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Layered learning design: Towards an integration of learning design and learning object perspectives

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ABSTRACT

The use of ICT to enhance teaching and learning depends on effective design, which operates at many levels of granularity from the small to the very large. This reflects the range of educational problems from course design down to the design of activities focused on specific learning objectives. For maximum impact these layers of design need to be co-ordinated effectively. This paper delineates a reference model of 'layered learning design' where designs at one layer should use and incorporate designs from lower (more specific) layers in elegant and powerful ways. This would allow different designers, or tutors, to focus on different levels of abstraction in the learning design process, and to collaborate in combining designs to make a substantial impact on practice.

The paper first delineates a model of the different layers of learning design. These layers range from the strategic structuring of learning activity (to achieve high-level goals) down to the design for basic learning activities. The paper then tackles the issue of the integration of this model with a major 'aggregation' model for learning objects. The essential insight is that learning objects should be viewed as instances of learning designs. This leads to a combined reference model where there is a correspondence between learning designs and learning object types at each layer. Finally, the paper applies the combined model to map some major contributions to learning design research and development.

1. Introduction

1.1. Context and motivation for the paper

There is widespread interest in developing, exchanging and re-using good designs for learning. The Australian Learning and Teaching Council (2009) and AUTC Learning Designs Projects (2002), for example, have sought to establish rich repositories of learning design descriptions. The JISC Design for Learning (D4L) programme in the UK has funded a range of projects that tackled different aspects of design for learning. International standardization work has been focused on the IMS LD framework, derived originally from the Educational Modelling Language (EML) of the Open University of the Netherlands (IMS LD, 2003).

There is some vagueness or latitude, however, over what is encompassed by the area of learning design or 'design for learning' (the term used in the JISC D4L programme). Learning Design, with a capital 'L' and 'D' usually refers to the technical standardization work associated with the IMS LD specification (IMS LD, 2003). Much of the work on learning design, however, operates outside this technical standardization sphere. A large proportion of the work is concerned with the representation and exchange of 'teaching plans' (e.g. the Australian repository projects, and Phoebe, 2009). Other work concerns higher level module or course planning (London Pedagogy Planner, 2008). Finally, there is work that is concerned with the design of specific learning activities and learning objects (Sharing the Load, 2008). This range of applications provides the background to the issues addressed in this paper.

There is a strong consensus on the need for adequate representations of learning designs (Laurillard, 2008; Littlejohn, 2007; Oliver, 2007). There are a range of different candidates for how to represent learning design (e.g. D4L, 2008; Harper & Oliver, 2002; Koper & Olivier, 2004; Lockyer, Bennett, Agostinho, & Harper, 2008; Wills & McDougall, 2008). There is also a growing parallel field of work on 'pedagogy planners' – tools that capture learning designs and make them available for reuse and repurposing (Dalziel, 2003; LDSE, 2009; LPP, 2008).

These projects, though sharing a common name, vary in their motivation and the 'size' of the unit studied – where 'size' needs to be defined in terms of educational ambition and scale, and the conceptual structure required to achieve that ambition. This leads to confusion

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in making sense of how these various initiatives and programmes of work relate to each other. This in turn leads to unnecessary duplication, failure to clarify clearly the scope of projects, and the failure to identify potential productive relationships. We need greater conceptual clarity about the nature of the underlying problem space. We need a conceptual model in which different types of learning design can be related to each other in a principled way.

This is a major challenge for the Learning Design Support Environment (LDSE) project. The project is part of the ESRC/EPSRC TEL (Technology Enhanced Learning) programme (TEL, 2009). The LDSE project aims to provide support for teaching and learning design that will cover the full range from courses, through sessions (e.g. lessons) down to specific learning activities (LDSE, 2009). This poses significant challenges for how to retrieve, use and *orchestrate* resources that already exist. An optimal position is that designs at the 'higher' layer should reuse and incorporate 'lower layer' designs in elegant and powerful ways. However, this requires a principled framework, or reference model, that (a) guides the identification of level of design 'granularity', and (b) elucidates the relationship between lower level and higher level designs. This paper concerns the development of such a reference model.

