Enabling creative learning design through semantic technologies

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The paper advocates an approach to learning design that considers it as creating digital artefacts that can be extended, modified and used for different purposes. This is realised through an 'act becoming artefact' cycle, where users' actions in the authors' software environment, named Learning Designer, are automatically interpreted on the basis of formal active 'concepts' embedded in users' activities as they create learning designs. This is underpinned by semantic technologies, which enable creating active, in computational terms, artefacts. The paper illustrates how the proposed approach integrates pedagogical considerations, expressed using the Conversational Framework, with semantic technologies, especially ontologies, providing a snapshot of the tool. It discusses evaluations and findings from the user studies that were carried out. Finally, some conclusions and next steps are provided.

Keywords: learning design; semantic web; ontologies; co-construction of knowledge; act as artefact

Introduction

In education the creation of new knowledge is sometimes achieved through a process of co-construction where individuals and peers explore a particular concept or piece of knowledge, reflect on it and rebuild it by reformulating its representation.

In learning design, for example, teachers create various knowledge products. They capture in lesson plans, learning designs and teaching activities the essential combination of the curriculum aims, the subject/topic under discussion and the learning context. The process is facilitated if they use (i) a shared vocabulary or common understanding about the particular concept or knowledge, (ii) a set of teaching–learning activities, and (ii) the underlying pedagogical principles to teach that knowledge.

Teachers also design assessments that measure students' learning experience in terms of the extent it meets the learning outcomes. This is a reflective process that should give the teacher a sense of whether or not a particular learning design is likely to help students' learning, before they go through the actual practice of delivering the teaching. That process of reflection may persuade the teacher to modify the design. The outcome is a learning design, i.e. an expression of how a student may learn by a particular means and how this might be examined.

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Technology in education adds another dimension to this complex task of creating learning designs and lesson plans. A variety of tools and technologies are available and teachers are expected to use technology-enhanced learning, to know when, how and what tools to apply, and to understand the impact of taking on such a challenge.

However, teachers have frequently been poorly supported in this difficult task, and it has been made clear in the relevant literature that a new approach to enabling technology-enhanced learning is needed. An approach that will bring the 'teacher as designer' into the frame. To this end, an authoring system should contain the concepts that the teacher uses as a designer, and then use them to facilitate communication with the user. This form of interaction can help representing partial but important information about how users' knowledge develops as they are creating their learning designs. If the teaching community is to be able to share knowledge products, both the pedagogic knowledge embedded in a design and the context of the process of its creation, i.e. the concepts used, their properties and the changes users make to existing designs, are important.

In this paper we describe how we have leveraged a type of computer-supported learning design and semantic technologies to support the creation of knowledge products. In particular we have drawn from the related field of knowledge engineering to bridge the gap between technology and education through supporting a *community knowledge vocabulary* about learning design.

The paper explains the importance of the semantic technology and in particular the use of ontologies in developing learning design tools. It illustrates how ontology-driven tools can support a learning design environment for teacher-designers to create designs under their own terms, and benefit from the learning design vocabulary by being able to construct designs quickly, and co-construct knowledge. The semantic framework models pedagogical approaches and through intelligent inferencing techniques can suggest ways of combining conventional teaching–learning methods with the variety of technology-enhanced learning (TEL) methods now available. With this computationally expressible model the teacher-designer can be given an analysis of their current learning design, together with recommendations for alternative learning designs created by the community. By adopting, adapting, trialling and sharing their learning designs in this way the teaching community builds a collective intelligence into the learning platform, based on the developing community knowledge (Charlton & Magoulas, 2010).

The paper builds on the Conversational Framework (Laurillard, 2002) to examine the co-construction of knowledge through the process of exchange, and show how learning design technologies can be part of this framework. We also draw upon semantic technology to develop mechanisms that enable a learning design tool, called Learning Designer, to support the concepts used in creating learning design.

Finally, we demonstrate the tool in terms of a walk-through of an example learning design, provide a summary of findings from the user evaluations and end with an overview of the conclusions and next steps to be considered from this research.

Co-evolution of knowledge and the Conversational Framework

The Conversational Framework is derived from theories, pedagogical principles and research findings in the educational literature and has been widely cited for use in different educational settings. As a meta-framework the Conversational Framework defines a process of learning through concepts and practice, and encourages an

iterative process for the negotiation and co-construction of knowledge between the teacher, the learner and their peers. This paper examines the teacher as being in the role of the student, i.e. they are in the process of learning how to teach, how to improve or reflect on their teaching practices. The Conversational Framework makes explicit the idea of learning as a process of exchanging concepts, either between teacher and learner, or between learners, or even with oneself.

Figure 1 presents a simplified view of the Conversational Framework for teachers as co-learners, exchanging ideas about learning design. At a general level the sharing and exchange of ideas, in particular the creation and sharing of learning designs between peers, is presented. Users and their peers communicate directly using their designs and/or discussions about designs. This is similar to how teachers and students may exchange ideas through some product/artefact (digital or paper). Each enables the other to learn from their modification of their design. Each teacher-designer acts in four different ways: defining or modifying concepts, constructing designs, commenting on designs and modifying the designs of others. Each user receives four different types of assistance from collaborating with peers: access to concepts, analysis of their design, comments on designs and access to the designs of others.

In Figure 1 we see that the process of exchange supports user practice and concepts. The concepts represent a pedagogical model of thinking that the teacher embeds within their design. This is enriched through practice and collaboration with peers.

This process is independent of whether or not digital resources are used as part of the design creation. Figure 2 introduces a digital resource. In many institutions there is a drive to use open educational resources (OER) and engage with technology for delivering teaching. The use of digital resources may provide opportunities to be more productive through re-use and sharing, building on the work of others

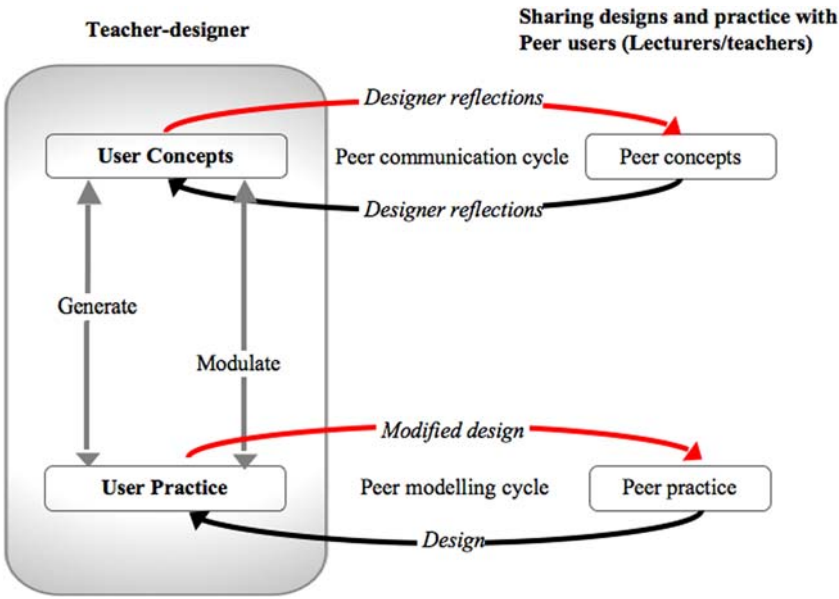

Figure 1. Sharing learning designs as a peer-to-peer learning process.

