Report of the Results of an IMS Learning Design Expert Workshop (Complete Version)

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Abstract— **Europe has seen a number of learning design initiatives in the past years. Among them are the Open University UK Learning Design Initiative, JISC's Design for Learning Programme, as well as the Open University of the Netherlands' development of the Educational Modelling Language and its conversion into the specification IMS Learning Design. Particularly the last initiative inspired an IMS Learning Design Expert Workshop, which was held at the University of Vienna on November 20 & 21, 2008. This report contains a description of the purpose of the workshop, its methodologies and the results. Participating experts first brainstormed visions and problems of IMS Learning Design, and then developed potential solutions to some of the identified problems. Three groups formed to work on two of the identified problems in more depth: the usability and utility problem, and the life cycle of a unit of learning. The proposed solutions regarding the usability and utility problem were to investigate how teachers' and learners' representations of a learning design can be brought together, and to set up a research program to identify how teachers cognitively proceed when designing courses, and to map this knowledge to IMS LD. In regard to the life cycle of a unit of learning problem, the group suggested a system that continually exchanges information between runtime and editing systems so that units of learning can be updated accordingly.**

Index Terms—**IMS Learning Design, future, problem, solution, vision.**

I. BACKGROUND AND PURPOSE OF THE WORKSHOP

A. The IMS Learning Design Specification

IMS Learning Design (IMS LD) was introduced in 2003 as a specification that represents a "framework of elements that can describe any design of a teaching-learning process in a formal way" [1]. The requirements for this framework were specified as follows:

Completeness: fully describe the teaching-learning process in a unit of learning.

Pedagogical Flexibility: express the pedagogical meaning and functionality of data elements within a unit of learning; flexible to describe all different kinds of pedagogies while not prescribing any specific pedagogical approach.

Personalization: describe personalization aspects within a learning design, so that the content and activities can be adapted to users.

Formalization: describe a learning design in a formal way, so that automatic processing becomes possible.

Reproducibility: describe the learning design so that repeated execution in different settings with different persons is possible.

Interoperability: support interoperability of learning designs.

Compatibility: use standards and specifications where possible.

Reusability: make it possible to identify, isolate, de-contextualize and exchange useful learning artifacts, and to re-use these in other contexts.

In the six years since its introduction, a number of projects have placed foci on developing tools for IMS LD and have applied the specification to different areas of teaching and learning. Examples of such projects include RELOAD[1], UNFOLD[2], COLLAGE [2], GRAIL[3], LD4P[4], TENCompetence[5], and PROLIX[6]. Next to a great number of conference and journal articles on IMS LD, the book "Learning Design" [3], and special issues in Educational Technology & Society ("Current Research in Learning Design[7]"), as well as in the Journal of Interactive Media in Education ("Advances in Learning Design[8]" and "Adaptation and IMS Learning Design[9]") were published that provided reference examples for course and tool developers.

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[1]   http://www.reload.ac.uk/
[2]   http://www.unfold-project.net/
[3]   https://gradient.it.uc3m.es/xowiki/main_page
[4]   http://www.jisc.ac.uk/whatwedo/programmes/elearningpedagogy/ld4p.aspx
[5]   http://www.tencompetence.org/
[6]   http://www.prolixproject.org/
[7]   http://www.ifets.info/index.php?http://www.ifets.info/issues.php?id=30
[8]   http://jime.open.ac.uk/2005/01/
[9]   http://jime.open.ac.uk/2007/01/

B. The Expert Workshop

Expertise for IMS LD has been built across Europe through a number of different projects. The purpose of the workshop was to funnel this expertise by having experts of IMS LD share the problems they have encountered regarding the specification, and to jointly develop approaches to solve these problems. Participants took different perspectives towards the IMS LD specification, the main perspectives being pedagogical and technical. The experts participating during the workshop came from industry as well as higher education (participants appear with their affiliations in alphabetical order):

- Tom Boyle (London Metropolitan University, UK)
- Francis Brouns (Open University of the Netherlands, The Netherlands)
- Luis de la Fuente Valentín (Universidad Carlos III de Madrid, Spain)
- Michael Derntl (University of Vienna, Austria)
- Michele Dicerto (Giunti Labs, Italy)
- Nils Faltin (imc AG, Germany)
- Dai Griffiths (University of Bolton, UK)
- Davinia Hernández-Leo (Universitat Pompeu Fabra, Spain)
- Hans Hummel (Open University of the Netherlands, The Netherlands)
- Michael Klebl (FernUniversität in Hagen, Germany)
- Petra Oberhuemer (University of Vienna, Austria)
- Amir Wasim (imc AG, Germany)
- Moderator: Susanne Neumann (University of Vienna, Austria).

II. WORKSHOP METHODOLOGY

Workshop participants first created a vision about the question: "What do you envision IMS Learning Design to be ten years from now?" Each participant wrote on index cards answers to this question. The cards were then collected and pinned onto a pin board, and each participant explained for his or her cards what the answers entailed.

The participants then described problems, which they encountered during their work with the specification. Again, the problems were written on index cards and collected on a pin board. Once all the problems were collected, participants grouped them in a joint effort. Each card stating a problem was discussed among the participants regarding its relevance to other problems, i.e. whether it fitted with an existing group of problems, or whether it represented a new idea that would start a new group. Using this method, five main problems (i.e. groups of problems) emerged.

After the identification of the main problems, participants voted which problems interested them the most for further discussion during the remaining time of the workshop. Each participant had three votes to cast (in the form of small round stickers), which could be distributed in any way across the main problems identified. The color of the stickers differed for those having a (mainly) pedagogical perspective and for those having a (mainly) technical perspective on IMS LD. This way, interdisciplinary problems could be distinguished from problems that interested specifically one of the perspectives.

To form groups for group work, the three main problems that received the most votes were included in a second round of voting. Participants were asked to place their name tag onto one of the three problems to identify who would be working towards solutions for what problems. When the name tags had been placed, participants wished to work on two problems during remainder of the workshop.

Three groups were formed for the group work phase of the workshop. To start off the group work, all participants jointly brainstormed "influence factors", i.e. factors that could be changed or adjusted to tackle the problem. Groups then formed and started developing solutions to the problems. They first formulated a problem and goal statement. Then, a solution was developed which was described on a poster along with the estimated effort of implementation and the barriers to implementation.

The groups presented their solution posters to all participants. This was followed by a short discussion. To wrap-up the workshop, the participants voted on the vision statements that were initially put forth. They were asked to indicate how the developed solutions related to the visions, i.e. what visions were worked towards with the proposed solutions.

