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A constructionist learning environment for teachers to model learning designs

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Abstract The use of digital technologies is now widespread and increasing, but is not always optimized for effective learning. Teachers in higher education have little time or support to work on innovation and improvement of their teaching, which often means they simply replicate their current practice in a digital medium. This paper makes the case for a learning design support environment to support and scaffold teachers' engagement with and development of technology-enhanced learning, based on user requirements and on pedagogic theory. To be able to adopt, adapt, and experiment with learning designs, teachers need a theory-informed way of representing the critical characteristics of good pedagogy as they discover how to optimize learning technologies. This paper explains the design approach of the Learning Design Support Environment project, and how it aims to support teachers in achieving this goal.

Keywords blended learning, constructionism, earning design, innovative teaching, teacher-designer, technology enhanced learning.

Introduction

The project described here is designed to promote the use of digital technologies for learning and teaching in higher education, in a way that better exploits what they can do for the lecturer's own context. Recognizing that academics are usually not trained as teachers, and that they are given little time or support to learn about either conventional teaching or learning technologies, we have set out to investigate the extent to which a specially developed computational environment could support the process of designing conventional, digital, and blended learning.

There have been several recent projects focusing on digital support for teachers, taking the various forms of a learning activity management system (LAMS, http://lamsfoundation.org/), a learning object repository (Boyle 2006; Littlejohn & Margaryan 2006), a toolkit (Conole & Fill 2005), a patterns collection (Agostinho 2006; Mor & Winters 2007; Derntl *et al*. 2009), a customizable inquiry learning platform (Schwartz *et al*. 1999; Anastopoulou *et al*. 2009), an elicited commentary on practice (Donald *et al*. 2009), a wiki (Masterman & Manton 2011), and an interactive tool (San Diego *et al*. 2008), and we have built on the many lessons learned from these projects (Laurillard & Masterman 2009). Digital technologies can play many valuable support roles, and given the complexity of the learning design process, all these methods all likely to be components of a fully supportive infrastructure for teachers. Our approach is to create a learning design support environment called *The Learning Designer*, which adds a different kind of component to the mix: a microworld for the domain of learning design.

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A microworld is an explorable and manipulable computational model of an aspect of the world, with its own constraints and assumptions, in which a user can experience all the necessary concepts by interacting with it – using a computer 'to understand scientific knowing as rooted in personal knowing' (Papert 1980), and 'to engage tasks of value to them, and in doing so . . . come to understand powerful underlying principles' (diSessa 2001). The idea of a microworld is to situate the learner within a rule-governed environment in which the goal is to construct an entity. They learn about the concepts and rules of that environment because the process of construction is constrained, and every action has an effect that helps them reflect, and adapt until they have something they can share, compare and discuss with their peers. The components of a microworld have recently been defined (Kalaš 2010) as

M1: A set of computational objects that model the mathematical or physical properties of the microworld's domain.
M2: Links to the multiple representations of the underlying properties of the model.
M3: An ability to combine objects or operations in complex ways, similar to the idea of combining words and sentences in a language.
M4: A set of activities or challenges that are inherent or pre-programmed in the microworld; the student is challenged to solve problems, reach goals, etc.

(The identifiers M1, etc. are used in referring to these components later in this paper)

These components are a useful formulation for a stable computational model in domains such as science and mathematics, where the idea of a microworld originated. The domain of learning and teaching is not so well specified, however. The objects, properties, and operations may be based on the literature and information from practitioners, but as a knowledge domain, it is still provisional, and should be able to develop in response to user interactions. By making use of Semantic Web technology, we can go beyond the classic microworld by enabling the underlying model to reconfigure itself as users customize the concepts and properties of the provisional model. This 'responsive microworld' is more suitable for the still developing knowledge domains such as education (the topic of a forthcoming paper).

Here we consider whether the 'constructionist' approach (Papert & Harel 1991), which supports conceptual learning through practice and collaboration, could apply to teachers developing their knowledge about technology-enhanced learning.

The basic idea is that a microworld for learning design would enable academics to articulate their learning design by constructing and analysing it. They could also explore, manipulate, and test it against the embodied underlying pedagogic principles, thereby relating their practice more closely to the provisional knowledge of learning design expressed in the microworld.

Academics have well-developed personal knowledge of teaching and learning from their own extensive practice, but it is rarely articulated, and is only minimally documented, most often in the templates of bureaucratic validation procedures, and in Microsoft PowerPoint presentations. It is unlikely that any one academic is aware of the full range of current knowledge about teaching and learning even though it is an important component of practice for the teaching profession, and a basic understanding is crucial for producing effective learning designs, especially in the context of new technology. Pedagogic knowledge is hard to learn and pass on, but as a type of knowledge, it has not been given sufficient recognition in the approaches to learning design so far, has not been adequately codified, and cannot be easily implemented within a computing environment using formalisms such as Petri Nets and unified modelling language. We are exploring a different kind of computational model.

There is as yet no well-structured body of knowledge about how to exploit fully the use of all the different kinds of learning technologies now available. However, there is a body of knowledge about pedagogy and learning theory (JISC 2004, 2007; David 2009), which can be represented in the microworld. Our aim is to make it easier for academics to enhance their teaching practice by making informed use of the range of learning technologies now available to them and their students.

Helping teachers exploit TEL

The optimal use of learning technologies is integral to the wider issue of how best to facilitate learning. In the context of compulsory education, learning design is more usually referred to as 'pedagogy' – 'the practice of teaching framed and informed by a shared and struc-

tured body of knowledge' (Pollard 2010) – but the fundamental nature of the practice is common to all the ages and stages in education. Teachers in all sectors engage in a complex process of planning, decision making, design, and creativity in their facilitation of student learning, so we use the more general term 'learning design' to make it more widely applicable, to include higher education as well.

To achieve a genuine and lasting change in what teachers do, we need to have an impact on the way they *think about* what they do (Biggs 2003), encouraging them to be more reflective and therefore more open to extending their practice to others' ideas and to technology-enhanced learning (TEL) designs (Schwartz *et al*. 1999; Ertmer 2005; Donald *et al*. 2009). The typical working life of a university teacher does not lend itself to this. There are very few opportunities to learn about TEL and it is not easy to share design ideas, or to engage in pedagogical reflection:

> University teachers do not typically have such tools and sensibilities . . . Nor is there a community of university teachers with a common pedagogical language or shared set of robust pedagogical constructs (Goodyear & Yang 2009).