The conceptual clarification given by such a model should aid both the initial development of learning resources and the reuse of existing resources. In terms of development, individuals and groups should be able to work intensely in developing particular areas of 'learning design' that can then be integrated into the overall framework. Studies that focus on enriching particular areas can be pursued in depth, while still being seen as part of an integrated whole.

The advantages of such a model for supporting the range of design activity envisaged in the LDSE project include:

1. Aid the 'location' of resources, e.g. retrieved from the Web, which can be placed in a specific area of the overall conceptual framework.
2. Assist in the coherent orchestration of different resources: the framework should clarify the relation of particular design resources and tools in relation to other resources and tools. This is particularly important for projects such as the LDSE as it needs to integrate resources retrieved from a number of disparate sources.
3. By providing a clearer conceptual base the model should provide input into the development of better (metadata) descriptions of the resources.

The contribution of particular research/development areas, e.g. IMS LD, can also be critically viewed within this wider conceptual map to establish their focus, scope and limitations, e.g. which layer(s) does IMS LD focus on and which designs are outside its scope. Establishing scope is very important as it identifies the boundary where one approach needs to be linked to others in order to provide an overall comprehensive approach to 'learning design'.

The emphasis in this paper is on pedagogical/conceptual relationships. The parallel issue of technical relationships is a separate but related topic. This focus is important because the development of the technical framework for reuse has tended to override and potentially distort the primary task of elucidating a sensible pedagogical framework. The issue of conceptual clarification of the pedagogical level should provide the grounding framework for the challenge of technical integration.

1.2. Structure of the paper

The first part of the paper is concerned with elucidating a framework for different layers of learning design. It begins with a critique of the layers arising from the JISC D4L programme (D4L, 2008). It then systematically delineates a set of layers, beginning with basic learning activity, and then working upward through different layers of tactical and strategic design. The paper begins with the base layer as this is often neglected in the learning design literature. Much of the discussion is focused on the relationship between this layer and the session (or lesson layer) as it is believed that this is the area where greatest benefit is to be achieved from conceptual clarification.

Two of the fundamental entities of the discipline of technology enhanced learning are learning designs and learning objects. There has been considerable work on both these topics. However, this work has been marked by divergences across disciplinary perspectives, and a general failure to integrate the work in different fields (Boyle, 2008). There is considerable theoretical clarity and potential practical benefit to be gained from linking these areas of work. The paper thus discusses the relationship between the layered learning design approach and 'aggregation' models for learning objects, in particular the ALOCOM model (Verbert & Duval, 2004). By treating learning objects as instances of learning designs it seeks to develop an integrated model combining learning designs and learning objects. Some of the major contributions to the learning design field are then mapped to the framework that emerges from this work. The paper culminates by re-iterating the benefits to be gained by adopting this approach.

2. Layered learning design

In an interim report for the JISC Design for Learning (D4L) programme, the Glenaffric evaluators identify the need . . ." to develop a discourse to address the potential vacuum between designing and using learning objects, and higher-level lesson planning (Glenaffric, 2007). They present an initial layered model to address linking these areas of work. At this point the model was represented as three layers: course, lesson and object.

This model is expanded in the interim final report from the JISC D4L programme (Beetham, 2008). This sets out four layers (Fig. 1).

The four layers are explicated as follows:

- *Course design*: Designing courses/curricula or whole programmes at the highest level e.g. leading to a grade or qualification.
- *Session planning*: Designing or planning sessions (or lessons, or units of learning in IMS LD).
- *Activity design*: Designing activities (things learners actually do – also 'tasks').
- *Designing learning objects* (reusable chunks of content, usually at a fairly small level of granularity).