III. VISION: IMS LD IN TEN YEARS

The first activity of the participants was to create a vision of what IMS LD could be in ten years. Participants wrote ideas on index cards, and contributed them successively to the group. This was done following a classical brainstorming procedure, where everyone could contribute a card while reading the contributions of others. The following visions were created:

- IMS LD v4.1: The IMS LD specification has been refined several times.
- User-friendly (teacher) tools are available.
- Large scale implementation of IMS LD is visible.
- Business models exist to sell IMS LD and its applications.
- Collaborative authoring takes place with IMS LD.
- Added-value of IMS LD is apparent.
- A "painless" container for collaboration tools exists.
- Whole study programs are implemented in IMS LD.
- IMS LD is widely used in learning management systems, but not only there.
- IMS LD improves social aspects of e-learning.
- IMS LD is used as a knowledge management instrument, capturing teaching-related knowledge.
- Student-centeredness is achieved.
- Learning plans are modeled: for the learner & by the learner.
- Blended learning: IMS LD provides a computer-interpretable representation that enables the automatic execution of teaching and learning processes by learning management systems. The implementation guide suggested by the specification proposes to differentiate the phases of design/creation, production/instantiation and delivery/execution/enactment. This approach is

especially appropriate for distance learning scenarios. However, in ten years the benefits of IMS LD will be also visible in blended learning situations, integrating distance with face-to-face, computer-supported with traditional activities, etc. A first blended learning experience making used of IMS LD has been carried out by Hernández-Leo, Bote-Lorenzo et al. [4]. The potentials of the specification for this type of scenarios are also discussed by Garcia-Robles, Ferrer, and Cagigas [5].

- There will be (one) standard (tool) for teacher education (not technology).

- IMS LD has evolved out of research & development into simplified commercial tools

- IMS LD allows flexibility [6].

- Interoperability exchange takes place via IMS LD.

- IMS LD allows natural integration between the online-offline traditions.

- Support of design processes (beyond the notation): IMS LD offers a common formal notation. Sloep, Hummel, and Manderveld [7] explain the basic stages (creating a narrative, then translating it into a UML activity diagram, etc.) that can be followed when creating an IMS LD unit of learning. However, this generic process is intended for learning designers, who have technological skills and are familiar with the IMS LD specification. In ten years, IMS LD will be widely applied since a number of design processes capable of facilitating the creation of units of learning will be available. The design processes will be specific to different pedagogical methods (such as collaborative learning [2], and may foster the reuse of learning design solutions [8]).

- IMS LD as the conceptual core for a discipline of Technology-Enhanced Learning

- IMS LD units of learning are interoperable and combinable with other (forthcoming) specifications: The scope of the IMS LD specification is limited to describing teaching and learning processes. LD was planned to interoperate with other specifications of IMS, such as IMS QTI for assessment tests or IMS Metadata for annotating the resources used along the learning processes. In ten years, IMS LD will interoperate with many other specifications, existing but mainly forthcoming, that will augment the potentials of LD. For example, there are currently many efforts devoted to making IMS LD work with services or mash-ups [4, 9] that may feedback standard bodies. Following this philosophy of "divide and conquer", it can also be envisaged a new specification, combinable with IMS LD, in charge of capturing the indications that enable a standard evaluation of the teaching and learning process.

- IMS LD supports hands-on learning, i.e. learning in augmented reality.

- Quality of teaching and learning is improved by using IMS LD.

- Designs are availabe that transform the effectiveness of learning scenarios

- There are IMS LD-compliant gaming patterns for serious games and virtual worlds available.

- IMS LD offers more control flow options

- Best practice templates are available (for workplace-based, higher education and school learning.

- IMS LD offers run-time flexibility.

IV. PROBLEMS WITH IMS LD

Participants brainstormed the question "What problems have I encountered in regard to IMS Learning Design?" Participants each received three cards onto which to write the problems (one problem per card). They wrote the problems and silently (without explanation) pinned them to the pin board. When reading each others problems, participants had the opportunity to write new problems onto cards.

Once the collection of problems was finished, participants grouped the problems with the help of a moderator. Five groups emerged from the identified problems, and each problem group was given a name. The identified problems are listed hereafter in alphabetical order so as to not imply value judgments. A breakdown of the vote regarding what problems seemed most pertinent to be worked on during the workshop is reproduced in section IV.F. The forthcoming sections V, VI, and VII describe next to concrete problem statements also potential solutions to the problems including efforts of and barriers to solution implementation.

A. Adoption

For the problem group Adoption, the workshop participants saw the following sub-problems:

- There is tension between complexity and functionality of a learning design. One of the main problems of IMS LD that hinders its adoption is its complexity. It is a specification with many elements and three levels (A, B, C) of complexity, with level B being the most difficult to use since it allows designers to exploit conditions and program adaptation features to control the learning flow, or to enable the upload of activity outcomes (e.g., reports, problem solutions), among others. Despite the broad functionality possibilities that IMS LD provides, there is still a number of facilities that the community is demanding (e.g., services, features for establishing groups). Therefore, there is a tension between the complexity already entailed by the specification and the functionality the community would like IMS LD to offer.

- There is a lack of IMS LD implementation in organizations, probably due to the needed organizational change, which is difficult.

- To get started on IMS LD, there is a high threshold to overcome. The threshold comprises cultural and technological hurdles.

- It is not quite apparent to stakeholders, yet, what the core and key benefits of IMS LD are.

- Next to IMS LD, there are several competitive specifications (IMS Common Cartridge, moodle-zip etc.).

B. Interoperability

For the problem group Interoperability, the participants saw the following sub-problems:

- Data flow: The flow of data between activities can be controlled using IMS LD level B properties.

However, it is not possible to manage the flow of data between the tools (or services) supporting the activities or between the tools and the activities since the tools are "black boxes" to the learning design [10].

- Global properties: how to manage global properties defined by other specifications like IMS Question & Test Interoperability [11]?
- Collaboration services: More types and standard parameters are needed for these.
- IMS LD services need to be extended to include rising technologies.
- Should each service be clearly specified in IMS LD, creating a heavy-weight specification, or should an approach like the current web 2.0 formats be adopted for services?

C. Level B Notation

This problem group includes problems that specifically relate to Level B of the IMS LD specification. The sub-problems contained in this group are:

- Using IMS LD Conditions is not easy, especially because the overview of what condition serves what purpose can be easily lost.
- Current IMS LD editors do not achieve good usability for designers to integrate level B elements in their learning designs.
- It is unclear, how acts are synchronized with level B: Do properties and conditions work around acts?
- Declarative language: IMS LD is a declarative programming language which enables expressing logic (what a program should accomplish) without describing its control flow (how the logic should be accomplished). When implementing sophisticated pedagogical methods (such as project-based learning with adaptation features), learning technologists sometimes ask for an imperative-oriented language capable of specifying more detailed descriptions of the programs to be run.

D. Life Cycle

For the problem group Life Cycle, the participants saw the following sub-problems:

- Editing [a learning design] is currently not integrated within the runtime system. To make changes to a unit of learning, it must always be returned to the editing software.
- There is an incomplete cycle between the authoring phase, the deployment phase, and the enactment phase and then again with the authoring phase.
- There is currently a lack of runtime flexibility: Once the unit of learning is "running" in a learning management system, hardly any changes can be made to it.
- Working process: How to go about building and employing units of learning?
- Creating groups of the same role represents a problem.

E. Usability & Utility

The last group of problems is Usability & Utility. The sub-problems of this group are:

- What happens in the "real world": learning objects can be used for learning as well as face-to-face learning situations.
- Teachers' concepts (of teaching and learning) may not be consistent with the concepts IMS LD foresees.
- There is a lack of authoring support, ranging from the conceptual mapping of a unit of learning to the actual XML coding support.
- The question of granularity: What are good choices of granularity for the different IMS LD components (activities, acts, plays, units of learning)?
- Visualizations for IMS LD: The abstractions and visual (or graphical) representations [12] of the concepts used in the authoring and enactment time should be closer to the understanding of their final users, i.e. closer to the teachers and learners. Also, visual representations may differ depending on teachers' and learners' profiles and the learning situation or context.
- IMS LD editors currently offer no unit of learning preview options of what the unit of learning looks like when executed in a learning management system.
- How to treat learning objects & the different layers of design within an IMS LD unit of learning?
- IMS LD player: How to represent the learning path in the user interface? Navigation support is not clearly defined by the IMS LD specification.
- Diagrams of activities are missing.

