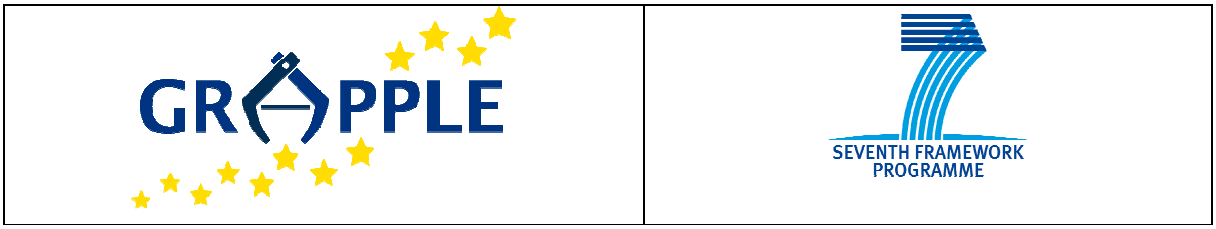

GRAPPLE

D5.3a Version: 1.0

Analysis, modelling and implementation of IMS-LD Units of Learning

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Abstract: This deliverable describes a full and solid set of Units of Learning developed with IMS Learning Design following adaptive learning scenarios. These Units of Learning have been modelled to show specific features of Adaptation, which are also identified in research carried out in WP3. In addition, this is the first of three deliverables that will analyse this specification, and identify shortcomings and possible ways of improvement in the specification. This technical and pedagogical report will include general purpose modifications but also extensions and changes focused on Adaptation.

Keyword list: IMS Learning Design; Unit of Learning; Modelling; Learning specification; Adaptation

Summary

Work Package 5 deals with packaging and learning standards to address the needs for expressing Adaptation in learning materials and processes by means of existing specification frameworks. One of the WP5 tasks is to look at a number of widely accepted open source LMSs (like, i.e. Moodle, Sakai, and Claroline) and commercial LMSs (i.e. learn eXact, IMC Clix) and to work on an integration with GRAPPLE focused on adaptive features.
In addition, WP5 also works with the learning specification IMS Learning Design, to explore how adaptive learning scenarios can be modelled with it and what shortcomings and gaps between conceptual modelling and the specification exist.

IMS Learning Design (IMS-LD) is a current asset in eLearning and blended learning, due to several reasons:

a) It is a specification that points to standardization and modelling of learning processes, and not just content; at the same time, it is focused on the re-use of the information packages in several contexts;
b) It shows a deeper pedagogical expressiveness than other specifications, already delivered or in due process
c) It is integrated at different levels into well-known Learning Management Systems (LMSs)
d) There is a huge amount of European research projects and groups working with it, which aims at sustainability (in academia, at least)

Nevertheless, IMS-LD is roughly an initial outcome (be aware that we are still working with the same release, dated on 2003). Therefore, it can and must be improved in several aspects, i.e., pedagogical expressiveness and interoperability. We concentrate on Adaptive Learning since this concept is a core aspect which the specification is built upon. Adaptation can also be used to improve the specification significantly. Adaptation makes personalised learning itineraries, adapted to every role, to every user involved in the process, and focuses on several aspects, i.e. flow, content and interface.
In order to achieve these goals we carry out a three-phase analysis that will be reported in three different deliverables:

a) D5.3a is focused on the analysis and modelling of a number of learning scenarios with IMS Learning Design. These scenarios show several features of Adaptation that have been discussed in the overall project and in other WPs (i.e., WP3 and Conceptual Adaptation Models, WP7 and Integration); in this deliverable we describe a taxonomy of pedagogical features and strategies and we also analyze the different types of Adaptation that IMS Learning Design could support;
b) D5.3b shows a new step, progressing from Units of Learning modelled in WP5.3a to re-usable templates and use cases that can be used elsewhere
c) D5.3c shows the conclusions and suggestions of improvement and modification needed to make IMS Learning Design more adaptable. Out of the results and outcomes coming from the first two deliverables, D5.3c shows a next step in the specification

This three-step process analyzes and reviews how IMS-LD models adaptive learning: we define, classify and explain several types of Adaptation and we approach them with the specification. A key part of this step is the actual modelling of UoLs showing adaptive learning processes. We highlight pros and cons and stress drawbacks and weak points that could be improved in IMS-LD to support Adaptation. As an additional result, general learning processes will get some benefit out of the process.

