Current Research in Learning Design

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ABSTRACT

A 'learning design' is defined as the description of the teaching-learning process that takes place in a unit of learning (eg, a course, a lesson or any other designed learning event). The key principle in learning design is that it represents the learning activities and the support activities that are performed by different persons (learners, teachers) in the context of a unit of learning. The IMS Learning Design specification aims to represent the learning design of units of learning in a semantic, formal and machine interpretable way. Since its release in 2003 various parties have been active to develop tools, to experiment with Learning Design in practice, or to do research on the further advancement of the specification. The aim of this special issue is to provide an overview of current work in the area. This papers introduces Learning Design, analyses the different papers and provides an overview of current research in Learning Design. The major research issues are at the moment: a) the use of ontologies and semantic web principles & tools related to Learning Design; b) the use of learning design patterns; c) the development of learrning design authoring and content management systems, and d) the development of learning design players, including the issues how to use the integrated set of learning design tools in a variety of settings.

Keywords

Learning Design, Instructional Design, IMS Learning Design, Educational Modelling Language

Introduction

Since the publication of the IMS Learning Design specification in February 2003 (LD, 2003) various parties have been active to develop tools, to experiment with Learning Design in practice, or to do research on the further advancement of the specification. The aim of this special issue is to provide an overview of current work in the area.

Authors were invited to submit papers that were, after acceptance by the reviewers, presented and discussed in a workshop. The workshop was organised by the European Commissions' project UNFOLD (IST-FP6-1), in collaboration with the PROLEARN network of excellence (IST-FP6-2), and took place at 22-23 September 2005 in Valkenburg aan de Geul, the Netherlands. About 60 participants were present and 22 papers were present, among which 10 papers of this special issue. Besides the authors for this special issue, we also invited the authors of a special issue of the Journal of Interactive Media in Education (JIME: Advances in Learning Design, 2005) that had been completed recently. In this introductory paper I will introduce the articles of this special issue against the background of the discussion topics we identified in the workshop.

The structure of this paper is as follows. First I will provide a short summary of IMS Learning Design (aim, design requirements and the roadmap for implementation). This is followed by a themed discussion of the different papers in this special issue. In the conclusion I will summarize the issues for future research.

The Learning Design Specification

The IMS Learning Design specification aims to represent the 'learning design' of 'units of learning' in a semantic, formal and machine interpretable way (Koper & Olivier, 2004). A 'unit of learning' can be any instructional or learning event of any granularity, e.g. a course, a workshop, a lesson or an informal learning event. A 'learning design' is defined as the description of the teaching-learning process that takes place in the unit of learning. The key principle in learning design is that it represents the learning activities and the support activities that are performed by different persons (learners, teachers) in the context of a unit of learning. These *activities* can refer to different *learning objects* that are used during the performance of the activities (e.g. books, articles, software programmes, pictures), and it can refer to *services* (e.g. forums, chats, wiki's) that are used to collaborate and to communicate in the teaching-learning process.

The IMS Learning Design specification is developed to meet some specific requirements:

1. *Completeness*: The specification must be able to fully describe the teaching-learning process in a unit of learning, including references to the digital and non-digital learning objects and services needed during the process. This includes:
   a) Integration of the activities of both learners and staff members.
   b) Integration of resources (learning objects and communication/collaboration services) used during learning.
   c) Support for both single and multiple user models of learning.
   d) Support for mixed mode (blended learning) as well as pure online learning.
2. *Pedagogical expressiveness*: The specification must be able to express the pedagogical meaning and functionality of the different data elements within the context of a Learning Design. While it must be sufficiently flexible to describe Learning Designs based on all kinds of pedagogies, it must avoid biasing designs towards any specific pedagogical approach.
3. *Personalization*: The specification must be able to describe personalization aspects within a Learning Design, so that the content and activities within a unit of learning can be adapted based on the preferences, portfolio, pre-knowledge, educational needs and situational circumstances of users. In addition, it must allow the designer, when desired, to pass the control over the adaptation process to the learner, a staff member and/or the computer.
4. *Compatibility*: The specification must enable learning designs to use and effectively integrate other available standards and specifications where possible, such as the IMS (imsglobal.org) and IEEE LTSC (ltsc.ieee.org) specifications.