F. Voting on Main Problems

After having grouped the problems, participants voted on the problem that each person would work on during the remainder of the workshop. In a first round of voting, each participant received three round stickers, whereby each sticker represented one vote. The stickers could be placed on any of the main problems previously identified, i.e. all three dots could end up on the same problem, or they could be distributed across three different problems. A distinction was made between participants that had a (mainly) technical perspective and participants that had a (mainly) pedagogical perspective on IMS LD – the two perspectives received differently colored stickers to tell them apart. This way, the interdisciplinarity of problems could be identified. Table I shows the distribution of votes.

TABLE I.
DISTRIBUTION OF VOTES REGARDING THE FIVE MAIN PROBLEMS OF IMS LEARNING DESIGN

Group of Problems	Number of Technical Votes	Number of Pedagogical Votes	Total Number of Votes
Adoption	3	2	5
Interoperability	3	1	4
Level B Notation	2	0	2
Life Cycle	3	5	8
Usability & Utility	4	8	12

Participants were then asked to place their name tag onto one of the three main problems that received the most votes. This was to indicate which problem

participants wanted to work on during the remaining time of the workshop.

As a result, participants decided to work on two of the identified problems: Life Cycle and Usability & Utility. Since the number of participants, who assigned themselves to the latter problem, was quite large, this group was split into two. Therefore, two groups worked on the Usability & Utility problem. Memberships in each group were as follows:

Workgroup: Life Cycle
> Francis Brouns
> Hans Hummel
> Luis de la Fuente Valentín
> Petra Oberhuemer

Workgroup: Usability & Utility I: IMS LD and Teaching Practice
> Michael Klebl
> Nils Faltin
> Michele Dicerto
> Michael Derntl

Workgroup: Usability & Utility II: Joining Teachers' and Learners' Representations of Learning Designs
> Dai Griffiths
> Davinia Hernández-Leo
> Tom Boyle
> Amir Wasim

For the online version of this report, we include the complete descriptions of problem statements and solution descriptions as well as goal statements, influence factors, as well as effort of and barriers to implementation.

V. RESULTS OF THE LIFE CYCLE WORKGROUP

(Authors of this section: Luis de la Fuente Valentín, Hans Hummel, Francis Brouns and Petra Oberhuemer)

A. Problem Statement

First, we discussed who our target group is. Currently, the lack of easy-to-use, end-user authoring tools means that IMS learning designs are created and developed by expert designers. These experts often are not the same people, who are involved in course delivery. Normally, teachers and tutors will change a course during its runtime. Obvious changes to be made are typing errors, or more elaborate changes become necessary due to unexpected events (e.g. students dropping out due to illness). Even students might make changes to a course design such as pointing out typing errors. Teachers might want to include student contributions like products of assignments in the course. These types of users, teaching staff and students, are not likely to have access to an advanced IMS LD authoring tool, let alone have the competences to create designs. However, these users should be supported in making relevant changes to the course, at least during the runtime of a particular course. When we want to close the lifecycle from authoring to runtime, it becomes particularly important to support teaching staff and students.

A person could easily spot mistakes or discover changes that need to be implemented, especially mistakes that a designer could not foresee when creating the learning design. Continuous checking for mistakes might be too labor-intensive (think of hyperlinks to websites which have to be kept up-to-date). Data collected automatically during the actual use of the course could suggest changes, which are not obvious but which could be determined by analyzing the system, log, and user generated data. This could result in suggested changes like a current recommender system offer. Of course, there are some privacy issues to consider as there are with any automated change maintenance.

The IMS LD behavioral model is exposed linearly and does not make reference to any possible course modification after instantiation. Therefore, it can be said that IMS LD neither defines nor suggests a proper method to reuse changes made after the course has been deployed. The workgroup Life Cycle discussed this topic, identifying three key problems.

The first key problem is the lack of runtime flexibility. As mentioned above, the specification guidelines do not consider course modification after a unit of learning's deployment; resolving this issue is left to runtime environments. As a result, existing IMS LD players do not provide change management functionalities. Answers to questions like, "Should changes be made to a specific run, or to all course instances?" would simplify development and management.

The second key problem regards versioning. Each course modification is a new package version. Thus, integrating runtime flexibility in platforms will demand a robust definition of a package versioning system, in order to deal with change reverts, branches, multiple authors etc.

Last but not least, most authoring tools cannot import compliant units of learning if they were created with different software. This lack of functionality in authoring software, in conjunction with the first two key problems, prevents the course life cycle from being fully closed.

B. Influence Factors to the Problem

Before our work groups' discussions, all the workshop participants brainstormed about major factors that influence the stated problem. The main ideas mentioned as influence factors are listed here in alphabetical order.

Mode of delivery: There are different ways to put a course into practice. IMS LD is pedagogically neutral allowing it to be used in different pedagogical settings. Thus, instructors can use IMS LD to model distance learning, blended learning and face-to-face courses. The ability of IMS LD to support this wide diversity of delivery modes is one of its strengths: IMS LD cannot only be used for different pedagogical models but also for different institutions. This flexibility, however, makes it difficult to standardize the compilation of feedback regarding changes needed in future instantiations of the same unit of learning. What adds to this problem is that institutions prefer a setup of different servers, i.e. a production server and a test server. Course material is uploaded to a production server, which is public and open to students. This server cannot be used for development. Sometimes the instructor creates or modifies the unit of learning in the test server and only then moves it to the production server. In the production server, courses can be downloaded but not modified. The setup using two different servers hinders adequate standardization of feedback regarding necessary changes to the course instantiations.

Producer vs. consumer mentality: Adoption of technology highly depends on how it fits with the working paradigm of target markets. In this sense, society is clearly devoted to work specialization where tasks are clearly defined and do not interfere among one another. The IMS LD specification fits this scenario: Course author and course consumer are roles played by different actors. The one-way flow of information between the course author and course consumer represents a handicap to the iterative design of learning material. Since the specification favors the producer-consumer paradigm, it is difficult for tool developers and institutions to deploy an integrated solution where information coming from the deployment stage can be incorporated into new course releases.

Target group & required qualifications: In relation to the point mentioned above, the current users of the IMS LD specification tend to be researchers or expert learning designers. For a full uptake of the specification and, in particular to be able to close the life cycle, the end-users (teachers, staff and students) should be supported. Instead of highly qualified, fully trained experts, less experienced users should be able to create and change existing units of learning.

Technology maturity: As will be mentioned again in section VI.B, IMS LD is still technology at the edge, not state of the art. It is expected that a massive adoption of the technology will lead to new releases of the specification with features not included yet. However, current IMS LD efforts are mainly research driven. These efforts work to provide proof of new ways of teaching. The focus is not on capturing and supporting current teaching practices such as the traditional lecture format but on demonstrating mature technologies and use of technologies in teaching. Technology use, however, still proves difficult for lecturers. The IMS LD technology is not stable and instructors don't deal well this instability. The current inability to provide stable IMS LD technology may lead to ignoring other relevant factors. Such a factor may be the tracking of the entire course life cycle during actual course implementations with students and instructors.