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List of Acronyms and Abbreviations

ALE	Adaptive Learning Environment
GRAPPLE	Generic Responsive Adaptive Personalized Learning Environment
IMS	IMS Global Consortium
IMS-LD	IMS Learning Design specification
LMS	Learning Management System
CAM	Conceptual Adaptive Model
CP	Content Packaging
SS	Simple Sequencing
QTI	Question and Test Interoperability
LIP	Learner Information Package
SCORM	Sharable Content Object Reference Model
ADL	Advanced Distributed Learning
SCO	Sharable Content Object
VLE	Virtual Learning Environment
RTE	Run-Time Environment
SN	Sequence and Navigation
UoL	Unit of Learning

1 Task and Deliverable Description

T 5.3 Modelling with and Extending IMS-LD (ATOS, OUNL, UCL, UCAM, GILABS)

Analysis and modelling of adaptive IMS-LD Units of Learning showing adaptive features with identification of gaps between the theoretical approach and the practice. In addition, this task will carry out an implementation of a complete set of use cases and templates showing the different findings and creations. Concrete adaptive learning material will be converted between LMSs so that they can be used in evaluation experiments in WP9 and WP10. Training material for importing, exporting and converting adaptive learning material will be prepared for use in WP11.
The study of IMS-LD may lead to proposals of extensions and modifications of IMS- LD, other specifications and some relevant LMSs to support the best implementation of adaptive features. When deemed appropriate we will start negotiations with standardization bodies and supporting institutions.

D5.3a Analysis, modelling and implementation of IMS-LD Units of Learning (ATOS, M18)

A full and solid set of Units of Learning developed with IMS-LD will be modelled to show specific features of Adaptation, expressed in CAM, and to identify shortcomings and possible ways of improvement in the specification. In addition, a rich repository of use cases and templates will be developed (M24), ready to use by end users (authors) dealing with adaptive learning, and needing to integrate their adaptive learning material in an LMS.

D5.3b Analysis, modelling and implementation of use cases and templates with IMS-LD (ATOS, M24)

Following up the work in D5.3a, a rich repository of use cases and templates will be developed, ready to use by end users (authors) dealing with adaptive learning, and needing to integrate their adaptive learning material in an LMS.

D5.3c Extensions and modifications of learning specifications and LMSs focused on adaptive learning (ATOS, M30)

Based on D5.3a and D5.3b input a set of extensions and modifications will be defined and delivered, very much focused on improving the expressive power of IMS-LD for adaptive learning

2 Introduction

IMS Learning Design is an expressive specification that steps into the eLearning panorama to build a bridge from pedagogic face-to-face models to eLearning and blended learning frameworks. IMS-LD allows teachers and other stakeholders to model regular lesson plans, and transform them into Units of Learning (UoLs) to be run in a certain online platform. UoLs are packed as learning objects in ZIP files and they can be re-used by other users and they can be executed by any IMS-LD complaint player.
In this deliverable we examine how to represent adaptive and adaptable Units of Learning with IMS Learning Design in order to model different types of Adaptation. Based on a literature study, a distinction is drawn between eight types of Adaptation that can be classified in three groups: a) the main group, with interfaced-base, learning-flow and content-base; b) interactive problem solving support, adaptive information filtering, adaptive user grouping; and c) adaptive evaluation and changes on-the-fly. Taking the various possible inputs to an eLearning process (i.e. user, teacher, set of rules), we analyze why and how to represent learning scenarios with IMS Learning Design.
This process will establish the ground floor to the forthcoming steps (and deliverables) scheduled in this Work Package, i.e. a) Units of Learning (in D5.3a), b) Templates and Use cases (in D5.3b), and c) Extensions and modifications (in D5.3c), which will lead to a comprehensive report that will aim at improving how IMS-LD models Adaptation.

