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Flexible authoring and delivery of online courses using IMS LD

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Abstract

Since the publication of the IMS Learning Design (IMS LD) specification in 2003 many initiatives have been undertaken to build authoring tools that are simple enough to be used by non-technical instructors and teachers. IMS LD's technical complexity is believed to be a major burden for the adoption of the specification. We have developed a new approach for course authoring and delivery that hides most of the complexities and is powerful enough to create highly flexible online courses.

Key aspects in this approach are (1) integration of IMS LD authoring and delivery tools in order to enable teachers to adapt courses in runtime, (2) use of templates to standardize aspects of the learning design. This article reports on the research and development of this approach, as well as a first implementation by the OUNL as part of an integrated e-learning system.

Keywords: online courses, IMS Learning Design, authoring tools, Learning Networks, integration

Introduction

In 2003 the IMS Global Learning Consortium published the Learning Design Specification with the objective “to provide a containment framework of elements that can describe any design of a teaching-learning process in a formal way” (IMS Global Learning Consortium, 2003). To this end the specification provides a conceptual model, based on a meta-model of learning (Koper, 2001), a detailed information model and an xml binding. McAndrew, Goodyear, & Dalziel (2006) point out that even at the simplest level (level A), IMS LD has the power to describe complex collaborative tasks with multiple roles and tools. Although the specification was conceived as very powerful considering its pedagogical expressiveness (e.g. Derntl, Neumann, Griffiths, & Oberhuemer, 2012; Van Es & Koper, 2006), it didn’t reach a high level of adoption, due to its perceived complexity of authoring and authoring tools.

The introduction of a new business model for distance learning and the resulting need for a different, non-traditional learning system, posed the Open University of the Netherlands (OUNL) for the challenge to create a flexible approach to authoring and delivery of online courses, taking the IMS LD authoring issues into consideration. This article presents the design and first implementation of this authoring and delivery system.

A new business model and implications for authoring and delivery

The Open University of the Netherlands (OUNL) is a distance teaching university that offers open higher distance education. In 2008 an internal task force outlined a new strategy for the delivery of education, originating from the ambition to give open educational resources (OER) and lifelong learning a sound position. The main goals within this new strategy can be summarized as:

- (1) attract new target groups through renewal of educational offerings;
- (2) promote retention;
- (3) support more efficient course development;
- (4) enhance visibility of the OUNL, both as a research and educational institution.

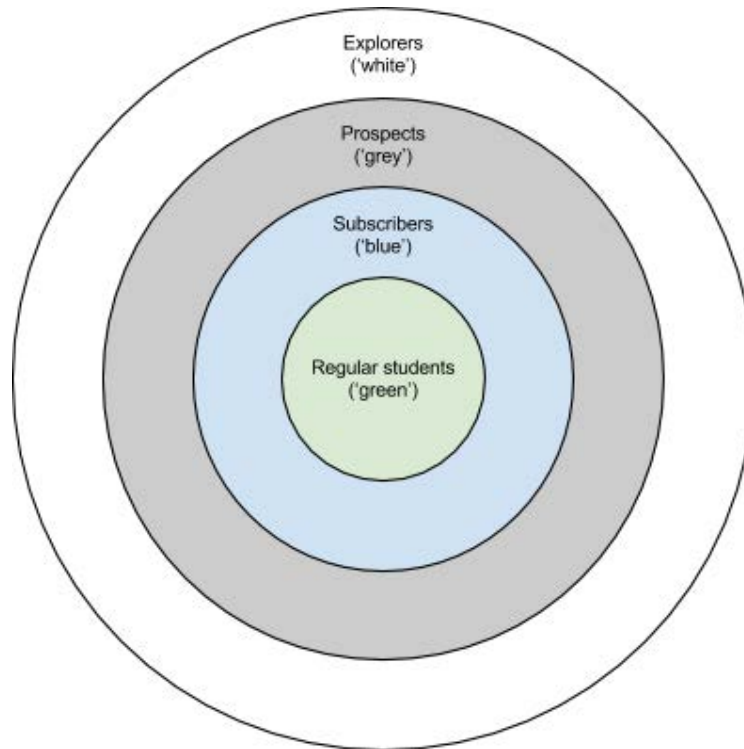


Figure 1. Concentric circles model.

The new model that was developed as a result of this strategy is depicted in Figure 1. Koper (2014) characterizes this model as a ‘concentric circles model’, dividing the target population into several groups, which are offered tailored course types like MSc courses, online masterclasses or MOOCs, and tailored services, such as discussion boards, assessment or tutoring. For the sake of readability, the various course types will all be referred to as ‘online courses’. The concentric circles model follows an incremental approach, meaning that the

collection of available online courses and services increases when moving from the outer circle to the inner circle of the model. Each circle reflects a different, colour coded learner target group, with its own main learning interest (Table 1).

Table 1: Target groups and main interests

Target group	Colour	Main interests
Regular students	green	BSc or MSc courses, PhD programs
Subscribers	blue	Post-initial, continuing education
Prospects	grey	OUNL offerings
Explorers	white	OER

In the period 2009-2013, this model was elaborated and implemented within the domain of Learning Sciences and Technologies, comprising an MSc program, post-initial education and a research program. Implementation of the model meant designing and implementing a new technological infrastructure (Vogten & Koper, 2014), as it was clear from the beginning that the OUNL's existing infrastructure was inadequate for the delivery of full online courses, since it was based on a traditional, commercial virtual learning environment (VLE), with its origins in more traditional, on campus learning and teaching approaches. The new e-learning system was founded on the concept of learning networks (Koper, 2009): a technology supported community of people in a particular discipline who are helping each other to better understand and handle certain events and concepts in work or life. The system aimed at improving the learner's user experience and accessibility by integrating formal learning, social learning and personal learning into one system (Hermans, Kalz, & Koper, 2014). Moreover, from a business point of view it was much more efficient to serve different target groups through one single system instead of

maintaining a cluster of dedicated e-learning systems for separate learner groups. So both from a learner perspective and the institutional perspective, *integration* was a key requirement in the development of the new learning system.

The demands from the business model, along with the choice for IMS LD, led to the following general 'a priori' requirements for the authoring and delivery system:

- R1. The system must allow for flexible delivery of online course within BSc and MSc programs, lifelong learning programs, or as open educational resources.
- R2. The system must be compliant to IMS LD's conceptual model. This implies that all components must relate to and can be expressed according to the IMS LD conceptual model.