Tool support: In order to achieve a critical mass that pushes the envelope on the IMS LD specification, it is mandatory to develop software prototypes as a proof of concept and tools ready for production able to manage large numbers of users. IMS LD is in an early adoption stage and, motivated by the producer vs. consumer mentality factor described above. Most applications are standalone tools instead of integrated solutions. Most IMS LD authoring tools are unable to import IMS LD compliant units of learning if the unit of learning was created with different editing software. Furthermore, runtime environments do not allow teachers or teaching staff to perform changes in course material or even to export a course. This relates to the life cycle of a unit of learning: Once the course is finished, the changes should be brought into the next version of the course. These functionalities are required to close the life cycle, and their absence in current tools leads to the belief that a packaged unit of learning can no longer be modified.

C. Goal Statement

As was mentioned in section I.A, upon its conception (1998-2000, in the beginning of the Web 1.0 epoch), IMS LD was intended to offer a specification that would model

(more complex) learning activities in advance, i.e. during design time (e.g. [13]). The result of this design and development process should be a self-contained unit of learning that could be exchanged (interoperability) and reused (sustainability) in various situations and on different platforms. The semantic expressiveness of IMS LD has proven to be powerful in these respects: A broad variety of pedagogical approaches and corresponding complex learning activities have been modeled with IMS LD [14]. Some of the resulting units of learning have indeed been reused and exchanged across various platforms and situations [15, 16].

The downside to designing complex learning in advance and in a top-down, expert-dependent way, has also become apparent in the current lack of runtime flexibility, extensibility and therefore sustainability. There is a need for natural mechanisms that close the life cycle and warrant continuous updates and improvements based on actual usage and evaluation. During recent years (2004-present, during the Web 2.0 epoch), IMS LD has been considered problematic in dealing with run-time deployment issues like course modification and versioning. There is a growing need for designing complex learning during runtime in a more bottom-up, expert-independent (user generated content) way (e.g. [17]). Currently, a large variety of social software tools (like wikis, weblogs, social bookmarking) are at our disposal that could cater to this bottom-up input by users to take some of the burden from the expert-designer. Our goal is thus to capture the activities of learners in the course and use it as feedback during new releases of the course in order to incorporate actual use experiences in the next releases of the course (cp. Fig. 1).
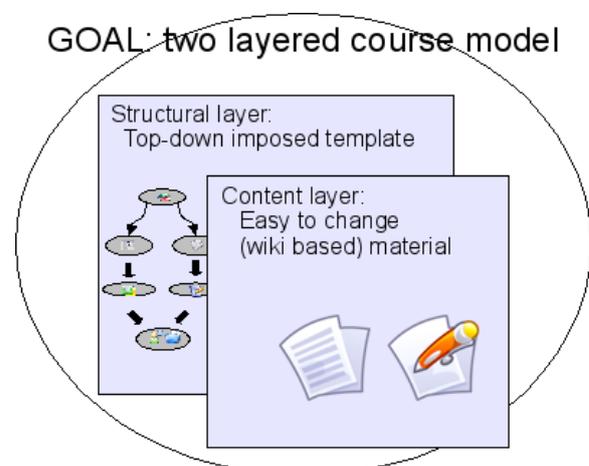

Figure 1.   Two layered course model
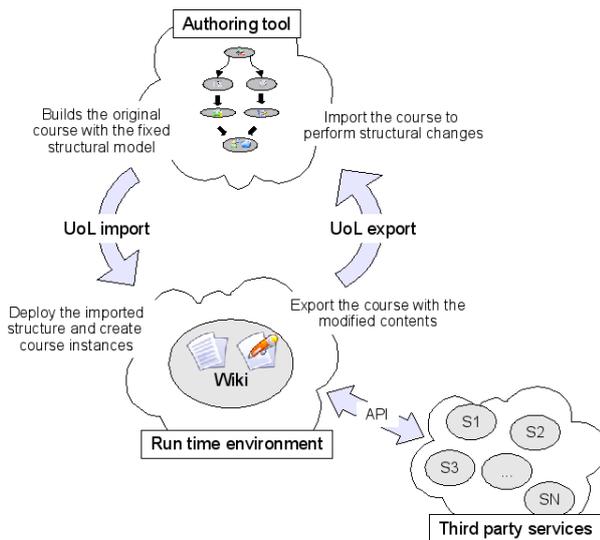
D. Solution Description

Figure 2. Solution Description for Life Cycle Problem

As a possible solution, our group has proposed a hybrid approach to modeling and refining learning material, attempting to preserve the best of both worlds, i.e. to benefit from the advantages while at the same time limiting the disadvantages of both the top-down and bottom-up approaches. The solution entails a two-layered design structure (cp. Fig. 2). The first layer comprises top-down imposed, fixed templates, which are modeled according to IMS LD. This template layer has a joint interface to the second layer, which contains bottom-up generated, flexible evaluations and course extensions (using, for instance, a wiki for storage). The second layer contains all "feedback" data collected during the course implementation. The two layers are then connected via a mechanism that feeds most needed and most popular changes from the feedback data layer back into the LD-templates of the first layer. Hybridly combining fixed ontologies with flexible social behavior (this is the same as the two-layered design structure) has recently been successfully applied in providing personalized recommendations in learning networks [18]. Therefore, the setup of the proposed solution has been justified.

During our brainstorm, we sketched a rough outline of the two-layered design approach without describing details of the concrete solution. In our initial brainstorming we thought about using a wiki for storing runtime behavior. The wiki is used to store runtime behavior while the course is running. Both, the learning management system and the unit of learning participants, write in the wiki. The wiki also stores who is making changes to the unit of learning at what point in time. A set of services could (automatically) feed information from the wiki to the layer containing the LD-templates.

The higher level layer contains the "master plan of pedagogy", i.e. the generic templates that correspond to various pedagogical patterns. The templates are modeled and stored in IMS LD (e.g. like in the Graphical Learning Modeller [19]). These templates were provided by expert designers and can be deployed via an import process to the lower layer. The lower layer contains the specific details of the course like activity descriptions. In the lower level hints on where to put descriptions are provided.

The lower level layer would contain specific content to be added to the generic templates as well as the interactions between that content and actors during runtime. The wiki would be flexible and emerge continuously from the bottom up by user generated content and comment (presuming). These data could be exported as new (generic) template to the higher layer. The runtime environment (learning management system) is thus used as an authoring environment and you can view the result directly in the platform.

The question is how could we feed back information from the lower layer to inform and actually change the higher level templates in order to close the life cycle? This is where our idea of data mining comes into play. User behaviors exhibited on the lower level (things that users do while learning with the unit of learning) can be channeled into the higher layer as modifications. This mechanism needs to be as labor-extensive as possible to warrant sustainability and independence from experts. It would involve specifying the data flow (by means of an Application Programming Interface (API)) between the services, which would require rules about the importance or minimal popularity of the comments. Experts may have to specify these rules in advance. An example for a needed rule is an answer to the question when actual content or user behavior should be fed back to the IMS LD layer.

