Learning object: A new definition, a case study and an argument for change

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A recursive definition of 'learning object' is proposed which supports the possibility of infinite variety in terms of how a learning object is constructed and used by teaching staff and students. The new definition is bound to two key properties of a learning object, reusability and use for learning, and places no theoretical limit on the size of a learning object. The proposed definition of learning object is derived from the development pattern that emerged during the course of a large collaborative project to develop a series of information literacy modules. The proposed definition is tested against the current generally agreed properties of learning objects, and against the outputs of the project from which the definition was derived. The new definition is also compared with some existing definitions and an argument is presented for why it may prove more useful, in both theory and practice, than its predecessors.

Keywords: learning object, recursion, reusability, granularity, SCORM

Introduction

Digital learning objects have been widely debated at least since 2000. After all this time, there is still no universally agreed definition of what they are (Kay & Knaack, 2005) and little evidence of their widespread adoption in Higher Education (Campbell, 2003). The recent view that "an object-oriented approach to teaching and learning resources is likely untenable" (Fill, Leung, DiBiase & Nelson, 2006) is supported by a recent blog post on learning objects from David Wiley:

> There have been lots of articles around the blogosphere of late ringing the death bell for learning objects. It's hard to tell if they're right or not, because no one can agree about what a learning object is

He goes on to say:

> I will here attribute learning objects' inability to live up to the incredible hype and investment they received to the fact that the premise of the possibility of simple reuse was simply wrong (Wiley, 2006).

Nonetheless there is a considerable body of research around learning objects, including from Wiley himself. Alison Littlejohn's edited collection of articles on reusing online learning resources demonstrates something of the scale and scope of research in this field (Littlejohn, 2003). Organisations such as Instructional Management Systems (IMS) Global, Advanced Distributed Learning (ADL), Centre for Educational Technology Interoperability Standards (CETIS) and others working in the elearning specifications and standards area continue to grapple with the concept. Major software companies including Blackboard, Macromedia, and Microsoft now support elearning specifications in their educational products. All of this suggests that whatever learning objects are they "ain't dead yet".

Information Literacy e-Learning Modules is a project funded through the New Zealand Tertiary Education Commission's e-Learning Collaborative Development Fund (eCDF). It is a two-year collaborative project between the University of Otago, Dunedin College of Education and Otago Polytechnic and at the time of writing we are one year into the project. The project was conceived to address four main areas in the tertiary sector associated with information literacy learning:

- Barriers to tertiary study which can occur as a result of poor information literacy skills and the diverse needs of marginalised, mature and distance students.
- A shortage of high quality online information literacy modules which are reuseable, portable and have pedagogical flexibility.
- A need for professional development opportunities for staff in the area of information literacy.
- A tertiary sector requirement for centrally maintained and managed, standards conformant online resources in this important foundation field.

Evaluation of the modules themselves is discussed elsewhere (Hegarty, Coburn, McDonald & Cone, 2006; Keen et al., 2006).

Achieving reusability of the information literacy modules across a range of digital platforms, both online and offline, in use in NZ tertiary institutions and in use by NZ tertiary students is a key goal. This project seemed like an ideal opportunity to try to apply the ideas behind learning objects in general and to work with the Sharable Content Object Reference Model (SCORM).

From the outset the desire for technical reusability, and the requirement for pedagogical coherence, that is, the need to provide a rich learning experience relevant to the needs of diverse groups of learners across the tertiary sector, set up a tension. This tension was anticipated and has been highlighted by many researchers, (e.g., Boyle, 2003; Fill, Leung, DiBiase & Nelson, 2006; Rehak & Mason, 2003). We set out to approach the problem from a practical rather than a theoretical perspective. Contract requirements with the NZ Tertiary Education Commission, (TEC) to produce a series of online modules suitable for use by students across the sector, within a defined time-frame, has helped us to retain a firm pragmatic focus.