No demands for interoperability support were formulated,

More specific authoring related requirements will be identified in the next section, following a brief explanation of IMS LD and a discussion of IMS LD authoring and publishing issues.

Learning Design authoring and delivery - state of the art

IMS Learning Design

The IMS Learning Design specification has its origins in the Educational Modelling Language (EML) developed at the OUNL (Hermans, Manderveld, & Vogten, 2004; Koper & Manderveld, 2004). The specification contains a *conceptual* model, providing instructional designers a common language to express and discuss their learning designs, as well as a detailed *information* model, a machine readable format for exchanging learning designs. The IMS LD specification

holds three levels:

- Level A: includes the core elements to create learning designs with pedagogic diversity;
- Level B: extends Level A with properties and conditions;
- Level C: extends Level B with notifications.

For a good understanding of the new approach to authoring and delivery of online courses we first summarize the key elements of IMS Learning Design's conceptual model that are marked grey in Figure 2.

- *person*: human being who can be involved in the learning and teaching process in one or more roles;
- *role*: specification of a learner or staff role in the learning design ;
- *activity*: planned learner or staff action; for learners the typical nature of activities is that of carrying out instructions whereas staff activities are aimed at supporting the learners in attaining the explicit or implicit learning objective(s);
- *environment*: container for wrapping a collection of learning objects and/or services;
- *method*: (work)flow within a learning design, expressed through concepts like 'play', 'act' and 'role-part' in analogy to theatrical performances;
- *outcome*: result of performing an activity within an environment.

A learning design that is to be run by computers is a *unit of learning*: a complete, self-contained unit of education such as a course, training, a lesson or a MOOC. A unit of learning is a package (zip file), including the learning design as well as the associated (physical) resources such as files, assessments, or references.

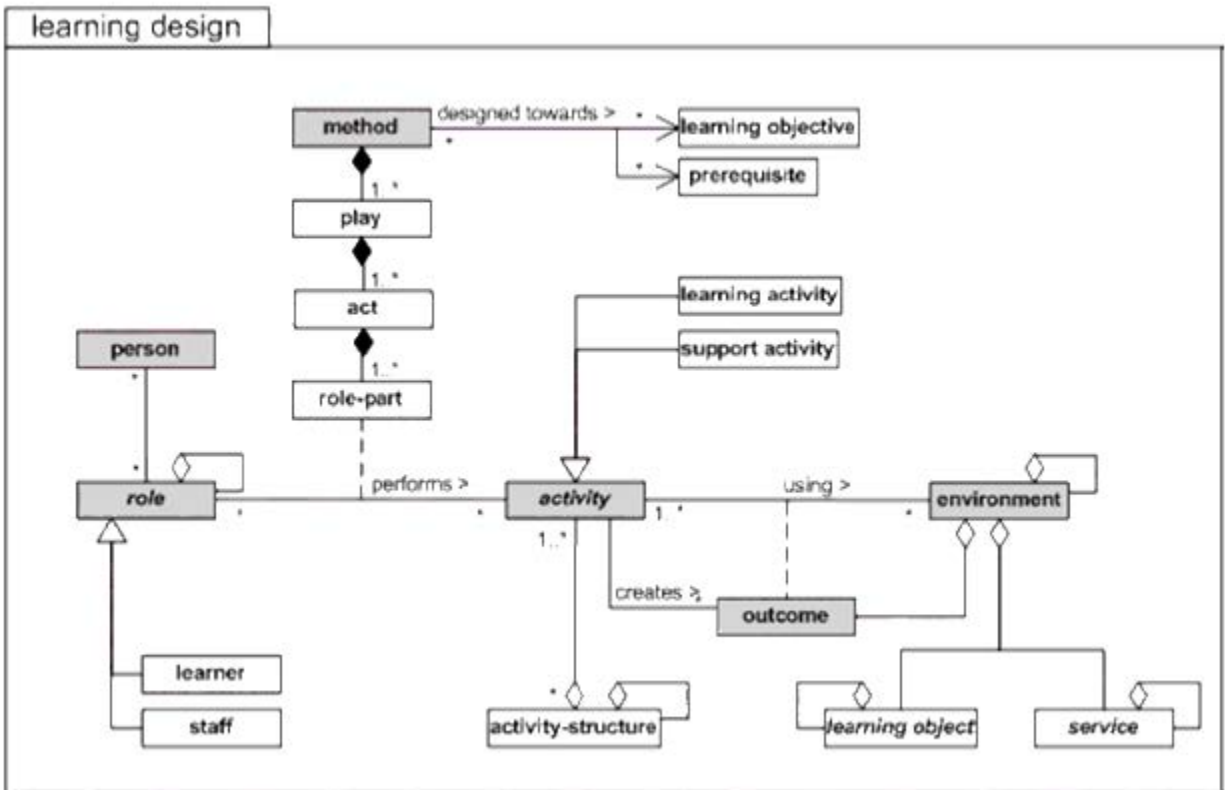


Figure 2. IMS Learning Design Level A: conceptual model.

Source: http://www.imsglobal.org/learningdesign/ldv1p0/imsl_d_infov1p0.html

Learning design authoring

Overviews of state-of-the art learning design editors is provided by Arpetti, Baranauskas, & Leo (2013) and Katsamani & Retalis (2011). In discussing what they call the last generation tools, Arpetti et al. (2013) state that these tools “have followed a trend away from the metaphor used by IMS LD in favour of representations that facilitate interpretation and understanding”. This statement reflects the ongoing struggle that has been present since IMS LD’s publication in 2003 on how to create efficient and usable learning design authoring and runtime tools. This struggle is expressed through debates (e.g. Martinez-Ortiz, Sierra, & Fernandez-Manjon, 2009; Neumann & Oberhuemer, 2009) on questions like:

- how do we represent IMS LD in a graphical user interface?
- how much IMS LD knowledge may we expect from instructional designers?
- which IMS LD elements can we hide for authors?

