific delivery functions associated with a LO repository, such as JORUM.

### ***Discussion of the properties and their significance***

The technical dependencies are defined so as to focus on the performance and preservation aspects. The remaining properties are technical dependencies for behaviour of LOs inside VLE packages, some of which might tend to affect the reusability of the objects. (See *isInteractiveResource*, above).

## **Group H: Rights Management**

<b>Reference</b>	<b>Property</b>	<b>Description</b>
H1	isSubjecttoTermsandConditions	For example, Creative Commons licenses
H2	isProtectedbyDRM	Digital Rights Management
H3	isLicensedbyJORUM	Resource is only available to authorised users of the JORUM service
H4	isCapableofRepurposing	Reuse of the object is not restricted by the IPR
H5	isHeldByANamedIndividual	An author and / or contributors are named as the copyright holder(s)
H6	isGovernedByPermissions	For example, Creative Commons licenses
H7	isGovernedByConstraints	For example, Creative Commons licenses
H8	isGovernedByRequirements	For example, Creative Commons licenses

H9	isHeldByANamedInstitution	A University or other HFE Institution is named as the copyright holder and/or holder of other rights
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**Source**

JORUM rights metadata fields.

**Discussion of the properties and their significance**

These properties are almost entirely IPR-based, and are best understood as a way of managing reusability of objects. See the JISC 2004 Report Section 6.2.1. "If sharing and reuse is based on some kind of money based market, then e-learning materials will need to be accompanied by clear IPR information that can be used to facilitate rights clearance. Even if e-learning materials are made available at no cost, perhaps through a licensing framework such as the Creative Commons (Creative Commons, N.D.), the ability to track rights, and assure authors due recognition for their work will still be important. A particular complication for Learning Objects may emerge when they are modified – raising the question of how to apportion authorship."

We decided we needed to add a DRM property, and this comes from our understanding of digital preservation. If the object is to be preserved, digital curation requires certain rights to transform the object as part of a migration strategy. If the other IPR properties impact on this, then preservation may be compromised. In this light, the DRM property is the only significant one for this project's purposes.

**Group J: Digital Object datatypes**

Reference	Property	Description
J1	isText	A resource consisting primarily of words for reading.
J2	isNumeric	
J3	isImage	A visual representation other than text. Examples include images and photographs of physical objects, paintings, prints, drawings, other images and graphics, animations and moving pictures, film, diagrams, maps, musical notation. Note that Image may include both electronic and physical representations.
J4	isSound	A resource primarily intended to be heard.
J5	isMovingImage	A series of visual representations imparting an impression of motion when shown in succession.

J6	isInteractiveResource	A resource requiring interaction from the user to be understood, executed, or experienced. Examples include forms on Web pages, applets, multimedia Learning Objects, chat services, or virtual reality environments.
J7	isCollection	An aggregation of resources. A collection is described as a group; its parts may also be separately described.
J8	isPartOfCollection	

**Source**

DCMI Type Vocabulary

**Discussion of the properties and their significance**

The terms here are intended to cover all the digital object properties that are used by Learning Objects. While many are generic and 'common', the aggregation properties are completely specific to ELOs. This is in line with our plan to characterise two types of Significant Properties: those which are inherent to the object type (document, presentation, audio etc.) and those which are specific to Learning Objects, which are typically aggregations of simple objects within specific packaging.

All the properties are deemed significant for performance and preservation.

**Group K: Look and feel**

Reference	Property	Description
K1	isDependentOnFonts	
K2	isDependentOnColours	
K3	isDependentOnLayout	
K4	isDependentOnTables	
K5	isDependentOnLanguage	
K6	isDependentOnCharacterSet	
K7	isDependentOnBoxes	
K8	isDependentOnDrawingobjects	
K9	isDependentOnEmbeddedobjects	
K10	isDependentOnPageBasedViewing	

***Source***

CEDARS (2002) and InSPECT (Wilson 2007).

***Discussion of the properties and their significance***

This Property Group covers the appearance of the object. The assumption in all cases is these are specific properties of the resource that, if lost, would seriously impair its ability to communicate or teach. All the properties are deemed significant for performance and preservation.

## 4 Case Studies

*In the following case studies we analyse objects stored in JORUM that we feel are representative of three common types of Learning Object, namely a simple presentation, an interactive object, and an object that includes an assessment.*

### 4.1 Case Study 1: Presentation object

#### 4.1.1 Overview

<b>Object title</b>	Wired design in floral art
<b>JORUM catalogue reference</b>	4752
<b>Retrieved on</b>	12/03/2008
<b>Description</b>	The resource is a PowerPoint slide show demonstrating the uses of wired techniques in floral art design. The JORUM metadata describes it as 'Expositive'.

