Combining reusable learning resources and services to pedagogical purposeful units of learning

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Rob Koper

Introduction

Over the last decade scholars in the field of learning technology have introduced the concept of the reuse of resources in education, analogous to software reuse and object oriented approaches. The expectation is that reuse will result in efficiency and quality gains in education and training.

A basic concept in reuse is the 'learning object'. A fundamental idea is that a learning object can stand on its own and may be reused. In practice, this means that learning objects are usually small objects – smaller than courses - that can be reused in different courses. One of the underlying factors is that courses in themselves cannot easily be reused, due to all kinds of local factors (see e.g. Downes, 2000).

A learning object can be described with all kinds of 'metadata', using 'vocabularies and taxonomies' to allow identification from a range of perspectives. The basic concepts have been described in the previous chapters and these include the granularity of learning objects, classification of these objects by metadata and controlled vocabularies/taxonomies, retrieval of learning objects, and the re-assembling of objects through packaging, aggregation or sequencing. A variety of reuse environments have been developed, including Ariadne (Forte et al, 1997), Cuber (Krämer, 2000) and LOK (http://www.ntwpracticumnet.ou.nl/lok).

It's now time for us, as learning technology scholars, to ask ourselves the following questions: how are we doing? Do users actually make use of our systems? In reality, do they share and reuse objects? What problems do they experience? How can we solve these problems?

In this chapter I will explore some current underlying issues in the reuse of learning resources and will present these within the context of a teacher and an instructional designer who wish to reuse resources within their own practice. This analysis will unearth specific problems with reusing resources. Next, I will present a framework which integrates these underlying issues. I will discuss the implications of this framework on the future direction of work in the learning technology field. Firstly, I will define some of the concepts more precisely.

Definitions

The IEEE LTSC (2000) definition of a learning object was introduced in the previous chapters as: "any entity, digital or non-digital, that can be used, reused, or referenced during

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[1] A version of this paper is published as: Koper, E.J.R. (2003). Combining re-usable learning resources and services to pedagogical purposeful units of learning. In A. Littlejohn (Ed.), *Reusing Online Resources: A Sustainable Approach to eLearning* (pp. 46-59). London: Kogan Page.

technology-supported learning". Wiley (2002, p.6) advocates strongly that this definition is too broad to be of any practical or scientific value. He proposes as an alternative definition: "any digital resource that can be reused to support learning". I will further narrow down the scope of this definition for this chapter to: "any digital, reproducible and addressable resource used to perform learning activities or learning support activities, made available for others to use".

This definition excludes a lot of things: for example non-digital materials, non-reproducible unique exemplars and non-addressable resources (for example those that are not connected with a URL and metadata for access). It excludes learning activities, and also learning objectives and prerequisites, since these are a function of the learning activities, not the resources. It also excludes courses (since these are aggregates of learning objects and learning activities) as well as 'people', 'activities' and 'services'.

Further sub-classification of learning objects has been introduced in chapters 1 and 2 and, in this chapter, I will use the following definitions:

- *Knowledge objects* are learning objects which contain information for people to *learn from* or to use while supporting the learning activities of others (for example teachers with students). An example is a web page with a series of information objects to learn, (e.g. about sensory systems); or a teachers' manual.
- *Tool objects* are learning objects to *learn with* or to use while supporting the learning activities of others. Examples include electronic tools (java applets for statistics) or simulations.
- *Monitor objects* are objects which provide information *about* the learning progress and tracking of one's own learning or that of others.
- *Test objects* are learning objects used to assess learning results, learning progression or prerequisites - for example a complete test or a test item.
- *Resource organization objects* are learning objects at a lower level that enable the resources to be organised in a particular way. Examples include aggregating pictures and text to a paragraph and paragraphs to sections and sections to chapters. These arrangements of objects, or'organizations', are used as the information reference containers in higher level objects such as knowledge objects, test objects and activity descriptions.

A learning object can be aggregated from other learning objects, but when a learning object is aggregated with non-learning objects the aggregate itself isn't a learning object anymore. For example, a website with information about a topic can comprise lower level learning objects, such as individual web pages, pictures and java applets. When the website is connected to a learning activity, then the aggregate is no longer a learning object - it is now a 'unit of learning'. A unit of learning provides an organized series of learning events for learners, satisfying one or more interrelated learning objectives. A unit of learning cannot be broken down to its component parts without loosing its semantic and pragmatic meaning and its effectiveness towards the attainment of the learning objectives. However, units of learning can contain other units of learning. In practice, there are units of study of varying types, sorts and sizes. A course, a study program, a workshop, a practical or a lesson could all be considered as a unit of study.