The JISC D4L work opens up the issue of layered learning design, and its role in communicating design ideas across teams working on educational design and development projects. It also suggests an initial starting point for identifying the main layers. However, this concept

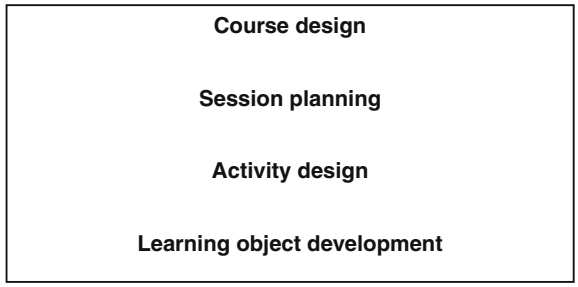

Fig. 1. JISC D4L programme layering model.

has been filtered through various levels in producing the evaluation report. There is a lack of clarity at important points. A key weakness, and one that is crucial in developing an adequate model, is the treatment of design below the session layer. This representation suggests a separation between layers of learning activity and learning objects. It will be argued in the next section that this division is not sustainable. This leads to the proposal of a more firmly grounded representation required below the session layer.

3. Articulating the layers

The initial focus of this section is to explore the design of learning activities below the session layer, as it is believed that this is the area where clarification is most urgent and crucial.

The JISC approach is to view sessions as composed of activities which in turn are composed of learning objects. However, it is argued that, this is an incorrect separation. If we start at the base layer of learning objects then two main issues become clear. The first is that the learning objects themselves embed the design of learning activity (at this 'micro' level). The second issue is that many of these learning objects are too small to fulfil the pedagogical functions specified in session level designs. There is a need for a further 'layer' between the learning object and session layers. However, this layer cannot be specified as 'activity' separated from (learning object) content. These issues are discussed in the remainder of this section. This begins with a discussion of design at the base 'learning object' level.

3.1. Base 'learning object' layer

Base level learning objects are usually defined in terms of achieving one clear learning goal or objective. This is what distinguishes a 'learning object' – it is about learning. Research on learning objects at this level has shown that it is the design of the learning activity that is often most crucial in ensuring effective learning (Boyle, 2003). Design principles for learning objects have been set out in Boyle (2003,2008). These include both pedagogical design principles that emphasise the creation of rich interactive learning experiences, and structural principles such as cohesion and de-coupling. The aim of the structural principles is to create self-contained learning objects that permit maximum freedom for designers of the evoking educational contexts in which the learning objects are reused. The RLO-CETL Web site gives access to nearly 200 learning objects developed in this way (RLO-CETL, 2009).

The natural consequence of this approach is to treat design as more important than content. This has been most systematically expressed in the 'generative learning object' (GLO) work of the Centre for Excellence in Teaching and Learning (CETL) in Reusable Learning Objects (RLO-CETL, 2009). The GLO approach sees learning objects as instances of underlying learning designs. These designs are represented conceptually in a formalism derived from generative linguistics (Boyle, Ljubojevic, Agombar, & Baur, 2008). This formalism provides the basis for an authoring tool that allows tutors to inspect the underlying designs and generate new objects based on these designs. These learning objects are also highly modifiable – they can be loaded back into the tool by local tutors and adapted to meet learner needs and preferences. The tool is free for educational users (GLO Maker, 2009). The GLO approach thus establishes a clear representational structure for capturing and manipulating learning designs at the base learning object level.

3.2. Session layer

The most influential approach to representing design at the session level is the IMS LD specification (IMS LD, 2003; Koper & Miao, 2008). Learning designs are viewed as orchestrations of learning activities. This approach is made clear in graphical authoring tools such as the PROLIX IMS LD authoring editor and the LAMS system (which is IMS LD 'inspired'). These tools provide a graphical representation of the learning design as a sequence of nodes or slots. The individual nodes represent holders for 'services' and 'resources' from the layer below. This provides a typical 'top-down' view from the session layer which looks to services and resources to fill out the slots in a session level sequence. IMS LD based learning designs thus embody an implicit two layer model (as does LAMS which is IMS LD 'inspired'). The focus, however, is on the session level, with only secondary attention paid to the 'resources' and 'services' needed to complete these designs. The view of base learning objects as 'content' loaded into these frames is particularly limiting. These 'slots' actually point to design spaces in their own right – and effective design at this level is often crucial for learning.