#### 4.1.2 Properties

Ref	Property	Comments
A1	IsInstructional	This object is simply an instructional presentation. The object's metadata confirms that its level of interactivity is 'very low', so we did not assign an A5 value.
B14	IsLecturePresentation	B14 was the closest match to describe this slideshow and none of the other LO terms were appropriate.
C4	IsImage/Slide	We decided to tag the object with C4 as it contains some images and it is a slide show.
D	[Contextual]	We argue elsewhere in the report as to why these Significant Properties apply exclusively to objects in a VLE, rather than to objects in a Repository.
E1	isCheckedByValidator	The JORUM metadata records a validator (Mary Jane Steer) in the form of a Vcard, including her organisation and email address.

Ref	Property	Comments
E4	isWrittenByAuthor	Author ("creator") is recorded by JORUM metadata as Geoff Foot in the form of a Vcard, including his organisation and email address.
F1	isSearchable	The object contains text, which we found to be searchable by the application software.
F2	isDiscoverable	The object's JORUM metadata allows it to be retrieved.
F3	isInteroperable	The use of SCORM packaging with XML and ZIP makes the object potentially exchangeable across a wide range of web clients and platforms.
F5	isCapableofWorkingin-DifferentApplications	Although written with MS PowerPoint, the object worked with an Open Source application (Open Office).
F6	isApplicableToOther-LearningEnvironments	The relative simplicity of the object makes it possible for it to behave properly in other VLEs. JORUM provides no record of this, however.
F11	isFlexible	This object seemed to us to be sufficiently simple to be reused in other contexts in which instruction about floristry is appropriate.
F12	isKeptInALOREpository	Object is stored in JORUM.
G3	isFormatDependent	The file format (ppt) is necessary for the object to perform as a slide show. Note that this property does not necessarily imply software dependency (i.e. MS Powerpoint alone), which is why this object is not tagged with G1. Nor does this property negate the F5 property.
G6	isDeliveredByZIP	JORUM delivers the object in SCORM-compliant ZIP file package.
G7	isDeliveredWithXMLSchema	JORUM delivers the object in SCORM-compliant ZIP file package, including IMS metadata file and associated schema (XSD) file.
H1-H9	[Rights management]	It was felt that all the Rights Management properties except H2 apply to this object, since it is held in the JORUM repository. Only Digital Rights Management (H2) is not sufficiently covered by the JORUM metadata.

Ref	Property	Comments
J1	IsText	The object contains both text and images.
J3	IsImage	The object contains both text and images.
K1	isDependentOnFonts	The object uses specific font <i>sizes</i> to communicate different points. The object's actual font (Comic Sans MS) may not be significant.
K2	isDependentOnColours	The object uses three different font colours to communicate.
K3	isDependentOnLayout	The object depends on bullet points and title headings.
K5	isDependentOnLanguage	The object is written in English.
K6	isDependentOnCharacteraset	Correct identification of character encoding is necessary to render the text correctly.
K9	isDependentOnEmbeddedobjects	The image objects are embedded on specific slides.
K10	isDependentOnPageBasedViewing	Like all PowerPoint objects, the object depends on a page-based approach to viewing.

### 4.1.3 Notes

In terms of the object's *reusability*, we noted that property F7 (isApplicableToOther-SubjectAreas) is not likely to apply. The object could not be repurposed to another educational discipline; this view is confirmed by the narrow range of keywords in the object's metadata, which are 'floristry', 'floral art', 'buttonholes', 'foliage' and 'wiring techniques'. This does not however negate F11, which reflects the object's flexibility in respect of its size and standalone nature: should any other discipline require a module on floristry, there is no barrier to that reuse.

We also noted that the object used PowerPoint custom animation on two slides, to make them 'spin' into view. This animation does not in our view constitute a C5 property of significance. It is up to a digital archivist to decide if this property is worth preserving at the level of J: Digital Object.

## 4.2 Case study 2: Interactive object

### 4.2.1 Overview

<b>Object title</b>	X-ray beam manipulation
<b>JORUM catalogue reference</b>	3216
<b>Retrieved on</b>	12/03/2008
<b>Description</b>	The resource is an animated simulation that shows the effects of mAS and KVp on x-ray beam quality and intensity. The resource allows the user to alter the mAS and KVp controls of a simulated x-ray machine and to see the effect that has on the beam and the final x-ray produced.