What we found in developing the project was that while the definitions, debate and discussion around learning objects provided useful background they were all largely useless as pointers to practical techniques to help us to meet the pedagogical goals of the project itself and the requirements for reusability across the sector. In this context we found ourselves increasingly turning to broader Web standards and techniques and applying and reapplying them to meet the project goals. Nonetheless, through this development process a pattern of development activity emerged that has led to the definition of a learning object proposed here. The proposed definition is assessed against generally agreed properties of learning objects, and against the learning objects developed in the information literacy project. Finally the new definition is compared with some of the more common existing definitions of learning objects and an argument is presented for why the new definition may prove more useful in both theory and practice than its predecessors.

A pattern of development activity

The information literacy project is a collaborative project involving staff from three separate tertiary institutions. As a group, the three institutions represent a broad cross section of the NZ tertiary sector involving a polytechnic, a college of education and a university. A group of a dozen or so people comprising teachers, librarians, educational technologists and educational researchers are involved in the project. This group is to some extent fluid but with a central core of committed individuals from each institution. There was and always has been complete agreement about the broad goals of the project described above, but it became apparent in the early stages of implementing the project that with up to *n* different people involved in the collaboration there were at least *n* different ideas about how the modules would look and function. The process of moving from conceptual ideas in individual minds, to the construction of tangible things that can be visualised and interacted with, instantiated a pattern of development activity.

There are many theoretical and practical models that can be used to aid educational technology development projects by providing some guidelines for development activity. Some models come from educational design, for example, 4C/ID-Model (van Merrienboer, Clark & DeCroock, 2002) and the Conversational Framework (Laurillard, 2002). Others come from software engineering and interface design, for example, Spiral (Boehm, 1988), Rapid Application Development (Martin, 1991) and Paper Prototyping (Snyder, 2003). In the information literacy project we did not rigidly adhere to any particular educational development or software development model. Our educational approach was broadly

constructivist and we used an open source content management system to create, and modify in response to ongoing feedback, the online modules. What most educational and software development models, and the development process we used, have in common is the description of a series of discrete stages and the description, or in our case the negotiation, of a set of rules or procedures for progressing from one stage to the next. The practical problem of sequencing stages is usually dealt with through allowing some form of iterative process as a result of feedback or evaluation from users.

The pattern of activity that emerged in the information literacy project is described below, and provides a general description of what actually occurred in the process of going from four very broad goals and objectives to five discrete digital information literacy modules that were required to be delivered at the end of the first year of the project. Broadly the pattern of development activity for the information literacy project can be characterised as follows:

Each of the starting goals began to decompose into sub goals with the processes of negotiation among team members about what the goals actually meant. The process of negotiation was repeated with sub-goals and the process repeated again and again until finally sub-goals decomposed into actions that resulted in the production of the online modules themselves. Frequently sub-goals were identified as unattainable. This usually occurred either because agreement could not be reached between team members that the sub-goal was essential to achieving its parent goal, or because a sub-goal was deemed to be counter to higher goals or counter to any of the four original goals of the project. When this occurred we were left with the parent goal. In other words we had travelled in a circle and had to either abandon the parent goal or renegotiate.

Three things are evident from this description:

1 the project may never have got started
2 the project may have started but failed to progress
3 the project may never stop.

An additional observation can be made: The process of negotiation between team members about goals, sub-goals and so on, in effect established the rules for constructing the modules. How the five complete modules, that we have produced, actually look and behave was not pre-ordained. How the five complete modules have turned out is just one among an infinite number of possible ways that they might have turned out. They have turned out the way they have because of the finite set of rules negotiated by the project team to construct the modules. Development of the five complete modules has stopped only because agreement has been reached about the rule for stopping!

This observed pattern of development activity looks very much like a recursive process and this is a central idea in the new definition of learning object that follows. Before proposing the new definition, it is worth taking a short detour to explain recursion; a concept from computability or recursion theory, (e.g., Godel, 1931; Turing, 1936) but with abundant examples in every day life. So, what is recursion?

A recursive definition is one which defines something in terms of simpler versions of itself (Hofstadter, 1979). It follows from this definition that a recursive process is one in which progressively more complex things are constructed from simpler versions of themselves. The simplest version must be obvious, self-evident or capable of being defined outside the recursive definition.