Jumpstart issue in these discussions is the pursued level of adoption of the specification: modelling language, interoperability specification, infrastructure or methodology (Griffiths & Liber, 2008). Olivier & Tattersall (2005) state that learning design tools should provide higher-level representations. For instructional designers to carry out their tasks comes first and they shouldn't be bothered by XML formats needed for interoperability. Authoring tools should follow the designer's perspective, distant from the specification (García-Robles, Ferrer, & Cagigas, 2008). Full-fledged IMS LD authoring is complex, requiring knowledge of the specification in a technical way (Burgos, Via, Juan, & Rioja, 2010), so authors may benefit from tools tailored to specific pedagogical models. Arpetti's statement confirms that these principles are increasingly applied in current approaches. Drawing on this discussion the following authoring requirement was defined:

R3. The system must have a focused task orientation that demands no IMS LD knowledge from authors.
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Learning design publishing

Most IMS LD approaches use architectures with a strict separation between design time and runtime, making it hard, if not impossible, to preview and test a learning design in action in the runtime environment. In these architectures, the publication process is often complex, requiring several steps to get a course, developed in an IMS LD authoring tool, up and running in an IMS

LD player.

IMS LD authoring discussions make clear that learning design tools should follow as much as possible the natural habitat of learning designers. Berggren et al. (2005) propose a ‘bricolage’ or ‘design on the fly’ approach, an organic way of iterative design and refinement as opposed to the planned ‘engineer’ way. This implies that a learning design authoring tool should provide access to a runtime environment, thus allowing authors to preview their learning design at the current stage (Olivier, 2006), or even better: a learning design editor which is fully integrated in the runtime environment, enabling authors to ‘design on the fly’ and allowing them to adjust the learning design even in runtime (*runtime adaptation*). Based on this discussion we formulated the following authoring related requirements:

R4. The system must allow for adapting the learning design and contents of online courses in design time as well as in runtime.

R5. The system must allow authors to easily test and preview the learning design in the runtime environment.

To be clear, runtime adaptation in this article relates to manually adjusting the flow and content of the learning design. Other interpretations (Burgos et al., 2010; Rosmalen & Boticario, 2005) may relate to dynamically adapting the learning design by the runtime system, based on rules ‘programmed’ in the learning design. The latter type of adaptation requires the IMS level B conditions and properties mechanism.

Design of the authoring and delivery system

Above requirements implied two main architecture principles for the system: (1) integration, following requirements R4 and R5, and (2) standardization, following requirements R1 and R3.

How these principles help address these specific requirements will be elaborated in the following section.

Integration and standardization

Application of the principle of *integration* means joining the tools for the processes of designing, developing, publishing, and running an online course in one system, and allowing for easy transitions between these processes. In this way an instructional designer or author can easily ‘move’ between design time and runtime environment, and test, preview and adjust the learning design at any time. Additional advantages of integrating these tools and processes are (1) the user experience is improved by providing a consistent user interface and (2) the design process is simplified as the available services in the runtime environment are known, whereas in the absence of a runtime environment only abstract modelling of services is possible.

Standardization is a way to ensure the presence of required and proper configured components in the learning design and can be achieved by adopting a layered model as depicted in Figure 3. This layered model meets the (software) design principle of ‘separation of concerns’ (http://en.wikipedia.org/wiki/Separation_of_concerns), which aims at easier management of complex systems by encapsulating functions in layers that have a well-defined interface (see also Katsamani & Retalis, 2011). The top of the figure shows the type of constraints that may affect the learning design.

- Business constraints typically determine the range of learner target groups to be addressed in the learning design. In case of the OUNL the concentric circles model accounts for the learner roles needed.
- Pedagogical constraints result from the organization's or faculty's pedagogical framework for teaching and learning like problem-based learning, competency-based learning, or game-based learning. These types of constraints are likely to influence all parts of the learning design (*roles, activities, environments and method*).
- The tools that are present in an institution's technological infrastructure determine the collection of *services* that can be addressed in the *environment*.

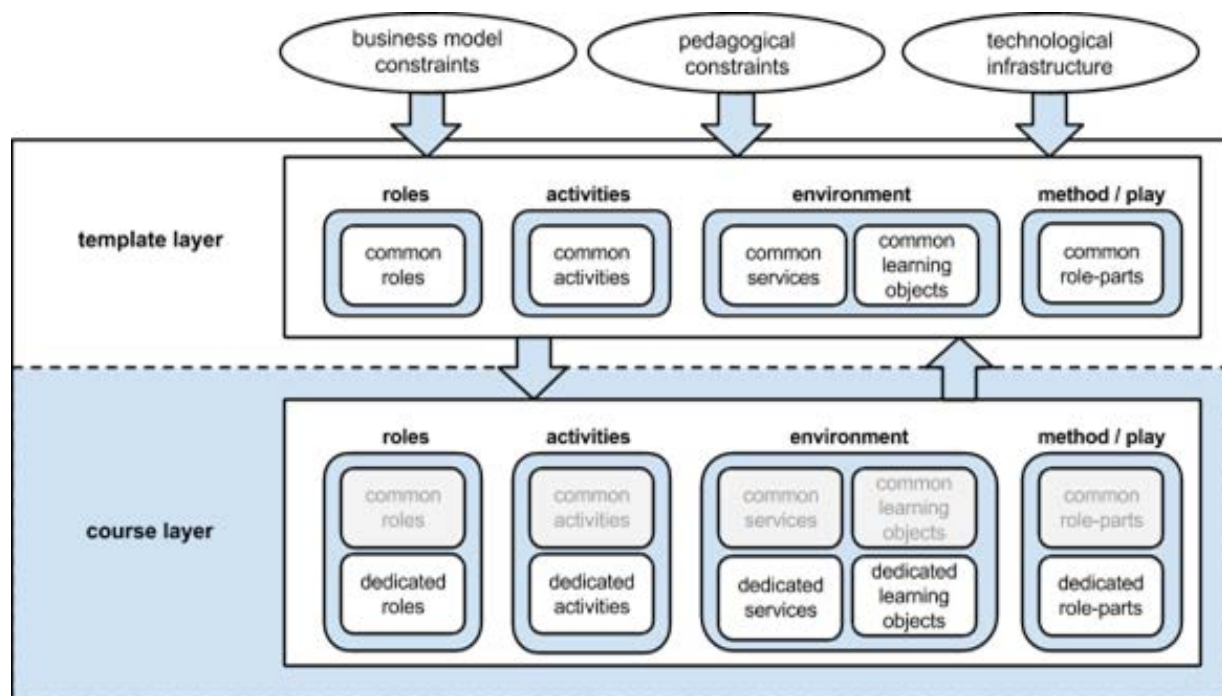


Figure 3. Layered learning design approach.

The first layer is the *template layer*, where an instructional designer can create templates for online courses. A template is the initial state of a course, containing all elements and pre-sets of

the learning design required by the business and pedagogical model and constrained by services available in the infrastructure. Templates provide a means to standardize and control the learning design to the level needed. The second layer is the *course layer*, in which authors can develop online courses derived from and controlled by templates. Within these courses authors can edit the learning design according to the degree of freedom provided by the templates.