Because a Learning Design specification extends existing specifications, it also inherits most of the more general requirements for interoperability specifications and standards, more specifically:

1. *Reusability*: The specification must make it possible to identify, isolate, de-conceptualize and exchange useful learning objects, and to re-use these in other contexts.
2. *Formalization*: The specification must provide a formal language for learning designs that can be processed automatically.
3. *Reproducibility*: The specification must enable a learning design to be abstracted in such a way that repeated execution, in different settings and with different persons, is possible.

The IMS Learning Design specification consists of several components. First of all it consists of a conceptual model (an ontology) for the description of teaching-learning processes. This model is expressed as an UML model (see figure 1).

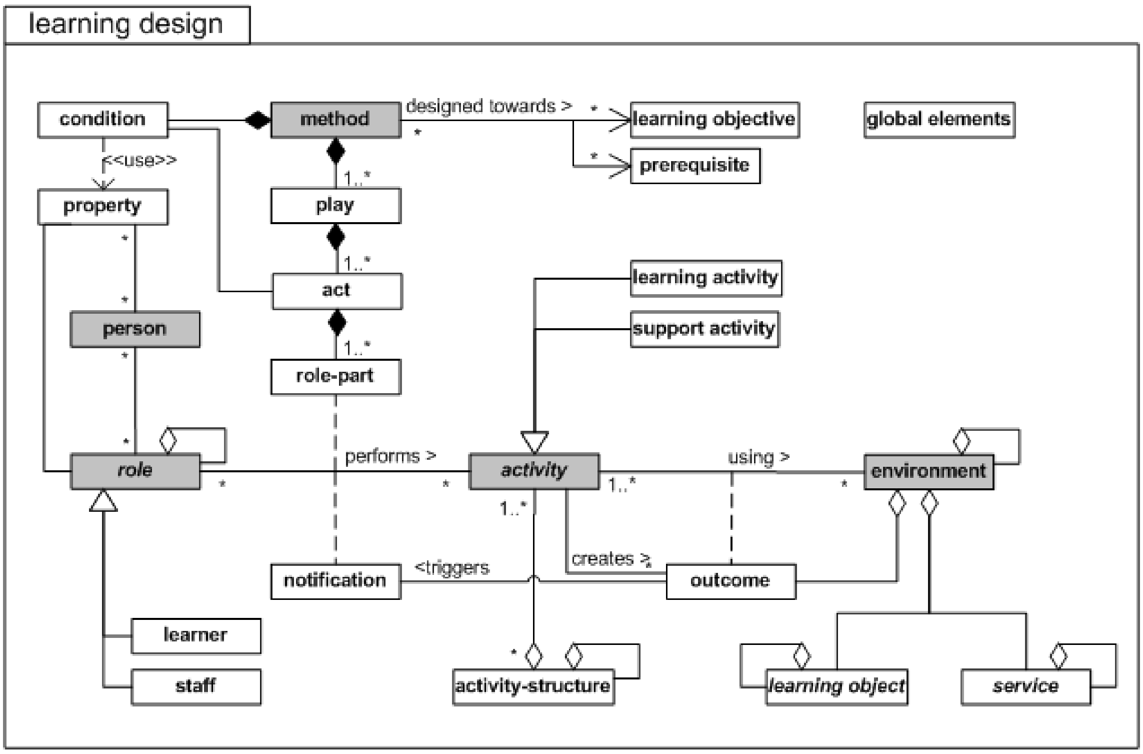

Figure 1. The conceptual model of IMS Learning Design

In essence the model says that learners perform a set of learning activities using learning objects and services (to be found in the activity *environment)* in order to attain some explicit or implicit learning objectives. As a result of the activities, the learners produce outcomes (e.g. reports, forum/wiki contributions, etc.) that subsequently can be used by others in their learning or support activities (e.g. a teacher can provide feedback to a report written by a learner).

Teachers, other staff members or peers can perform support activities to help learners when needed. The design can be static or adaptive, taken into account the existing competencies, needs and circumstances of the persons involved.

The second component of the specification is the Information Model. This document specifies exactly how the entities in the conceptual model relate to each other. Furthermore it contains a description of the expected behaviour of runtime systems. The information model is the core document of the specification.

The third component of the specification is the Best Practices and Information Guide. This guide specifies some use cases and (expected) best practices.