To illustrate these ideas consider the following sequence. Sentences 2–4 are each derived from the previous sentence. Sentence 5 is left to the reader to construct.

1 This is the car that Jill drove.
2 This is the cat that ran under the wheels of the car that Jill drove.
3 This is the man who saved the cat that ran under the wheels of the car that Jill drove.
4 This is the ticket to Wimbledon that Jill's mother bought the man who saved the cat that ran under the wheels of the car that Jill drove.
5 ...

The rules of grammar in any language are finite. Language itself is not (Fasold & Connor-Linton, 2006). The reason language itself is not finite is because all grammars incorporate recursive devices. This means that it is theoretically possible (albeit exhausting) to construct a sentence of infinite length. The example above, drawn from familiar childhood word games, demonstrates the effect of embedding (reusing) one sentence in another; this is an example of a recursive device. There is nothing ungrammatical about any of these sentences and the game above could go on in an infinite variety of ways for an infinite length of time.

To return to learning objects: Is it possible to define learning objects in terms of simpler versions of themselves? In other words, can they be defined in terms of the recursive process used to produce them? The following section proposes a recursive definition for learning objects which is informed by the pattern of development activity described.

Learning object definition

A learning object is the result of applying a finite set of rules to a simpler learning object, in order to construct some meaning, activity or purpose which is used for learning. The degenerate case of learning object is a digital element.

This recursive definition says three things about learning objects:

1 Learning objects *are* reusable because they are always defined in terms of simpler versions of themselves. The simplest object, from which one can create a learning object by applying some rules to construct meaning, activity or purpose, is a digital element.
2 A learning object is as big as it needs to be in order to construct some meaning, activity or purpose. There is no theoretical limit to the size of a learning object.
3 A learning object must be *used* for learning.

The finite set of rules in the definition can be equated with the goals and sub-goals of the developers of the learning object. Table 1 provides a concrete example of how this works. Note that only one sub-goal (a) is expanded into sub (sub-goals) in this example, and the original design goal is itself a sub(sub...(sub-goal)…) of one or more of the overall goals of the module and of the project itself.

Table 1: Expansion of a selection of design goals from the Information Literacy Project, Module 4, Writing a Science Report

Design goal	**Explain the use of tables in a science report**
Sub-goals	a. Provide a written explanation of purpose b. List the key formatting requirements c. Illustrate with an example d. Provide the opportunity for practice through critical examination of tables from existing reports. e. Provide an opportunity for assessment of own understanding of the use of tables in a science report.
Sub (sub-goals) a.	Construct the written explanation applying the rules of English grammar. Check for consistency and for any ambiguity with novice science report writers. Proof read the explanation. Format the explanation in the agreed module style.

What is a digital element? Is a word or a pixel a digital element? Is a blog or a learning management system a digital element? The answer is, it doesn't matter as long as whatever it is, is capable of having a finite set of rules applied to it in order to construct meaning, activity or purpose. Can an element be non-digital? The definition specifies that an element is digital because learning objects arose out of the digital domain. Again, it probably doesn't matter. Digital elements are required as the degenerate or limiting case of learning object. This is essential if the definition is to avoid infinite regress but it is important to realise that this does not mean that a digital element is equivalent to a learning object; it is not.

In order to be a learning object, a learning object must be used for learning. As noted, a major stumbling block in the information literacy project was negotiating the tension between technical reusability and meeting diverse pedagogical needs. Our approach to resolving this was to ensure first that each module met a specific need, drawn from any of our collaborating institutions, and that the module was used by students to evaluate whether the need had been met. We dealt with the provision of mechanisms by which the module or any part of it can be easily adapted to meet similar needs drawn from any other institutions second. This approach and our proposed definition are consistent with Wiley's observation that, "If the educational resources we create don't meet our own needs well, why would we think they would meet another's?" (Wiley, 2003).