Another weakly defined concept is that of 'reuse'. In this chapter I will use it in the following way, to proceed the learning objects definition: "… made available for others to use". In practice this means that an object used in learning context X is made available for reuse in

context Y, for example by making it searchable and accessible through the internet. This can be done either by including the context bound references, or it can be achieved in a de-contextualised way, providing users with the freedom to contextualize the object.

There are other dimensions to reuse. For example, by considering both the user and the 'reuser' , we can identify three levels of reuse. The first level is when a person reuses something he has created himself. The second level is when a person is reusing something created by someone else within the same community or organization. The third level of reuse is when a person reuses something created by someone else from an external community.
A further perspective is offered by considering how an object is 'licenced': is it a copy or is it a link to the original? Is it permissible to edit the copy? Is it permissible to edit the original? Can the original copy or adapted be redistributed?

1 Problems with reuse

Let's think about a large community of teachers (let's say in Psychology), who have access to a database containing a large number of learning objects which they can share. I am a teacher who has been asked to design and develop a new course entitled 'Introduction to Biological Psychology'. The aim is to introduce students to the relationships between internal biological processes and human behaviour. The course includes topics such as sensory processes, emotions, sleep and the effects of hormones on behaviour. The course will comprise study texts and practical experiments. Students will be assessed during a final exam. Therefore, how do I proceed in building this course using the objects already available?

Given access to state of the art of learning technologies, we can imagine the following scenario. I would first search the database using metadata (as well as shared vocabularies and taxonomies) referring to each learning object. Firstly, I search for objects which are about 'sensory processes'. It returns 3572 matches (in a thriving Learning Object Economy!). Looking through these, I see all different kinds of objects: a picture of the eye's nervous system, a text about polysensory systems, a table about the seven primary odours with chemical examples, a manual for an experiment about the volley effect and so on. I decide to narrow my search, but what am I searching for? What criteria must I use? Ok, let's look at the visual system first: 947 matches. In the end, I have 12 objects representing the anatomy of the eye: some are pictures, some texts and some are test items. In order to construct my course, I have some additional criteria: I want the text to be available on the web and the pictures must be included in my PowerPoint sheets. Ok, stop! The poor teacher - is this the way he or she should build courses from learning objects? Is this more cost efficient, more flexible or of higher quality than a traditional course? How complex will this become when constructing collaborative courses, personalised by student's competences and delivered through a variety of settings (online, residential, blended mode)? We didn't even consider the effort required to ensure the learning objects are sharable, to aggregate and sequence the learning objects and to adapt them for use within a specific context. Nor did we reflect upon language and cultural issues or how to deal with the underlying business model (including intellectual property rights) and so on.

Of course this analysis is far from complete, but the issue is clear. In order to facilitate the sharing and reuse of resources in education and training, we should be able to address these problems faced by educators when reusing learning objects –especially the problem of reusing learning objects within specific contexts. We must take into account the balance of workload and added value for teacher and learners.

In practice, learning technology is moving in the opposite direction: creating specifications and tools which are 'neutral' in terms of pedagogy, context and format, etc.. Although this may seem sensible from a technical interoperability and reuse point of view, it introduces the danger that all the factors which could be useful to the teacher are removed. Teachers often work within specific educational models, they think within the boundaries of specific subject contexts and in terms of the actual media available to them – much of this is in evidence in the case studies cited in Chapter 16. This mismatch between the users perspective and the design perspectives underpinning the software tools and specifications hinders both acceptance and proper use of these learning resources.

Assumptions of reuse

The concept of the reuse of learning objects has its foundation in the object-oriented approach within software engineering (see for example Meyer, 1988; Booch, 1991; Blair, Gallagher, Hutchison & Shepherd, 1991). In that domain, reusability is governed by certain principles. Applying them directly to learning resources, means that learning objects must meet the following conditions in order to be reusable:

- the objects itself are abstracted towards: pedagogy, context and media.
- the objects must be small (granularity) in order that they can be aggregated to larger, meaningful chunks.
- the objects stand on its one (encapsulated): have no side effects to e.g. dossiers of learners, enabling reuse without care for side effects.

I will address these issues in the next section.

Abstraction of pedagogy

In an ideal world of reusable learning objects, all objects could be udes by a teacher for a course, irrespective of the pedagogy or 'learning design'. Let's explore this assumption further.