The fourth component is called a 'binding', that is the technology used to represent the information model. The learning design specification is delivered with several bindings: a series of UML diagrams (Vogten, Verhooren, 2002), an XML schema (see figure 2) and XML DTD's. The UML diagrams were created from the initial DTD. The tables in the information model and the XML schema's were automatically generated from the UML diagrams.

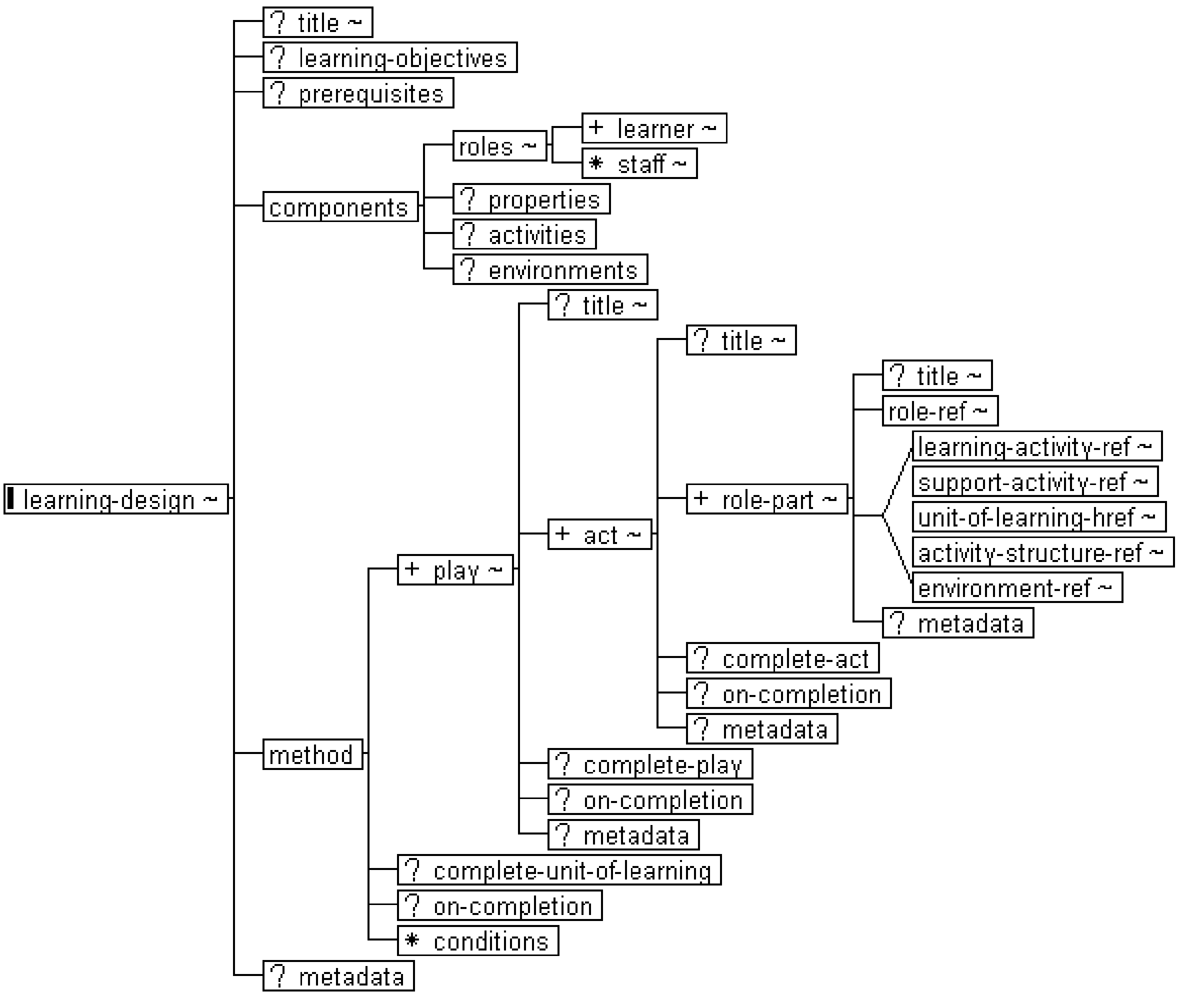

Figure 2. Part of the XML schema tree of IMS Learning Design

The result of this all is that a teaching-learning process can be codified into an XML file with references to the learning objects and services needed to perform the activities. In practice, IMS Learning Design is used to create a zip-file using the IMS Content Packaging specification (CP, 2004). This zip-file can be exchanged and interpreted by any learning design aware runtime engine. This engine will manage the workflow ('activity management') by presenting all the actors with adequate activities and resources at the right time in the teaching-learning process.