The requirement for use for learning has also come out of our experience in this and many other projects that evaluation with students should start as early as possible, if not right at the outset. The earlier evaluation with real users begins, the more likely the outputs of the project are to be used in learning. If we want to start creating learning objects that will be used in learning, we need to evaluate them even before they hit the drawing board.

There is one further point to make. The definition does not say who uses the learning object for learning or that there is a requirement for the learning outcome to match the learning goal intended in developing the learning object. It is possible to develop a learning object with a specific learning goal in mind, and once in the hands of a learner, for the same learning object to meet an entirely different goal. By definition, *when this occurs the learning object has become a new learning object*. Ensuring that goals match outcomes comes from the skill of the learning object designers. Ensuring that in some cases goals don't match intended outcomes comes from the infinite variety and skill of the learners themselves.

In a sense, the learning object can be thought of as a ball, constantly changing shape, form and colour as it passes between the hands of learners, teachers and learning object designers, each pass resulting in a new learning object as each individual applies their own rules to the ball.

It is important when thinking about this analogy to remember that the learning object is not equivalent to a digital object or even to a physical object. The learning object is constructed from simpler learning objects by the application of rules for meaning activity or purpose. It is therefore feasible for parts of any given learning object to reside in a number of places at once: for example, in digital storage, in a learner's head, and in a teacher's hands.

Learning object properties

Does the proposed definition support the existing generally agreed properties of learning objects? The properties addressed here are: Reusable, accessible, interoperable/portable, and durable (Rehak & Mason, 2003). To examine each in turn:

- **Reusable:** By the proposed definition a learning object *must* be reusable.
- **Accessible:** The definition says nothing about accessibility *per se* but it implies that learning objects *should* be accessible if they are to be reused.
- **Interoperable:** The definition says nothing about interoperability *per se* but again if a learning object is to be reusable it *should* operate on a variety of hardware and software platforms.
- **Durable:** Since the definition is not concerned with specifying hardware or software the learning object *must* be independent of hardware and software changes but whether it persists in a particular digital state is another matter.

The new definition establishes *a priori* that learning objects are reusable, can be of any size and must be used for learning.

While accessibility, interoperability and durability may be properties of some learning objects they are not defining properties of all learning objects. So for example, in the case of the information literacy project, the project team agreed that the information literacy modules must be:

- easily accessible via the Web
- available to be used either online or downloaded for use offline
- able to work in a SCORM 1.2 run-time environment
- look and function the same way on all common browsers and computer platforms
- they must be conform to XHTML/CSS standards for Web delivery
- modules must be able to be easily edited/re-contextualised by non-technical users and the new edited modules saved and made available for anyone else to use.

The learning objects themselves did not determine any of these properties, we did. We established these properties as we negotiated the goals of the project. For example, we had made a decision to work with the SCORM early in the project but we soon discovered we could not work exclusively with the SCORM if our modules were to have the properties listed above. To illustrate this point, Table 2 assesses SCORM against our properties and notes some additional key issues.

Testing the definition against the information literacy modules

Do the five information literacy modules produced thus far meet the proposed definition of a learning object?

Each module is the result of a process by which we defined the rules for the construction of a learning object and then applied them to construct new learning objects. At the most fundamental level every time a member of the project team wrote a phrase or a sentence they were in effect constructing a learning object by applying the rules of English grammar to words, for meaning, activity or purpose. New rules were applied when we combined the resulting text with images, audio, video or animations and when it came to ordering and organising these collections of digital media. In the process of constructing meaning, activity or purpose in this way, we were using the learning objects for our own learning. At several points in the development process we also made materials available for others, including students, outside the project team to use. We have formally evaluated one completed module, Essay writing with Readings, with students in the course for which it was originally designed. In addition this module has been evaluated with students from each institution for whom it was not specifically designed, but for whom the module was likely to have some relevance. The results of this evaluation support the requirement in the definition that the module is used for learning (Keen et al., 2006).

On the face of it, at least one module meets the proposed definition. Provided we evaluate the remaining completed modules with students and can demonstrate that these have been used for learning, we would expect them to meet the definition also.