Such activities modeled in IMS LD would not have a pre-designed learning activity structure (on a higher, top-down level), but rather this structure would emerge from the collective behavior of the students (lower level of actual behavior and interactions in the network). Like described by Hummel et al. [18], we used indirect social navigation and collaborative filtering (data mining) techniques to derive the advice. When most peers having the same or similar user profile would have successfully completed B after having completed A (data stored in a transition matrix), it would be most likely that A, B, ... would become the 'standardized' sequence for these students. After passing a certain threshold (certainty of at least 70%, after occurring at least in 100 cases), these formations could be revised and stored within the overall learning design. Similar examples can be conceived for the formation of groups, most popular content to study, et cetera.

We still have to decide what set of (communication) services is needed as well as if these services should be loosely (open interface) or tightly integrated and specified.

E. Effort of Implementation

Decisions have to be made what repository builds the foundation of the solution (for data and information storage and exchange). Furthermore, rules for the design have to be created, e.g. if 10 people use a resource it becomes part of standard library or standard learning path. The importance of resources emerges from their application, similar to the Web 2.0 approach. To allow this identification of resource use, data mining techniques have to be explored.

In order to prevent corruption of a design (representing both a problem and an effort at the same time), we have to ensure that runtime changes do not "mess up" the design altogether. To adequately answer these concerns, we suggest the hybrid approach: Top down and bottom up are integrated. Next to this, it may be difficult to design rules

to decide whether changes have to be propagated to the original designs or other parallel or previous runs. Sometimes a run asks for a change due to unforeseen events.

F.   Barriers to Implementation

When designing or even implementing solutions for the life cycle problem, we need to take into account several aspects. These are of varying nature, scale and importance.

It is not an easy task to decide which changes should result in changes to an original design or alternative (parallel or previous) runs. For example, how would you decide whether a change is a change regarding just this instance or a persistent one? More importantly, what to do with changes to the actual design of the course, i.e. the method, or changes to existing properties? What to do when a learner has already submitted an assignment and the setup of the assignment within the unit of learning is being changed? Likely we can come up with some business rules for these, but they will be generic rules. Currently, some runtime environments even prohibit changes to the actual structure of the unit of learning (such as the method and properties). The runtime environment may, for instance, not allow deleting the content of properties. It will be cumbersome to describe a set of decision and business rules that will work in any architecture. This will be even more difficult when a runtime environment is capable of playing any IMS LD package created in any authoring environment and there is no direct link between the authoring and runtime environments.

Most IMS LD authoring tools available at the moment are not able to use all functions that IMS LD provides. Rather, they are dedicated tools that support a set of specific functions when creating learning designs. All these specific-purpose tools use a graphical representation of the underlying XML structure. These tools are not able to import any random IMS LD package or to transform IMS LD packages into their proprietary visual representation. Some authoring tools are not able to import even their own generated XML format, because they use an internal proprietary format. The question is how to make IMS LD packages exchangeable without losing their original graphical representation. That might need development of a specification for the visual representation. Also, some kind of processing instructions or metadata could be used that allow the authoring tool to recognize IMS LD packages originally created in that particular tool. Even that might not guarantee that import will succeed. For example, when a learning design has been created based on a particular template but has been changed in the runtime by adding activities or changing the method, the tool no longer might be able to recognize the template it was originally based on. The authoring tool remains an important part of the unit of learning life cycle because it allows changing and exporting units of learning independently of a different learning management system.

The IMS LD specification is quite open and allows extension by other specifications. This is the way to refer to services required for the course, like chat, forum, mindmap etc. IMS LD only allows declaring that services are required, but it is up to the runtime environment to set up these services. Currently, there is no common set of services used in any IMS LD package when referencing within a unit of learning that a "synchronous conference service" is needed. The learning management system interprets "synchronous equals chat". The runtime system must choose the service according to the explanation or description of the service. The interpretation always leaves a grey area of uncertainty. The runtime dictates the actual usage. That also means that a learning design developed for a particular runtime system, taking into account services available in that specific runtime, might not run in any other runtime environment because that runtime does not support these (exact same) services. The same applies when the unit of learning wants to react on the outcomes of a quiz or exam specified in IMS QTI [11]. At the moment it is not clear how properties of the IMS LD and IMS QTI specifications are related to each other.

VI.   RESULTS OF WORKGROUP USABILITY AND UTILITY I: IMS LD AND TEACHING PRACTICE

(Authors of this section: Michael Klebl and Michael Derntl in cooperation with Nils Faltin and Michele Dicerto)

A.   Problem Statement

Starting from being highly innovative, IMS LD as a technology still has to make its way to everyday practice in technology-enhanced learning. The problem statements subsumed under issues of usability and utility stand for one general assumption described by theories of technology adoption and diffusion: In everyday life, people interact with artifacts, not with technology. In order to attain a large and significant impact beyond research and development, technology has to be implemented in marketable products like tools and applications, which prove their utility in real life situations [20].

Considering IMS LD as a technology, its acceptability can be described in terms of practical acceptability as well as in terms of social acceptability [21]. Focusing on practical acceptability, the impact of interoperability standards is influenced by factors of technical scope, expressiveness and quality, as well as, of course, by the effects of networks and critical mass (cf. [22]). However, besides technical and economic factors, and given social acceptance, usefulness is the key factor for the integration of technology in everyday life. Usefulness can be described in terms of usability and utility (cf. [23]). Utility relates the functionality of a system to the needs of users. The acceptance of a technology depends on the benefits people gain from its use. These benefits should not be considered as purely functional and rational. Affective and emotional benefits like status and enjoyment also foster the adoption of technology. Usability then relates functionalities to the interaction of humans with technical systems. Usability determines how users can actually make use of functionalities. Usability of tools and applications in its various facets (like ease of use, learnability, task efficiency, but also hedonistic quality) causes utility and allows for the perception of benefits from a technology. However, usability of tools for teaching and learning has to connect to the everyday practice of teachers and learners, employing terms, symbols, metaphors, processes and interactions from the field of application. Starting from these considerations, we define usability matters as a first key problem.

IMS LD has not proven its usability and utility in real life situations on a large scale yet, and if so, the wider community of educators concerned with technology-enhanced learning was not reached and convinced by reports and publications on the results [24, 25]. Hence, we consider communication to practitioners and stakeholders in education beyond the discussion within the scientific community related to IMS LD to be the second key problem.

B. Influence Factors to the Problem

The entire workshop group formulated major factors that influence the stated problem before our separate working group discussed the challenge and developed solutions. These influence factors gave momentum to the discussion. Based on theories of technology diffusion and adoption (cf. [20, 26]), the influence factors can be summed up to five facets of technology dissemination (portrayed in alphabetical order):

Critical mass: Diffusion and adoption of standards for technical interoperability depend on the widespread usage of both tools and content conformant to those standards. There is a reciprocal effect of critical mass similar to the progression of diffusion and adoption of communication technologies: The more people use IMS LD, the more attractive this technology becomes. Hence, the formation of further projects that focus on the user perspective of IMS LD will add to the dissemination, even more, if these projects cover a wide range of areas of application. Still, a key component in these projects to foster IMS LD should be that tools, and especially content produced and employed here, are oriented towards reuse and exchange.