Time for staff development has to compete with developing administrative skills and research skills, so there is little time for learning about teaching, even of a conventional form. This means that an improving knowledge and practice of learning design may only ever be developed as a natural and ongoing part of the process of teaching. It could be similar to the development of knowledge and practice in the context of research, where academics are familiar with the requirements of knowledge building: to build on the work of others (from a literature search), to develop and test their own ideas (through experiment or debate), and to share their results (through publishing). Could the knowledge-building process for conventional and digital pedagogies work in a similar way? Could we support academics as 'teacher-designers' (Goodyear & Yang 2009), with respect to their role in creating and designing learning activities?

In addressing both of these questions, we have conceptualized the Learning Design Support Environment (LDSE) project as the development of an interactive microworld that enables teacher-designers to act like researchers by developing knowledge and practice about teaching and learning. We call this system *The Learning Designer*.

It gives academics a way of developing and testing their teaching ideas in terms of the established principles of effective learning design. Here we illustrate only the phases of work within the project that (1) elicit users' conceptions of the learning design process; (2) balance their requirements and concepts against the existing knowledge base of teaching and learning and the aims of the project; and (3) provide a formal representation of a learning design that can be analysed in terms of the underlying principles. The interactive design tool is being tested with target users, and later publications will report on the results. Our other publications discuss the implementation of the overall concept as a computational system (Charlton *et al*. 2009; Charlton and Magoulas 2010a,b), addressing the first requirement of a microworld, M1, i.e. the set of computational objects that model the properties of the domain of learning design, and the computational mechanisms that provide the technical support needed to meet M3.

Eliciting practitioners' conceptions of learning design

For any design tool to have value for practitioners, it must at least support and facilitate the ways in which they set about their normal practice, even though the aim is to enhance it. Our research study therefore began with extensive interviews with ten 'informant practitioners' (IPs) in order to elicit their conceptions of learning design, and to probe further the findings from previous studies (Masterman & Vogel 2007; San Diego *et al*. 2008; Masterman & Manton 2011). IPs were selected for having at least 5 years experience in learning and teaching and the use of TEL, and from roles that represented subject lecturers, staff developers, and learning technologists, summarized in Table 1. These criteria placed the selected IPs in a strong position to provide us with a comprehensive range of user requirements, and to articulate clearly the requirements of early-career lecturers or of seasoned academics who have not yet engaged with TEL. For *The Learning Designer* to scaffold teachers from current practice to optimal practice, it is important to have a good model of what the latter should be, and to be aware of what users might find difficult, or the misconceptions they may hold. The IPs, a mix of male and female, were identified by team

Table 1. Informant practitioners recruited in the first year of the project.

ID	Role	Teaches students
IP1 (M)	Manager of learning technologists	PhD only
IP2 (M)	Staff development; director of PGCHE	Y
IP3 (F)	Subject lecturer	Y
IP4 (M)	E-learning consultant	
IP5 (M)	Subject lecturer	Y
IP6 (M)	Lecturer in professional development	Y
IP7 (F)	Subject lecturer, project officer in HEA subject centre	Y
IP8 (F)	Manager of learning technologists; staff development background and PGCHE	
IP9 (F)	Lecturer in academic skill development and business studies	Y
IP10 (M)	Subject lecturer; director of online MSc course	Y

HE, higher education; HEA, higher education academy; PGCHE, post-graduate certificate of higher education.

members from their involvement in previous learning design projects.

The interviews were conducted using a set of agreed questions on themes such as 'personal approach to course design', 'staff development for TEL', etc., generated from the project objectives (see Appendix 1). All the questions were addressed, but the interview style remained open to allow probing of issues where an interviewee had a particular contribution to make. Interviews averaged 98 min and were audio recorded and professionally transcribed. They were analysed by one researcher on the basis of the themed questions, to generate a broad set of practitioners' conceptions of learning design, and to provide detailed information for user scenarios for designing the interface. Three other members of the team collectively reviewed this distillation of categories and quotes, to ensure computational interpretability, and the interface designer then took the user requirements analysis and scenarios to specify the detailed graphical user interface architecture.

The following sections summarize the critical requirements elicited from this group of target users that relate to their conception of the learning design process.

Building on the work of others

There are two main ways in which teacher-designers can build on the work of others to inform the decisions they make in their learning design:

1 Using educational research findings.
2 Learning from other teachers' teaching ideas and practices.

The first is not a common practice in higher education. From IPs' testimonies, it appears that there is now a greater awareness among academics of the value of evidence-based practice for supporting the changes they want to make to courses, for example, in the curriculum or the assessment methods. However, they take a rather instrumental approach to the use of educational research, not motivated by a desire to learn from the research. In fact they reported scepticism about the idea of higher education as a discipline appropriate for research, and were concerned about the lack of time for engaging with this additional research field.

The second opportunity for building on others' work comes more naturally, as IPs fully acknowledge the value of learning from their peers.

> There's a lot of sharing . . . they do ask for course outlines and particularly for 'What seminars did you do?' . . . It's quite common in classics, 'Can you give me your course outline, the lecture schedule?' The thing is that we do share it, quite often the entire databank of handouts (IP7).

> The main thing is for the example to be 'very pretty close' to the kind of thing that one wants to do, if not in terms of subject discipline, then in terms of structure and approach: 'it needs to be pretty close in some sense. We find that people find it quite difficult to move from one . . . from things that are very different.' (IP1)

However, it can be difficult for a lecturer to see beyond the content of another discipline to the underlying pedagogic idea: 'they're so bogged down in content that they can't see past it' (IP7). They must be able to discern something of relevance to their own teaching:

> I don't know anybody who has stuck with the same thing from what they've borrowed: there is this desire to edit it and make it yours because your areas of focus will be different (IP7).

Being able to adapt what is adopted, to 'make it your own', is essential:

> If I was going to take over [a colleague's] class I would feel, well, I'd love to use that as a basis but I'd want to tweak and tweak and do this and do that . . . [Reusable learning objects] are very small; you can use them in all different contexts. And I can design it where it suits me in my class. And somebody else can design it or use it where it suits them in their class (IP3).