OUNL implementation

This section describes how the requirements for flexible authoring and delivery have been met in a first implementation at the OUNL.

Platform

The OUNL has implemented the authoring and delivery system as part of a new, integrated e-learning system called OpenU (<http://openu.nl>), which is built on the community based Liferay Portal platform (Liferay, 2014). This open source platform contains an advanced, customizable roles and permissions system, which was needed to be able to split up courses into configurations that could be flexibly delivered to the target learners groups from the business model (requirement R1). The service oriented architecture of the portal allows for standardized integration of additional services. Through the portal's web interface these services are delivered as configurable portlets that can be arranged on web pages.

The platform's 'community' entity has been used as a container for design and delivery of online courses. In order to explain the implemented solution for the authoring and delivery system we first provide a simplified overview of Liferay's community structure, depicted in Figure 4.

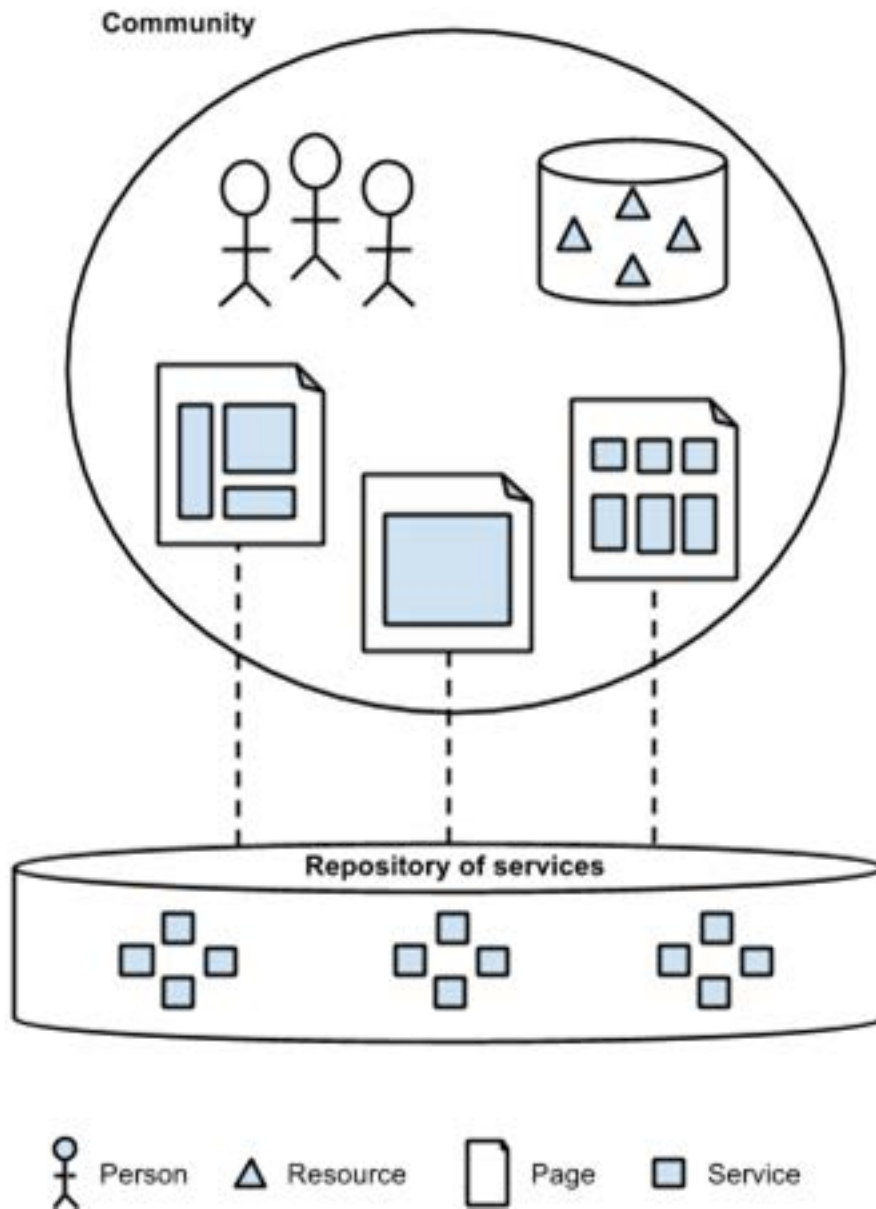


Figure 4. Platform community structure.

A community is a grouping of users, which hold some common interest, web pages and resources. Each page has a layout, where configurable portlets can be added and arranged. A portlet is a user interface component, wrapping some service or application, like a blog, wiki, or forum, and providing access to its functionality. Through configuration a portlet's display

settings, permissions and preferences can be adjusted. Considering the requirement of flexible delivery (R1), it is important to stress that for each page, portlet and resource within a community, an extensible range of permissions can be granted to the roles in the learning design.

The OpenU authoring and delivery system

To standardize aspects of the learning design, templates were developed for two online course types. These templates were technically built as containers holding pages and resources that can be easily copied into a community. Functionally, the templates were developed as learning designs, containing standardized roles, activities, environments and role parts. Out-of-the-box available platform services, like wiki, forum and RSS feed reader, were extended with, among other things, course services e.g. for authoring and monitoring by a team of OUNL developers.