When teachers have to design or plan a lesson or course, there are several ways they can proceed (Hoogveld et al, 2001). Vermunt and Verloop (1999) have identified that the majority of teachers employ an implicit design idea based on 'knowledge transmission'. When preparing a lesson or course (subsequently termed a 'unit of learning'), they think about the content, the potential resources (texts, figures, tools), the sequence of topics and how to assess the learners. In this way, the teacher is designing his or her own teaching activities within the context of a specific teaching environment. Students expect straightforward activities in order to learn: listening, taking notes and thinking. So not much effort has to be put into the design of these activities. If these teachers design e-learning courses using the transmission model, they proceed along the same lines: deciding on content, resources, the sequence of the topics and work within the constraints of the e-learning environment. The older instructional design approaches (e.g. Bloom, 1956; Glaser, 1977; Gagné & Briggs, 1979; Merrill, 1988; Reigeluth, 1989) are based upon this model and these still form the basis of many teacher training courses. However, these instructional design models include a "cascade" approach to design which begins with an analysis of the learning objectives and learning outcomes. In practice, this cascade approach is seldom followed and most teachers start to think in terms of the content instead of the objectives, which often remain unarticulated.

In many countries worldwide, this rather traditional view of education is rapidly changing. Many educational institutions and training companies are adopting new approaches in order to increase their effectiveness (Koper, 2000). The demand for change arises from several factors, including:

- The need for a more individualized, personalized approach to learning. Cognitive research has shown that knowledge cannot be transferred, but is (re-)built within a cognitive framework (schema, mental model) in the long term memory by each individual (Mayer, 1992, p.431; Winn & Snyder, 1996). The creation of these frameworks is dependent on each learner's cognitive style.
- The need for collaboration, discussion and product creation. Research in (social) constructivism has shown that dialogue and context both play an important part in learning (Duffy & Cunningham, 1996; Dillenbourg, Baker, Blaye, & O'Malley, 1996).
- The need to focus more on teaching complex skills, such as analysis and critiquing, instead of transferring chunks of information (Van Merriënboer, 1997).
- The focus on life long learning and the need for the accreditation of previously acquired competences (Klarus & Nieskens, 1999; MEA, 2000). For example training companies now focus on performance improvement instead of knowledge transfer (Stolovitch & Keeps, 1999).

One of the major shifts in these new approaches to learning is that more emphasis in placed upon the design of learning activities for learners, instead of the content to be transferred through teachers' activities. The key problem in education is to make learners active by providing them with a range of tasks, problems and prompts (here referred to as 'learning activities') to stimulate thinking, discussion and learning. In addition, it is essential that educational institutions can assess the performance and competences of learners in a valid and comparable way. The role of the teacher is changing: they are now being asked to think from the perspective of the learner and to place themselves in a supporting role while designing courses. Learners have to be more responsible for their own learning, as advocated by scholars such as Shuell (1988, 1993). In response to these new approaches to learning and teaching, new instructional/learning design approaches have been devised (see for example Reigeluth, 1999 for an overview).

So, when learning technology is said to be 'pedagogically neutral', it should be able to support both ends of the spectrum of approaches to teaching (from knowledge transfer to active learning) and any model in between:

1. Technology designed to search, order and package resources in a way that fits into the traditional view of teaching. The basic components in this approach are the 'resources' or 'learning objects'.
2. Technology designed to stimulate learning activities, discussions and advanced assessment at the other end of the spectrum (see, for example, Colloquia by Liber,O., Olivier,B. and Britain,S. (2000) as well as other collaborative environments). The basic components in this approach are the 'services' which support the learning process (such as email and discussion fora).

In practice, learning technology specifications are not neutral to these perspectives. For example the IMS Content Packaging specification (http://imsproject.org), the ADL SCORM (http://www.adlnet.org) and the IEEE LTSC LOM (http://ltsc.ieee.org) pertain to a traditional approach to learning, though most of these specifications claim to be 'neutral' to pedagogy.

What this means in reality is that, given the traditional pedagogical model described above, teachers can apply whatever learning strategy (sequence and aggregation level of learning objects) they want. More advanced environments can also personalize the learning strategy according to certain criteria. In this way the learning technologies are not prescriptive nor expressive. (For example,when writing a poem with MS WORD the editor does not force you to write a specific kind of rhyme schema for the poem (prescriptive) nor does it express the syntax/structure of the poem at all: it isn't even aware of the fact that you are writing a poem).