We encountered few examples of established practice of collaborative design, although there was certainly an interest in the idea of working together and learning from each other:

> You need to have the shared domain so that you're kind of talking about the same things and doing the same things, and that helps you form a more natural community of practice (IP4).

> There's sort of an increasing need as well, in terms of developing a design, to do it as a community practice, to share and critique ideas and to get the students' feedback on those (IP6).

Building on the work of peers is acceptable to these lecturers, therefore, and is a viable objective for the LDSE project. However, they are likely to adopt only material that is clearly relevant and can be easily adapted. A learning design support environment must therefore make it very easy to find existing designs that are relevant and adaptable to the user's perceived needs, and mediate the process of fitting these designs into their own workflows of designing and editing learning.

Ideally, a library of learning designs would enable users to search on any or all of the candidate concepts: discipline topic, learning approach, learning outcome, teaching challenge, and should be able to learn from users' searches.

Balancing the needs for both structure and free expression

The activity of learning design, for teacher-designers, is traditionally a balance between their own teaching ideas, those of their colleagues, and the constraints set by the institution and formal academic user requirements, such as intake numbers, classroom sizes, credit hours, and assessment. Lecturers will be familiar with these formal constraints, with the layering of degree programmes, courses, modules, sessions, and activities, and also with the idea of setting learning outcomes for their courses. Nevertheless, they still want the sense of a creative process:

> . . . design should be I think fairly loose and allow for innovation and creativity and collaboration between participant . . . a design needs some kind of architecture so that it can actually stand up, but it also needs to be "soft" in the sense that people will find it welcoming (IP4).

> I think it is all the, you know, the kind of the structuring . . . the conceiving, the designing, the structuring, particularly the structuring I think with or without technology (IP6).

Although structure was seen by some to be important, others were worried by the idea of constraint. For them, the term 'learning design' could be redolent of ' instructional design', with negative connotations of rigidity, which was not what they felt education should be about.

> It has echoes for me of going back to kind of instructional design, I mean it has echoes of that. It sounds to me like one is trying to set up a sequence of activities to bring about particular learning goals. And I think that's not always what one's doing in education. I mean, I think a lot in . . . particularly in education about education, I think a fair chunk of what people are doing is about values and changing people's values (IP1).

However, 'changing people's values' is also a goal, and one that requires some considerable care and planning if it is to succeed, so we would argue this does not actually run counter to our approach of helping users work out how best to bring about particular learning goals. Nonetheless, the resistance to design and structure is such a common comment from teachers, when they are faced with a formal articulation of the teaching process, that we cannot ignore it. We could not design *The Learning Designer* to be a blank sheet of paper, if it aims to assist the design process that necessitates some kind of pre-existing structure. However, the tool cannot presume to constrain the user to that structure and must allow them to go their own way, if they wish.

From previous projects, we found that the most difficult aspect of flexibility is terminology (Masterman & Manton 2011). This is because terminology varies widely among educational contexts. A 'module' may refer to a collection of sessions, or a subset of topic-specific sessions within a larger content stream. Terminology may even vary across faculties within an institution. To cope with this, the current strategy in *The Learning Designer* is to employ 'core concepts ontology' and a 'pedagogical thesaurus'. The ontology formalizes the structure of the domain (i.e. concepts, relationships, and knowledge), and makes greater demands on specificity, completeness, and coherence

than is normally required in educational discourse. Its value is that, knowing what it is, the user can interrogate, inspect, test, and improve it, as part of the support offered during learning design. The ontology should act as a catalyst for iterative development of teaching and learning theory and practice through the self-configuring capability of the system (Charlton and Magoulas 2010a). Collecting alternative terms for particular definitions provided by users enables the community to develop the corpus of terminology further, and the user can adapt *The Learning Designer* to their preferred terms. There are several synonyms for concepts, such as 'module' (or 'course', 'unit', 'course unit'), for 'block' (or 'week', 'unit'), and for 'supervised class' (or 'lecture', 'presentation', 'class').

Aligning the elements of learning design

As they plan their teaching, users have to bring together the disparate set of components involved in learning design: aims, learning outcomes (or objectives), curriculum topics, teaching and learning activities, and assessment. As one would expect from experienced practitioners, our interviewees were aware of the interdependence between the components of learning design:

> . . . what decisions do I make about what goes into my curriculum, and how do I design the curriculum, the assignments and the learning outcomes to be aligned with each other (IP8).
>
> Learning design to me is . . . , I'm going to have a group of students, we've got some learning outcomes, how can I best design my lecture, seminar, whole course, my guest lecture, it's how can I get [to] do this (IP3).
>
> When I think of learning design I would think about the interplay of aspects of learning . . . an optimal situation which would enable learning . . . content, . . . delivery, . . . the environment (IP5).
>
> For me a learning design says, what does the student need to demonstrate at the outcome of this; how can we build them up in the sequential steps and how can I check along the way that the learning has occurred (IP9).

The awareness manifested in these comments finds resonance in Biggs' emphasis on the importance of finding the internal alignment among the components of a learning design:

> Learning outcomes, teaching and learning activities, and assessment must be aligned by the teacher to enable constructive alignment by the learners (Biggs 2003).

The fact that teacher-designers and theorists alike believe that there is a clear relationship between the components of learning design underpins our formalization of these concepts and relations into an 'ontology' of learning design. This is a different kind of requirement from the two others discussed above, which specified the type of content that should be accessible, and freedom of navigability within the environment, respectively. For help with ensuring the alignment of components, *The Learning Designer* needs to have some representation of knowledge of the components and their relationships, and to be able to check or advise on a design, or offer suggestions.

The field of education in general, and even learning design itself, has not yet developed a stable ontology. Our strategy, therefore, is to compile an initial ontology, which creates well-defined relationships between the components of a learning design, based on an existing framework (Laurillard 2002), so that it can be published and subject to peer review. The ontology defines the nature of the pairwise relationships among learning outcomes, teaching and learning activities, and form of assessment (Charlton *et al*. 2009). By this means, *The Learning Designer* can support the user in aligning and analysing the components in their design.