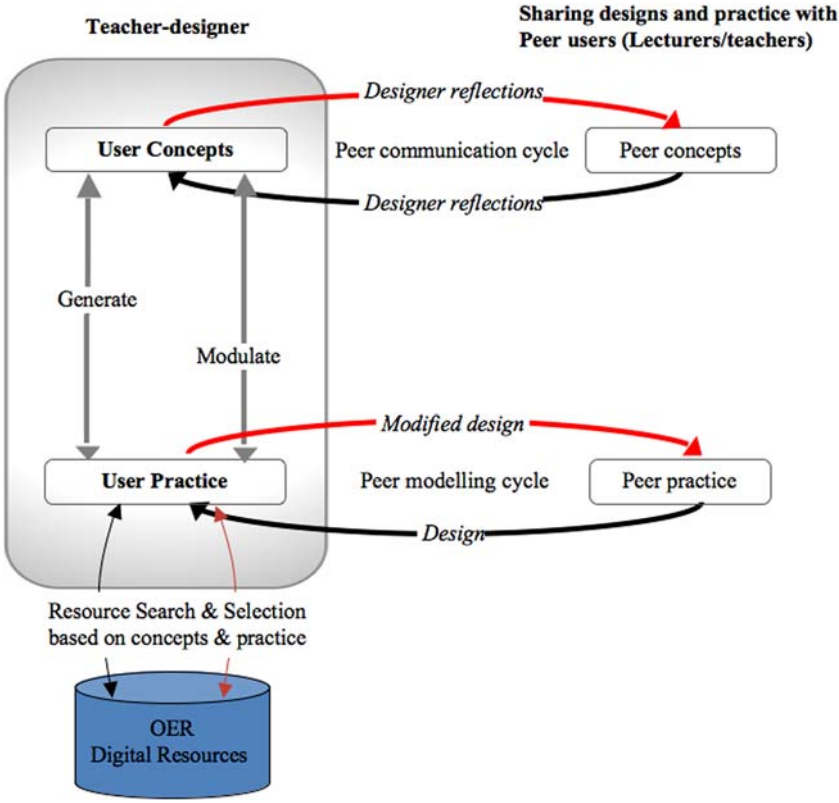

Figure 2. Sharing learning designs as a peer-to-peer learning process and including explicit digital resources.

and delivering leading-edge up-to-date knowledge. However, there are barriers to the use of digital resources as a natural part of knowledge production as outlined in the introduction.

To capture and structure this communication of knowledge between peers, embedding the conceptual and pedagogical thinking within a learning design that teachers can examine, exchange and share is challenging. To this end, the Conversational Framework offers a reference model that unifies concepts and their relationships, helps software designers to better understand the problem, identifies roles, and can be used as a basis for communicating design choices to practitioners. In the Learning Designer, the vocabulary, represented in an ontology, becomes transparent at the interface level through the terms used to create a conceptualisation of learning design, capturing both theory and practice. This is in contrast to many learning design and authoring tools where transparency is rarely the case (see Charlton, Magoulas, & Laurillard, 2009). Current learning design (LD) tools can be roughly organised into the following groups: (a) standards based, such as Educational modelling languages and IMS-LD (Koper & Tattersall, 2005); (b) generic form based, which include tools for designing, managing and delivering learning activities and content, e.g. LAMS,[1] Moodle,[2] CompendiumLD;[3] (c) authoring tools (Papanikolaou & Grigoriadou, 2006) and (d) ontology based (see Barn, 2006). The

analysis (see Charlton et al., 2009) of a number of tools and gathering user requirements that are driven both from practice and theory identified a gap between the teacher-designer needs and the tools that have been created, thus limiting their use. Alleviating this situation requires bringing theory and practice together by combining cohesively the results of knowledge engineering modelling and the functional requirements based on human factors around design practice. To support the community design practice and theory we need to model the process of knowledge co-construction. We have used the Conversational Framework for teaching and learning to model this process. The semantic technology captures the design process, the knowledge as concepts, and the exchange and creation of knowledge. The components that achieve this are the learning design ontology and the inferencing engine. The engine uses the concepts modelled in the ontology to find, create and modify learning design knowledge. The learning design product, which is a digital artefact, carries with it the concepts that have been used and created during the design.

Figure 3 illustrates knowledge co-construction through a digital means when we combine semantic technology with the Conversational Framework for knowledge exchange. The 'Tool' supports the body of knowledge that captures the critical vocabulary of the teacher-designers. In the process of constructing their learning design the software tool supports the embedding of the concepts. Practitioners often design on the basis of available resources they will use. The resource, through the tool, is now captured with contextual knowledge of pedagogy supported by the Conversational Framework, and the learning design can now be tagged with this

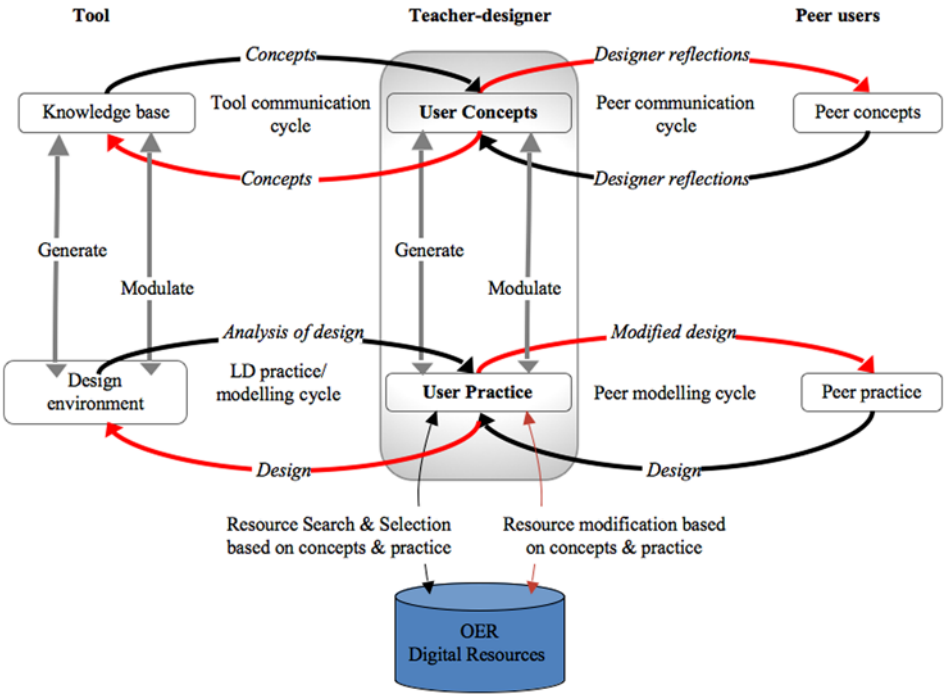

Figure 3. Making explicit the semantic technology's role as part of the Conversational Framework in digitally capturing the embedding of knowledge into the learning designs for knowledge co-construction.

same knowledge. The software incorporates a predefined learning design knowledge base in the form of learning design concepts and relations. The designer can change the properties of the concepts, e.g. choosing or creating a different learning outcome, editing the one available, adding their own teaching and learning activities, and editing the activities to reflect their more discussion-based approach to teaching. All this is captured as they design, and is shared immediately with the knowledge base, and is accessible with the same terms in the interface.