Technology maturity: A technology like IMS LD can be considered as matured, if both layman and experts are able to use it. However and just like with other innovative approaches to technology-enhanced learning, research and development of IMS LD is primarily driven by science, not by the idea of service. While the notion of science is to increase knowledge by exploring the edges of human understanding and cognition, a service-driven approach towards IMS LD should focus on the benefit of everyday practice. We consider a service-driven approach to be the provision of marketable products to end-users. IMS LD is still technology at the edge, not state of the art. Furthermore, the thus far science-driven advancements in IMS LD, opposite to service-driven developments, lead to its application mainly for innovative educational scenarios, whilst the support for basic learning scenarios is not in the focus of efforts (cf. [24]). We differentiate between basic scenarios, which are everyday teaching scenarios that are commonly applied, and innovative educational scenarios, which are new developments not commonly practiced such as a competency-based educational approach. Focus should be placed on basic scenarios and how IMS LD can express these and make them available. Otherwise, the impression might appear that IMS LD is too complex and too sophisticated for everyday use.

Users' Acceptance: The intention to use a technology and the subsequent usage of that technology depend on various factors. The needs and preferences of individual users are highly important. Hence, the dissemination of tools and applications for IMS LD is influenced by common needs and preferences of teachers. These dispositions to expecting a benefit from the use of IMS LD-related tools and applications vary in different areas of education and for different roles that educators take. Therefore, it is essential to define and investigate target groups, who have their specific approach and acceptance factors for IMS LD.

Users' cognition and action: The usability of tools and applications depends mainly on their being fit for purpose. Hence, the consideration of how users act when they are performing tasks that are to be supported by IMS LD, and what cognition regulates their action will be essential for the diffusion and adoption of IMS LD. This relates to the mental concepts that instructors have when planning and implementing instruction. Questions to be asked in this regard are: Do the IMS LD concepts acts and activities support and guide the actions of planning instruction, or do instructors approach the instructional design task with different concepts? These questions also concern the visualization of elements in IMS LD (basic building blocks such as roles and activities). The question is how to represent the IMS LD concepts, especially the different layers of a learning design, i.e. play, act, activity (taxonomy of an activity tree). The question is also whether users understand the navigation within an activity tree (the most common way of representing the learning design), or if they require a simplified view on the learning design that reduces complexity.

In order to explain users' cognition and action, there are two aspects to consider: First, teachers, like other professionals, act on the base of tacit knowledge, i.e. on pedagogical assumptions not necessarily expressed by theories of instructional design but informed by (personal) experience (cf. [27]). Second, and again as for other professionals, educators become proficient practitioners in a long course of formal training and informal learning. If IMS LD could be related to and integrated in teacher education, then IMS LD and relevant tools have a greater chance of being used in teaching practice.

User Requirements: To facilitate true innovations, sometimes there is a need to disregard user requirements in order to think out of the box and to transcend everyday practice. However, for successful technology dissemination and adoption user requirements are essential. For instance, most development process models in engineering disciplines regard analysis of user requirements as one central starting point. For IMS LD, the most important user requirements concentrate on the integration of both editing and runtime functionalities in learning management systems. IMS LD formally describes all elements of a learning situation and describes the relations between the elements. Because of this comprehensive and formal description, IMS LD is in the centre of a learning scenario. Thus, the benefit of IMS LD is hard to communicate, if IMS LD tools and runtime environments are an add-on to the established platforms for technology-enhanced learning. The users don't notice a difference because they are still working with the same platform as usual. Users may not know what to do with an IMS LD add-on or may not notice the benefit of using IMS LD as nothing has changed in their view. The goal would be to bring the best features of IMS LD to the foreground and advertise them. Furthermore, both editing and runtime functionalities in learning management systems have to provide for adaptation and

localization[10]. There is a need to allow creating specific appearances and experiences for learning scenarios based on IMS LD related to the target group of learners, to learning objectives, and to content. For instance, IMS LD does not specify how style information is to be carried in the unit of learning and to be applied within the runtime environment. The danger is that the runtime systems impose their own style even though a localized style of depicting the unit of learning is preferred.

C. Goal Statement

Based on the thorough discussion of the problem statement and the influence factors, our working group decided to focus on the perspective of the users utilizing IMS LD. Considering users' requirements, users' acceptance as well as users' cognition and action, this focus led to a two-stage goal statement:

The main goal is to enhance professional development of teachers by improving IMS LD tools in usability and utility. The second goal is to provide better education for students by having improved teachers' expertise.

The main goal explains usability and utility of IMS LD as a mutual process. On the one hand, there is a need to design tools and applications for IMS LD matching users' requirements, so that they integrate seamlessly and effortlessly into the everyday practice of teachers. This way usability and utility of IMS LD is determined by needs and preferences of educators. However, on the other hand, the everyday practice of teachers is going to change if supported by educational technology. This way, IMS LD requires mental change, rethinking and modifications in everyday practice, at least as evolutionary and gradual learning. Both lines of development in the implementation of IMS LD, i.e. development of tools and applications as well as individual development of teachers' proficiency are closely interconnected.

Advancements in the everyday practice of teaching that are facilitated by IMS LD result in new requirements for tools and applications and vice versa. Since IMS LD influences the process of educational planning und instructional design, the implementation and dissemination of tools, applications and content relies on the professional development of teachers. IMS LD has the potential to add to the professional development of teachers because it shifts attention towards pedagogical methods and it offers a systematic structure along which to plan and visualize instruction. A prerequisite is that adequate tools, applications and content are available.

However, change in the practice of teaching and learning facilitated by educational technology is not of value in itself. Enhancement of the learners' experience is the intention where any innovation in education should be directed to. Common wisdom has it that learners may benefit from the use of technology in education. But, it is not the technology itself, since only adequate methods of teaching will foster learning [28]. For IMS LD, we

therefore consider improved teachers' expertise to be essential for better education.

D. Solution Description

After an analysis of ways and means to advance towards the stated goals, our working group agreed to propose further research and development activities with regard to usability and utility of IMS LD-related tools and applications. However, these activities in research and development are supposed to focus on practice, application, and impact rather than on theoretical foundations of both pedagogical and technical aspects. To facilitate the implementation, the group devised a number of concrete activities ranging from multiple small scale projects to complex programs.

Research Program on Educators' Proficiency, Cognition and Action related to IMS LD: In order to bring IMS LD to the everyday practice of educational experts in different areas of education and training in a way that both educators and learners benefit considerably, it is indispensable to comprehend the practice of educators thoroughly. This comprises educators' proficiency, cognition and action, which inform and control the design of learning experiences, e.g. while preparing lessons, developing learning environments or guiding students through learning scenarios. How could IMS LD be used to support these design processes? With regard to a cognitive level, this is connected to the learning biography of teachers from novice to expert; it is indispensable to understand the growth of educational expertise. The understanding of how teachers act on the base of tacit knowledge will give insights on how IMS LD and related tools add to the process of teachers' proficiency.

This would be best framed as an interdisciplinary, multi-institutional research project covering three years time, e.g. a Specific Targeted Research Project (STREP) in the 7th Framework Programme for Research and Technological Development of the European Commission (FP7).

Timeline-based representation of activities in IMS LD: Flowcharts are a common way to represent activities in IMS LD and to allow their graphical aggregation to a learning design. Flowcharts document a process flow quite expressively; yet, they lack an immediate representation of time. Other visualizations of processes, like Gantt charts, establish a timeline in order to better represent scheduled events. Since schedules are often important for the design of a course, there is a need to develop graphical representations for IMS LD that comprise a timeline, time limits and targeted dates. In addition to the provision of a tool for designing units of learning, this representation would help to communicate with learners about the learning scenario. This development could be well undertaken within current projects on IMS LD.