Collaborative environments used in education are focussed primary on the second pedagogical model described above (promoting active learning). In this model, the collaborative learning environment is used to support the sharing of ideas and resources through discussions which aim to stimulate the creation of new ideas. In this case, the reuse of shared content is not really a problem - the main issue is the reuse and sharing of ideas. However, the arrangement of the collaborative environment can be reused and described by a learning design which enables collaborative learning.

In practice, most teachers applying modern pedagogies use a more eclectic stance (Roblyer & Edwards, 2000): sometimes they use principles gleaned from the resource based approach and at other times they use a more constructivist approach.

In our view, a modern e-learning environment, including the underlying learning technology specifications and standards, should support pedagogies coming from both ends of the spectrum. Not by being ignorant of the pedagogy, not by being prescriptive in any of the hundreds of different pedagogical models around (for example Koper, 2001), but to allow the pedagogical model to be explicit.

Abstraction of context

In an ideal world, learning resources would be developed independently of the setting, in order that they can be reused in other contexts. However, teachers normally design within the context of the educational setting. There are several ways we can think about this. Educational settings are defined by the organization of the educational institution: individuals as well as groups of people who are engaged in learning at a certain time/place and have the means by which to organise the educational experience. Educational settings can be as follows:

- Campus based education and training;
- Distance education and training;
- Situated learning;
- Informal education and training.

When designing e-learning within one or more of these contexts, teachers in campus based education usually consider the possibility of face-to-face meetings, last minute changes, an institutional environment where copyright is less restrictive, a tradition of exams and so on. As a result, the e-learning products which are successful in residential settings are often difficult to use in other contexts, such as distance education. Within most institutions of distance education working in knowledge transfer mode, most teacher activities are ‘baked into’ the learning materials, reducing the requirement for expensive distance contact. Examples include learning objectives, self tests and student portfolios. Real collaborative environments, based on the group model, are seldom used by institutions of distance learning, because groupwork is difficult to organize in settings where students can learn at their own pace, in their own time and location. The same is true for the other two settings. In general, when designing resources, teachers take into consideration the constraints of the educational setting, resulting in resources which are context dependent and less reusable in other settings.

Abstraction of media

In an ideal situation learning resources would be produced such that the same content could be published or used in different formats. This could be achieved by applying a specific stylesheet to suit each format. Furthermore, the format should be selected after a teacher knows what to teach and who will be the students (see the classical medium selection models, for example from Romiszowski, 1988). In practice, however, when designing a course, teachers first decide upon the media. When a teacher writes a text, it may not be in the best format to publish on the web, alternatively when a teacher produces a website, it may cause problems for students trying to print out the text. This makes learning resources difficult to reuse in other formats (see Koper, 1989).

Granularity

In an ideal world of reusable learning objects, teachers would produce small chunks of reusable information which could easily be assembled and aggregated into larger chunks. However teachers (or rather 'authors' in this case) usually view their course as one large integrated chunk. When writing a textbook they refer to other chapters in the book, making it difficult to use (parts of) the chapters in another context (like this book!).

Encapsulation

When reusing learning objects, we don't want to take into account any side effect of the learning object. We want the objects to be within a closed system, encapsulating all the necessary content and logic in itself - totally ignorant of the outside 'world' in which the object functions. However, in most educational settings there are additional factors to consider, such as student administration, dossiers/portfolios. Also, in an educational setting, there can be a relationship between the learning object and its position in the hierarchy. For instance, a test object has a different function when it is used before a task to teach certain skills, than when used afterwards (pre- or post testing). Ideally this doesn't matter. However, in practice, the side effects of the difference in use of a test object , as a pre-test or a post-test , can be completely different. For instance in pre-testing a different type of student record will be kept than in post-testing.

Integrative framework for reuse

From the previous analyses, we can conclude that the ideal conditions for reuse are not aligned with current practice in education. It is hard for teachers to learn to produce abstract, reusable learning resources and it's difficult to create real courses from these objects. There seems to be a gap between the needs of the teachers, who view courses within contextual perspective, and the current model behind the reuse of learning objects.

We tried to elucidate an abstract model which combines the perspectives of small-grained reusable objects with that of a holistic, integrated course. We wanted to understand how the course design relates to the underlying learning objects and visa versa. The resulting model provides a starting point for integrating the perspectives of the teacher (who usually thinks at the level of a course) with that of reusable learning objects.

I will now introduce this model step by step. Let's start with a repository of unordered and different learning objects (e.g. files) that are described by metadata, for retrieval purposes.