3 Connection to other Work Packages, Tasks and Deliverables

Taken from the GRAPPLE DoW, the following diagram (Figure 1) shows the interdependency between the different GRAPPLE WPs.

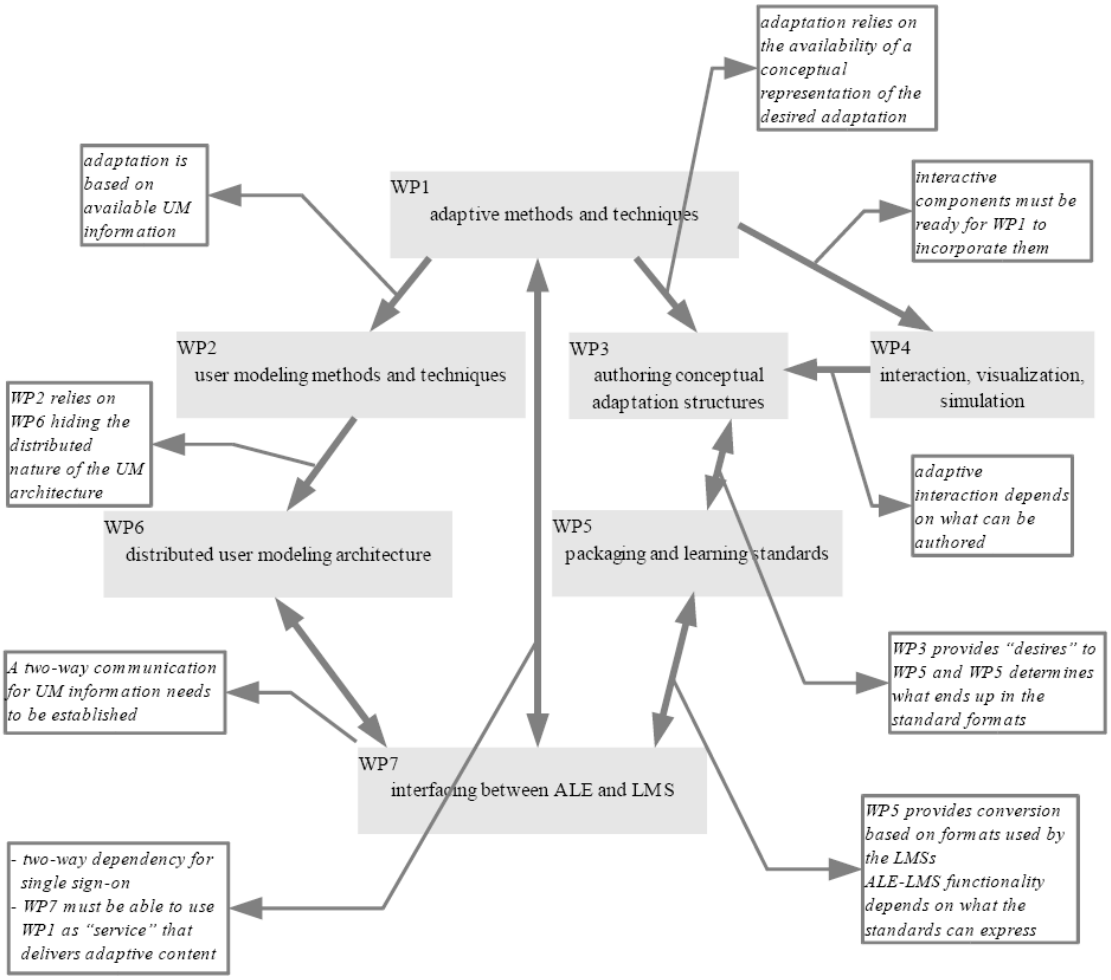

Figure 1. Interdependency between the different GRAPPLE WPs

As presented in the diagram, WP5 is mainly connected to WP3 and WP7. In general, the focus is on matching the needs for expressing Adaptation in learning materials and processes (essentially CAMs created in WP3) within the capabilities and properties of existing specification frameworks like IMS-LD, possibly with extensions, so that these standards can be used within the Grapple framework (WP7).