For instance, when the design of a unit of learning is as follows:
1. Learners discuss a problem with each other, analyse it and search for background information.
2. Learners discuss possible solutions and decide upon a preferred course of action. This is written into a report.
3. The teacher reads the report and provides formative feedback: additional resources to look at, identifies problems with the proposed solutions.
4. The learners correct the report and send it in for grading.
5. The teacher grades the report.

In this design there is a sequential ordering of five activities. Each person within a learner group will get the first activity; this can be something like this:

> *Activity Description:*
> Attached you will find a problem that you have to solve in collaboration with your fellow students. Discuss the problem with your fellow students (e.g. using the forum or in a class room). Search and study material that you think is necessary for the solution of the problem (using the library and/or Internet resources).
>
> *Environment (learning objects and services):*
> Problem
> Forum
> Internet Resources

The result of the second activity is that the learner group will produce a report (outcome). The teacher will be notified that the outcome of group X is available and s/he will get the support activity to provide feedback to the report. When the teacher has provided the feedback, the learners will be notified and get learning activity 4. When activity 4 is completed, the teacher is notified that the report is send in for grading. The learners again will get a notification of the teachers grade.

It is good to notice that IMS Learning Design is nothing more or less than the set of aforementioned components: some documents and some bindings. Before the specification can be used in practice, several tools have to be developed: authoring tools, content management systems and runtime environments. The roadmap for the practical implementation of Learning Design was defined as follows (Koper, 2004):
1. Specification (February 2003)
2. Awareness Raising (February 2004)
3. First generation of tools (February 2005)
4. Demonstrators, usability improvement of tools, application profiles and conformance testing (2005/2006)

Actual use of Learning Design in practice and the development of a community of users (> 2006).

At the time of writing it is October 2005. Where are we now in this roadmap?

In the period 2004-2005, the European Commission funded the project UNFOLD (2004) to support the co-ordination and dissemination of Learning Design activities. The project was highly successful: many meetings were organised throughout Europe. The participants came from all over the world. People presented their work to each other, were trained to use the newly developed tools, tested the interoperability of tools, discussed the design of new software and informed each other about new plans. In conjunction to this, the EU funded the TELCERT project (2004) that is working on application profiles and conformance tests for a variety of specifications, among which Learning Design. The results should be delivered in 2006. Also the EU project PROLEARN (2004) has the coming years some work packages that are directed to IMS Learning Design. Outside Europe, the Canadian LORNET project (2004) is, among other things, working on learning design ontologies and authoring environments. Besides these large scale funded R&D projects, many smaller projects, e.g. PhD research work, is executed at the moment all over the world. Some of the work is reported in this special issue.

The first tools indeed appeared in the beginning of 2005. At the moment there are more then 20 different tools available (see Griffiths et al., 2005 for a discussion and overview). Several authoring environments are available that support the development of the learning design XML files and zip-files. To be mentioned are Reload (2005), MOT+ (Paquette *et al,* 2005), Ask-LDT (Karampiperis & Sampson, 2005) and CopperAuthor (2005). Furthermore there is the CopperCore engine (Vogten & Martens, 2005; Martens & Vogten, 2005) that can interpret and set up learning design files. CopperCore however does not provide a user-interface (a so-called 'Learning Design Player'). A player adds a user-interface, but also integrates services (chats, forums, etc.) that are referred to in the learning design. Furthermore it includes an administration module to import/export learning design packages, to create a run of a unit of learning, to add persons, to put persons in the correct roles and to connect to external systems (e.g. student administration, portfolio systems, etc.).

There are several prototypical players available, but most of them are still too underdeveloped to use in actual practice. Also several integrated systems (Alfanet: Van Rosmalen et al., 2005; LAMS: Dalziel, 2003) are available, however these are or very prototypical (Alfanet) or do not yet conform to the IMS Learning Design specification (LAMS). Last but not least, there is a growing set of examples and test units of learning available at moodle.learningnetworks.org that can be used to demonstrate the different possibilities of learning design. The challenge for the coming period will be to build a player and to integrate some of the tools into a platform that can be used to use learning design courses in actual practice. Given the enormous amount of activity in the field, we can expect that this will be realised in the next year. One factor of importance will be a new large EU funded project, called TENCompetence (2005) that will have as one of its main tasks to build an open source learning design platform that can be used in lifelong competence development.