### 4.2.2 Properties

Ref	Property	Comments
A1	IsInstructional	The resource is described as a 'Simulation' and can be used as 'a demonstration of the variation in, and causes of, x-ray beams'.
A5	IsInteractive	This animated resource can be manipulated by the end-user. The use of Flash animation allows the animation to change. The object's metadata confirms the Type of Interactivity as 'Active', even if the level of interactivity is described as 'low'.
B1	isActivity / Exercise / Fieldwork	The object can feasibly be tagged with these three Learning Object Classification properties, although B3 is clearly the predominant property.
B3	isSimulation Model	
B19	isDemonstration	
C5	isVideo/Movie/Animation	The object uses Flash animation.
C9	IsSound	The object also teaches by using audio materials which deliver the same content as the text components.
D	[Contextual]	We argue elsewhere in the report as to why these Significant Properties apply exclusively to objects in a VLE, rather than to objects in a Repository.

Ref	Property	Comments
E1	IsCheckedByValidator	The JORUM metadata records a validator (Mary Jane Steer) in the form of a Vcard, including her organisation and email address.
E4	IsWrittenByAuthor	The JORUM metadata records an author (Paul Bartholomew) and also a creator (Chris Poole) in the form of a Vcard, including their organisation and email address. Chris Poole is also identified as a "Technical Implementer".
F2	isDiscoverable	The object's JORUM metadata allows it to be retrieved.
F3	isInteroperable	The use of SCORM packaging with XML and ZIP makes the object potentially exchangeable across a wide range of web clients and platforms.
F5	isCapableofWorkinginDifferentApplications	The SWF (Shockwave Flash) format can be embedded in many applications.
F6	isApplicableToOtherLearningEnvironments	The relative simplicity of the object makes it possible for it to behave properly in other VLEs.
F12	isKeptInALORepository	Object is stored in JORUM.
G1	isSoftwareDependent	Object is dependent on Shockwave Flash player (however implemented).
G3	isFormatDependent	Format used is SWF (Shockwave Flash).
G6	isDeliveredbyZIP	JORUM delivers the object in SCORM-compliant ZIP file package.
G7	isDeliveredwithXMLSchema	JORUM delivers the object in SCORM-compliant ZIP file package, including IMS metadata file and associated schema (XSD) file.
H1-H9	[Rights management]	It was felt that all the Rights Management properties except H2 apply to this object, since it is held in the JORUM repository. Only Digital Rights Management (H2) is not sufficiently covered by the JORUM metadata.
J6	IsInteractiveResource	The object is multimedia (animation, sound, text, image) and it teaches through interaction with the user.
K1	isDependentOnFonts	The object is dependent on fonts in both the static and animated parts of the resource.

<b>Ref</b>	<b>Property</b>	<b>Comments</b>
K2	isDependentOnColours	The animation and diagrams are heavily dependent on colours.
K3	isDependentOnLayout	The elements are laid out in a very specific order.
K5	isDependentOnLanguage	The language of the resource is English.
K6	isDependentOnCharacteraset	Correct identification of character encoding is necessary to render the text. The object identifies the Encoding as ISO 8859-1 in its XML/HTML header.
K8	isDependentOnDrawingObjects	The resource uses drawing objects in the main diagram.
K9	isDependentOnEmbeddedobjects	The resource uses embedded objects in the diagram and animation; and the sound file is also embedded.

### 4.2.3 Notes

### 4.3 Case study 3: Assessment object

#### 4.3.1 Overview

<b>Object title</b>	The Verb 'To Be'
<b>JORUM catalogue reference</b>	355
<b>Retrieved on</b>	12/03/2008
<b>Description</b>	The resource is an HTML/text file demonstrating grammatical usage. It also uses embedded Javascript to implement an interactive assessment in the form of a cloze test with drop-down options. Marks are awarded on submission of the completed test. JORUM describes the object type as “Exercise” and “ActivityExerciseFieldworkNotes”.

#### 4.3.2 Properties

Ref	Property	Comments
A1	IsInstructional	The first part of the object contains instructions about the uses of the verb “to be”.
A3	IsAssessment	The embedded cloze test assesses the student's understanding of the instructional material.
A5	IsInteractive	The student interacts with the object by completing the embedded test.
B1	IsActivityExerciseFieldwork	The extent to which an exercise is also an assessment depends on the context in which it is used. In the absence of further information, we determine it may be either.
B2	IsActivityExerciseFieldworkNotes	We follow JORUM in ascribing this property.
B6	IsAssessmentItem	In our view this is the predominant classification of this object.
B7	IsComputerBasedTutorial	The combination of instruction and interactive assessment suggests CBT is also an appropriate classification.