D5.3a is closely linked to D5.1, which shows conceptual basis of Adaptation.

The interaction between WP5 and WP3 results in an understanding of the various inputs, roles, interactions, Adaptation methods & techniques which are feasible within the limits of the explored standards.

The interaction between to WP5 and WP7 results in the implementations done by WP7 of the theoretical LMS-based conversion models described by WP5.

Specifically, deliverable D5.3, including all three phases (D5.3a, D5.3b and D5.3c), demonstrates possible use cases where adaptive IMS-LD Units of Learning showing adaptive features. In this sense it is mainly connected to D3.2 and D7.4.

"D3.2a. The definition of a concept relationship type tool" is a research report investigating the definition of the components that constitute the building blocks of a concept relationship type. Its main input to deliverable 5.3a is the determination of the kinds of CRTs that can be expressed in the GRAPPLE environment and the exchange formats to be defined in WP5. Through the analysis we bring in this report, deliverable 5.3a performs the matching to the available LMS and IMS-LD, which will feedback into WP3's deliverable 3.3b.

Last, D5.3a relates to WP7 and, specifically, to “D7.4b.Operational infrastructure - second prototype”, which will likely use the results and considerations outlines by the analysis provided by deliverable 5.3a in the implementation of the second system prototype.

4 Taxonomies about learning

In order to support the learning view on Adaptation inside IMS Learning Design we use two taxonomies which describe learning categories and strategies. They will be useful to focus the Units of Learning, Templates and Use Cases that we develop within the analysis of this specification; furthermore, they will draw a theoretical framework where our production is based upon. In the description of the scenarios (Section 8) these categories will define the pedagogical layer which supports the technical coding of UoLs. This approach will help us to keep a pedagogic strategy of modelling, against the simple challenge of a technical approach. Since the modelling of Adaptation with IMS-LD is a quite difficult task, there is a need for not loosing the learning part and the pedagogic bottom line. The taxonomies are:

a) Learning categories by Bloom (revisited by Anderson) (Anderson & Kratwohl, 2001; Bloom, 1956), where the learning process is described via actions (verbs)

Learning category	Keywords	Examples
Remembering (Can the learner RECALL information?)	Recognising, listing, describing, retrieving, naming, finding, memorising, reproducing.	Recite a policy. Quote prices from memory to a customer. Name the safety rules.
Understanding (Can the learner EXPLAIN ideas or concepts?)	Interpreting, summarising, paraphrasing, classifying, explaining, generalizing, exemplifying.	Explain in one's own words the actions of a character in a story. Devise examples for quadratic equations that have no real solutions.
Applying (Can the learner USE information in another familiar situation?)	Implementing, carrying out, using, executing.	Use a manual to calculate an employee's vacation time. Apply laws of statistics to evaluate the reliability of a written test.
Analysing (Can the learner DIFFERENTIATE between constituent parts?)	Comparing, organising, deconstructing, attributing, outlining, finding, structuring, integrating.	Classify the actions of the characters in a story. Compare the graphical and the analytical representation of quadratic equations.
Evaluating (Can the learner JUSTIFY a decision or course of action?)	Checking, hypothesizing, critiquing, justifying, experimenting, judging, testing, detecting, monitoring, contrasting.	Evaluate a character's actions in a story. Select and justify the most effective solution. Judge the qualification of the candidates.
Creating (Can the learner GENERATE new ideas, products, or ways of viewing things?)	Designing, constructing, planning, producing, inventing, devising, making.	Write about your feelings about a character's actions in a story. Design a machine to perform a specific task.

Table 1 Learning categories by Bloom

b) Learning strategies by (Weinstein & Mayer, 1986) and (McKeachie et al., 1986), where they extract several sub-categories, like cognitive, meta cognitive and resource management strategies

Learning strategies	Examples
Cognitive Strategies (Strategies that help learners to actively process information and structure this information into memory)	Rehearsal Strategies. Elaboration Strategies. Organizational Strategies.
Meta-cognitive Strategies (Strategies that help learners to self-regulate their learning)	Planning Strategies. Monitoring Strategies. Regulating Strategies.
Resource Management Strategies (Strategies that concern the quality and quantity of the task involvement)	Time Management. Study Environment Management. Effort Management. Support from others.