When a teacher designs a course he or she has a ‘containment framework’ in mind: this is the 'learning design' of the unit of learning. It describes the purpose and relationships of a collection of reusable objects from a repository (see figure 1). Depending on how the teacher prefers to design the course, this framework can be explicitly stated in advance, or can implicitly developed during the process of course design.

A real learning situation not only comprises learning objects - there are also 'services'. These include methods of communication such as face-to-face discussions, email, conferencing, chat, etc as well as search engines and course announcements. During assessment there can be a distinction between the test resources (questions) and the test services (assessment engines). The ‘learning design’ brings together a series of services and resources, which may come from digital repositories or be self generated by the teacher.

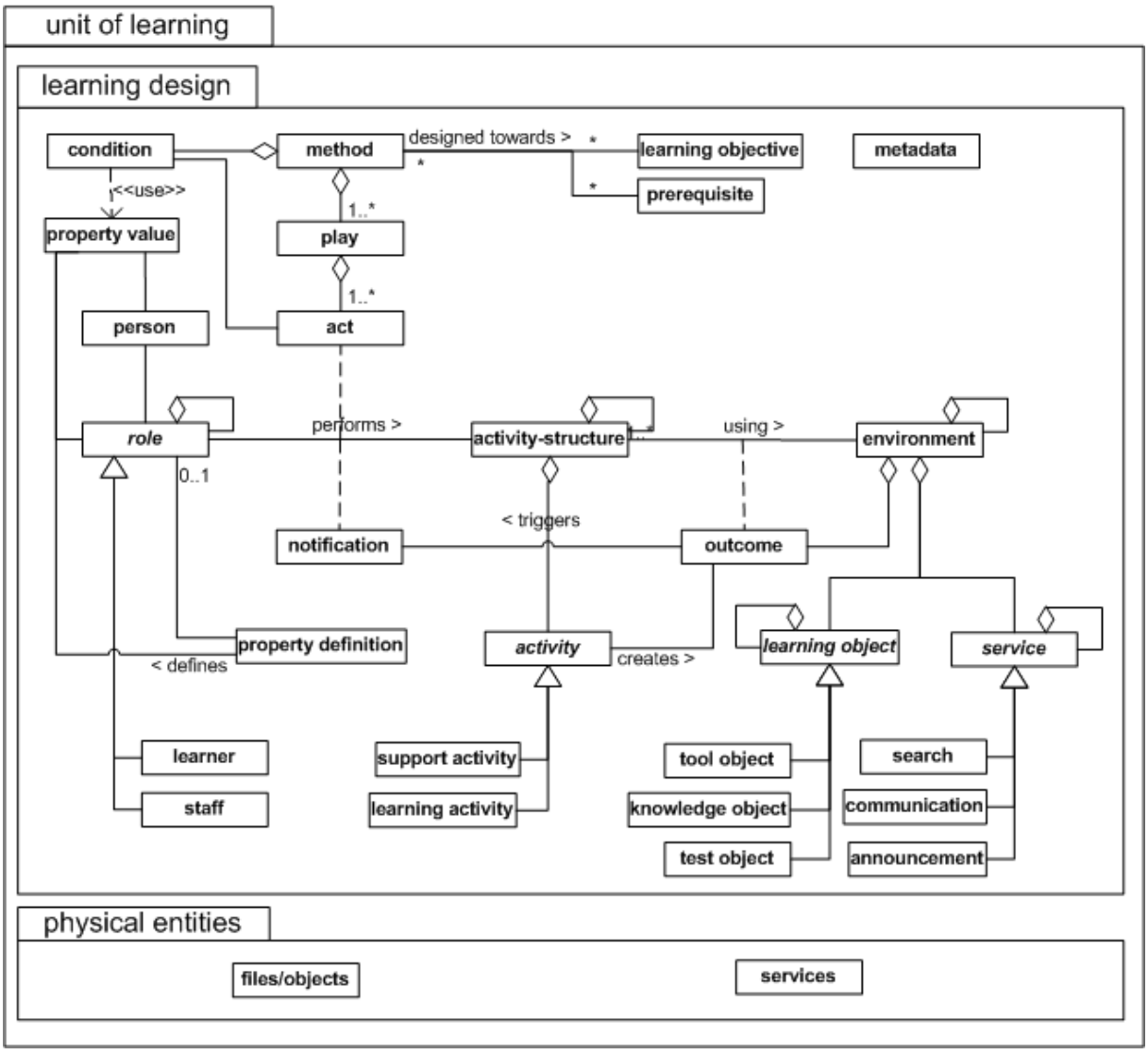

Figure 1. A framework for a unit of learning, containing reusable objects and services.