Summary of implications

The LDSE project has explored many other aspects of the learning design process, such as learner characteristics, tools and resources, teacher and learner time modelling, and user collaboration, to name a few. They are not covered here, as the focus of this paper is on the design features needed to support the construction of the learning design itself. Yet, there is sufficient complexity in the three issues outlined above to illustrate the challenges of developing a learning design support environment. These user requirements are particularly relevant to the collaborative construction of learning designs.

It is essential that *The Learning Designer* should respond to user requirements, but the intention is also explicitly to take teacher-designers beyond their current practice. Therefore, we have to address users' requirements by interpreting them in relation to the overall objective. For the three user requirements discussed here, we worked iteratively across the interdisciplinary

expertise in the team to generate the following list of design requirements that takes into account both user requirements and the principles for improving practice:

- Offer well-targeted, 'context-aware' links to relevant research findings.
- Recommend existing learning designs that are clearly relevant to current needs.
- Allow users to edit the content and structure of recommended learning designs in order to maintain flexibility.
- Offer a default design process to support a structured approach, the steps of which are easy to follow.
- Provide a flexible approach, allowing the user to navigate their own pathway through the design process, beginning at any point.
- Provide an evaluation of the design constructed by the user and allow the user to edit the assumptions in the analytical model to fit their own context.
- Develop an ontology of the concepts and relations relevant to learning design, in order to assist the user in ensuring that the components of their design are aligned, and subsequently to enable constructive alignment by the learner.

Theoretical underpinning

As the main aim of *The Learning Designer* is to have a positive impact on teachers' practice in making effective use of learning technologies, its design cannot be driven by users' requirements alone. It must also contain the expectations derived from theory that will challenge and develop their existing practice. This section sets out our approach to embedding a knowledge base of the theory and practice of pedagogy within the environment to provide that challenge and support.

The Learning Designer enables users to design a module (i.e. a sequence of sessions), or a session (i.e. a sequence of teaching and learning activities or TLAs), or a TLA, each of which has properties such as aims, outcomes, teaching methods, assessment, learning approach, duration, resources, etc. Pedagogic principles and concepts are introduced to the user through the natural process of constructing a sequence of sessions or learning activities for a session, whether class based or online, for group or individual study. In this sense, it conforms to the microworld feature M3: enabling the user to combine objects and operations in complex ways in order to express their design idea.

The effective use of technology means that the technology chosen must be appropriate for its context of use. Digital technologies should only be used if they add value, being deployed alongside conventional methods of teaching in a mix that optimizes the learners' experience and enables them to achieve the agreed learning outcomes. Therefore, a learning design support environment should not make any assumptions about preferring technology-based designs, but must provide a set of principles that help the teacher-designer to develop a rationale for whatever methods they choose. The theories and accounts of effective practice embedded in the advice, guidance, and knowledge in *The Learning Designer* must challenge both conventional and digital methods to meet the learning needs of the user's students.

The pedagogic principles underpinning the operation of *The Learning Designer* have been based on the conversational framework (Laurillard 2002, 2009), because it was developed as a distillation of the main theories of learning and teaching in order to challenge both conventional and digital methods. In principle, any such framework could be embedded in the environment as long as it identifies the contrasting learning experiences afforded by different types of teaching and learning activities.

A recent analysis of evidence-informed principles for effective pedagogies in UK higher education produced by the Teaching and Learning Research Programme (David 2009), can be used to test the extent to which *The Learning Designer* is capable of addressing this representation of the current understanding of what counts as good pedagogy for higher education. Table 2 lists the principles that are most relevant to the detail of designing learning activities, and for each one shows how *The Learning Designer* supports the user in addressing that pedagogic principle.

If *The Learning Designer* is to support the teacher-designer in constructing a good design, with respect to these pedagogical principles, then it needs the following functionality:

- To address (a), it must ask the user for information about what kind of learning activity is to be included, and how long learners are to spend on it. Users are

Table 2. Extract from the characteristics of effective pedagogy (David 2009) mapped to features in *The Learning Designer*.

Effective pedagogy:	*The Learning Designer* helps teachers address this in their design through:
(a) Fosters both individual and social processes and outcomes.	Providing feedback on the nature of the learning experience designed by the user in terms of the proportion of time spent on 'individualized', 'social' and 'one-size-fits-all' methods.
(b) Promotes the active engagement of the student as learner.	Providing feedback on the nature of the learning experience designed by the teacher in terms of the proportion of time spent on learning through 'acquisition' or on the more active forms of 'inquiry, discussion, practice, and production'; offering examples of learning designs that engage the learner in explicit activities; linking to the literature on active learning.
(c) Needs assessment to be congruent with learning.	Offering a visualization of the relationships between the learning outcomes, teaching and learning activities, and assessment methods in the user's design.

invited to select from a predefined list of learning activities, each of which is characterized as personalized (e.g. an assessed assignment), social (e.g. small group work), or one-size-fits-all (e.g. lecture) – properties that can be edited by the user; it can then provide an analysis as feedback on the design.

- To address (b), it must use predefined, editable, properties of learning activities to provide feedback on whether an active learning experience has been designed, and provide links to pre-developed libraries of learning designs and research literature.
- For (c), it must use the user's inputs or selections of learning outcomes, activities, and assessment methods to display a visual representation of the links between them for inspection and revision by the user.

This functionality is the 'constructionist' feature of the environment that enables the teacher-designer to make something – here, a learning design – and test it against a set of pedagogical principles that provide an analysis of its likely fit to their goal, as the next section shows.

The characteristics of effective pedagogy assembled by David (2009) make no reference to the role and potential value of learning technologies. If *The Learning Designer* is to assist teacher-designers in making a rational comparative judgment between using conventional and digital methods in their teaching, they will also need an analysis of the relative value of alternative teaching and learning activities, in terms of the learning experience they facilitate (Laurillard 2006). The user's design must be elicited in a way that makes it understandable to the software, and interpretable in relation to its pedagogical value. This places a requirement on the knowledge embedded in *The Learning Designer*: each TLA incorporated in the user's design must be described in terms of its pedagogical properties, so that it can be interpreted to provide feedback to the user, prompting further reflection on their design. This is what makes it a 'constructionist learning environment' for the teacher. In Papert's terms, we treat the user's learning as 'learning without being taught' as in Logo (Papert 1980; diSessa 2001), or as 'building knowledge structures . . . in a context where the learner [*i.e. the user*] is consciously engaged in constructing a public entity [*i.e. a learning design*]' (Papert 1980; Papert & Harel 1991), and the 'public' here is a collaborative community of peers who also engage in or use what has been constructed. What form should that 'public entity' take? What does a learning design consist of, that can be constructed by the teacher-designer, and understood and evaluated by *The Learning Designer*? These questions are explored in the next section.