Table 2 Learning strategies

This previous taxonomy is extended in the following table:

Learning strategies	Examples
Rehearsal Strategies Help the learner to remember material using repetition.	Repeating the material aloud. Copying material. Underlining. Mnemonic hooks.
Elaboration Strategies Help the learner to connect what is currently being learned and previous knowledge.	Paraphrasing. Summarizing. Finding examples. Creating analogies. Generalizing.
Organizational Strategies Support the learner in organizing the information she learns.	Selecting the main idea. Diagramming the information. Classifying

Planning Strategies Help the learner to set goals and to structure their learning.	Setting goals. Skimming material. Generating questions.
Monitoring and Regulating Strategies Help the learner to check themselves for knowledge or skills.	Checking attention-focus. Employing test-taking tactics. Adjusting reading rate. Re-reading.
Time Management Helps the learners to organize learning in respect to time.	Scheduling (daily ritual, weekly pattern).
Study-environment Management Helps the learners to develop a setting that is conducive to learning.	Designing a quiet and organized study-environment.
Effort Management Helps the learner to control the effort for learning.	Persisting. Self-motivating with incentives. Self-reinforcing.
Support from others Helps the learner to seek support from peer learners or from instructors.	Establishing a learning group. Maintaining a learning group. Contact the instructor regularly.

Table 3 Learning strategies (extended)

As we said before, in this deliverable, we make use of these taxonomies when modelling Adaptation with IMS Learning Design. In order to provide a meaningful connection we establish the relation between the taxonomies and specific examples in the showcase. In doing so, we describe the theoretical background on learning and the techniques and structures to implement with IMS Learning Design.

5 E-Learning specifications and modelling languages

IMS Learning Design is a quite flexible specification which a designer can model any type of pedagogical approach and strategy with. At least, in theory. We will show how many features and resources used in the specification can be improved, simplified and, in general, changed or extended, to better support learning.

However, at present, IMS-LD seems the most powerful specification to model learning processes, the adaptive ones included. There are many other eLearning specifications (mainly from the IMS Global Consortium) that structure and pack learning content, user profiles, accessibility issues and other features related and with learning flows. However, IMS-LD is the only one that models flexible and adaptive learning flows. In addition to formal specifications, a few learning languages, like i.e. LDL (Martel et al, 2006), E2ML (Botturi, 2006), and PALO (Rodríguez-Artacho & Verdejo, 2004), also describe the learning context and process. They show significant efforts and elaborated notations and languages. However, they are not specifications and their penetration is little, unfortunately. Following, we show some of these quite interesting specifications closely related amongst them.

5.1 CP: Content Packaging (IMS, 2001)

Educational content often needs to be packaged in some electronic form, so as to support efficient aggregation, distribution, management and deployment. Authors of educational materials need tools and technologies to assist them in creating content; learning management system vendors, computing platform vendors and learning services providers want efficient distribution and management of the educational materials created by authors; and students need good deployment and delivery of tools.

To meet these needs it is important that content is packaged in a known structure and file format, with good supporting documentation. IMS Content Packaging meets these needs by describing the contents, structure, and location of online learning materials and defining some particular content types. It enables the author to encapsulate all the required resources, place them in a structure, and add metadata. The user can then describe and package learning materials, such as an individual course or a collection of courses, into interoperable, distributable packages.

Thus, Content Packaging provides a structure that integrates a number of elements. A Content Package can group, for example, LD (Learning Design), SS (Simple Sequencing), Meta-data and QTI (Question and Test Interoperability).

Final Version 1.1.2 of the IMS Content Packaging Specification was released to the public in August 2001.

5.2 LIP: Learner Information Package (IMS, 2001a)

The Learner Information Package is a specification for the records of information held about learners.

It was designed in order to allow records relating to learners and their progresses to be transferred between different software applications and institutions. Version 1.0 of the IMS Learner Information Package Specification was published in March, 2001.