Unknown ways of visualizing IMS LD: The activity tree, which was inspired by the object tree, is a simple way to visualize IMS LD. However, this representation is owed more to the structure of XML documents (IMS LD units of learning) than to the requirements of the users. Process charts like flow charts and Gantt charts are taken over from process modeling, but are still not widespread amongst teachers. Hence, there is an opportunity to investigate unknown ways of visualizing the structure of a

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[10] With the term "localization" we refer here to the easy and quick adaptation of terminology to different educational settings. For instance, vocational training users might be familiar with the term "roles" as defined in IMS LD, while in higher education, the term "roles" may not be appropriate and be swapped for another term. A localization file would keep track of the local terms that are matched to the IMS LD terms.

learning experience denoted in IMS LD in a few creative, divergent and experimental projects. An idea to realize this is to work with an arts academy.

An additional facet of this aspect is the technical terminology used by IMS LD. Practitioners with different backgrounds may use different terms for concepts modeled in IMS LD, or may have different views on the meaning and relationships of these concepts (e.g., method, activity, activity structure, environment, learning object, role, etc.). Previous research (e.g. [19]) has suggested that this gap between the language of practitioners and the terminology of the specification may pose entry and usage barriers and thus hinders the widespread adoption of IMS LD. Alternative forms of visualizing or localizing IMS LD units of learning might be successful in overcoming this gap by abstracting from technical details (e.g., by employing different metaphors) and providing more user-centered interfaces to the specification and its artifacts.

These projects could be well assigned to several students for a thesis in graduate studies or to PhD students.

Marketing campaign for IMS LD: As already stated, the wider community of educators concerned with technology-enhanced learning either hasn't been reached or hasn't been convinced by the notion of IMS LD. There are common misunderstandings on IMS LD, like the idea of IMS LD being restrictive and fostering teacher-centered instructional design as mentioned in the analysis for the integration of IMS LD and Moodle [29]. Hence, there is a need to start a marketing campaign in order to bring the notion of IMS LD, with its focus on activities of learners and teachers, and the notion of IMS LD as a modeling tool similar to CAD software in engineering (data chain from the sketch to the implementation, and in order to depict the production chain of an educational measure) to different areas of educational practice. This marketing campaign has to reach vendors of learning management systems and content providers beyond academia and should rely on networking within as well as beyond Europe.

This marketing campaign needs a strong association of stakeholders interested in the dissemination of IMS LD and adequate funding.

E. Effort of Implementation

For the advocated activities ranging from a complex research program to several independent thesis assignments related to IMS LD, the following efforts of implementation can be estimated:

1. Research Program on Educators' Proficiency, Cognition and Action related to IMS LD: 3 person-months for identifying an adequate call and gathering a consortium; 9 person-months for the preparation of the project proposal; total budget for 3 years: €4 million.
2. Timeline-based representation of activities in IMS LD: 2 person-months development (integration in existing authoring tools and runtime environments); 6 person-months pilot evaluation (with different user groups).
3. Innovative ways of visualizing IMS LD: 2 PhD theses: 24 person-months each; several (up to 7) master theses: 6 person-months each.

4. Marketing campaign for IMS LD: 6 person-months for gathering partners in an association and fund raising; marketing campaign on a budget of approx. €100,000.

F. Barriers to Implementation

In order to launch the advocated activities some, obstacles have to be overcome. Our working group identified the following main barriers:

Research Program on Educators' Proficiency, Cognition and Action related to IMS LD: Here, a suitable project call has to be identified. Probably, Information Society Technologies (IST) does not represent the best thematic priority within the European Commission Seventh Framework Programme. Possibly this proposed research program rather corresponds to the topics within the Socio-Economic Sciences and the Humanities Programme.

Timeline-based representation of activities in IMS LD: Since the required knowledge appears to be already within reach, this activity should concern existing projects. For the realization of this development, the roadmaps of current projects concerned with developing tools for IMS LD need to be aligned towards this goal.

Innovative ways of visualizing IMS LD: Smaller projects to investigate this topic could easily be initiated. However, PhD students need funding, and scholars need to be convinced and committed to assign matching master theses. A single academic institution could start this activity. However, a both competitive and coordinated approach between multiple institutions would enhance the outcome.

Marketing campaign for IMS LD: It is not quite apparent, which institution would take the lead role for this activity. Currently, organizations from academia like the Open University of the Netherlands or standardization bodies like IMS Global Inc. do not have great interest in disseminating IMS LD. Therefore, a major sponsor from industry could help to get an association and a marketing campaign for IMS LD started. Analogies to different standards such as the ISO9000 family of standards could be taken as reference points to indicate how agenda items relating to IMS LD dissemination can be placed on universities' agendas.

VII. RESULTS OF WORKGROUP USABILITY AND UTILITY II: JOINING TEACHERS' AND LEARNERS' REPRESENTATIONS OF LEARNING DESIGNS

(Authors of this section: Dai Griffiths and Davinia Hernández-Leo in cooperation with Tom Boyle and Amir Wasim)

A. Problem Statement

Our working group has formulated the following problem statement: "The representations of the teachers' designs are not consistent with the representations of learners' designs."

From some perspectives this is not a problem. There is often a difference between authoring views and user views, for example, in most programming tasks. If the development of a unit of learning were equivalent to a programming task, then there is no problem with having different representations. A (pedagogic or technical)

expert designs a learning activity, which is then delivered to the learners so that they can follow the steps, which the expert has determined. This will move the learner on to a new understanding.

In some contexts, however, it is important that the learner either

1. understands the reason why a particular activity has been proposed, and how it fits with other activities, or

2. participates with the teacher in determining the learning activities to be followed, for example, by choosing alternatives, or by participating in the design process itself.

Point 1) has not been properly explored in the current IMS LD approaches and tooling. Until the moment, many efforts have been devoted towards exploiting the potentials of IMS LD as an instrument for teachers or designers but not explicitly for learners. This issue is motivated by the following sub-problems of the global problem statement:

- The process followed and reasoning used by the teacher when creating the learning designs is not captured in the final design and therefore is not presented to the learners. This is a general problem of instructional design but can also partially be attributed to IMS LD because it only contains limited elements for description.

- The way of visualizing the learning designs may depend on the user role and their objectives. Teachers need to be supported during the authoring, but they also have to fulfill a teacher role at runtime. For each role, different visualizations may prove useful. The support required may be also different depending on the teacher's background (e.g., humanistic vs. science background resulting in a preference for text or diagrams, respectively) and the educational context (high school vs. Open University).

- There is some research on representations for teachers (see, for example, [12]). However, further investigations on learners' representations and their consistencies with teachers' abstractions are needed.

- Learners should be guided through the learning process. The visual guidance and abstract representations provided to learners may depend on the pedagogical ideas behind the learning design.

- The activity tree, which is commonly used in current IMS LD players to depict the learning design, may not be the most appropriate way of representing designs. Learners don't like it, but there is currently no alternative or better way.

Point 2) has to do with what we refer to as 'participatory' design. In view of this, we can expand the problem statement to the following:

Participatory learning design is an important strategy in some pedagogic perspectives, but it has so far been hard to work with IMS LD using this approach. This is due to two reasons:

- IMS LD editors are hard to use, for teachers and for learners.

- The representation of units of learning at runtime is quite different from the representation at design time

due to the separation and differing setup of design and runtime environments.