3.3. Linking sessions and base level designs

It is interesting and instructive to compare the IMS LD 'top-down' view (from the session layer) to the bottom-up view from the perspective of single goal, stand-alone learning objects. The first clear point is that good design at both levels is crucial. We need an explicit multi-layer view of learning design. The second issue is that there is often a gap between design at the learning object layer and design at the session layer. The simplest model would be that each session level node/slot would be filled by one learning object. A single 'session

level' task slot, however, may actually be quite complex to unfold. Learning objects are often too small and focused to fill the session layer slots. Logically, this points to an intermediate design consideration which will involve a complex of one or more learning objects. Following this line of argument the design layers would look like:

Session (lesson).
Complex (or compound) learning activity.
Base, reusable learning activity (at the learning object level).

The base learning units – focused on one clear learning goal or exchange – would thus need to be combined in principled ways to form learning activity complexes. An illustration of such a learning activity complex is given in Boyle (2003). This is an example from a project where learning objects were used as part of a blended learning approach to improve pass rates in introductory programming.

Fig. 2a shows a design frame for linking two or more learning objects operating together to create a coherent learning experience. The frame consists of three parts: the focal (text based) learning object, which is the entry point for the learner, the link column, and the linked learning objects. The key structural feature is the link column as a separate and distinct entity. This enables learning objects or resources to be easily 'plugged in' and out. This structural feature together with the principle that each element should be independently reusable provides the core features of this 'design structure' for compound learning objects.

Fig. 2b gives an example created using this pattern. In this example the text based learning object in the background (embedded in a WebCT page) explains the syntax for the 'while' loop in Java. The window in the foreground contains a separate learning object that provides a multimedia-based explanation of the basic concept. This is one particular example of a complex learning activity formed from two basic learning objects. Many other ways of creating these learning complexes are possible.

As the word 'complex' has particular connotations in learning, the term 'compound learning activity' is used to describe the learning activities that build on basic learning units. For the same reasons the term 'base' is used instead of 'simple' for the basic level learning objects. The model derived from these considerations is set out in Fig. 3. Compound learning activities reuse and structure base learning activities. However, it is clear the session layer plan may use either type of resource, so the structural relationship needs to be represented as in Fig. 3. There is no need for any further layer, as any elaboration of a compound learning activity (e.g. by linking two compound activities) is itself a compound activity.

3.4. Discourse based learning

Can this model also accommodate discourse based learning? It is noticeable in systems such as LAMS that core tasks orchestrated by the LAMS tool are often discourse based. These learning tasks fall into the compound learning activity level. LAMS may orchestrate several of

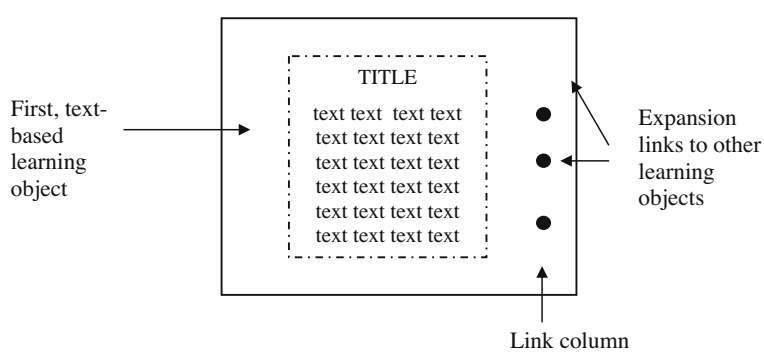

Fig. 2a. Schematic layout of format for the realization of compound learning object from Boyle (2003).