Overview of Research Issues

The papers in this special issue can be classified in the following three themes:

1. Learning Design & Ontologies
2. Developing Learning Designs: methods, patterns and integration with other standards
3. Learning Design Engines

I will now discuss each topic and the papers within that topic.

Learning Design & Ontologies

As stated above, the Learning Design specification contains a conceptual model, or better an ontology, of the teaching-learning process (see figure 1). The tradition of IMS is to use XML schema bindings for all implementations. This has its advantages and disadvantages as is explained in the papers of Knight *et al* and Amorim *et al.* Both papers present the idea of using a new binding: OWL instead of XML schema. Knight *et al* use this new binding to unify the description of learning designs and learning objects to increase the level of reusability. The idea is to use a three part model: an ontology for learning design (called LOCO), an ontology for learning objects (ALOCoM) and an ontology for the intermediate level between learning design and learning objects (the learning object contextual model, LOCO-Cite).

The paper of Amorim *et al* elaborates a precise definition of the learning design ontology. They argue that the informal description of the information and behavioural model increases the complexity for programmers, because they are not educational specialists. This could invoke unnecessary errors in the technical implementations. Their proposal is to replace the XML schema's with an explicit and formal ontology language (OWL). The authors provide a modelling example (description of the Jigsaw Methodology).

In the discussion at the workshop, one of the main problems identified was that a new binding like OWL could have the danger of increasing the complexity of the specification instead of decreasing it. This can be justified when some common identified problems have been solved by re-representing the specification. The work on Learning Design ontologies is however in a too early-days stage to answer this question definitely. A further remark could be made on the positioning of ontologies in the field of Learning Design. Providing an alternative binding is one type of use, but another could be even more advantageous: the use of ontologies to represent learning design knowledge. Learning Design captures a large variety of pedagogical models and ideas that a learning designer applies. The knowledge of the learning designer himself is however not captured in Learning Design: it only represents the result. An idea would be to make a set of different ontologies that represent learning design knowledge for each pedagogical model, e.g. an ontology for the application of problem-based learning principles. Such an ontology could then be used to build software agents that apply these ontologies to help learning designers to develop units of learning according to a specific pedagogical model.

Developing Learning Designs: methods, patterns and integration with other standards

The next theme contains five papers in this special issue: Hernández-Leo *et al*, Van Rosmalen *et al*, Pawlowski *et al*, Paquette *et al* and Bailey *et al.* Each of the papers addresses a means to support learning designers to develop adequate learning designs, using the IMS Learning Design specification.

The first paper of Hernández-Leo *et al* looks at the idea of using patterns to support the development of collaborative designs. The authors developed the Collage tool, that is based on the Reload editor. The tool helps learning designers to develop the rather complex collaborative learning scenario's by reusing and adapting patterns, called Collaborative Learning Flow Patterns. In this special issue this is the only paper that deals with patterns. However in the workshop we had presentations of 5 papers related to patterns. One of the issues was the definition of patterns itself. After a discussion we agreed upon a description that is similar to the one found in Wikipedia (http://en.wikipedia.org/wiki/Pattern): 'a *pattern* is defined as a form, template, or model (or, more abstractly, a set of rules) which can be used to make or to generate things or parts of a thing, especially if the things that are generated have enough in common for the underlying pattern to be inferred or discerned, in which case the things are said to exhibit the pattern. The detection of underlying patterns is called *pattern recognition*.' The next problem identified is how patterns can be developed. The first approach is called an inductive method and is based on pattern recognition (Brouns *et al.,* 2005): the idea is to compare a series of Learning Design coded courses to identify the presence of a set of underlying reoccurring XML constructs. The second approach is referred to as a deductive approach and is used in the development of 'pedagogical patterns' (Goodyear *et a.l,* 2004). In this case, the patterns are developed by experts, based on their interpretations of teaching practice. The idea of learning design patterns and the possibility to recognise them automatically with pattern detection algorithms is a new field of work that is worthwhile to elaborate in the future. Also, the *use* of patterns (including tooling) by learning designers has to be explored further.