Formal representation of a learning design

Learning design has been represented computationally through the IMS LD specification (Koper & Olivier 2004) in order to provide a pedagogically neutral form of representation that identifies actors, roles, and a sequence of activities, without any imposition of theory or evaluation. This creates the opportunity for the creation and sharing of designs, but does not in itself assist the evaluation and improvement of the designs (Laurillard & Ljubojevic 2011). That can only be done by implementation in practice, with evaluation data being collected and analysed by the designer in a separate process.

The information recorded in a learning design that conforms to the IMS LD specification does not need to

Table 3. A text-based representation of a learning design for a topic-specific learning outcome (version 1).

Learning outcome	To develop the skills of interpretive pluralism	
Sequence of activities		Time
Tutor presentation	1. Read/view the text/presentation illustrating the importance of interpretive pluralism	10
Resource-based individual activity	2. On your own explore multiple perspectives from an archaeologist, a classicist, and a modern historian on the origin, purpose, meaning, and references of the Altar of Pergamon, and note down the key points made.	30
Individual practical activity	3. On your own, answer the factual MCQs about the origin, purpose, meaning, and references of the Altar of Pergamon, where the feedback will refer you back to the different interpretations. Summarize the different interpretations.	15
Small group discussion	4. In pairs discuss your summaries of the different interpretations and note down your agreed summary of the differences between them	35
Group activity	5. Discuss with the whole group the ways to interpret and evaluate multiple interpretations, making use of your notes from the previous activity	10
Total learning time in minutes		100

MCQ, multiple choice question resource.

capture or analyse the pedagogy. However, a learning design support environment has to represent a learning design in a more explicit way, in order to be able to evaluate the pedagogical properties of that design. The properties required are

- *Learning outcome*, *sequence of activities*, and *assessment*. These must be aligned for effective pedagogy
- The *sequence of TLAs*. These must be classifiable according to their different pedagogical and logistical properties, defined in the knowledge base of *The Learning Designer* (and editable by the user).
- The *time* for each TLA. This makes it possible to estimate the proportions of different kinds of learning experience afforded by the sequence, and hence, provide an overall evaluation of its pedagogic value.
- The *tools and resources* required by the learners. These alert the user to the type of topic-specific content they will need to provide for their specific instantiation of the learning design.
- The *designer's reflection*. This provides an opportunity for the user who is sharing the learning design to pass on any additional reflection to potential reusers.

Visual representation of a learning design

The visual representation of a learning design is intended to give the user some purchase on how well their design is shaping up. Because we can assign to the components of the learning design formal definitions based on the educational literature, it is possible to make them interpretable by *The Learning Designer* software. For example

- A 'tutor presentation' is defined as providing a learning experience that is 100% learning through acquisition.
- A social constructivist type of 'small group discussion' is defined as providing 90% learning through discussion, and 10% learning through acquisition, where proportions depend on the group size.
- A collaborative learning group activity is defined as providing 10% learning through acquisition, 20% learning through discussion, 40% learning through practice, and 30% learning through production, where again the proportions depend on the group size.

This provides a degree of structure to the design process, but is balanced with the user demand for flexibility by making the default properties of the TLAs editable. They can also create new TLAs to make *The Learning Designer* as responsive as possible to their own practice.

Once the user has selected and defined these components of their learning design, and assigned time durations to them, the design can be analysed to offer feedback in the form of an estimate of the nature of the learning experience it provides. For example, if a learn-

Table 4. Comparative analysis of the nature of the learning experience provided by two versions of a learning design.

Type of learning	Percentage of time (version 1)	Percentage of time (version 2)
Acquisition	43	27
Inquiry	26	27
Discussion	25	18
Practice	3	18
Production	3	10

ing design is represented as in Table 3 can be analysed by *The Learning Designer* in terms of the total learner time spent on different kinds of learning, because its knowledge base includes the pedagogic properties of each activity type.

The analysis of the learning experience in Table 3 is shown in the middle column of Table 4, where the TLAs (tutor presentation, individual activity, etc.) have been interpreted in terms of their pedagogic properties (such as 90% discussion + 10% acquisition), and these are aggregated across the whole session.

Now suppose the user replaces the multiple choice question resource with an online adaptive resource capable of eliciting and prompting reflection on the learner's own construction of their ideas, then the analysis shows a different distribution of learning type. This will show more emphasis on learning through practice because the learner is developing their own ideas, and less on learning through acquisition, where the learner would be reading about others ideas. The new analysis is shown in the third column of Table 4. These values are accessible and editable by the user by viewing the properties of their selected teaching-learning activities.