Moreover, as learning designs are continually generated or modified, knowledge is constructed by automatically annotating user designs with knowledge already embedded into the tool. This process of sharing, exchanging and modifying, illustrated in Figure 3, exploits the Conversational Framework. From a technical point of view, this is materialised as the Learning Designer (see Charlton & Magoulas, 2010, 2011), which:

- captures theory and practice as a body of conceptual knowledge represented in an ontology;
- provides a conceptual representation of theory and practice and makes it available for inspection, use and modification by the designer;
- supports modifications, changes and additions to concepts, via the creation of designs, by extending the ontology with new instances. This is done seamlessly through the interface and interaction when creating the designs;
- creates through the shared vocabulary (ontology) a formal way to semantically tag the learning designs with the same concepts that have been used in the designs. This results in 'embedding the learning design knowledge into the plans' (Morris & Hiebert, 2011, p. 6).

The importance of embedding learning design knowledge into a learning design enables a change.

First, knowledge analytics can be applied to the learning design. This is only possible if the knowledge behind the scenes and the knowledge being created by the Learning Designer are based on the same vocabulary – that is, the same representation about the design. Analytics about learning design is enabled supporting the teacher in viewing designs from different perspectives, e.g. social dimension of activities, collaborative dimension of activities, individual practice, the proportion of the time spent on production (an example is discussed later in Figure 6).

Second, the re-use and sharing of designs can happen in different ways, e.g. re-use of your own designs, or discovery of 'like this' designs, where 'like this' can be as specific as supporting 'production and practice' to a general activity set that makes up a session. While the details of each design product may be different the concepts used may be contextually similar, e.g. addressing a similar learning outcome or activity sequence. However, the delivery of 'practice' may be different; teachers can modify this representation of activity to include their interpretation. This becomes part of their design and part of the knowledge of practice embedded within pedagogy theory. Furthermore, knowledge analytics can assist the teacher to investigate how much re-use of their own work and that of their peers has been included in the learning design and how much of their work they have shared.

Third, in knowledge co-construction nothing is lost in the process and co-evolution takes place as a digital means. Act becomes 'a knowledge artefact' because contribution is through conceptual knowledge that is shared between the knowledge

base, the interface and most importantly the users. As a designer adds and changes knowledge this is reflected in the knowledge base and users of that knowledge base can have access to that or the designer can share the design with the knowledge through the export function.

Fourth, recommendations can be supported at learning design concept level, e.g. providing activities that are useful for online teaching. New ways and old ways of looking and thinking about users' designs are possible, e.g. conventional lectures versus online lectures, the possibility to search for more activities with production or individual support, etc.

Fifth, resources that embed pedagogy now have explicit representations and contextual knowledge to enable re-use and sharing and knowledge construction. Hence, if an OER is used it is supported with all the knowledge including the design itself.

The learning design tool, discussed in this paper, supports the above five dimensions. The tool is intended for use by teachers and lecturers to assist in creating learning designs. It provides a 'starter kit' of the core concepts of learning design, elicited from experts, from the literature and from teaching practice. Before considering the approach to designing and building a tool that includes learning design core concepts, we present some of the background about semantic technologies.

Semantic technologies

With more semantic-aware computing technologies, e-learning is expected to be more intelligent in the new era of the educational semantic web (Anderson & Whitelock, 2004). Roschelle and Pea (2002) proposed that Wireless Internet Learning Devices can offer further affordances that lead to learning activities that deviate significantly from conventional classroom-based, computer-supported collaborative learning activities and in addition lead to new ways of aggregating activities coherently across many students, introducing new ways of conducting the class. They propose that 'act becomes artefact'. Act becoming artefact is not just about changes in the way teacher and students engage with technology in and outside the classroom. It can apply to the way a teacher, through acting in collaboration with other teachers and with a learning design tool, creates an artefact, i.e. a learning design, in the process.

While the 'web' part of the semantic web considers that resources can be connected and shared, the 'semantic' part of the web refers to an explicit representation of how that sharing might be interpreted and understood. One of the richest forms of representations in computer science to date is ontological models.

The 'ontology' as a form to model knowledge has been around since the time of Aristotle and in its original form was defined as the study of 'being' or 'existence'. Ontologies are used in artificial intelligence, information management and the semantic web providing a formal explicit specification of a shared conceptualisation of a domain. Without an ontology or domain model the possibility to consider digital knowledge co-construction and the opportunities that are enabled within the field of learning design will be limited. And one may argue that if a conceptual model, such as an ontology, is not in place then very little of the 'semantic' part of the web can be considered. It isn't that an ontology is the semantic web but it is a critical part of the design process when creating an application that is to share, exchange and co-construct knowledge. This is exactly the idea behind the Conversational Framework. Knowledge is shared, exchanged and co-constructed

when there is a conceptual understanding with which to exchange and construct products of learning knowledge of which learning designs are part of these products. To this end, a common vocabulary is needed.

An ontology incorporates the core concepts of the domain, together with the formal definitions of the relations between them. The properties, characteristics and logic of ontologies may be encoded using ontology languages and embedded in software packages. The ontology representation plays a large role when determining the meaning of words, i.e. semantics, which provides several advantages compared to using simple character strings that have no intrinsic meaning for the software. Such a formal semantic representation goes beyond metadata and XML and other related mark-up languages because the semantics is formally and explicitly represented, so that the software can recognise and interpret what the user is doing as their actions or interactions are interpreted using those concepts. For example, in the Learning Designer, the concept of 'learning activity' is instantiated as 'discussion group in class' and is *linked to* the concept 'learning experience' instantiated as 'social'. The formal links allow the software to 'understand' the meaning of the concepts in the sense that it knows how they are linked and what counts as an instance of a particular concept. In this sense it can find a learning design that is relevant to the user, which is a valuable feature in a learning design tool. All representations have semantics but an explicit representation brings meaning by embedding knowledge in the formal definitions of the properties, values and relationships.

To apply this to learning design: the learning design is a digital artefact that can be configured and used for different purposes; more than this, the 'act' of interacting creates, extends and modifies the learning design 'artefacts'. Hence the use of semantic technology means that content, resources and documents are not static and purely user driven through interactions anymore. Instead, these are active, in computational terms, artefacts. This is materialised through an 'act becoming artefact' cycle, introduced by Roschelle and Pea (2002), where the software system interprets the teacher-designer's acts by using the formal active 'concepts' embedded within their design, as well as the resulting artefact, i.e. the learning design itself. Thus, the designs or any digital entity created in this way co-evolve as users interact, exchange, change and modify these digital artefacts. This requires an ontology about learning design and that this ontology forms the knowledge from which the whole tool draws a representation and understanding. Thus the learning design concepts used by the designer in the interface level have a direct impact on the knowledge base, which in turn has a direct impact on what is on offer to the designers. It is cyclic, following the exchange that we see as representative of the Conversational Framework.