Ref	Property	Comments
D	[Contextual]	We argue elsewhere in the report as to why these Significant Properties apply exclusively to objects in a VLE, rather than to objects in a Repository.
E1	IsCheckedByValidator	The JORUM metadata records a validator (Paul Meehan) in the form of a Vcard, including his organisation and email address.
E4	IsWrittenByAuthor	Author is recorded by JORUM as “X4L West Midlands”
F1	isSearchable	The object contains text, which we found to be searchable by the application software.
F2	isDiscoverable	The object's JORUM metadata allows it to be retrieved.
F3	isInteroperable	The use of Open Standards (HTML, Javascript) for text, as well as SCORM packaging with XML and ZIP makes the object potentially exchangeable across a wide range of web clients and platforms.
F5	isCapableofWorkinginDifferentApplications	As with F5, effective use of the object is not limited to any specific vendor or software application.
F6	isApplicableToOtherLearningEnvironments	The relative simplicity of the object makes it possible for it to behave properly in other VLEs. JORUM provides no record of this, however.
F11	isFlexible	This object seemed to us to be sufficiently simple to be reused in other contexts.
F12	isKeptInALORepository	Object is stored in JORUM.
G3	isFormatDependent	The file format (HTML) is necessary for the object to perform. Note that this property does not necessarily imply software dependency, which is why this object is not tagged with G1. Nor does this property negate the F5 property.

Ref	Property	Comments
G6	isDeliveredByZIP	JORUM delivers the object in SCORM-compliant ZIP file package.
G7	isDeliveredWithXMLSchema	JORUM delivers the object in SCORM-compliant ZIP file package, including IMS metadata file and associated schema (XSD) file.
H1-H9	[Rights management]	It was felt that all the Rights Management properties except H2 apply to this object, since it is held in the JORUM repository. Only Digital Rights Management (H2) is not sufficiently covered by the JORUM metadata: no embedded restrictions on access or use are evident.
J1	IsText	The object contains text.
J6	IsInteractiveResource	The object is interactive.
K3	isDependentOnLayout	The object depends on bullet points and title headings.
K5	isDependentOnLanguage	The object is written in English.
K6	isDependentOnCharacterSet	Correct identification of character encoding is necessary to render the text. The object identifies the Encoding as ISO 8859-1 in its XML/HTML header.
K9	isDependentOnEmbeddedobjects	The drop down and text box objects are essential to the assessment

### 4.3.3 Notes

We know that the object is intended for use by students, and one would expect many systems to maintain records of which students used which objects (including assessments), and when, and with what outcomes. This is not recorded here. Property E2 (isUsedByStudent) would be an obvious place to implement those relationships with student records.

Similarly there is no record in JORUM of any uses this object may have been put to in any VLE or Assessment package (G4, G5).

## 5 Conclusions

This study has attempted to identify Significant Properties of Learning Objects by combining an analysis of existing approaches to LO use, classification and management with a consideration of the likely expectations of LOs in a preservation context.

In many ways the survey has had to be superficial, given that the canvas of Learning Objects is broad, even if we limit our scope to the subset of smaller, often atomic reusable as defined by Wiley and Shepherd. We should remember also that any Learning Object is also likely to inherit a raft of Significant Properties from other aspects of its manifestation, whether as an instance of one of the broader types of file suggested by the DCMI list, or from the characteristics of the specific file format used. For these we refer readers to InSpec, and the other Significant Properties studies of this JISC programme (for Software, Vector Images and Moving Images).

We have therefore concentrated on identifying high level category functions that are explicitly tied to the real functions of Learning Objects. We have defined classifications of named Learning Objects using, as far as possible, terms that were already recognised or widely used in the literature; and the same for named learning units. We have added detail on the context in which Learning Objects are used and presented, and the roles of the people who do this.

As part of our approach, and as a result of conducting the case study analysis, we developed a more elaborate version of the SPeLOs property set, in an attempt to quantify the significance of properties. The original chart plotted the properties and their significance to educators and archivists. To enrich this, we added more "communities" columns, to demonstrate explicitly the significance to key classes of interested party. (This approach also makes the chart easy for others to amend if they want to extend or revise it.)

Reusability emerged as a strong and distinct feature of Learning Objects, and clearly has meaning to the intended audience (even if not necessarily significant for preservation purposes); we identified 12 separate reusability properties.

Rights management is likewise crucial for those operating and working with VLEs and repositories, hence our nine defined properties.