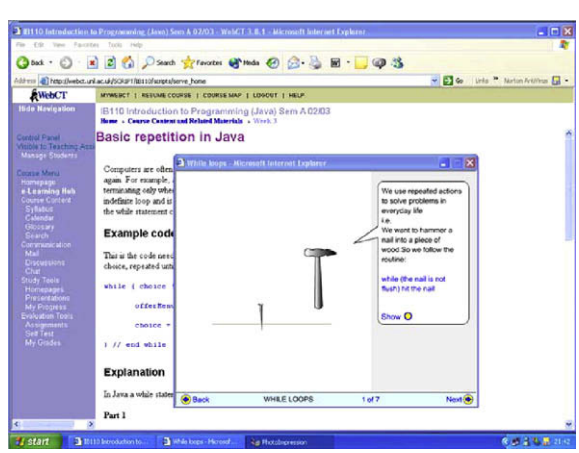

Fig. 2b. Example created using the design frame shown in Fig. 2a.

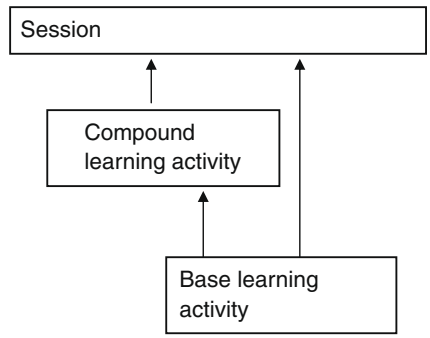

Fig. 3. Layers at the session layer and below.

these to create a session level plan. However, very little design structuring is provided beyond giving a topic and organizing the learners into groups.

Other systems do provide well-designed structural support at this level, i.e. explicitly designed to elicit and support learning dialogues. One example is the Interloc tool (Ravenscroft & McAlister, 2008). This uses the concept of dialogue games to support and foster rich dialogue based learning. In particular, Interloc provides support for learners in making their 'moves' in the games through the provision of structuring prompts called 'openers'. These openers are used to support the students in creating deeper, more meaningful exchanges. These exchanges, in turn, help foster and build up more effective dialogue (Ravenscroft, 2007).

The key point here is that there are two levels of design – a session plan (as in LAMS) and deep designs for discussion based learning. These can and should work together to foster more effective learning. It is not necessary to postulate a dialogue-based equivalent at the base activity there. However, it is interesting to note that the basic unit of discourse is the exchange, e.g. a question and answer adjacency pair. Social systems such as Twitter base their information exchange, and associated learning, at this base level. In Interloc the learning dialogues are improved primarily by producing improvements at the exchange level. So there is clearly scope to extend the model to this level. However, although this may be a productive development, it is not required for the layered model to be effective.

3.5. Extending the model

This discussion has focused mainly on the layers below the session layer, as it is believed that this area had the greatest need of elucidation. However, brief examination reveals that a similar structure is required to link a session and the next layer above. There is a problem of terminology as the level above the session level may be referred to by different names including 'course' and 'module'. This suggests that we should invent new descriptive terms to reflect this level of abstraction. However, abstract terms are difficult to relate to. The terminology used is a compromise. It is influenced most by university education as the LDSE project is aimed primarily at university learning. The term selected, therefore, is that of 'module'.

A module may consist of a sequence of individual sessions or classes. In teaching many technical subjects, however, it is more usual to have weekly units of lecture + lab, where the lecture introduces the concepts and skills which are then practised and applied in the lab. This 'compound session' is composed on two basic sessions (lecture and lab). So the representation elicited in the earlier discussion is mirrored in the relationship between sessions and modules. Fig. 4 extends the framework to include these layers. This model shown in Fig. 4 could be extended further upward to include 'courses' which organise modules into coherent subject offerings.

Up to this point we have focused on learning design. However, learning designs lead to outputs as specific, concrete learning events and structures. To get a full picture it is necessary to examine the work on different levels of 'learning objects'.