Methodology and walk through the tool

Most systems require a heterogeneous approach to design taking into account different requirements and demands that need to be considered to support different levels of requirements, i.e. deep expert knowledge of domain, the user's common approaches, innovations possible through new approach, etc. The Learning Designer tool is no different and our work has drawn from a number of approaches and methods to model and create a learning design ontology. While on the one hand we followed a Seven Steps method (Noy & McGuinness, 2001) to construct the learning design ontology, on the other we needed to include the flexibility for users

to change and adapt the knowledge. The latter is part of the inference system, which supports adaptation and inclusion of new knowledge.

Noy and McGuinness (2001) recommend the following seven steps:

(1) Identity the purpose, the domain, and the scope of the ontology.
(2) Consider using a pre-existing ontology, if one exists.
(3) Identify the 'important terms in the ontology' (i.e. its properties and relationships).
(4) Identify the classes, sub-classes and their hierarchy.
(5) Identify the properties of the classes, objects or concepts.
(6) Identify the allowed values, value type, etc., of each property.
(7) Create instances of each class or sub-class by defining real objects having values conforming to the objects' allowable properties.

The seven steps do not mean that an application will be designed with knowledge-aware capabilities, such as knowledge evolution, self-configurability, etc., but provide the underlying structures that can be exploited by such designs. Charlton et al. (2009) illustrated the type of details required in the knowledge engineering process when modelling knowledge and aspiring to ontology-driven software. Table 1 summarises the approaches used to establish the learning design community knowledge.

This approach enabled us to establish the concepts typically used in learning design practice and illustrated the loose way theory was encapsulated both in scenario descriptions and in current learning design products. The theory is tacit knowledge to the expert and ambiguous and diverse in the initial definitions. Through knowledge iterations and testing the theory, through tool usage, refinements were made. The process of refining the theory model and explicitly identifying with the experts when theory should be used within the process of design is the first step to addressing Wiley's use of theory in computational models (Wiley, 2000), and may help to address the barriers to use by practitioners.

We used Protégé (http://protege.stanford.edu/) to model the concepts and the relationships of theory and practice. This process of developing the domain ontology enabled us as knowledge engineers to determine the concepts and ideas that were not well defined. The concepts in practice are modelled as part of the domain ontology and are understood in context from using a user-centred methodology of gathering user needs to functional requirements. A snapshot of some example concepts and instances that exist within the core knowledge based from the protégé model is provided in Figure 4.

In Table 2 we examine the concepts and their properties provided in Figure 4 (it is not possible to present all the details of all of the concepts supported in the knowledge base).

The recommended teaching and learning activities (TLAs) are created at runtime and are updated as the knowledge base changes. Core concepts that form the LD ontology do not change. However, as the teacher adds in his/her own instances through the process of creating a design these are exposed to the recommendation inference and new properties are added. This means at runtime the tool can recommend designs, TLAs or learning outcomes depending on the contextual knowledge that underpins the teacher's design.

Table 1. Methods adopted in our approach to inform design of a learning design support environment.

Method	Major advantages	Major disadvantages	Outcome
Evaluation of previous work on learning design systems	Builds on previous work. Shows common approaches by learning designers, expectations and barriers to use.	Assumes previous studies have followed accepted methods. Open to Chinese whispers interpretation.	Informs specification of learning design (LD) structure and conceptual models for LD practice; additional experts and case studies confirmed those concepts that are highly compelling.
Questionnaires on learning design practice	Structured information about LD approaches can be identified; useful for LD structure and conceptual models.	Difficult to confirm that inputs reflect actual user behaviour in learning design practice.	Certain contextual data was either verified or queried for evidence of support. The knowledge was used to create profiles of types of users and further knowledge about barriers to use.
Semi-structured interviews on learning design practice	Confirmed a number of previously identified concepts and expectations. Provided more explicit concepts about 'living design artefact' for sharing.	Time-consuming in analysis. Illustrated the use of concepts in different ways.	Convergence on clear usage and understanding of learning design terms appeared complex if not impossible. Handling different uses of concepts emerged as a strong requirement to assist in addressing cognitive overload and barriers to use.
Focus group task analysis of learning design practice	Concepts used from this method have been supported by previous research findings. Helps obtaining agreed and different views on usage.	No research method to validate results. Can be dominated by an individual.	Confirms concepts identified before. Reveals a new requirement about ease of sharing the designs with students and other practitioners.
Scenarios of learning design practice	Creates example steps in the learning design process. Allows different sources for creating scenarios that reflect common set of requirements.	Potentially subjective.	Generating and expanding the general expected set of practitioners' concepts building on the previous knowledge elicited. Modelling of reasoning process and implicit knowledge when creating learning designs.

Evaluation of existing tools	Can explore usage of tools by users. Reveals potential limitations of tools, such as usability issues.	Subjective and a thorough analysis is very time-consuming.	A lack of explicitly used theory described and used meant further knowledge elicitation was needed. Identified the gap between learning design systems, learning design practice and theory.
Knowledge modelling of learning design	Common concepts identified and defined as core for further evaluation.	Still focused on practice and little theory included in model.	Iterative development of the domain ontology refined the model and identified lack of clearly articulated theory. So theory was expressed as part of meeting learning outcomes and thus activities.
Learning design case studies	Clearly identified the points where learning theory may be used, commonly used theories and rationale for use.	Potentially subjective. Illustrated by ill-defined concepts.	Iterative knowledge elicitation process between knowledge engineer and the experts led to refined concepts and rationale for use, representing LD community knowledge.
Knowledge modelling of theory	Identifies differences between learning theories, and explicit relationships between learning outcomes, learning theories and activities.	Subjective in terms of theory modelling as the individual experts often have different views about theories.	To include theory, the concepts are formally expressed. Identifies what can be formally modelled and records concerns. Leads to need to define loose relationships between theory and practice within the knowledge base.