Designated communities are clearly also a key factor in assessing the significance of an object's properties: there is a complex relationship between who is using the object, what they do with it, and how it interacts with other objects in the context of a course or curriculum. This reinforces our view that a holistic, "life-cycle management" approach (see Section 2.1.4) is the most satisfactory way to address preservation of the full range of potential properties, something that extends the information we need to record about an LO. Looking at the distinct requirements of the principal user community / consumers:

*The academic community:* Tutors, authors, students and co-ordinators will be interested in properties such as metadata for discovery, audit trails, rights management, and other distinct properties that will enable them to use and reuse the object. These requirements could be summarised as "Discovery and Use" when referring to objects kept in the live VLE environment; and as "Retention and re-use" when referring to objects kept in the repository environment. It may be possible to plot these Significant Properties against the SPeLOs set.

*The preservation community:* Digital archivists and curators will be interested in preserving those properties of the object that enable them to turn it into an AIP in OAIS terms; and also in preserving the legibility of the object for future use (thus meeting the requirements of the designated user community of researchers). The archivist may not necessarily be concerned with the entire contextual history of the object's original use within a VLE. If these assumptions are fair, it may also be possible to plot "Preservation" properties against the SPeLOs set.

The user community spreadsheet (Appendix B) analyses each SPeLOs property group for each of the seven communities, in an attempt to assess its significance to them. This expands on the overview diagram which shows the place of each community mapped against each of the likely phases in the LO lifecycle where they are likely to interact with it (VLE, LO Repository, Digital Archive).

Finally we should note that objects relating to assessments have a particularly complex set of potential relationships, particularly if information about their relevance to a particular curriculum, examination, assessment or verification process, or even student is to be preserved. The conclusions and models of this study might profitably be fed into a consideration of the issues around item banks, as described in the IBIS study (Sclater 2004).

In brief, we came to see LOs as rich and complex resources, with many Significant Properties that were concerned with deeper issues than legibility and rendering. We feel that there is a need for further categories, dimensions and elements to the InSPECT category set, expanding it considerably, as described in Section 2. The remaining property sets are concerned with technical software and hardware aspects of Learning Objects. These, by and large, are informed by aspects of the InSPECT, CEDARS and CAMILEON notions of readability and look and feel.

Our case studies in JORUM revealed that there is still much information about usage, reuse and delivery is not among the metadata required to deposit the object in the repository. Contextual properties (such as the actual use made by a student or tutor of any given object at any specific time) are not expressed in JORUM either. Transfer from the VLE of an audit trail of reuse does not seem to survive the custodial transfer of an object into JORUM. In particular, since complex or compound objects are likely

have to be disaggregated before they can enter into an archive or repository – not least to facilitate reuse – it would seem desirable for the archivist to capture the record of the LO's use and reuse from the VLE.

This information may not fall into the category of characteristics essential to assess the authenticity of future performance, but it is key to understanding the object's context, and it is regrettable if it is not preserved, particularly if it already exists in the VLE.

We feel that it is not enough to settle for preserve the simple 'raw' object, without any contextual history of how it was deployed, used, and reused in its original environment; and this confirms our view that cradle-to-grave management of LOs, like any other digital object, is the optimum approach for their preservation.

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## Appendix A: Definitive List of LO Properties

This is a complete list of the properties described in Section 2.4.

*An explanation of the column Boolean, Value and Relationship:* These terms are used as short hand to indicate how we would expect the object to be represented.

- By *Boolean* we mean a property that need be represented only as being present or not - a simple indication of Yes/No, True/False.
- By *Value* we mean a property that we would expect to be represented by some value, such as a name or a number. A property like "isSoftwareDependent" is going to be most useful if it records the name and version of that software.
- By *Relationship* we mean that the property implies a relationship to one or more other objects or records, such as a Course, an Author, an Institution.

These are only illustrative, and in some cases we suggest that more than one type might be appropriate. For example, depending on approach, the isWrittenByAuthor property might simply be one or more names, or it might equally be considered a Relationship on one or more Author objects (for example in a preservation system using the entity model of PREMIS). Yes and No, on the other hand, are clearly not useful values for isWrittenByAuthor.

Ref	Property Group	Property	Boolean/Value/Relationship	Description
A1	Functional	isInstructional	B	Examples include interactive guided learning, coursework, streamed audio and video based online seminars, and demonstrations.
A2	Functional	isCollaborative	B	Examples include one-to-one, expert-led, and peer-to-peer human interaction in a media rich online environment.
A3	Functional	isAssessment	B	Examples include prescriptive, validated, and compliance testing.
A4	Functional	isApplicationTask	B	Examples include hands-on experience with real job tasks in a controlled environment.
A5	Functional	isInteractive	B	Not the same as 'isCollaborative'. This refers to interaction between the user and the LOs, commonly found in objects like multiple-choice tests and exercises, and often confirmed by the 'isInteractiveResource' property of the object at the digital level.