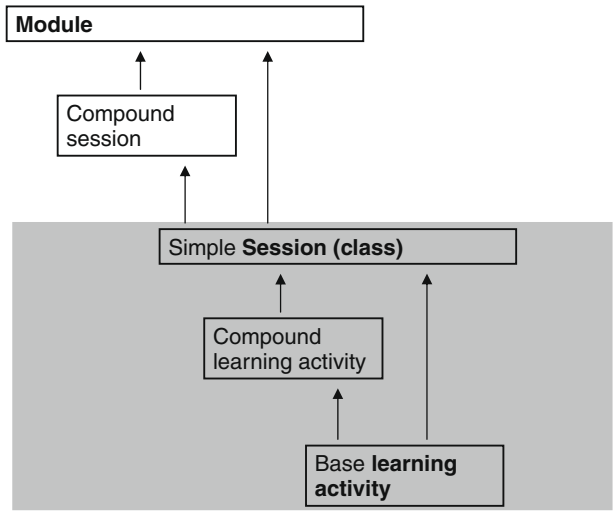

Fig. 4. Layers of learning design.

4. Linking with learning object aggregation models

The aim of this section is to broaden the discussion to a parallel area of work in looking at classifying learning objects into different units of 'aggregation'. There is considerable potential benefit to be gained by exploring the correspondence between these two areas.

At this point there is a need to clarify the two distinct meanings that are attached to the term 'learning object'. The first meaning is to identify basic building blocks out of which more complex applications can be constructed. We can call this type 1 learning objects. The discussion in the paper so far has concerned type 1 learning objects. This is the focus of the generative learning object (GLO) approach discussed earlier in the paper. The JISC model uses learning objects with type 1 meaning. This is the approach taken also in the CETL for Reusable Learning Objects (RLO-CETL, 2009).

The second meaning is encapsulated in the definition given in the IEEE LOM (learning object metadata) standard where a learning object is described as any entity concerned with learning or training (IEEE LOM, 2002). We will call this type 2 learning objects. The confusion is unfortunate, but is deeply embedded in the learning object literature. The problem arises because the concept 'learning object' was used to try to achieve two quite different things. The first was to find a basic learning unit out of which all other units could be constructed. The second was to provide a technical package structure into which all entities could be loaded and made interoperable – i.e. IMS CP (2008) and ADL SCORM (2009).

This section examines learning objects from the broader type 2 perspective. In particular, it examines work on organizing learning objects into different 'layers' depending on their size. There has been considerable work into 'aggregation' models for learning objects. The aim is to identify different 'sizes' of learning objects, and specify the relationship between these in an inclusion hierarchy.

The clearest and most comprehensive model of layers of learning object aggregation is the ALOCOM model (Verbert, 2008; Verbert & Duval, 2004). Verbert reviewed all of the major models of learning object aggregation levels, and produced an abstract model that synthesises the results. The ALOCOM learning object aggregation layers identified in the ALOCOM model are presented in Fig. 5. The terms are rather abstract, so each term has some more concrete, illustrative labels attached. A detailed mapping of the reference model to the classifications used by a range of leading learning object providers is available online in Verbert (2008) (see Table 2.6: Content model comparison, p. 36)

The main ALOCOM levels that concern us in relation to the design layers identified earlier in the paper are the 'single objective' learning object, and the 'larger objective' and 'aggregation' levels. Of the other two levels, 'assets' are raw content and are thus outside the domain of pedagogical design; 'content objects' refer to structural divisions with single objective learning objects. These are best managed as structural units embedded within GLO level learning designs.

If we regard learning objects as instantiations of learning designs then we can explore the possibility of an integrated framework. Integrating the two perspectives produces a more powerful and comprehensive model than either alone. This integration aligns the layers of learning design with the learning object aggregation types identified in the ALOCOM work. Such an alignment, relating the main design layers identified earlier and the main learning object aggregation levels, is set out in Fig. 6. This is a simplified diagram that focuses on the core layers and the two major dimensions that link entities at these layers.

The two major dimensions are 'service' and 'instantiation'. Each learning object entity is viewed as an instantiation of the learning design at that layer. This approach suggests that they are more than mere aggregations – they embody design structures, typical and distinctive of that layer. These structuring principles organise the selection, incorporation and sequencing of the 'services' supplied by the layer below. Learning objects are thus *embodiments* of learning designs; learning designs are the generative structures from which learning objects are created.