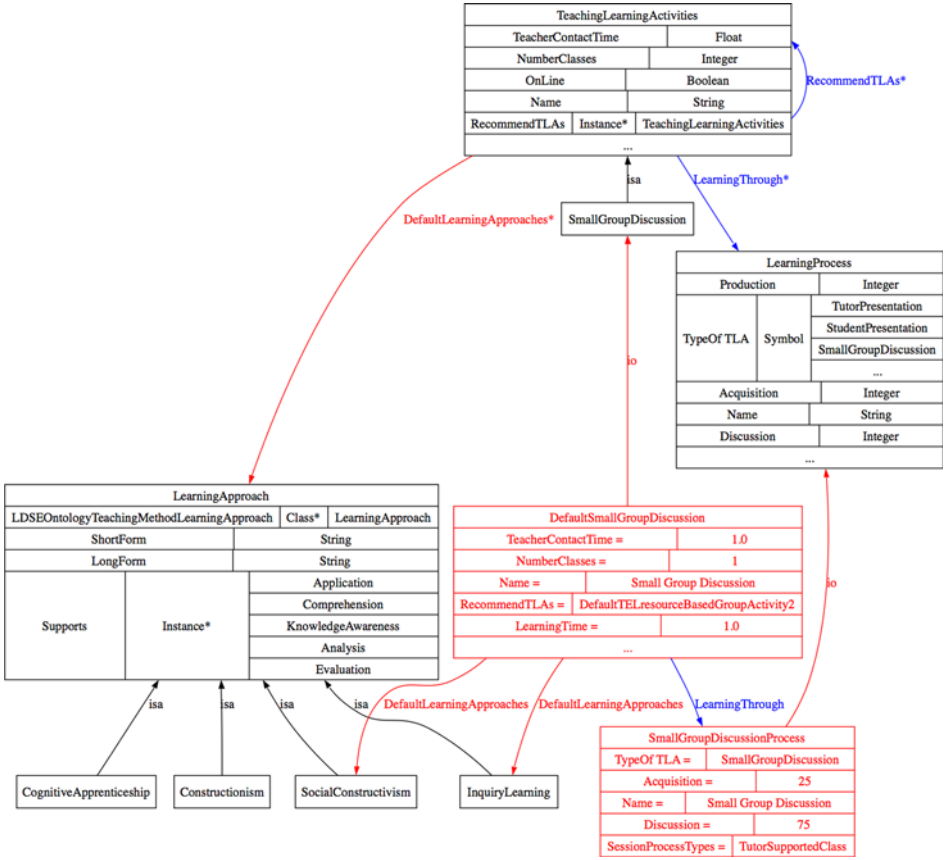

Figure 4. Example of some of the concepts, properties and relationships that are modelled in the knowledge base and used by the inference engine.

Using such a methodology is useful when an application can benefit from concept processing as part of the design. The conceptual model captures the domain of discourse and the relationships between the concepts. This makes the application knowledge-aware because of the shared vocabulary with the users through the semantic mark-up. This is dependent on two design observations:

(1) the conceptual model captures a shared understanding between the application designers and the users of the application (not just for software/computer use); and
(2) there is an intrinsic value in concept processing rather than data, information or metadata; in the system understanding the design of situated concepts.

Ontologies involve the capture and encapsulation of domain knowledge; when mined by intelligent algorithms new knowledge can be created from the source content that is encapsulated by the same conceptualised knowledge. In our learning design tool the 'intelligent algorithm' is the inference engine, a software component that reasons about the semantic mark-up of the learning designs (ontology instances, classes, properties, etc.). This building of a self-referential system provides multiple

Table 2. Selected concepts and their properties in the knowledge base.

Concept & description	Key properties and relationships	Matching and knowledge co-construction
Learning Approach (LA) is the characterisation of teaching and learning according to the way in which learning is structured and the different roles played by teacher and students. LA is an abstract concept that has nine concrete concepts (of which four are shown in Figure 4): Didactic instruction, Inquiry-based learning, Social constructivism, Experiential learning, Constructionism, Collaborative learning, Guided discovery learning, Problem-based learning, Cognitive apprenticeship.	*Properties:* Key properties are the relationships with concept 'Learning outcomes' and the Teaching and Learning Activities (TLAs). *Relationships:* Each Learning Approach supports a set of learning outcomes; both concept level and instances created. Each TLA has a default learning approach(es).	Inferencing about Learning Approaches is relative to two other pieces of contextual knowledge: The Learning Outcomes and the TLA(s).
Teaching and Learning Activity (TLA) is an interaction between a student (or a number of students) and the tools and resources available to them in order to achieve a given learning outcome in a session. A TLA is always associated with a specific TLA type. TLA is an abstract concept that has >50 TLA concrete concepts (referred to as TLA types), and each has a number of instances. In Figure 4, *SmallGroupDiscussion* is a TLA concrete concept that inherits its properties and relationships from the class called Teaching and Learning Activity.	*Properties:* A TLA has properties such as name, class size, learning time etc. *Relationships:* Learning Approach(es), Learning Experience, and Recommendation. In Figure 4 an instance of *SmallGroupDiscussion* called *DefaultSmallGroupDiscussion* has an inherited relationship with two Learning Approaches: Social Constructivism and Inquiry Learning. This creates a contextual relationship between this TLA and Learning Approach concepts that can be used by the inference engine. This TLA inherits an instance of the concept learning process called *SmallGroupDiscussionProcess*. This provides context for the inference engine, which is linked to the learning experience of the student.	The recommendation inference works from the properties of a TLA and particular properties that are best matched e.g. Learning Approaches, outcomes and learning experience.
LearningProcess captures a number of properties about how the student may experience and achieve learning.	*Properties*: Acquisition, Discussion, Inquiry, Production, Practice and Session Type. *Relationship*: with TLAs and	The values attributed to the properties can be changed to express a teacher's individual practice. This will then

(*Continued*)

Table 2. (*Continued*)

Concept & description	Key properties and relationships	Matching and knowledge co-construction
It is a concrete concept that has over 160 instances. In Figure 4 *SmallGroupDiscussionProcess* is an instance of LearningProcess.	indirect relationship with Learning Approaches and Learning Outcomes.	change both the knowledge base by adding the modified concept and the knowledge analytics of the design.

knowledge configurations of the learning designs and the appropriate sub-sets of the conceptual knowledge. This same process is used to construct various useful knowledge structures about a learning design, such as the 'path' the user has followed to construct the design. It is this basic self-referential feature that enables us to design a self-configurable system. In our approach, taking into account both learning design theory and practice in an ontology of concepts and relations and using it to make inferences enables the system to contextualise the advice and recommendations to the current context of the teacher-designer, which includes making use of knowledge from the community.

A walk through the learning design tool

Figure 5 illustrates an example walk-through and provides some of the context for how the learning designs are marked up with semantic representations.

The learning outcomes palette is selected and from the category 'knowledge/awareness' the description 'List the features of' is picked. Using this they then describe the learning outcome. In the design, illustrated in the top part of Figure 5, there are three learning outcomes.

Behind each interaction there is a concept that supports each action. So for example the TLA in Figure 5 is named 'Tutor Guided Class Discussion on VLE communication tools' by the user but has been selected from the palette category of 'Tutor guided group discussion'. In the knowledge base this activity is identified as a 'Tutor guided group discussion'. A contextual link is made between 'Tutor Guided Class Discussion on VLE communication tools' and the TLA 'Tutor guided group discussion' by the tool. Later when a user queries for example 'designs that use Tutor guided group discussion' this design will be returned.

The learning design being created is anchored semantically by the concepts. This is not displayed to the user, although many of the properties and concepts are available in the interface. The values of the properties and concepts are editable, such as renaming an activity to be more meaningful to the user, or deciding the activity can potentially contribute more towards inquiry learning than the tool illustrates, etc. These specific properties of the design are personalised to each designer. They can choose to edit these aspects or not. They can add content, create their own TLAs and so on.