Ref	Property Group	Property	Boolean/Value/Relationship	Description
B1	Learning Object Classification	isActivity / Exercise / Fieldwork	B	A task that students are asked to do to help them develop particular skills, knowledge, or habits of mind.
B2	Learning Object Classification	isActivity / Exercise / Fieldwork Notes	B	A set of notes or instructions associated with an activity, exercise or piece of fieldwork.
B3	Learning Object Classification	isSimulation Model	B	A representation of a process, activity, organisation or object.
B4	Learning Object Classification	isExamination Test	B	Materials, typically made up of several assessment items, that are designed to measure student learning (exams, questionnaires, quizzes) or to support educator design or development of such materials (rubrics).
B5	Learning Object Classification	isQuestion Bank	B	A collection of assessment items and associated software to enable the storing of content to support the assessment of student learning.
B6	Learning Object Classification	isAssessment Item	B	An item (e.g. a question/answer pair) that is designed to measure student learning. A complex object, consisting of a question together with its associated data such as score, feedback and either any media files required or links to those files.
B7	Learning Object Classification	isComputer-based Tutorial	B	A computer-based resource that provides guided, practical information about a specific subject.
B8	Learning Object Classification	isEvaluation Form	B	A form (computer-based or hardcopy) designed to solicit feedback with the intention of evaluating an activity or process.
B9	Learning Object Classification	isCourse / Module / Unit / Programme	B	A sequence of instructional activities designed by an educator (or a faculty or other group of educators) to advance significantly student skills, knowledge, and habits of mind significantly in a particular discipline and to help students meet specified requirements (as set forth in curricula or government policy).
B10	Learning Object Classification	isResource Pack	B	A complete package for a course, module or unit, including learning resources of several types, and possibly including supporting documentation such as tutors' instructions and learning objectives specified.

Ref	Property Group	Property	Boolean/Value/Relationship	Description
B11	Learning Object Classification	isCase Study	B	A learning resource which is a detailed account of a process or activity.
B12	Learning Object Classification	isProject Outline	B	A description of a set of activities organized around a particular academic topic.
B13	Learning Object Classification	isStudy Guide	B	A guide created to provide students with hints, techniques, or management ideas in a particular area.
B14	Learning Object Classification	isLecture Presentation	B	A video or audio recording or a transcript of a lecture, presentation, speech or classroom session.
B15	Learning Object Classification	isGlossary	B	A collection of specialized terms and their meanings.
B16	Learning Object Classification	isCourse / Lecture / Presentation Notes	B	A set of notes or overhead slides that accompany a course, lecture, presentation, speech or classroom session.
B17	Learning Object Classification	isWorked Example	B	A written problem or exercise designed to illustrate a rule.
B18	Learning Object Classification	isTextbook	B	A book with an explicit goal of explaining a field of inquiry to students.
B19	Learning Object Classification	isDemonstration	B	A video or audio recording or a transcript of a practical exhibition of a process, activity or object.
B20	Learning Object Classification	isReading List	B	A list of resources that accompany a course, module, unit or other activity.
B21	Learning Object Classification	isTeaching Tip	B	A piece of practical advice primarily intended for an educator.
B22	Learning Object Classification	isCurriculum Syllabus	B	Outlines of courses and modules and their contents. General material describing a course or unit of study.
B23	Learning Object Classification	isEducator Guide	B	A guide intended for use by educators.
B24	Learning Object Classification	isEducational Policy	B	A document containing statements or series of steps for particular way of accomplishing an activity related to education.
B25	Learning Object Classification	isEducational Report	B	Detailed account or statement, often outlining the results or events of a meeting, endeavor, activity or study (e.g. review, evaluation) related to education.

Ref	Property Group	Property	Boolean/Value/Relationship	Description
B26	Learning Object Classification	isLesson Plan	B	A plan for helping students learn a particular set of skills, knowledge, or habits of mind. Often includes student activities as well as teaching ideas, instructional materials, and other resources. Is shorter (in duration) than, and often part of, a unit of instruction. Goals and outcomes are focused.
C1	Learning Unit Classification	isPhysicalObject	B	Also called an 'Artefact' or 'Realia'.
C2	Learning Unit Classification	isCatalogueRecord	B	
C3	Learning Unit Classification	isDataset/Dataset table	B	Structured data in lists, tables, charts, databases, etc., normally in a format for direct machine processing. Data may be numeric, spatial, statistical or structured text.
C4	Learning Unit Classification	isImage/Diagram/Figure/Graph/Slide	B	Visual representation of a person, object, scene or process. Includes diagrams, icons, drawings, graphics, illustrations, logos, paintings, pictures, photographs, etc.
C5	Learning Unit Classification	isVideo/Movie/Animation	B	
C6	Learning Unit Classification	isTool/Software	B	
C7	Learning Unit Classification	isNarrative/Story	B	
C8	Learning Unit Classification	isMap/Geospatial	B	A geospatial representation, for example of a geographical area or road network. Includes navigational charts.
C9	Learning Unit Classification	isSound	B	
C10	Learning Unit Classification	isIndex	B	
C11	Learning Unit Classification	isOrganisationChart	B	
D1	Contextual	isPartOfCourse	R	Object is used (most likely along with other objects) to build up a Course