In this model, the learning design is a time ordered series of activities to be performed by learners and teachers within the context of an environment consisting of (re-) purposed resources and services. In our analysis of existing design approaches (see Koper, 2000, 2001),

we identified this approach as a common model behind the different behaviourist, cognitive and (social) constructivist approaches to learning.

The order in which a teacher designs a course usually depends upon his or her pedagogical standpoint. Most instructional design strategies start with the learning objectives, but they may also begin with the development of learner activities, teacher activities or the environment (as a set of resources and services). Usually, many of the design variables are set and this may constrain the design process. For example, in most educational situations the roles are set (student, teacher, mentor, assessor, etc) and the global time schedule is fixed (semesters, terms etc). In the traditional, knowledge transfer model, learning activities are always implied as, 'learn the knowledge provided', so teachers can concentrate on which content and assessment resources should be provided (see the previous examples). Teacher activities within campus-based courses are often constrained within the variety of possibilities set within the classroom.

For more advanced purposes, properties, conditions and notifications are included into the framework. Properties are needed to store information about a student in progression files or portfolios. Conditions are needed to express rules to adapt to specific circumstances, preferences or the characteristics of specific learners (for example students' prior knowledge). An example of such a condition is "when the learner has learning style X, the activities should be presented in random order to allow the student to explore". Notifications are mechanisms to trigger new activities and are based on an event during the learning process. For instance: the teacher may be notified to answer when a particular question is posed by a student (or alternatively the teacher may be notified to grade a report, etc.).

In practice, when building units of learning, this framework can be implemented in two ways:
1. bottom up – building a course by starting with the available reusable learning objects and services and ordering them within the context of the learning design.
2. top down - starting with the learning design, then searching for objects and services which fit within the framework. In this case, the learning design can automatically guide the search process. The different entities can act as place holders for queries (see also Ostyn, 2001).

Any pedagogical stance which lies between these two extremes can also be modelled through an iterative process: starting with a rough outline of the learning design, searching for reusable objects at the place holders, then refining and adapting the learning design and so on.

The framework also works in reverse: disaggregating existing courses to identify reusable parts which are contained within them. These reusable parts of a course are:
1. The learning design itself.
2. Patterns within the learning design (for example recurrent activity structures, environment structures, property structures).
3. The physical resources and services used within the learning design.

The key is to purpose, re-purpose and de-purpose the different learning objects and services within the context of the learning design framework.

In conclusion

All sorts of questions can be asked from the framework presented above.

Does it work in practice? What are the implications for future learning technology? Does it help to make common teaching methods reusable within education and training? Most of these questions are yet to be answered. However, some parts of the framework already exist. Within the IMS organisation, discussions are underway concerning the learning design specification to model units of learning. This is known as the IMS Learning Design specification and is based on a combination of the Educational Modelling Language published by the Open University of the Netherlands (http://eml.ou.nl) and existing IMS standards, such as content packaging, LOM metadata binding and question and test interoperability (http://imsproject.org). Our work on the EML focussed on learning design and has been tested within university curricula and vocational training, through the development of authoring environments, converters and interpreters which were used to build real courses. However, we didn't test the concept of reuse extensively through providing open access to searchable repositories. Nevertheless, these sorts of environments are already being set up: for example the Ariadne framework, Cuber and LOK project (referenced earlier). This combination of ideas of reusing learning objects with learning design will inform and enhance future work. For example, different designs could be used on the same set of resources and services or different resources and services could be sourced within the context of a particular design. An important issue for future investigation is that of 'learning design patterns'. These patterns document learning design solutions which have effectively solved recurring learning design problems. Patterns are currently being explored within the context of UML (Gamma et al, 1995; Buschman et al, 1996; Fowler, 1997; Larman, 2002). Some initiatives in this area have already begun (Bergin, http://csis.pace.edu/~bergin; Sharp et al, 1996-1999).

There is still much work to be done in terms of the semantic description of the structure and processes within specific parts of learning and instruction. These frameworks could serve as functional architectures for more technical, smaller and lower level interoperability specifications. One example is the study by Hermans and others (2002) on the semantic description of learning interactions and assessment which go beyond the technical interoperability descriptions provided by the IMS Question and Test Interoperability Specification (http://imsproject.org/question). More general, semantic frameworks like these are necessary, not only to identify the standard specifications required, but to examine how these should be interpreted and used.

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