A user can view the overall analysis of the design; this is illustrated in Figure 6, providing an analysis from the cognitive learning types and the learning experience.

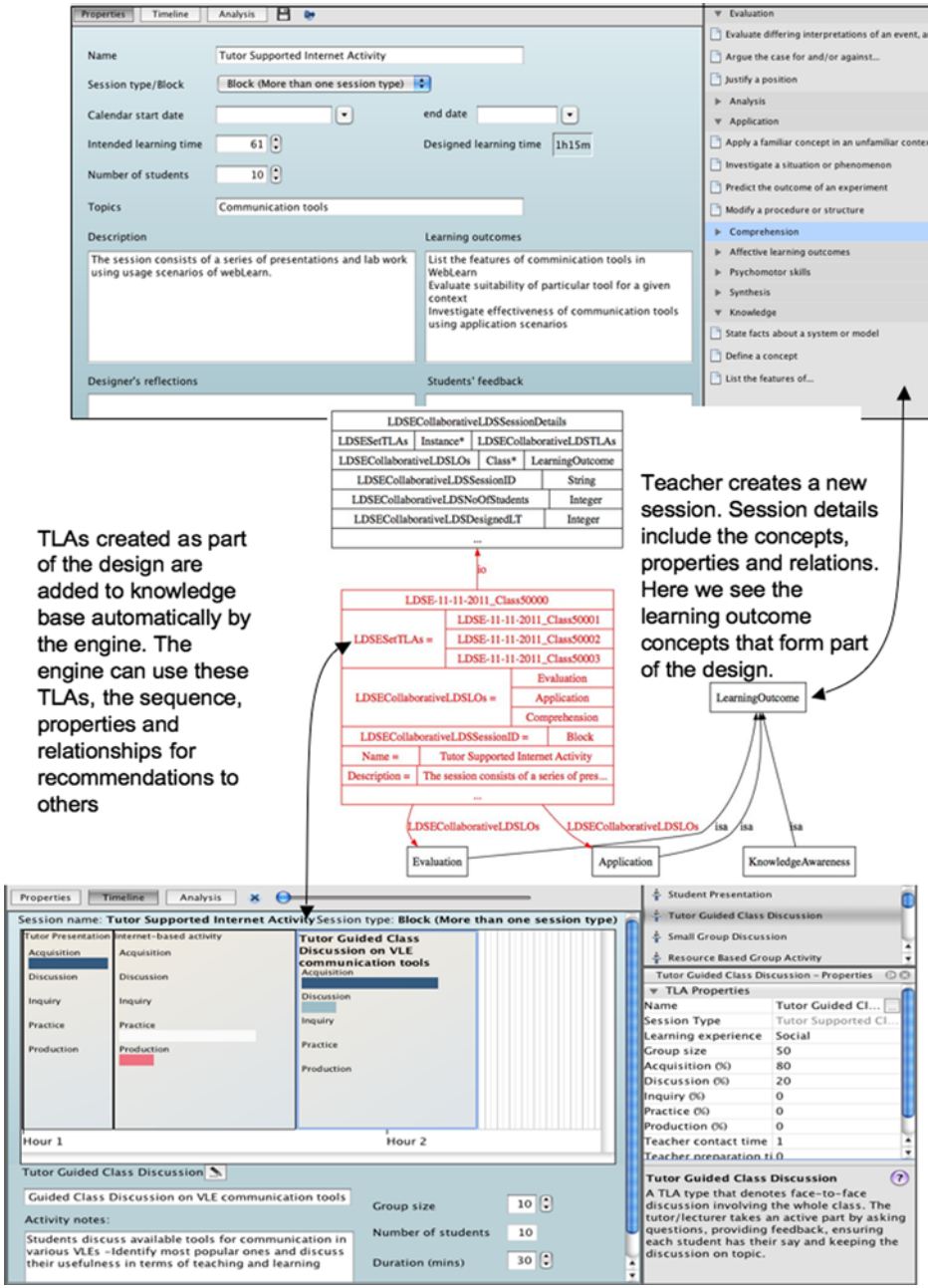

Figure 5. Example of session properties.

This can help in the process of reflecting about the design from different viewpoints (cf. with Figure 3).

Users can import and export learning designs so designs can be easily shared. There is the option 'export to open office template' for personal use, or for sharing aspects of the design with the institution, e.g. for validation purposes, or for sharing

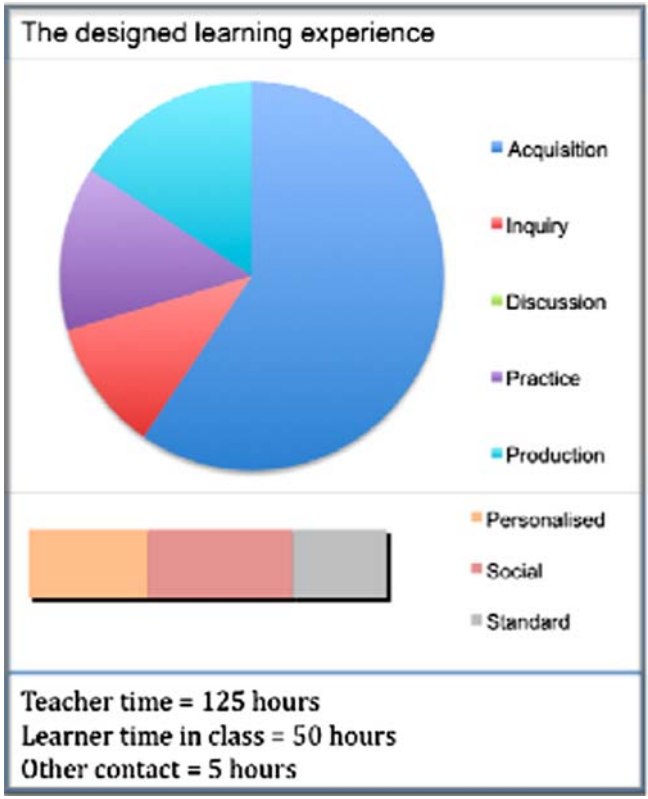

Figure 6. Example analysis of a learning design.

with the students. The templates can be tailored by the user to export only certain contents of the design as felt appropriate.

Semantic mark-up of designs

Before considering the evaluations of the system we will present more details of the process of the semantic mark-up of the learning designs. Continuing from the partial learning design view of the tool presented in Figure 5, Figure 7 presents some of the key concepts that mark up the learning design. This shows the mark-up of a teaching and learning activity called Tutor Guided Class Discussion.