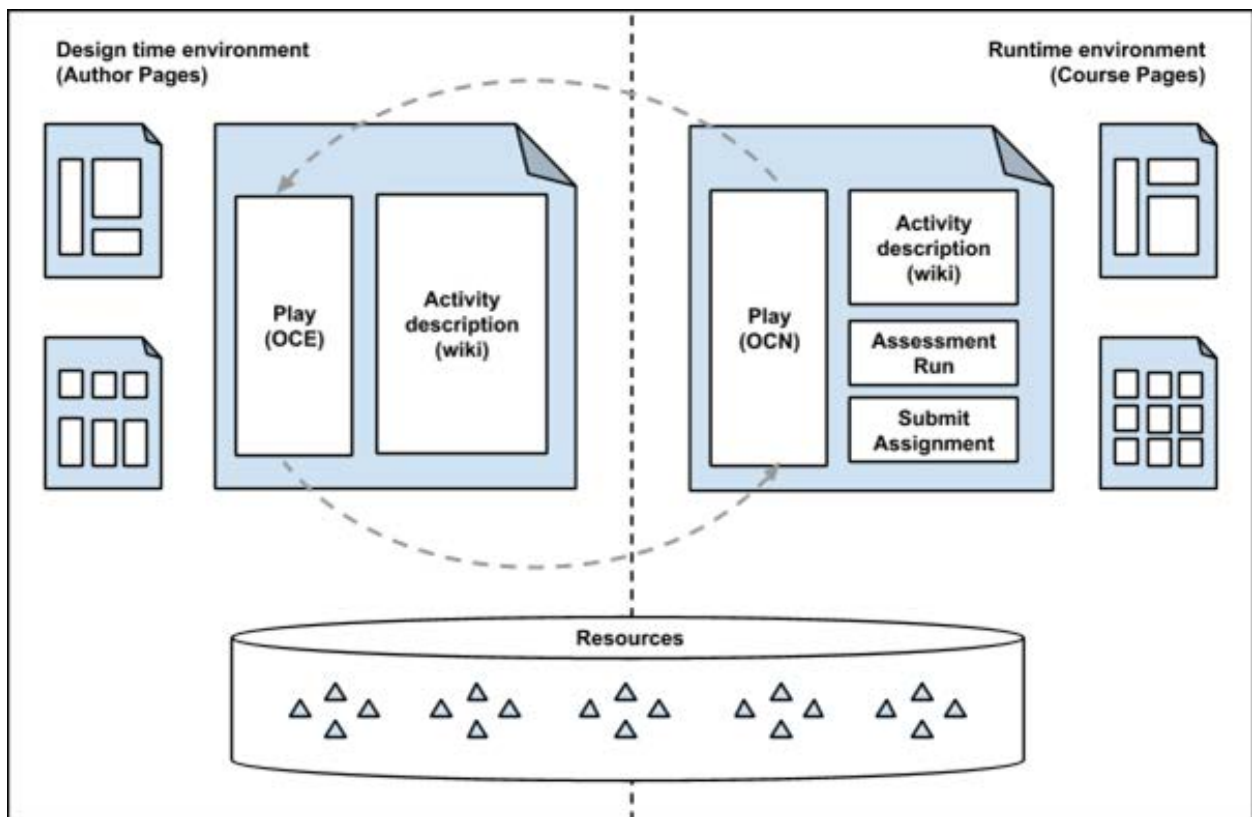


Figure 5. OpenU template structure.

Each template contains both a design time environment and a runtime environment (see Figure 5) that share resources. Both environments have been implemented as a collection of web pages with role based access. The design time environment is composed of ‘author pages’ holding all the services needed for elaborating the learning design and managing resources such as assessments, documents and images. The runtime environment contains ‘course pages’, offering all services needed for executing the learning design such as learning design player, a virtual classroom and a student monitor. In addition, the runtime environment is split up in learner access levels, corresponding to the levels in the concentric circles model. When moving up to a higher level in the learner hierarchy, learners receive added value, like access to all course resources (blue users) or assessments and tutoring services (green users).

OpenU Course Editor

Key service in the design time environment is the OpenU Course Editor (OCE), which has been developed by the OUNL’s ICT developers for editing the learning design. It was developed as a specific purpose tool (see Griffiths, Blat, Garcia, Vogten, & Kwong, 2005), tailored to the requirements of the business model, requiring no IMS LD knowledge from its users. The editor supports all main constructs of IMS Learning Design level A.

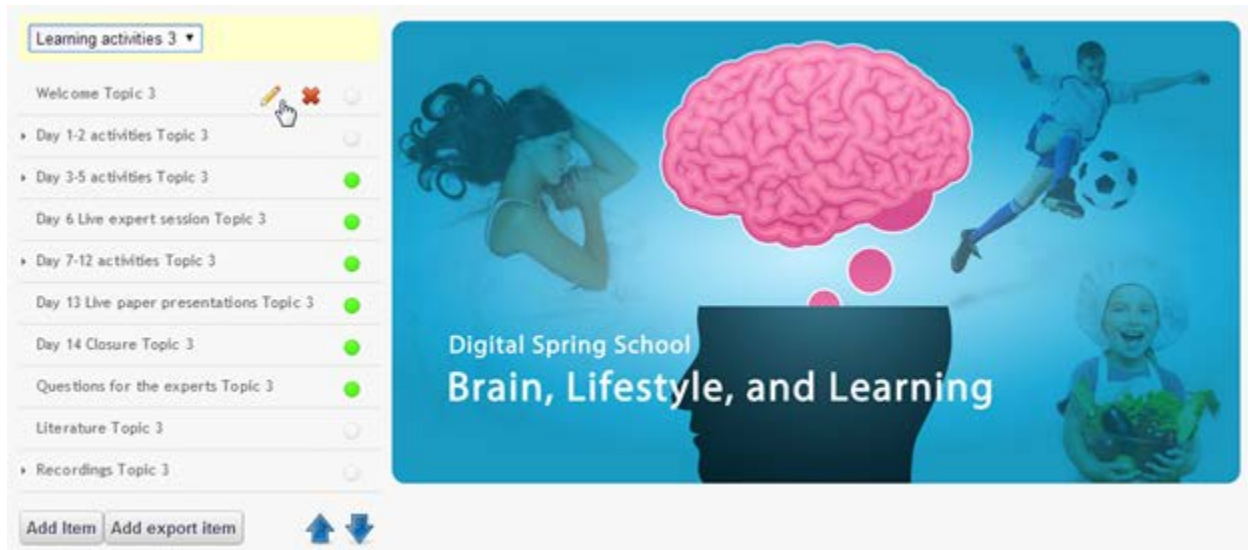


Figure 6. OpenU Course Editor.

The editor has a graphical, tree based user interface (see Figure 6), representing a learning design's *play*, containing branches (activity structures) and leaves (activities). The activity tree can be adapted by adding, moving or nesting learning or support activities. Each activity can be configured with respect to IMS LD elements like activity completion and activity outcome. The platform's wiki service is used for editing the *activity description*. Use of the wiki ensures that the change history is kept and allows for co-authoring of activities. Besides, depending on the course's pedagogical model, students can be involved in authoring learning activities by granting them authoring access to the wiki.

Distinctive feature of the OCE, addressing the business model requirements and serving efficiency purposes, is colour scheme based activity assignment. Activities can simply be assigned to a specific learner target group by selecting the corresponding colour next to the activity title. Figure 7 shows an overview of colours corresponding to the learner target groups in the concentric circles model.