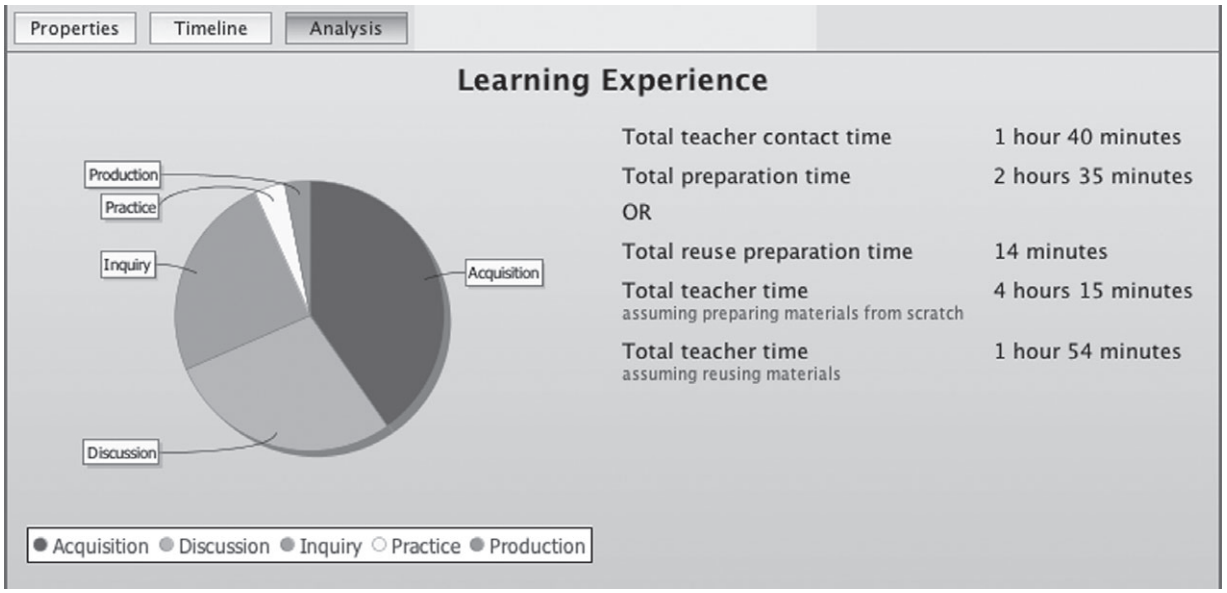
This approach is an attempt to capture what the academic community means by effective pedagogy so that it becomes possible to represent pedagogic decisions in an explicit way, and to provide feedback to a user on the learning design they have in mind. We may wish to offer more collaborative learning, smaller group sizes, more active learning at the expense of lectures, etc., and these are quantitative statements, which can therefore be modelled quantitatively, recognizing that the quantification will be approximate and context specific. Currently, *The Learning Designer* presents this analytical feedback in the form of a pie chart (see Fig 1), which provides a visual impression of the distribution of types of learning, rather than numbers, avoiding an unwarranted precision. The aim is for designers to be able to form a useful overall impression of the results of their design work, so that they can make informed choices about the elements of their learning designs, rather than to provide specific percentages for finely tuning the design based upon essentially approximate quantifications.

Theories and practice written up in the educational literature do make assertions about the importance of differentiating between different types of learning, and prioritizing some over others (Laurillard 2002). If a 100-min session is all tutor presentation, it differs substantially from one that involves the learners in alternating between individual and group activities: that is, they spend their time very differently in the two situations, and they are likely to achieve different kinds of learning outcome. We have set out to demonstrate that difference through formal representations, both text based and pictorial. In the sense that teachers are also learners when they are learning about learning design, pedagogic theory expects that teacher-designers will benefit from active reflection on whether their intended design is likely to achieve the goal they are hoping for, prompted by feedback on the learning experience that it appears to offer. In this way, *The Learning Designer* provides the microworld component M4, and supports constructionist learning through problem-solving challenges for teachers.

Alternative representations of a learning design

The text-based template is a standard way of representing a learning design, but some projects, such as LAMS and interoperable content for performance, have also developed more graphical forms of representation (Dalziel 2009; Derntl *et al*. 2009): viz. diagrams consisting of boxes corresponding to learning activities, linked by arrows to denote the sequence in which they are performed, and colour coded to differentiate between different types of activity. To represent fully the pedagogical properties of a learning design, it is important, as the microworld component M2 suggests, for the user to have access to multiple representations of the underlying properties of the domain model. Given that a learning design plays out over time, we need to include a time-based representation as well. *The Learning Designer* therefore offers the alternative format of a timeline, with defined time intervals for each TLA, e.g. resource-based individual activity, collaborative

a



b

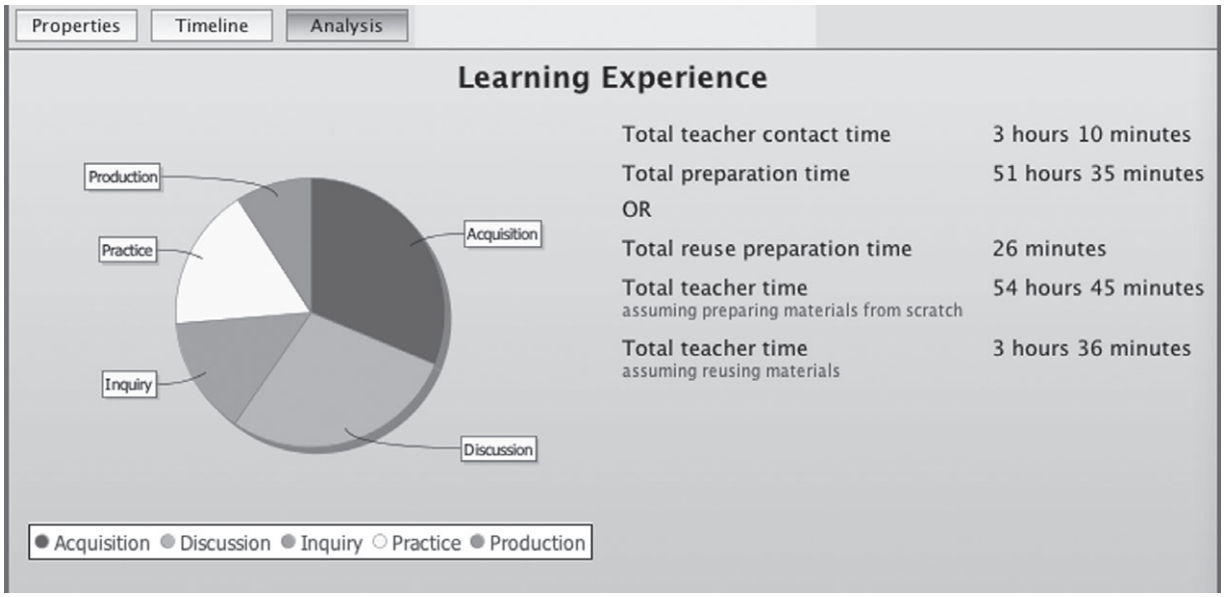


Fig 1 A pictorial representation of the analysis of the learning experience the user's design is likely to provide. As the user selects learning activities and timings, *The Learning Designer* calculates and displays the resulting change in the learning experience as a pie chart and estimates of teacher time needed (an adaptive resource requires a lot of preparation), enabling alternative designs to be compared.

project, online discussion, etc. Figure 2 shows the prototype version of this form of representation, which has been undergoing evaluation with potential users.