New concepts and instances are automatically created for an activity as depicted in Figure 7. This allows the system to construct a context path for this learning design by making an automatic copy of the core concepts used and instances created. The process of copying the concept means that when a user creates a learning design the system keeps a copy of where the user starts from within the knowledge base, e.g. TLA 'TutorGuidedClassDiscussion' and the changes the user makes, e.g. creates a new name 'Tutor Guided Class Discussion on VLE communication tools' and may change other properties and values. This new version of the TLA is available. Figure 7 shows automatically generated instances and concepts created at runtime as the user creates a design as is indicated by the 'LDSE' label. The contextual knowledge captured can be used to offer recommendations both from the original set of concepts and those generated by other teachers. Copying relevant

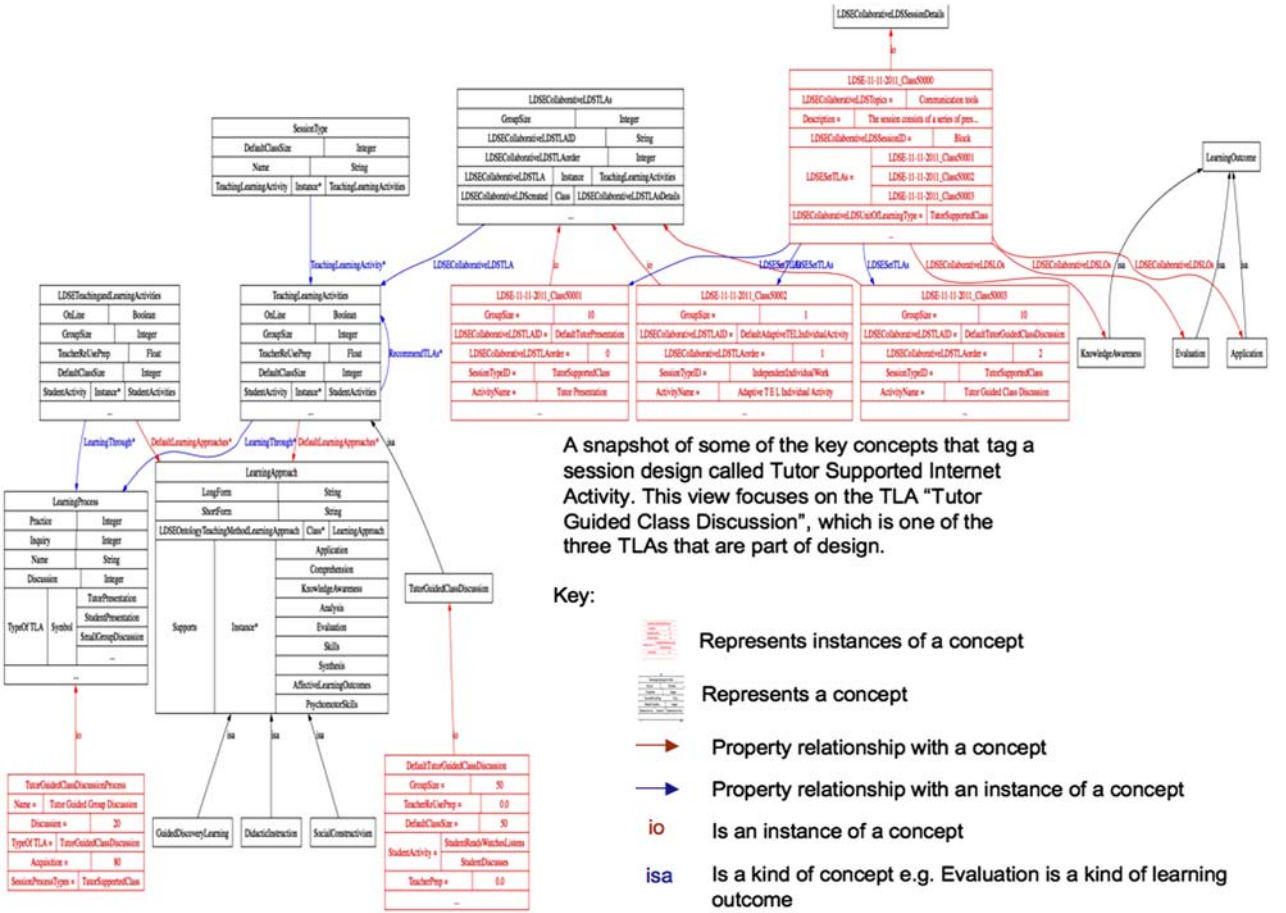

Figure 7. Automatic creation of semantic mark-up for annotating learning design.

concepts, modifying concepts with the user's changes and situating this design with the relevant knowledge represents the process of knowledge co-construction as illustrated by the Conversational Framework (see Figure 3). Recommendations come associated with content that can be edited or used directly. As the user adds concepts/objects to complete their learning design the tool is constructing new concepts relevant to the context of their learning design. The system is able to monitor and track this process and the relationships, for example, TLAs (original, modified or new) placed on a timeline creates a relationship between them and with the other properties already defined for the learning design they are creating, such as its learning outcome. The tool creates contextual knowledge automatically for a TLA sequence, which is the construction of relevant knowledge for the user's design context. Knowledge is being constructed about process such as the sequence and about the actual design pedagogical theory (learning approaches and teaching and learning activities) and practice (teaching and learning activities and the design content). When editing or sharing designs the same knowledge is used to reference appropriately the concepts and provide different views of the knowledge, such as the tool view, user view, modified view illustrating the changes, e.g. activity, class size support and learning experience view. When changing properties and concepts, such as class size, use of activities, e.g. online resources versus face-to-face teaching, the implication for a particular design for both the learner and teacher is immediately viewable. It is the system's perspective, built on the knowledge from the learning designer community. The tool determines when to use system concepts and/or modified concepts. While terms can be changed, so can the 'context of use'. The system provides a 'common context of use'. The modifications are held as the contextual preferences about designs for the user.

Evaluation from current usage

We conducted a number of studies to evaluate how the system is perceived and understood by the users. The learning design practitioners were working in a variety of backgrounds, e.g. higher education, staff development, transport studies and general business across disciplines. Many had over 10 years of teaching experience and were comfortable in using technology as part of their teaching practice. This assisted in the initial evaluation, as we wanted to avoid evaluating interface usability, difficulties or unfamiliarity with the use of technology in teaching and planning and domain terminology confusion. The number of different evaluations have yielded interesting results and assisted us in improving the tool from various perspectives. Many of the evaluations have focussed on different aspects of the terminology used, the ontology concepts and properties present in the interface. Here we focus on a particular workshop evaluation where the users mapped a set of teaching activities to the set of TLA concepts that were available in the palette. The ontology represents a particular view of the learning design. One research question was to determine how closely the learning design ontology reflects the user's view of what design is (i.e. what 'design' means to the user as a concept and a process). We were trying to understand how well the ontology supported the way the user goes about the process of design and what role the concept model assisted in or detracted from that.

The workshop evaluation lasted two hours and a number of tasks were completed by the users. Before starting the evaluation the tool was presented to the

group of users (there were 18 participants in this particular evaluation). After the presentation the users worked in pairs on an existing design and were asked to explore and to improve the design by adding new teaching and learning activities and/or modifying current teaching and learning activities that existed. They worked with a version of the system that didn't offer any advice and/or guidance. After this task the users were taken into focus groups to explore their findings and to provide feedback on the system. At this stage the users had had about 30 to 40 minutes of exposure to the tool and the concepts that existed. Next they were asked to take a list of tasks set by teachers ('real' examples of tasks that lecturers and teachers set their students) and to choose teaching and learning activities that they felt would help to achieve this task. They worked on their own for approximately 15 minutes. A summary of the list of tasks provided and the teaching and learning activities chosen by the users is provided in Table 3.