Using LIP a record of all the learner's achievements can be obtained, so LIP information on students' progress could even substitute for paper certificates. Information can also be stored about the learner's preferences, which can help, for example, to support the needs of learners with disabilities. All the information related to learners is stored in an XML file, which uses tags to specify what each piece of information in the record means.

In this way the LIP enables internet based Learner Information systems to interact with the other systems that make up the internet learning environment. It defines a series of packages that can be used to import and export data from an IMS compliant Learner server, so that they can be exchanged with Learning Delivery systems or other Learner Information servers. The Learner server allows the owner of the information to define which part of this information can be shared with other systems. The main structures of LIP are based on accessibilities, activities, affiliations, competences, aims, identifications, interests, qualifications, certificates and licences, relations, security keys and transcripts. LIP can be mapped to IMS Learning Design properties.

5.3 SS: Simple Sequencing (IMS, 2003a)

This specification is used to define rules that determine the learner's path through learning content. Alternative navigation paths through a learning material collection can be defined, which are followed in

response to users actions. It defines a method to represent the intended behaviour of a learning object so that any compliant learning technology will be able to sequence learning activities in a consistent manner.

The Simple Sequencing binding provides a unique namespace which is embedded in the *organization* element of a Content Packaging manifest. Because Simple Sequencing uses the Content Package structure, it is possible to integrate a sequence into IMS Learning Design.

The Simple Sequencing Specification was published in March, 2003.

5.4 QTI: Question and Test Interoperability (IMS, 2003b)

The IMS Question and Test Interoperability specification makes it easier to share assessment information such as questions, tests and results. It provides a standard way to share data defined in XML, so that users can import and export questions, tests and results. The specification supports both simple and complex questions and tests, which are defined clearly and concisely so as to avoid ambiguity. In this way information about questions and about the learner and his or her results can be shared through different learning management systems and different software packages. Authors of assessments can create their own questions, or include questions designed for other IMS QTI users, making it easier to create question banks for reuse on different systems.

Today the IMS QTI specification is implemented in a large number of assessment systems and virtual learning environments. Some of these systems still record the assessment data in their own formats but also allow the user to export or import data in a QTI format, to provide portability to other systems.

IMS QTI aspires to being pedagogically-neutral, enabling users to develop online assessments with a range of question types and flexibility, and a number of frequently used techniques: multiple choice/response, true and false, image hot spot, fill the blank, select text, elide, drag object/target, order objects, match items, and connect points.

Version 1.0 of the IMS Question and Test Interoperability Specification was first released to the public in June, 2000. In January 2005 Version 2.0 was published, which introduced some significant changes to the specification.

5.5 SCORM (ADL, 2000)

The SCORM (Sharable Content Object Reference Model) is a part of the Advanced Distributed Learning (ADL) initiative strategy. The primary sponsors of this initiative are the United States Department of Labour, Department of Defence and the National Guard Bureau.

SCORM was designed to facilitate moving courses and information from one platform to another and to allow content to be reused in various courses by packing it into modular objects. SCORM is not a specification of the same type as those described above, but rather a model that references a set of published technical specifications, standards and guides. Indeed some of its components are themselves IMS specifications. It aims to ensure that compliant systems will provide reusable, interoperable, durable and accessible content, regardless of the content delivery and management systems used. In this way learning objects can be easily shared between different learning management systems, with the web generally seen as the main means of distributing information.

SCORM represents Sharable Content Objects (SCOs) as structures in XML. SCOs are individual units of learning to be combined to create a course of study, and they should be:

- Durable: electronic resources that do not need to be updated or modified with changing technology.
- Interoperable: resources that can be launched correctly by different Virtual Learning Environments.
- Accessible: resources that can be found when needed. SCOs are linked to a description of their content, making them easier to search for.
- Reusable: are developed only once and used in many courses.

In the SCOs the instructional material and meta-data is packed and can be imported and exported between different VLEs. SCORM documents are technical and specify the functionalities that systems must have in order to be compliant. They do not say how to create good SCORM material or effective e-learning. SCORM works well, but has limitations, because it is principally applicable to the multimedia, self-paced, stand-alone instruction traditionally accomplished with computer-based training. Training guided by a teacher or instructor is not within the scope of SCORM.