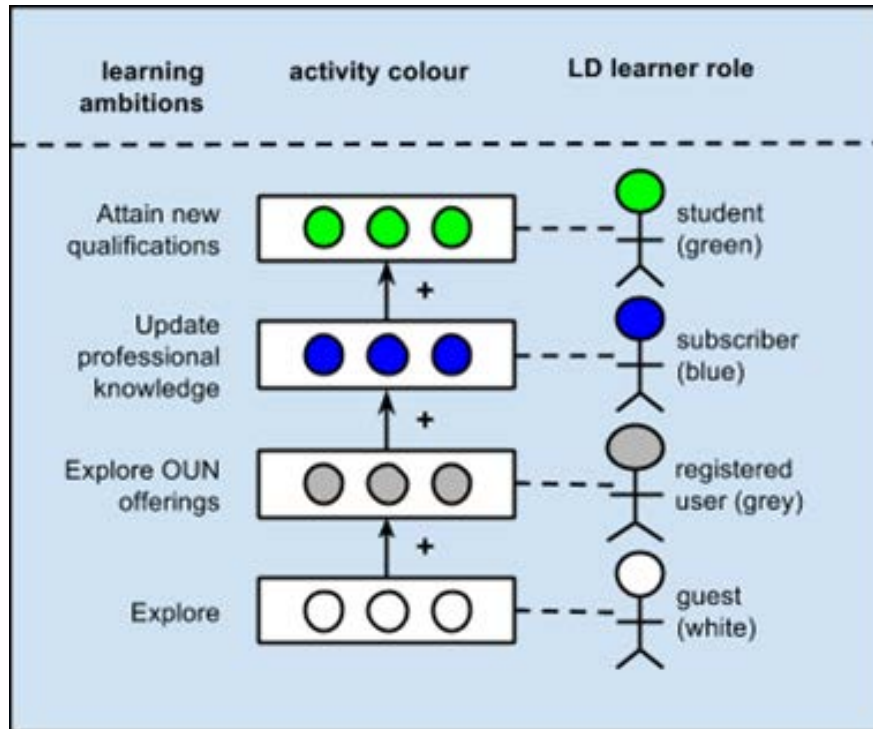


Figure 7. Learning activity colour scheme.

OpenU Course Navigator

The learning design, elaborated in the OCE, is interpreted and run by another service, the OpenU Course Navigator (OCN). This service is available in the runtime environment. It runs and personalizes the activity tree based on the user's (learner) role. Through the OCN's preview facility, authors can easily check the effects of their adjustments for each particular learner target group. The OCN is aware of modifications in the OCE, and instantly re-calculates the activity tree after a learning design has been updated. Changes in the activity tree as well as changes in content can be made at any time with no need for authors to republish the course. In this way the requirement of runtime adaptation could be addressed. The publication process has in fact been reduced to simply turning on learner subscription. The personalization process follows the incremental model of the concentric circles model. Stepping up the learner 'hierarchy', ranging

from explorer (white user) to student (green user), the number of accessible learning activities increases (see Figure 7).

Besides web delivery the OCN also supports EPUB (International Digital Publishing Forum, 2014) and PDF delivery. Both delivery types are optional, and have to be enabled in the OCE. When enabled, learners can download their personalized course e.g. for studying from print or some mobile device like an e-reader. As the platform's internal storage format is XML (Bray, Paoli, Sperberg-McQueen, Maler, & Yergeau, 1997), it has the potential to export the learning design to a range of formats.

System usage in the context of Learning Sciences and Technologies

The authoring and delivery system was adopted within the domain of Learning Sciences and Technologies. For each of the course types 'MSc course' and 'online masterclass' a template was developed in cooperation with faculty staff. An online masterclass is a newly developed course format, with a turnaround of one week, in which experts and learners discuss trending topics in a structured way, using synchronous and asynchronous services. The templates offered authors a considerable amount of freedom with respect to type of activities, the activity flow (play), and resources to be used. A basic, though extendable set of course tools (services) was used to assure a consistent user experience throughout the MSc courses as well as the online masterclasses. From May 2011 to February 2014, a total of 26 MSc courses (4.3 ECTS¹ credits each), 32 online masterclasses and one MOOC were developed and delivered using this system. Until February 2014, these online course communities have an average amount of 224 registered members ($n=59$) with a minimum of 23 and a maximum of 904 members. Kick-start for the development

¹ European Credit Transfer and Accumulation System (http://ec.europa.eu/education/tools/ects_en.htm).

of the MSc courses was a one-week training and implementation session for the core authors in May 2011.

A typical usage scenario for the authoring and delivery system looked as follows. First, a course was created based on one of the available course templates, containing the initial learning design choices and restrictions, stemming from the business model and pedagogical choices agreed at faculty level (requirement R3). Next, teachers who were instructed about the business model and faculty's pedagogical framework, were assigned to the course as course *authors*, allowing them to access the author pages (design time environment) as well as the course pages (runtime environment). Using the OCE, and supported by typical assessment and document storage services, teachers could stepwise (co)author the course's learning design. At any time, teachers could simply switch from author pages to the course pages in order to preview and check the course for each targeted learner group in the OCN (requirement R5; see figure 8). Any learning design adjustment could easily be applied through the OCE, regardless of a course's publication status (requirement R4).

The screenshot displays a course page for 'Learning Sciences and Technologies' with the course title '022921 Approaches, Strategies and Methods for Educational Design' and the Open Universiteit logo. The breadcrumb trail is 'Dashboard > Learning Sciences and Technologies > Course content'. A navigation bar includes 'Course content', 'Group discussion', 'Participants', 'Virtual classroom', 'Feeds & Twitter', 'Authors', and 'Monitor'. A 'Manage' button is also present. On the left, a 'View as' dropdown menu is open, showing options: Student (selected), Anonymous, Registered user, Member, Subscriber, Former student, and Full access. Below this is a list of course items: 'Assignment 1.1', 'Assignment 1.2', 'Collaboration 1', 'Assignment 1.3', 'Submit assignments and...', and 'Study task 2'. The main content area is titled 'Collaboration study task 1' and contains four sub-tasks (A, B, C, D) related to discussing groupings, prior knowledge, glossary terms, and definitions of 'learning'.

Figure 8. Preview of the learning design.