This synthesis provides a framework to link the previously disparate areas of learning object and learning design research and development. It provides a more powerful basis in which to develop pedagogically oriented research in these fields. The next section discusses how present work in these fields may be mapped to this framework. The paper then concludes by discussing the wider theoretical and practical benefits derived from this framework.

5. Mapping to this model

The LDSE project aims to produce an integrated learning design support space for learning design at all levels. To do this it requires a conceptual framework for organizing the full range of contributions to design for learning. Table 1 sets out a preliminary mapping of various contributions to 'design for learning'. The contributions are mainly those referred to in the paper. Additional contributions are noted in italics below the table.

The contributions are organized vertically in terms of the layer at which they reside and horizontally along the instantiation dimension in terms of whether they are a design concept, tool, or artefact produced. These placings may give rise to debate. But that is exactly what is

Aggregation	*(e.g. module, or a 'course' as an aggregation of modules)*
Larger objective	*(e.g. session, lesson)*
Single objective	*(e.g. at GLO level)*
Content objects	*(reusable components within single objective LOs)*
Content fragments	*(assets, such as pictures, that have no intrinsic pedagogical value)*

Fig. 5. ALOCOM reference model adapted from Verbert (2008).

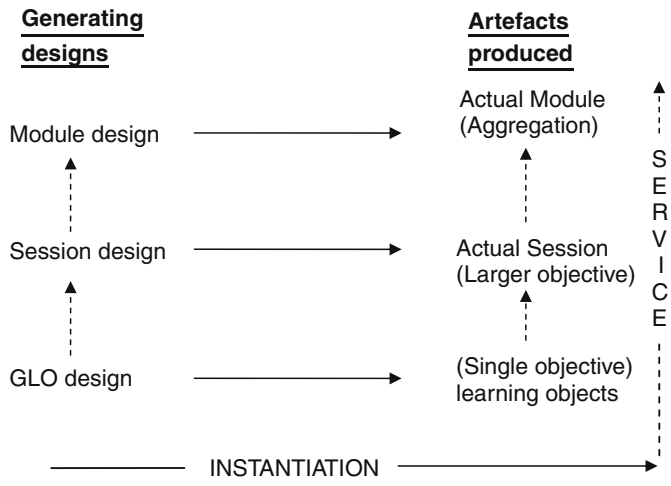

Fig. 6. A simplified view of the integrated 'Layers and service' model.

Table 1
Mapping contributions to design for learning.

	Design model	Tool	Artefact
Module	LPP model University module requirements	LPP University module templates	Module design High level design spec.
Compound	Tell-do-explore compound session format		An (often weekly) combination of lecture + practical session
Session	IMS-LD model lesson plan formats	LAMS, IMS LD authoring tools	e.g. LAMS online session
Compound	LO-link-LO design pattern;	HTML template	Compound learning object
Learning activity	GLO model	GLO Maker	Learning object

Note: LO = Learning object. LPP = London Pedagogy Planner – a tool operating primarily at the module design level, which is a project that feeds into the LDSE project (LPP, 2008).

required – debate on the focus and scope of various contributions to learning design, so that we may see how they relate to each other in the bigger picture.

6. Conclusions

The paper has set out a reference model for layers of learning design. In this model the relationship between any two adjacent layers is one of organization and service. The higher layers contain the organizing principles and structures required for managing complex learning goals. At the same time they reduce the details that need to be considered; the detailed design is managed at the lower layers. The result is that, in designing for a complex learning domain, we can effectively 'zoom in' and 'zoom out' across the complex landscape of learning.

This conceptual framework is then mapped to the ALOCOM model for learning object aggregation. This introduces a second major organizational relationship – that of instantiation. By treating learning objects as instantiations of learning designs we provide the basis for a powerful integrated reference model.

The view of the services supplied by lower levels is especially enriched in the paper. This area, which focuses on the specific activities carried out by learners, has been surprisingly neglected in many 'learning design' studies. This improvement arises mainly through the integration of GLO level designs which operate at the base learning object level.

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