Users can select from the palette on the right the types of TLA they want to place on the timeline and adjust the duration by resizing the object. *The Learning Designer* automatically interprets the duration of each to calculate the distribution of types of learning (pie chart) as shown in Fig 1. The information in the timeline view is equivalent to that in the text-based view in Table 3, but is easier for the teacher-designer to reflect on and change. They can switch between the two views, as the

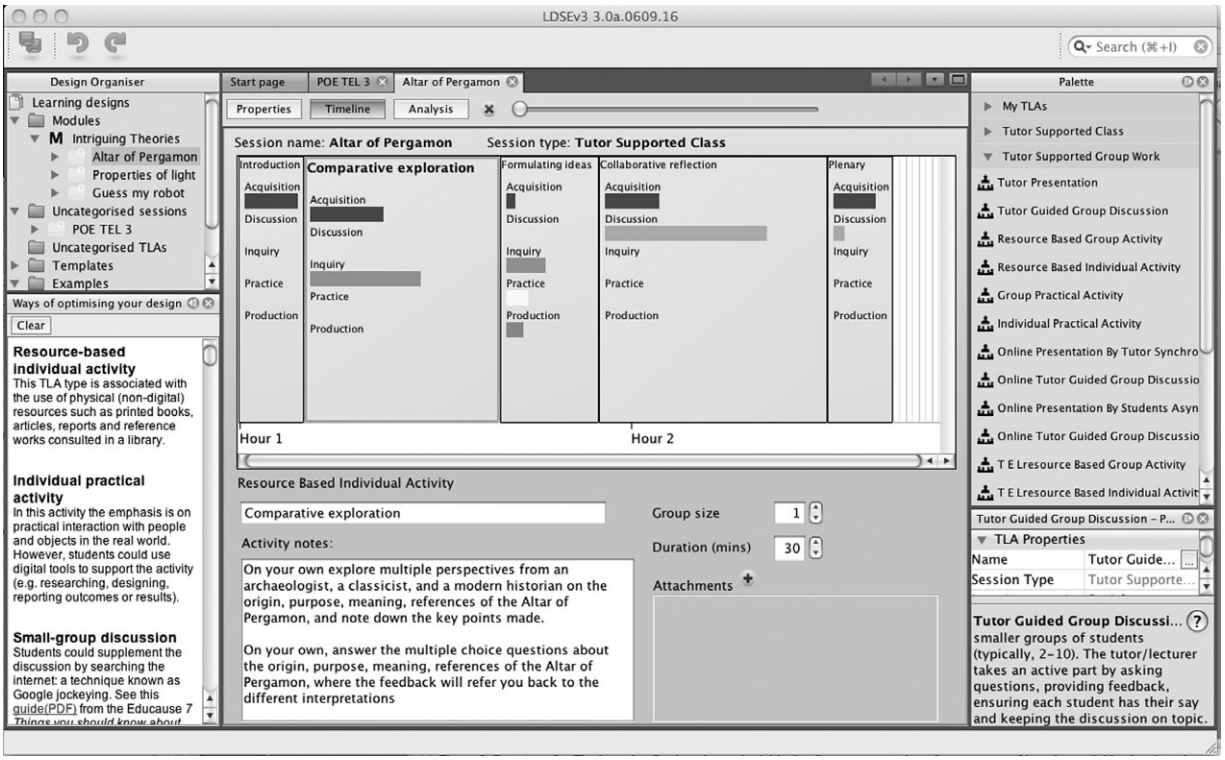


Fig 2 Prototype for *The Learning Designer*'s manipulable timeline representation of a sequence of predefined learning activities (dragged from the palette on the right) in a learning design for a session. The learning type properties of each activity are editable in the right-hand pane.

text-based view more easily shows detailed information about the nature of each activity.

Evaluating the representations of learning design

The Learning Designer's approach to providing online support for learning design addresses user requirements by tackling the need to build on the work of others, balance structure against free expression, and align elements of the learning process. Earlier forms of representation of learning design and the types of feedback derived have been tested in initial pilots with six target users (all teachers in higher education experienced in using technology in some way, all male, coded P1 to P6). They all had positive comments about the general approach and specific features, as well as suggestions for how these could be improved.

In particular, they responded favourably to timeline representation of a learning design, although they were clear that they need both this and the text-based format:

> I think it is very helpful, this is very positive, it is better than seeing the sequence . . . , I can see the left to right through the phases here, I would say this is much more mappable to a variety of different learning areas (P4).

> For me, these are just mapped lovely . . . starting with the diagrammatic representation would be a better point for me than the instance narrative representation . . . (P2).

> Mapping of the steps and phases works for me fine (P3).

> I can see there is a need for both, you are actually, this is mapping more clearly these steps to these stages . . . given the degree of freedom here [in the timeline], it gives you a fair amount of freedom to record those, it does not give you space to connect across (P6).

There is also support from IPs for the idea of offering an analysis of the quality of the design in the form of a pie chart of the percentage of types of learning it facilitates (through acquisition, inquiry, discussion, practice, or production), and a bar chart of the types of learning experience (individualized, social, or one-size-fits-all):

> I really liked the pie, I really liked that . . . 'Cause that tells you what you're all doing (IP9).

> [It's] aiming for offering people a sort of teaching-oriented clarity on what they've already got . . . So I think

> it's . . . its very useful for anyone to think about balance in their teaching (IP2).
>
> I'm thinking that [this representation of learning experience types] it's quite nice (IP3).
>
> Yeah I think it's great. I think, it's really, really useful to understand that (IP6).

Practitioners seemed happy to have this representation of the types of learning experience, although the initial terms we used (*personalized*, *social*, and *standard*) were seen as problematic by some of them. We changed 'personalized' to 'individualized', and 'standard' to 'one-size-fits-all' as better ways of expressing the contrast.