As mentioned above, SCORM is not simply a specification, but rather a framework for the web and computer based learning which is defined by guidelines, specifications and standards. These are grouped into three topics: Content Aggregation Model, Run-Time Environment, and Sequence and Navigation (SN). The model describes the creation, deployment and behaviour of the SCOs when running in web-based learning management systems.

SCORM was first released in January, 2000. It has been extensively adopted, with the cooperation of industry, government and academic stakeholders. SCORM 2004 incorporates some modification of the learning flow that make the learning process more flexible.

Although these specifications are not used in Grapple for modelling Adaptation, they are closely related. In fact, some of them are the base for IMS-LD. For instance, the IMS-LD description is embedded in an IMS-CP learning object. In addition, IMS-LD models assessment following the criteria defined by IMS-QTI, as we show in the scenarios in Section 8. Last, SCORM and IMS-CP are two sides of the same coin, since they both pack learning objects in a specific, re-usable structure. Thus, they all are the bottom line which we base on to model Adaptation, as a further step.

6 IMS Learning Design and Adaptation

IMS Learning Design (or simply IMS-LD) (IMS, 2003) is aimed to transform regular lesson plans into interoperable Units of Learning (UoL). This specification is able to use any pedagogical model to get a UoL run-able and editable in an interoperable way. IMS-LD augments other well-known e-learning specifications aforementioned, like SCORM, IMS Content Packaging, IMS Question and Test Interoperability or IMS Simple Sequencing. Furthermore, IMS-LD provides a language to describe the teaching and learning process in a Unit of Learning. It describes among other things the roles, the activities, the basic information structure, the communication among different roles and users; and all these under the pedagogical approach decided by the teacher and-or the learning designer. In this section, we show what is IMS-LD and how it is structured, as well as how it provides Adaptation within the UoLs.

6.1 The IMS Learning Design specification

IMS-LD is able to describe a full learning flow with several elements -such as roles, activities, environments or resources- and features -such as properties, conditions, monitoring services or notifications (Burgos & Griffiths, 2005; Koper & Tattersall, 2005).

The usual life-cycle starts with a lesson plan modelled according to the IMS-LD specification, defining roles, learning activities, services and several other elements, inside an XML document (W3C, 2003) called Manifest (Tattersall et al., 2003). An information package written in IMS Content Packaging (IMSCP, 2001) is used as a container for the resources and links them with the IMS-LD structure. Later, the Manifest is packaged with the nested resources in a compressed ZIP file, meaning a UoL. Several examples available are shown later on.

IMS Learning Design uses the metaphor of a theatrical play to visualize how to model Units of Learning. A play is performed by a number of actors, who may take up a number of roles at different times in the play (Figure 2). Similarly in learning design a learner can take up different roles at different stages of a learning process. At the end of each act the action stops, all the learners are synchronised, and then a something new can begin.

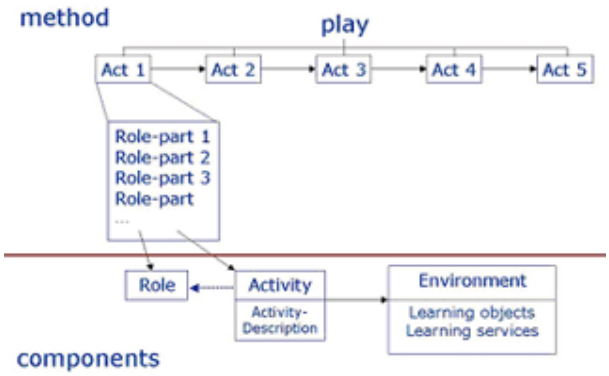

Figure 2. Diagram of a play [Source: Olivier, Bill, 2004]

6.1.1 Unit of Learning

Quoting (Koper & Tattersall, 2005) "*A 'Unit of Learning' refers to a complete, self-contained unit of education or training, such as a course, a module, a lesson, etc. The creation of a Unit of Learning involves the creation of a learning design and also the bundling of all its associated resources, either as files contained in the unit or as Web references, including assessments, learning materials and learning service configuration information*"

Therefore, a Unit of Learning is a ZIP file with:

- a XML manifest, describing method, plays, acts, roles, activities, environments, properties, conditions and/or notifications of the IMS Learning Design specification. It also points to the related resources
- a set of files or resources mentioned in the XML manifest

Once the UoL is validated, published and run in a player, the player will coordinate the teachers, the students and the activities during the learning process (Koper & Tattersall, 2005).