Progress is being made on the ease of use of IMS LD editors. It remains to be seen if the current level of improvement is sufficient, and whether achieving the needed balance between expressivity of a learning design and usability of the editing software proves problematic. Little or no work is being done towards representations of learning designs intended for teachers[11] that are consistent with those intended for learners, or indeed full convergence of the two views.

We note further that this discussion is closely related to some of the ideas recently discussed by Sue Bennett of Wollongong University [30]. In the case of the Learning Activity Management System (LAMS[12]), one of the interesting uses of the application was for teachers to be able to discuss learning activities with learners, and to plan future activities with them. As LAMS is inspired by IMS LD, we take this as an indication that a participatory approach to IMS LD is not unreasonable.

B. Influence Factors to the Problem

The influence factors are the same as the ones described in section VI.B since the group worked on the same problem. An additional influence factor is the degree to which it is possible to satisfactorily balance authoring and expressivity in IMS LD.

C. Goal Statement

The goal is to bring the representation for teachers and learners into a single context, and to make the design understandable to learners. This goal can be achieved by transferring ideas captured within paper documents into creative formal representations. The teachers decide on the representations to be shown to learners. This is contrary to the general representations that current players employ, such as the activity tree.

By "creative uses of formal representations", we are referring to two ideas. First, we refer to working with learners on the planning of learning activities. Second, the representations could also be dynamic. In the latter case, the representation takes into account the pedagogical ideas behind the design and accordingly adapts to learners.

One simple way to engage learners with the learning design is to actually use paper documents. The printer can be seen as a player, creating a "graphic" representation of the learning activities to be carried out, formatted according to the needs of the teachers, the learners, and the unit of learning.

This goal is also relevant to teacher education. The representations can get teachers to think about what they design. To achieve this we need a representation, which allows the teacher to view the learning design from the perspective of a learner in the same way as viewing the learning design from the perspective of the instructor.

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[11]   In the original problem statement it says "teachers' designs are not consistent with learners' designs". We interpret this as meaning both a) representation of designs intended for both teachers and learners, and b) learning designs created by both teachers and learners. The latter is a special case of the former, and a more complex case because of the challenges of designing usable authoring interfaces.

[12]   http://www.lamsinternational.com/

The big picture is that we have a formal representation of learning designs, and we would like to be able to make wider use of this than orchestration of learning activities within a learning management system.

D. Solution Description

The teacher has an idea or intent on how to structure the instruction. S/he goes through a complex and iterative authoring process, constantly refining, making the instructional idea explicit. When the teacher is satisfied with the representation of his or her idea, s/he creates an IMS LD unit of learning and places it into the player or learning management system. Teachers and learners are given access to this orchestration. Inside the player, the teacher recognizes his or her instructional intent both in the design representation and in the orchestration of the unit of learning. S/he recognizes the context for the orchestration. The teacher knows why certain activities and resources are appearing because s/he has developed the instruction over a set of iterations. The player orchestrates the activities by parsing the teacher's design decisions and supporting the learners' and teachers' actions. The learners, on the other hand, only see the results of the orchestration, as they are revealed. The learners lack the original development context that the teacher had, meaning that they don't see the reasons why activities were chosen and placed in the sequence at hand.

Functionality is required which enables the learners to see the intent behind the unit of learning's resources and activities. Providing this information could at the same time be useful to other teachers, who wish to reuse and adapt the unit of learning for their own teaching. How should the unit of learning as a whole be represented to the learner? First ideas, how this may be achieved, are presented below.

- Giving learners a choice and/or control over the representation of the unit of learning in the forms of:
  o A printed output
  o Runtime system presents the teacher's ideas
  o A running commentary that is part of the unit of learning
  o A combination of views
- "Intelligent parsing": this would merge choices of learners and choices of teachers regarding wanted instructional elements. The runtime system automatically, i.e. "intelligently", parses the choices into the orchestration creating a flexible setup of a unit of learning.

Further, we can consider if the learner can be directly involved in the design of the learning activities (when this is pedagogically appropriate). An exemplary use case where this would take place is in teacher education. This would require an environment where the learners and teacher(s) can design together. To keep things simple, this suggests an environment where the design-time and runtime systems have similar or identical interfaces. On the other hand, we remember that the reason that the interface is different at design time is that there is more complexity at this stage. The variety of the available options at design time is higher than the variety of the options available at runtime. If the interfaces are to be the same then this may mean a sacrifice of functionality and available choices as a compromise between design and runtime interfaces is established.

E. Effort of Implemenation

The conceptual side of a learning design - how does the design look to the learner – is a whole research programme in itself. Much of this could be done without using IMS LD, using representations on paper, or stick-on components for existing learning systems, or a generic drawing application. The aim would be to find out what kinds of representations are useful to whom in what circumstances. For instance, a mathematical representation could be useful to teachers, but not to learners. Certain types of graphical representation could help learners most.

There are generic issues concerning the runtime environment as the choice of representation has a lot to do with the runtime system used. At present, the only candidates of runtime systems are CopperCore, SleD, and .LRN. Neither of these have the flexibility we require. The TENCompetence project is planning to create a substitute for SLeD, namely, the AstroPlayer. This player may become relevant for the considerations made here. To give us the flexibility we need, the runtime would need to be configurable so that visualizations can be adapted according to the teachers' intentions and learners' needs. A possible solution may be that the author would include configurable widgets (or similar) in the interface. The problems associated with having a joint design and runtime interface are discussed by the "Life Cycle" group contained in this report.

F. Barriers to Implementation

We divide the barriers to implementing the proposed solution into three groups: conceptual barriers, barriers of the technological environment, and barriers related to the present infrastructure.

- Conceptual barriers between teachers and learners.
- Teachers' intentions are always richer than their representation
- Teachers education and culture can be resistant to making their planning more transparent, or to sharing control with learners
- Teachers do not only design in the abstract for "generic" learners, they also design for particular individuals that they are working with. IMS LD is set up to represent abstract units of learning because actual persons that claim the roles are never specified during design time but only when the unit of learning is prepared for a run. Only when the unit of learning has been prepared for a run, it becomes a specific unit of learning. Before a unit of learning is instantiated this way, the unit of learning may be abstract.
- Different types of application areas and contexts, e.g. institutions may have different needs and create different barriers to adoption.
- What works in one community or country may not work in another, for cultural or pedagogical reasons.
- Technological environment: Barriers in this group are more general and more difficult to change because they are more tied to the social environment or institutions' constraints (what teachers and learners prefer) and how familiar teachers are with computers.

- Learners' environments include lots of channels and services not considered by teachers' contexts. This means learners' environments may include technologies, such as mobile devices, serving manifold needs. Learners may use different tools that cover a similar range of functionality, and teachers may not even be aware of that. The question for teachers then is which tools to select within the unit of learning to support learning? Those that teachers prefer or those that could be selected by the learners?

- The technical infrastructure is usually run by institutions, not teachers. Teachers do not necessarily have control over the decision to introduce new technologies if they would like to integrate them in their units of learning.

- Present IMS LD infrastructure: Barriers in this group relate to the current situation regarding the available learning design tools.

- Current infrastructures are not sufficiently attractive and useful. As a result, there is little motivation to get into the runtime – practical barriers (see technical complexity).

- It is still technically quite complex to set up and run a unit of learning (although much easier than it used to be).

- How teachers and learners use an editor together and design together – current tools are not necessarily set up to allow this type of design.

ACKNOWLEDGMENT

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