Ref	Property Group	Property	Boolean/Value/Relationship	Description
D2	Contextual	isPartOfVLE	R	Object is not necessarily part of a course, but is available as a resource or research tool within the Virtual Learning Environment
D3	Contextual	isPartOfCurriculum	R	Object is not bound to a single course, but does take its place in the University curriculum.
D4	Contextual	isPartOfLearning-Episode	R	Object is used by a student as part of their learning episode; a Course may contain many episodes.
D5	Contextual	isPartOfLearning-Assembly	R	Object is used by a tutor as part of their learning assembly.
D6	Contextual	isPartOfLearning-Objectives	R	Object is not necessarily part of the episode-assembly sequence, but may constitute 'background reading' or research in support of the learning objective
D7	Contextual	isPartOfSequence	R	This refers to a very specific step in the learning assembly.
D8	Contextual	hasPlaceInSequence	V	This refers to a very specific step in the learning assembly.
D9	Contextual	isPartOfAccreditation	R	Object forms part of a student's accreditation. Probably includes assessments.
E1	People / roles	isCheckedbyValidator	R	Object has been checked by a Validator to ensure its value as part of a Course. (See D1)
E2	People / roles	isUsedbyStudent	R	Object is used by a Student to learn something. (See D4)
E3	People / roles	isAssembledbyTutor	R	Object has been assembled by a Tutor to form a Learning Assembly.
E4	People / roles	isWrittenbyAuthor	R	Object has been written by a named individual (and see H5 in Rights Management).
F1	Reusability	isSearchable	B	The content of the resource can be searched (for example a text search can retrieve specific words or phrases in the resource)
F2	Reusability	isDiscoverable	B	Object or resource can be found or accessed by its high-level metadata

Ref	Property Group	Property	Boolean/Value/Relationship	Description
F3	Reusability	isInteroperable	B	Object is stored in an interoperable format. See section 8 of the JISC Report: "there is an extremely important distinction to be made between the internal operation of a learning object and its external interoperability. E-learning specifications and standards will facilitate the latter, but not the former."
F4	Reusability	isAccessible	B	This refers to 'controlled access' within the context of a VLE, where the curriculum and its objects have been mapped to certain elements which can be separately assessed or recorded.
F5	Reusability	isCapableofWorkinginDifferentApplications	B (R)	See Section 7.1.2 of the JISC Report, which exposed particular problems among Assessment applications. "There are noticeable differences between applications in how they import, render and export question and test content."
F6	Reusability	isApplicableToOtherLearningEnvironments	B (R)	Object can be removed from one VLE and made to function / behave correctly in another
F7	Reusability	isApplicableToOtherSubjectAreas	B (R)	Object is associated with a certain discipline (eg Geography) but could feasibly be repurposed in another (eg Mathematics)
F8	Reusability	isCustomisable	B	Content and look and feel of the object could be changed by an author to suit their purposes; also the object could be disaggregated to be reaggregated with other objects
F9	Reusability	isCapableOf-GeneratingLessons	B	IMS CP metadata separates data about the internal file structure from the various views/applications/aggregations of it. Through the concepts of packages and manifests and the following of certain rules, chunks of data can be recombined into new e-learning resources without, say, hypertext links being compromised. New resources, such as an entire course or individual lessons, can be put together so that they are completely self-contained and can stand alone. This is the special contribution of IMS CP.