Nonetheless, ‘used for learning’ raises a number of questions that are worth further investigation but are beyond the scope of this paper. Is a learning object still a learning object if it is not currently being used for learning? Is there a place for the idea of strong or weak learning objects based on the number of people who use a learning object? Is frequency of use important?

Comparison with existing learning object definitions

How does the proposed definition compare with existing definitions? Does it really take us any further ahead?

The definition of a learning object is complex. Teachers, software designers, researchers and media producers, amongst others, have tried to turn the learning object concept into a reality (Haughey &

Muirhead, 2005). Although not referring directly to learning objects, Laurillard (2001) has already pointed out that:

> The development of educational media has an odd mix of engines driving it, technological pull, commercial empire building, financial drag, logistical imperatives, pedagogical pleas, and between them they generate a strange assortment of equipment and systems from which the educational technologist must fashion something academically respectable" (p.83).

Table 2: Information literacy module 'rules' compared with the SCORM

Properties for information literacy modules	**SCORM**
Easily accessible via the Web	Yes, provided that a SCORM compliant player is available to run the module. The SCORM compliant player or run-time environment (RTE) must support the version of SCORM for which the SCORM package was created. For example, SCORM 1.2 packages will not run in a SCORM 2004 RTE without some modification.
Available to be used either online or downloaded for use offline	In principle, SCORM packages can be used online or offline but in practice this would require end users to have a SCORM RTE on their offline computer system
Able to work in a SCORM 1.2 run-time environment	Yes.
Look and function the same way on all common browsers and computer platforms	A package may be SCORM compliant but still look and even function differently on different browsers.
They must conform to XHTML/CSS standards for Web delivery.	Being Web-based is a foundation SCORM concept (ADL, 2004). It is left up to developers to follow good design principles including separating web page data from the presentation of that data.
Modules must be able to be easily edited/re-contextualised and the new edited modules saved and made available for anyone else to use.	This is beyond the scope of SCORM in terms of being able to edit at the level of, for example, text within an individual Shareable Content Object (SCO) or Resource. Provided a SCO or resource is not in a proprietary format or protected in some way, there is nothing preventing someone with sufficient technical knowledge from editing an individual SCO or Resource. This does however move away from our requirement that editing and re-contextualisation should be easy for non-technical users.
Some additional practical SCORM issues	
RTE availability and stability: We were unable to source a freely available SCORM 2004 RTE robust enough for evaluating modules with students. At the time of writing, even though all collaborating institutions use the same LMS, only the University had the SCORM 1.2 RTE setup and this was only available in a development server environment. This really dictated our decision to stick with SCORM 1.2 and meant that simple sequencing features of SCORM 2004 were not an option for this project.	
Data handling: A key feature of SCORM is the ability to exchange data with an LMS. There may be constraints within an LMS itself in terms of what and how data is saved. We found the time taken to work around these issues far exceeded the likely benefit of implementing the data handling features we wanted *in the context of this project*.	
The glossary problem: This has been identified by others (Wirski, Brownfield and Oliver, 2004) for SCORM 1.2. There are workarounds but these are not entirely satisfactory for all situations.	
Packaging: By the time glossary-type features, communication with LMS and stability concerns had been addressed (by deletion), our SCORM packages offered no discernible advantage over IMS Content packaging. That said, the SCORM 1.2 packages we created did comply with SCORM 1.2. This was verified by both external review and testing with the ADL test-suite. In addition the packages displayed correctly in several SCORM RTEs and were easily disaggregated using a suitable package editor.	

The same 'odd mix of engines' drive learning objects today. The following are two definitions of learning objects from Rehak and Mason (2003):

> A digitised entity which can be used, reused or referenced during technology supported learning (p.21).
>
> A small chunk of learning which serves a learning objective (p.21).

Here is a definition from the Institute of Electrical and Electronic Engineers (IEEE), Learning Technology Standards Committee (IEEE LTSC, 2002):

> Any entity, digital or non-digital, that may be used for learning, education or training.