The paper of Van Rosmalen *et al* decribes the result of the EU-funded Alfanet project. This project offered one of the first implementations of IMS Learning Design in a learning management system. The focus of the project was on adaptive learning designs. Tools like CopperCore are developed in the context of this project. It was also the first project that tried to develop a prototypical platform that was fully based on a large set of learning technology standards and specifications. They used and integrated among other things: IMS LD (2003), IMS QTI (2003), IMS CP (2004), IMS MD (2001) and IMS LIP (2001) to realise adaptive learning designs. The paper presents a model that enables a structured, integrated view on (the support for the) development of adaptive learning designs. They report pilots with users who use the models and the tools. The project identified two major issues: first of all that the 5 specifications used are not really harmonized to work together. Some of these issues have already been taken-up by IMS to change some of the specifications. For instance, IMS QTI has been changed recently to integrate better with IMS Learning Design. Another issue, not unique for this project, is the problems with the usability of the tools. The different standards impose a rather high complexity for the users. One of the future problems to be solved is how this can be presented to the user in a user-friendly and flexible way.

The paper of Pawlowski *et al* deals with the problem to make learning design knowledge reusable. This is related to the earlier discussion of ontologies and patterns. The authors argue that in order to make learning design knowledge reusable, information about the context of use and about the experiences of users should be added to the learning design. They developed the Didactical Object Model in the context of the German Standards Body (DIN) to be used in conjunction with IMS Learning Design. They report some first experiences with the use of this model.

The paper of Paquette *et al* discusses the use of a graphical modelling method and tool to support learning designers to develop units of learning. They explain that the coding of a unit of learning is the result of a knowledge engineering process where knowledge, competencies, learning design and delivery modes are constructed in an integrated framework. The authors present a graphical language (MOT graphic language) and a knowledge editor adapted to IMS Learning Design.

A major reoccuring topic addressed by this paper is the use of a graphical representation of learning designs (see also Giacomini Pacurar *et al*). At the moment there are many proposals, e.g. the once build into the LAMS and ASK-LDT products and the proposal to use the standard language BPMN (2005). One of the suggestions for future work is to develop a standard graphical meta-language for Learning Design that has an explicit translation to the IMS Learning Design specification. This works preferably in both directions: from visual notation to XML and from XML to visual notation, however the latter could be quite complicated without additional constructs added to the XML.

The last paper in this theme is from Bailey *et al*. It is an example of a pedagogical approach and tools that has been developed to support teachers and learning designers to develop effective learning designs. The problem is solved without using the IMS Learning Design specification as a reference. Later on the approach is mapped to IMS Learning Design. They identify several issues with the specification, like the absence of learning objects and prerequisites elements in the learning activity structures of the Learning Design specification (this is a known issue and will be corrected in one of the next revisions of the specification). Looking at this paper from a distance it does the following: it solves a pedagogical problem and then, for interoperability purposes, it translates the approach to IMS Learning Design. This is opposite to approaches where Learning Design is taken as a starting point to solve educational problems. Because Learning Design is designed to represent any pedagogical approach (see requirement 2), my personal preference would be to follow the first approach: concentrate on the educational problem, find solutions and implement the solutions in IMS Learning Design. This has the advantage that people are not distracted from the problem itself by all the possibilities that the specification itself has to offer. At the other hand, knowing the specification (especially the conceptual model) can also help in structuring the problem and to use the same terminology in the learning design community.

Learning Design Engines

This last theme addresses the development and use of learning design runtime engines, and it includes four papers: Zarraonandia *et al*, Weller *et al*, Klebl and Giacomini Pacurar *et al*.

The paper of Zarraonandia *et al* addresses an issue that is related to the fact that IMS Learning Design specifies a unit of learning in *design-time* and not in *run-time*. Each unit of learning is instantiated to create a run for that unit of learning, i.e. by providing a start-date, adding users to it, and by assigning users into roles. The same unit of learning can be instantiated as many times as needed for new users. This increases the reuse possibilities considerably (see Tattersall *et al*, 2005), but also brings some additional complications. One of these complications is the question how runtime adaptations should be dealt with. In essence there are several possibilities depending on the kind of change that is made to the run of the unit of learning: a) changes are made to the unit of learning, the run of the unit of learning, or only for particular users or roles in a unit of learning; b) these changes should be propagated to all the current runs of the unit of learning that run in parallel; c) these changes should be propagated to the (design-time) unit of learning itself.