Runtime adaptation

The aim of this study was to present a new approach to IMS LD based authoring and delivery within the context of a changing business model for distance education. The requirement for runtime adaptation (R4) aims in fact at offering authors more freedom, and as such implies increasing flexibility in how to develop their courses. To get an indication of authors' editing behaviours, we analysed each course's history with respect to modifications in wiki pages. As mentioned earlier, we used the courses' wiki's to edit the contents of the learning design activities. By comparing the version dates of wiki pages with the course publication dates, we were able to pinpoint modifications as being made in design time or runtime. Figure 9 provides an accumulated overview of the percentage of learning design activities modified in design time, runtime or both.

The overview provides further support to the requirement of runtime adaptation: 41% of all course activities have been created and/or modified in design time, whereas 59% have been modified or even created in runtime.

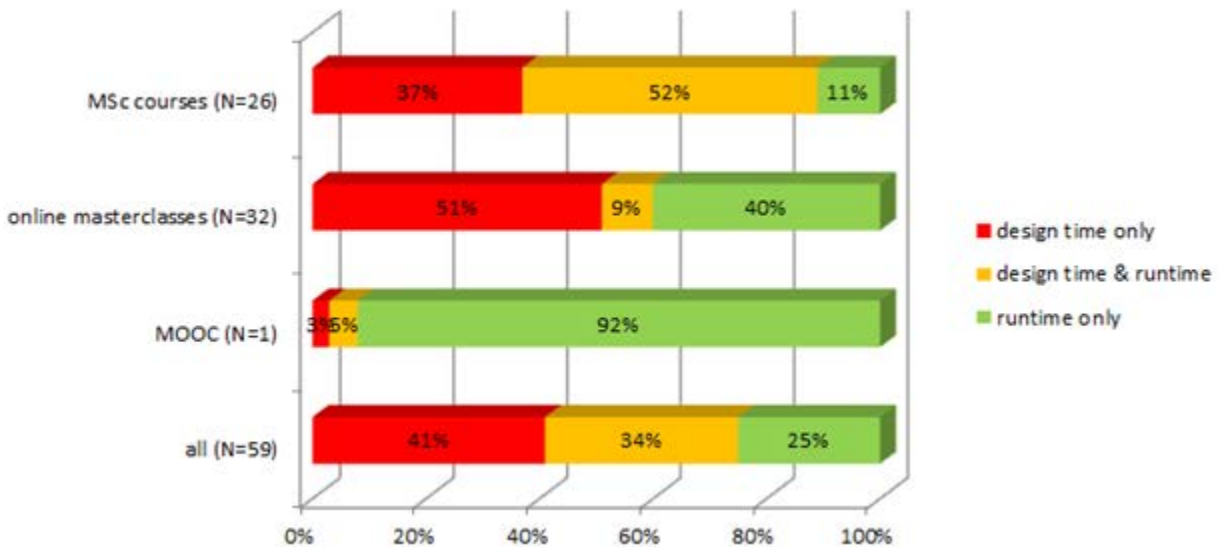


Figure 9. Distribution of learning design activities modified in design time and/or runtime.

Flexible delivery

Supporting the concentric model required the development of online courses that can be flexibly delivered to the identified learner target groups. To get an impression of how the various target groups actually have been addressed, all courses' activity trees ($n=59$) were examined with respect to the distribution of activities across the various target groups. Figure 10 presents the results for the different course types. The charts show the dominant presence of *subscriber* activities and a fairly small proportion of *student* activities within both course types. Noteworthy is the absence of 'prospect' activities within the MSc courses.

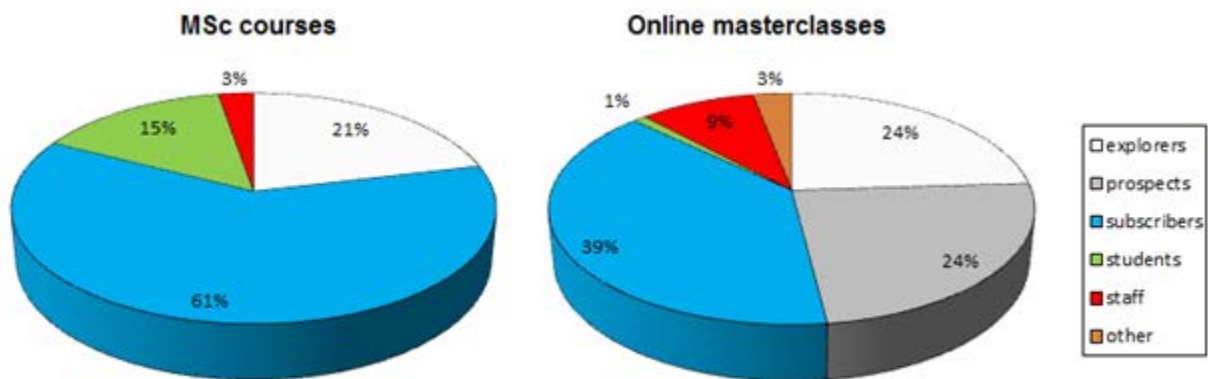


Figure 10. Distribution of learning design activities to learner target groups in the concentric circles model.

Conclusions and discussion

In this article we have introduced a new approach to IMS LD based authoring and delivery of online courses to meet the demands of (1) flexible delivery, stemming from the OUNL's changing business model for distance education, (2) IMS LD compliancy and (3) efficient IMS LD authoring, based on a reflection of the main IMS LD criticisms. Key aspects in this approach are integration of LD authoring in the runtime environment and use of templates to standardize aspects of the learning design.

A first implementation of the approach was realized within a new, integrated e-learning system (OpenU) which the OUNL has built and used in the period 2009 – 2013, founded on the principles of learning networks. To support the advocated approach a specific purpose IMS LD editor and player were developed within a portal architecture that allows for seamless integration of tools and also provides the role and permissions system needed for flexible delivery (requirement R1).

The resulting authoring and delivery system was used within the domain of Learning Sciences and Technologies. Starting from May 2011 until February 2014 a total of 59 online courses, either MSc courses or online masterclasses, were developed and delivered using this system. Our implementation proves that it is possible to break down the walls between IMS LD authoring and delivery by integrating design time and runtime tools that are aware of each other, and thus allowing authors to easily switch between design time and runtime. The collected usage data confirm the need for runtime adaptation: 59% of all course activities have been modified or even created in runtime.