Kay and Knaack (2005) provide a useful review of many definitions and suggest that definitions are either technology focussed or learning focussed. They redefine learning objects using components from both learning and technical definitions:

> reusable, interactive web-based tools that support the learning of specific concepts by enhancing, amplifying, and guiding the cognitive processes of learners (p.231).

And finally a description from Wiley (2001):

> Any digital resource that can be reused to support learning (p.7).

As Rehak and Mason point out, ideas about what a learning object is can range from just about anything (e.g., IEEE) to something requiring specific objectives and assessment (Rehak & Mason, 2003).

What none of these definitions provide is any sense of the internal structure of the learning object. The learning object has always been viewed, not surprisingly perhaps, from an object-centric perspective; it is simply an object with some properties.

What sets the proposed definition apart is that it provides a coherent description of the internal structure of a learning object. The defining property of reuse is a logical consequence of its recursive structure. The proposed definition also directly challenges notions of granularity and learning object size. If we accept the proposed definition, then we accept that the inherent size of a learning object is of no consequence in order for it to be a learning object. The proposed definition also demands that in order for a learning object to be a learning object, it must be used for learning.

From this position then, does the proposed definition resolve the key problem highlighted in this paper: the tension between technical reusability and pedagogical coherence? If it does, is it possible to chart a new course for learning objects?

An argument for change

I have claimed, by using a recursive definition, that learning objects are reusable. From this follows the possibility for infinite variety in terms of how a learning object is constructed and used by teaching staff and students. So the answer to the question of whether the new definition resolves the tension between technical reusability and pedagogical coherence is an unequivocal yes. If this is the case, why have so many of us been struggling with learning objects? I think the answer to this lies in the imprecise way we have been using the word reusability and the merging of technical and pedagogical rules that we use to construct learning objects.

Software and systems designers look at reusability from a technical perspective: "The design must ensure that I can unplug a learning object from your system and plug it into straight mine without any tweaking or fiddling". Teachers and educational designers look at reusability from a pedagogical perspective: "I can take a learning object that you have created and use it for my students. I accept that I may need to tweak or fiddle with it in order to fit my context. Indeed, I must be able to do this because I have an infinite variety of students to work with".

My contention is that the recursive definition of learning object is implicit in the non-deterministic way that teachers, educators, and students operate. By contrast, for software and systems designers and developers, and paradoxically it seems for many in the educational technology field, the object-centric or software engineering view of learning objects predominates. The object-centric view addresses reusability from a necessarily deterministic perspective.

If we can accept that a learning object is recursive by nature we can embark on an agenda of designing software, services and systems which make it easy for teachers and learners to tweak, fiddle and apply their own rules to construct new learning objects for meaning, activity or purpose.

In summary, the new definition affords the following benefits:

- It allows for an infinite variety of meaning, activity and purpose in the education setting. It does not preclude or mitigate against the use of any educational strategy or combination of strategies to develop a learning object.
- It provides a new way of thinking about learning objects that closely parallels how teachers and students actually construct meaning, activity and purpose whether in the digital domain or not.
- It makes explicit the structure of learning objects that is absent from existing definitions and aids understanding of both the learning object and the development process.
- It does away with the confounding problems of size and granularity and directly challenges the object-centric view of learning objects. Both these features have fuelled debate and our experience has been that they have rendered learning objects largely useless as a practical concept in a Higher Education environment. This supports the view of Fill and co-workers (Fill, Leung, DiBiase & Nelson, 2006).
- There is infinite scope within the definition for rules to be applied which restrict a given learning object's domain. So for example someone who says that their learning objects have to have clear educational outcomes and some form of assessment can specify this in the finite rules for construction of the learning object. What they cannot specify is that the domain will remain restricted in the hands of their students!
- It does not preclude the work going on in the specifications and standards field. For example, the Essay Writing with Readings module from the information literacy project meets the new definition, and it is also available as a SCORM 1.2 compliant package for those who want to use the SCORM.
- It demonstrates that software, systems and services used in the construction of learning objects should support the goals students and teachers have in developing learning objects. The concept that somehow we should be mapping pedagogical principles to learning objects in order that they will 'plug and play' is anathema.

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