The user-acceptance testing of these prototypes for representing and analysing learning designs generates considerable detailed advice on the way the interface needs to work, as well as further elaboration of user requirements, beyond what they were able to offer in the initial interviews. When users see a learning design support environment in action, it prompts very detailed comments and reflections on their own current practice. As a device for eliciting user requirements, therefore, the version designed in response to the initial requirements gathering inaugurates a further extensive data analysis and redesign process that will be reported on in later publications. At this stage, the focus is on the intelligibility and acceptability of the approach.

Concluding points

The principal aim of the LDSE project is to have a positive impact on teacher-designers' practice in designing technology-enhanced learning. We aim to make it easier – and more appealing – for them to draw inspiration from good practice by other teacher-designers, and to gain access to the fruits of scholarly research in their own teaching and learning.

We also want to encourage teachers to experiment with new tools and pedagogical approaches in their learning designs, and to engage in critical reflection on their practice in order to evaluate their success in improving students' motivation and learning outcomes.

The approach is to take inspiration from the educational literature that promotes the idea of constructionist learning, and to build an environment that enables teachers to learn about new pedagogies in the adaptive and supportive way that we aim to offer to our own learners. Teachers do not have the time to learn through books, papers, courses, and workshops; therefore, the environment has to embed within its operations information, advice, and guidance on the current knowledge about teaching and learning, with both conventional and digital technologies. Equally, since this knowledge is still developing, we want to provide the means to document, share, adopt, adapt, and republish these new pedagogic ideas as they develop in practice.

The software as it has been developed so far, and the forms of interface needed, are being evaluated with practitioners to determine the extent to which it meets their needs and expectations, and achieves the intention of enabling them to develop further their conceptions of learning and teaching. Further publications will report on the outcomes of the evaluations and the lessons learned.

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Appendix 1

Interview themes and questions

The LDSE project objectives are

1. Research the optimal model for an effective learning design support environment (*The Learning Designer*).
2. Achieve an impact of *The Learning Designer* on teachers' practice in designing TEL.
3. Identify the factors that are conducive to collaboration among teachers in designing TEL.
4. Embed knowledge of teaching and learning in the learning design software architecture.
5. Improve representations of the theory and practice of learning design with TEL.

The user requirements interview themes are listed in Table 4, along with the rationale for their inclusion.

Table A1. Interview themes and rationales mapped to the project objectives.

Theme	Rationale:
1. What does the term 'learning design' mean to you?	Objective 1(i) is to 'scaffold the learning design process' so it was important to appreciate the different ways in which teachers interpret the concept of 'learning design' in order to establish an unambiguous definition within *The Learning Designer*
2. Personal approach to course design	Objective 1(ii) requires us to 'challenge teachers' current pedagogy', so it was important for us to understand features of their current practice which we had not explored before.
3. Institutional strategy re TEL: ◆ Top-down vs. bottom-up initiatives ◆ Attitudes towards individual experimentation	Objective 3 is concerned with fostering collaboration in TEL within and across institutions, which will involve customizing *The Learning Designer* to different institutional contexts. Understanding the characteristics of these contexts will both enable us to identify the aspects of *The Learning Designer* that need customizing, and the parameters and values that will need to be set. However, it will also help us to appreciate the enabling factors and constraints placed by institutions on lecturers' individual practice and on their ability to experiment and innovate [i.e. help to further objectives 1(ii) and 2(ii)].
4. Staff development for TEL: ◆ Drivers for development ◆ Programmes in place for early-career lecturers ◆ Programmes in place for experienced lecturers	On the basis of the evaluation of Phoebe, we envisage that *The Learning Designer* will be used primarily in support of professional development, so in pursuit of objectives 1(i), 1(ii) and 2(ii) we need to understand some of the key motivations for engagement with TEL and how both early-career and more experienced lecturers are introduced to TEL.
5. Supporting everyday practice: ◆ Is there a community of TEL enthusiasts? ◆ Importance of human (F2F) contact ◆ Implications for the design and deployment of supportive design tools	Objective 1(v) aims to foster a community of practice and objective 3 addresses collaboration, both of which will rely heavily on existing communities within each institution. We need to find out how widespread and how active such communities are. The question of the human touch, and the extent to which computational support can substitute for hand holding by another person, was another carry-over from the evaluation of Phoebe that needed to be probed further in the LDSE project.
6. Research-informed teaching: ◆ Attitudes towards pedagogic research ◆ The extent to which lecturers keep up with latest developments in teaching and learning	Objective 2(i) is directed towards helping teachers to develop 'effective practice' through espousing guidelines derived in part from pedagogic research and evaluation. Finding out the extent to which they already keep up with developments in this field will help to give us a baseline against which to assess their response to research-informed guidance *The Learning Designer*
7. Building on the work of others: ◆ Taking over someone else's teaching ◆ What artefacts are shared ◆ Mediators of sharing and reuse ◆ Sharing across disciplines and institutions	Within communities of practice, objectives 1(iv) and 1(v) envisage teachers sharing and taking inspiration from each others' learning designs. Understanding their current experiences and perspectives in this respect should inform the way that *The Learning Designer* presents others' work as exemplars, and provide a baseline against which to assess users' response to this form of support.
8. The place of theory in lecturers' practice: ◆ The value of theories, models etc. to lecturers ◆ The theories of which they are aware; theories relevant to HE ◆ Handling of theory in staff development programmes ◆ Theories underpinning learning technologies	Objective 2(i) is directed towards helping teachers to develop 'effective practice' through espousing guidelines derived in part from pedagogic and related theories (including commonly espoused analytical frameworks, models, and taxonomies). Knowledge of (a) the extent to which lecturers currently make use of theory, (b) the theories etc. that experienced lecturers consider relevant to their practice, and (c) how professional development programmes introduce lecturers to theory should help to ensure that *The Learning Designer* offers relevant theories at relevant decision points and introduces them in a 'gentle' manner [cf. objective 1(i)].
9. Reflective practice: ◆ To what extent is it promoted? ◆ Reflection as a social act	Reflection as a means to improve one's own practice is built into objectives 1(vi) and 2(iii), and we wanted to determine when and how teachers reflect on the learning experiences that they have facilitated.
10. Work in cross-institutional bodies	Objective 3 also addresses collaboration across institutions, and since one IP was employed by a cross-institutional body, we wanted to know how actively lecturers participated in it (i.e. whether they could be said to form a community)

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