Flexible delivery of online courses to the learner target groups in the concentric circles model was achieved by creating course access layers, making use of the portal's roles and permissions system. Moreover, applying these access layers enabled to implement additional business rules, e.g. learners enrolled as a student (green access level) in an MSc course automatically receive 'subscriber' access to all other MSc courses. Assembly and delivery of courses in this respect will be reported upon in a next study. Remarkably, our study revealed that 'prospects' (grey users) were not addressed in the MSc courses' learning designs. As this constitutes an important target group in the OUNL's strategy, further research is needed to understand why this is.

Finally, a nuance has to be made with respect to runtime authoring which reflects a limitation in our implementation so far. Runtime authoring requires mechanisms to assure that learners are notified of (small) changes and, in the case of major changes, a new version of the course is delivered for new cohorts of students. For example, adding a new learning activity to study task "A" may cause an update for each learner's activity tree, although a learner may

already have finished study task “A” or even fully completed the course. Learning design versioning will be needed to provide a proper solution to this issue.

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References

- Arpetti, A., Baranauskas, M., & Leo, T. (2013). Making Design Easy: a Usability Evaluation of Latest Generation Learning Design Tools. In *World Conference on Educational Multimedia, Hypermedia and Telecommunications* (pp. 960–965).
- Berggren, A., Burgos, D., Fontana, J. M., Hinkelman, D., Hung, V., Hursh, A., & Tielemans, G. (2005). Practical and pedagogical issues for teacher adoption of IMS learning design standards in Moodle LMS. *Journal of Interactive Media in Education*, (1).
- Bray, T., Paoli, J., Sperberg-McQueen, C. M., Maler, E., & Yergeau, F. (1997). Extensible markup language (XML). *World Wide Web Journal*, 2, 27–66.
- Burgos, D., Via, G., Juan, R., & Rioja, L. (2010). What is wrong with the IMS Learning Design specification? *18th Intl. Workshop on Personalization and Recommendation on the Web and Beyond*.
- Derntl, M., Neumann, S., Griffiths, D., & Oberhuemer, P. (2012). The Conceptual Structure of IMS Learning Design Does Not Impede Its Use for Authoring. *IEEE Transactions on Learning Technologies*, 5(1), 74–86.
- García-Robles, R., Ferrer, L., & Cagigas, D. (2008). An IMS-Learning Design Editor for a Higher Education Blended Learning Scenario. *2008 Eighth IEEE International Conference on Advanced Learning Technologies*, 199–203.
- Griffiths, D., Blat, J., Garcia, R., Vogten, H., & Kwong, K. (2005). Learning Design Tools. In R. Koper & C. Tattersall (Eds.), *Learning Design* (pp. 109–135). Springer Berlin Heidelberg.
- Griffiths, D., & Liber, O. (2008). Opportunities, achievements, and prospects for use of IMS LD. In L. Lockyer, S. Bennett, S. Agostinho, & B. Harper (Eds.), *Handbook of Research on Learning Design and Learning Objects: Issues, Applications, and Technologies* (pp. 87–112). IGI Global, Hershey, PA.
- Hermans, H., Kalz, M., & Koper, R. (2014). Toward a learner-centered system for adult learning. *Campus-Wide Information Systems*, 31(1), 2–13.
- Hermans, H., Manderveld, J., & Vogten, H. (2004). Educational modelling language. In W. Jochems, J. Van Merriënboer, & R. Koper (Eds.), *Integrated E-learning, implications for pedagogy, technology and organization* (pp. 80–99). London: Kogan Page.

- IMS Global Learning Consortium. (2003). Learning Design Specification. Retrieved November 10, 2014, from <http://www.imsglobal.org/learningdesign/>
- International Digital Publishing Forum. (2014). EPUB. Retrieved from <http://idpf.org/epub>
- Katsamani, M., & Retalis, S. (2011). Making learning designs in layers: The CADMOS approach. In *Proceedings of the IADIS Multi Conference on Computer Science and Information Systems* (pp. 305–312).
- Koper, R. (2001). Modeling units of study from a pedagogical perspective: the pedagogical meta-model behind EML. Heerlen: Open Universiteit Nederland. Retrieved from [http://dspace.ou.nl/bitstream/1820/36/1/Pedagogical metamodel behind EMLv2.pdf](http://dspace.ou.nl/bitstream/1820/36/1/Pedagogical%20metamodel%20behind%20EMLv2.pdf)
- Koper, R. (2009). A Conceptual Model of Learning Networks. In R. Koper (Ed.), *Learning Network Services for Professional Development* (pp. 313–328). Springer Berlin Heidelberg.
- Koper, R. (2014). Changing the business model of a distance teaching university. In R. Huang, Kinshuk, & J. K. Price (Eds.), *ICT in Education in Global Context* (pp. 185–203). Springer Verlag Berlin Heidelberg.
- Koper, R., & Manderveld, J. (2004). Educational modelling language: modelling reusable, interoperable, rich and personalised units of learning. *British Journal of Educational Technology*, 35(5), 537–551.
- Liferay. (2014). Enterprise open source portal and collaboration software. Retrieved November 10, 2014, from <http://www.liferay.com>
- Martinez-Ortiz, I., Sierra, J.-L., & Fernandez-Manjon, B. (2009). Authoring and Reengineering of IMS Learning Design Units of Learning. *IEEE Transactions on Learning Technologies*, 2(3), 189–202.
- McAndrew, P., Goodyear, P., & Dalziel, J. (2006). Patterns, designs and activities: unifying descriptions of learning structures. *International Journal of Learning Technology*, 2(2), 216–242.
- Neumann, S., & Oberhuemer, P. (2009). User Evaluation of a Graphical Modeling Tool for IMS Learning Design. In *Advances in Web Based Learning–ICWL 2009* (pp. 287–296). Springer Berlin Heidelberg.
- Olivier, B. (2006). Learning Design Update. Retrieved from <http://dspace.learningnetworks.org/handle/1820/582>

- Olivier, B., & Tattersall, C. (2005). The Learning Design Specification. In R. Koper & C. Tattersall (Eds.), *Learning Design* (pp. 21–40). Springer-Verlag Berlin Heidelberg.
- Rosmalen, P. van, & Boticario, J. (2005). Using learning design to support design and runtime adaptation. In R. Koper & C. Tattersall (Eds.), *Learning Design* (pp. 291–301). Springer-Verlag Berlin Heidelberg.
- Van Es, R., & Koper, R. (2006). Testing the pedagogical expressiveness of LD. *Educational Technology & Society*, 9(1), 229–249.
- Vogten, H., & Koper, R. (2014). Towards a new generation of Learning Management Systems. In *Proceedings of the 6th International Conference on Computer Supported Education*. Barcelona.