Ref	Property Group	Property	Boolean/Value/Relationship	Description
F10	Reusability	isModular	B	All LOs have to be modular to some extent if they are going to be reused. This may not be a useful SP.
F11	Reusability	isFlexible	B	See JISC Report section 5.2.1 on Granularity. "If a learning object is too large or conceptually complex it may be difficult to reuse it in different contexts. Ensuring that learning objects are created at an appropriate level of granularity is therefore seen as a key requirement for reusability."
F12	Reusability	isKeptInALORepository	B, V, R	Object is stored, along with descriptive metadata, in a specialist repository such as JORUM.
G1	Delivery	isSoftwareDependent	V, R	Object is dependent on the software that created it in order to perform
G2	Delivery	isHardwareDependent	V, R	Object is dependent on hardware in order to perform
G3	Delivery	isFormatDependent	V, R	Object is dependent on a certain format in order to perform
G4	Delivery	isDeliveredbyVLEpackage	B, V, R	The object is delivered by VLE packaging standard such as SCORM, COLA or Moodle.
G5	Delivery	isDeliveredby-Assessmentpackage	V, R	The object is delivered by an assessment package such as TOIA (online assessment) or IBIS (Item Banks - banks of questions for exams)
G6	Delivery	isDeliveredbyZIP	B, V	Object is zipped up inside a repository
G7	Delivery	isDeliveredwithXMLSchema	B	Object has an XML Schema associated with it
H1	Rights Management	isSubjecttoTermsandConditions	V	For example, Creative Commons licenses
H2	Rights Management	isProtectedbyDRM	B, V	Digital Rights Management
H3	Rights Management	isLicensedbyJORUM	B, V, R	Resource is only available to authorised users of the JORUM service
H4	Rights Management	isCapableof-Repurposing	B	Reuse of the object is not restricted by the IPR
H5	Rights Management	isHeldByANamed-Individual	B, V, R	An author and / or contributors are named as the copyright holder(s)
H6	Rights Management	isGovernedBy-Permissions	B, V, R	For example, Creative Commons licenses
H7	Rights Management	isGovernedBy-Constraints	B, V, R	For example, Creative Commons licenses

Ref	Property Group	Property	Boolean/Value/Relationship	Description
H8	Rights Management	isGovernedBy-Requirements	B, V, R	For example, Creative Commons licenses
H9	Rights Management	isHeldByANamed-Institution	V, R	A University or other HFE Institution is named as the copyright holder and/or holder of other rights
J1	Digital object	isText	B	A resource consisting primarily of words for reading.
J2	Digital object	isNumeric	B	
J3	Digital object	isImage	B	A visual representation other than text. Examples include images and photographs of physical objects, paintings, prints, drawings, other images and graphics, animations and moving pictures, film, diagrams, maps, musical notation. Note that Image may include both electronic and physical representations.
J4	Digital object	IsSound	B	A resource primarily intended to be heard.
J5	Digital object	IsMovingImage	B	A series of visual representations imparting an impression of motion when shown in succession.
J6	Digital object	IsInteractiveResource	B	A resource requiring interaction from the user to be understood, executed, or experienced. Examples include forms on Web pages, applets, multimedia learning objects, chat services, or virtual reality environments.
J9	Digital object	IsCollection	B	An aggregation of resources. A collection is described as a group; its parts may also be separately described.
J10	Digital object	isPartOfCollection	B	
K1	Look and feel	isDependentOnFonts	V	
K2	Look and feel	isDependentOnColours	V	
K3	Look and feel	isDependentOnLayout	V	
K4	Look and feel	isDependentOnTables	V	
K5	Look and feel	isDependentOn-Language	V	
K6	Look and feel	isDependentOn-CharacterEncoding	V	
K7	Look and feel	isDependentOnBoxes	B, V	
K8	Look and feel	isDependentOn-Drawingobjects	B, V	

<b>Ref</b>	<b>Property Group</b>	<b>Property</b>	<b>Boolean/Value/Relationship</b>	<b>Description</b>
K9	Look and feel	isDependentOn-Embeddedobjects	B, V	
K10	Look and feel	isDependentOn-PageBasedViewing	B	

## Appendix B: Designated user communities

The table below illustrates broadly the differing significance of each Property Group to each of the 7 communities, indicated with the following:

✓ = Significant

✗ = Not significant

	Learners and Students	Teachers, Authors and content creators	Examiners / validators	Re-users of content (teachers)	Scholars / historians / researchers	Repository managers / records managers	Digital archivists / curators
A. Functional	✓	✓	✓	✓	✓		✗
B. Learning Object Classification	✓	✓	✓	✓	✓		✗
C. Learning Unit Classification	✓	✓	✓	✓	✓		✗
D. Contextual	✓	✓	✓	✓	✓		✗
E. People / roles	✓	✓	✓	✓	✓		✗
F. Reusability	✗	✓	✓	✓	✓		✗
G. Delivery	✗	✗	✗	✓	✓		✓
H. Rights Management	✗	✓	✓	✓	✓	✓	✓
J. Digital object	✗	✗	✗	✓	✗	✓	✓
K. Look and feel	✓	✓	✓	✓	✓	✓	✓