Table 3. Tasks used to determine how users map the system's teaching and learning activities to 'real' student activities.

What I want my students to do	TLA in the 'TLAs Palette' chosen by the users (percentage indicating preference by the users)
In pairs, construct and run a model of the spread of Foot & Mouth disease, using a computer modelling tool	TEL resource-based group activity (69%) Adaptive digital group activity (31%)
Hunt for examples of *X* in the web and send a tweet about it to the class hashtag	Resource-based individual activity (20%) TEL resource-based individual activity (30%) Adaptive digital individual activity (20%) Online student-only group discussion (synchronous) (30%)
Provide a knee jerk reaction to a concept and share it with the class (e.g. do you believe in God?) so that I can see how you all agree – or not	Tutor-guided class discussion (63%) Student-only group discussion (27%) Online student-only group discussion (synchronous) (10%)
In small groups (3–4) create a mindmap presenting a landscape of issues around *X* as discussed in the most recent literature	Resource-based group activity (8%) Group practical activity (76%) Adaptive digital group activity (16%)
Follow on from task above: Swap your mindmaps with another group for peer review	Peer-assessed formative assignment (100%)
In small groups (2–4) conduct interviews about *X*, analyse data, and write up a report	Group practical activity (38%) Adaptive digital group activity (24%) Group project (38%)
Continuation of the above: Present your findings using PowerPoint during a videoconference with other students, who will also be presenting their results. The videoconference will be moderated by the tutor	Online presentation by student(s) (synchronous) (61%) Online presentation by student(s) (asynchronous) (7%) TEL resource-based group activity (32%)
After doing the readings, what is your opinion about *X*? Post it in the forum, read what others have written and discuss	Individual practical activity (9%) TEL resource-based individual activity (18%) Online student-only group discussion (asynchronous) (73%)
While reading *X* reflect on the following issues: *x,y,z*	Resource-based individual activity (22%) Individual practical activity (28%) Formative activity (22%) Individual project (28%)

A key result is that the users did not all choose the same TLAs. In most cases a percentage of users selected the same or similar teaching and learning activity. There are a number of reasons why this may have happened:

- The natural-language descriptions were decontexualised and thus 'not owned' by the users.
- Uncontrollable variations in individual interpretation: 'Doing the mapping is difficult because there is so much variation in people's verbal reasoning.'
- The participants used a version of the software that didn't offer advice and guidance. As a result definitions of TLAs were not provided, making it difficult for users to compare alternatives, especially as there is a large number of TLAs for first-time users to work with.

However, the users were able in a short time to find reasonable TLAs that they felt could support the task. Given that they had not set the task and they were presented with a range of choices the task was well managed by the users. While this was felt by some users to be challenging, given the scope and time allocated to the task, it shows promising results that users use the concepts and they find them useful. From the co-construction of knowledge perspective this is also very promising. It is through a process of debating with oneself and others that new knowledge about learning design can be created and captured. This is a communication cycle (cf. with Figure 3) where participants' views sometimes move towards consensus and maturity, whilst other times they move away. The tool can support this communication process enabling the sharing of users' differences and agreements. The tool can assist the users to develop designs that use different approaches and evaluate the possible impact of their features, for example on preparation time and student learning experience. The tool can automate the change because of the semantic representation of the concepts. This means that the user can experiment with different types of modifications, e.g. by requesting the tool to show a more online version of their design or a more discussion-based design experience for the students.

There have been many important results from this workshop evaluation and other evaluations of the tool indicating the interest and usefulness of the support of structuring learning outcomes, the analysis of learning designs (e.g. pie chart and the provision of the teaching and learning concepts.). Table 4 provides a summary indicating users' perceptions of the Learning Designer's impact along four key aspects, based on the analysis of our post survey. The statements shown in this table are related to levels 2 and 3 of the HEA framework for measuring impact.[4]

Table 4. Summary findings of impact of tool on users.

Statement:	% rating statement as highly or fairly applicable:
I can see benefits to planning my teaching using the LDSE.	76%
From working with the LDSE, I have learned new ideas and had insights that could change my teaching practice.	43%
I will download the LDSE and explore it further on my own.	71%
I would like to explore the LDSE further, but I would like support to do so.	71%

Impact on participants' thinking in relation to eight concepts from the ontology when working with the tool had prompted 54% of participants to re-evaluate concepts, with learning outcomes, session and learning time prompting the most re-evaluation. So, after only two hours with the tool, participants could perceive benefits to their practice (level 2 of the HEA framework).

We are now in the final stages of the project and further evaluations are taking place as the final parts of the tool are put in place to help exploit the semantic mark-up in terms of further design recommendations and helping designers investigate and explore using alternative teaching and learning activities, such as TEL. The tool can automatically present what impact such changes have on student learning experiences, teacher time (contact and preparation) and learning experience. The view can be purely a tool perspective, or the properties can be modified to provide the designers' perspective if they do not agree with the values given.

Conclusions

This paper has presented the research and development of the Learning Designer, a software tool to enable and facilitate theory-based learning design. The software employs an ontology to enable semantic mark-up of the learning designs, and exploits a shared conceptualisation (semantic mark-up) between the learning design domain and the users to enable knowledge co-construction, which has resulted in the possibility of the co-evolution of learning design knowledge. This process of co-evolution of knowledge is critical for enabling users to creatively produce learning designs and share experiences and artefacts with the community.

The research and development of the tool, as presented in this paper, has aimed to illustrate:

(1) the importance of the semantic technology and in particular ontology-driven software for the learning design community to enable and benefit from semantic mark-up of the learning designs;
(2) the exploitation of the shared conceptualisation (semantic mark-up) between the learning design domain and the users to enable knowledge co-construction, which has resulted in the possibility of the co-evolution of learning design knowledge;
(3) an insight into how to explore and evaluate ontology-driven software for users during the creative process of creating learning designs;
(4) the evaluation of findings showing while the knowledge maps closely to the users, the users do not always do the same mapping thus co-evolution of knowledge is critical for enabling users in the process of creative learning design and as a result to be able to share this process and artefact with the community.

The analysis of the results from user evaluations has indicated that impact is present. This is just the initial insight of the potential impact as only over a significant long-term use of the system can true evidence of impact be established. However, promising indicators are there to help establish the next steps. Finally on this point of impact, the very process of co-construction of knowledge being enabled and processed as part of the semantic mark-up means that change in practice can be

evaluated by the tool on behalf of the user, e.g. in the future queries like 'how do my designs differ between previous and current sessions' will be possible.

Notes

1. LAMS: http://www.lamsinternational.com/.
2. Moodle: http://moodle.org/.
3. CompendiumLD: http://kn.open.ac.uk/public/workspace.cfm?wpid=8690.
4. Higher Education Academy (HEA) (2009) Evaluation and impact assessment. www.heacademy.ac.uk. Its central purpose is to help those seeking to enhance the learning experience of their students, by improving the quality of their teaching and learning support. It has a wide range of uses.

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