The paper of Zarraonandia *et al* discusses these different adaptations, and concentrates on the adaptations that do not propagate to the design-time unit of learning (1, 2 & 5). They created an adaptation to the CopperCore engine and demonstrate its use in several examples.

Weller *et al* addresses the question how to integrate Learning Design into an e-learning environment that consists of a number of services/components that interact with Learning Design (e.g. tests, forums, chats, portfolio's). The paper describes the work on the SLeD project that aims to develop a Learning Design Player, using the CopperCore engine. The architecture of SLeD is presented to solve the problem how to integrate services into a Learning Design Player. The solution is somewhere in between a generic solution and an application specific solution, however the idea was to use generic service descriptions as a universal acid. The pro's and con's are discussed. This paper is also related to the work of Van Rosmalen *et al,* who also integrated a variety of services in a similar way in the Alfanet project (see description above).

Klebl reports on an empirical review of Learning Design using an implementation in Moodle (Dougiamas & Taylor, 2002) in a university context. The basic questions he had were as follows: a) can Learning Design be used in blended learning approaches (related to requirement 1 of Learning Design, see above) and b) is the solution provided usable from a human-computer interaction perspective. He concludes as follows: “Though limited in scope, the successful implementation of IMS Learning Design in higher education proves the possibility to support mixed mode learning scenario's.” He furthermore notes that extending Learning Design with a kind of 'activity situation' where teachers and learners interact intensively could solve some restrictions he found. In the current specification, these strict division of activities of learners and teachers leads to a complex and redundant description of the teaching-learning process.

The last paper in this theme is from Giacomini Pacurar *et al*. They created a web-application that can be used by teachers to generate course structures, to edit pedagogical content and to instantiate, run and administer their courses. Part of the tool is a graphical editor for IMS Learning Design. They report on the development of the so-called 'netUniversité' environment and provide an example of a course website created with the application. The paper is related to the idea that is also discussed by Bailey *et al* to support the teacher (instead of a specialised learning designer) to use Learning Design. This issue has raised some interesting discussions: can teachers (or even learners) act as designers, and if so, what support should they be given to develop effective designs? Because Learning Design is often compared to musical notations, this issue is compared to the question whether musicians can be (or: should be) composers?

Conclusions

This special issue aims to provide an overview of the current work in the field of Learning Design. Eleven papers were analysed on the basic topics that are currently the focus of research. In summary these issues are the following:

1) The use of *ontologies* and semantic web principles and tools to:
    a) create a new, and more precise binding for Learning Design;
    b) integrate learning objects and learning designs;
    c) to represent specific pedagogical approaches (learning design knowledge);
    d) to build software agents that operate on the learning design knowledge to support in the development of units of learning.
2) The use of learning design patterns:
    a) to support learning designers to develop specific learning designs (e.g. collaborative designs, adaptive designs);
    b) that are automatically detected (pattern recognition) in Learning Design coded units of learning;
    c) to capture best practices and learning design knowledge (relates to ontologies ad c and d).
3) The development of Learning Design *Authoring and Content Management* Systems, including the following issues:
    a) The development of a (standard) graphical notation for learning designs;
    b) How to support the reuse of Learning Design Knowledge and Learning Design Packages;
    c) The development of learning design specific tools to support teachers in a specific context;
    d) The question how learning designers should be supported with tools and how teachers should be supported with tools (the teacher as a designer);
    e) The integration of learning design and assessment editors in a single authoring environment.
4) The development of *Learning Design Players,* including the following issues:
    a) How to integrate the variety of specifications (eg, IMS LD, IMS QTI, SCORM, IMS LIP) and the connections to other systems in an e-learning infrastructure (student administration, portfolio systems, financial systems) into a single, easy to use learning environment.
    b) How to instantiate and integrate communication and collaboration services that are called by a Learning Design. Eg, forums, wiki's, chats; are generic service oriented architectures suitable to do the job? At what costs?;
    c) How to design a usable, powerful and flexible user-interface for a Player environment?
    d) How to integrate Learning Design into existing Learning Management Systems (like Moodle, Blackboard and LAMS)?
    e) How to integrate Learning Design Authoring Systems and Learning Design Players, including the question how to deal with runtime adaptations?
    f) How to use an integrated set of Learning Design tools in an integrated way in a variety of settings (e.g. in universities, training, blended learning).

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