If we compare IMS-LD with another related specification, the aforementioned IMS Content Packaging, this one builds also packs with resources under certain conditions, but without any method or pedagogy underneath (Figure 3). Therefore, the difference between IMS Learning Design and IMS Content Packaging is that IMS-LD adds to IMS CP a full declaration under the Organizations label.

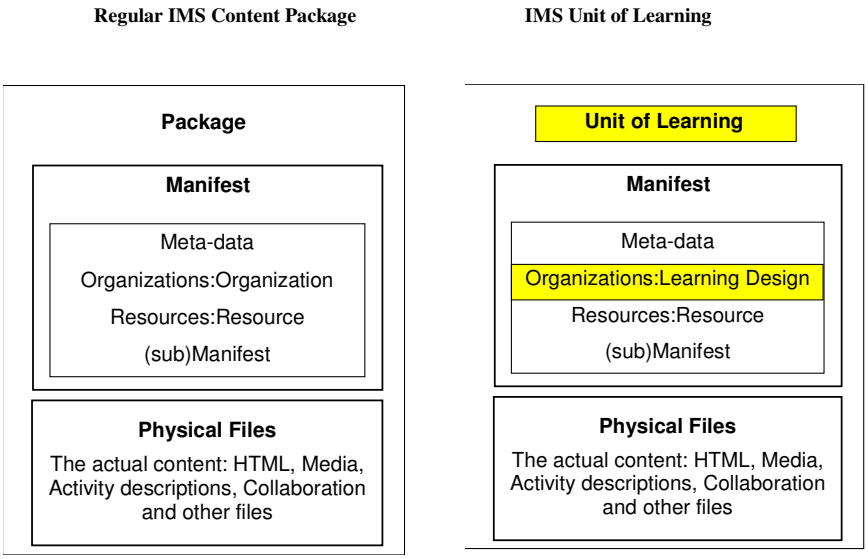

Figure 3 IMS Content Packaging vs. IMS Learning Design packages

Furthermore, if we compare just contents in HTML with the structure written in an XML manifest of IMS-LD, we can notice that, besides the different mark-up language, there are other differences:

- An XML manifest is a single file that points to contents and resources, whereas a HTML is a resource itself and can contain also references to other resources
- An XML manifest shows the skeleton and the method of an Unit of Learning, whereas a HTML website is just a set of linked and/or structured webpages
- An XML manifest can provide conditions, properties and notifications, this is, a kind of behaviour depending on user's actions, whereas a HTML website is a passive source of information

6.1.2 Levels of implementation

IMS-LD consists of three levels (Figure 4): Level A, with the definition of the method, plays, acts, roles, role-parts, learning activities, support activities and environments. It is the core of the specification, contains the description of the elements that configure IMS LD and the coordination between them. For instance, role-parts define what activities must be taken by a role in order to complete an act and, subsequently, a play.

Level B, adds properties, conditions, calculations, monitoring services and global elements to Level A, and provides specific means to create more complex structures and learning experiences. Properties can be used as variables, local or global ones, storing and retrieving information for a single user, a group or even for all the characters involved. Through these mechanisms the learning flow can be changed at the run time, as decisions can be made taking into account dynamic content. Logically it is the used level to express the most of the pedagogical needs concerning Adaptation, personalization, feedback, tracking and several other usual requests of teachers and learning designers.

Lastly, Level C adds notifications to Level B, meaning an email sent and a show/hide command to a specific activity, depending on the completion of another one. (Koper & Burgos, 2005).

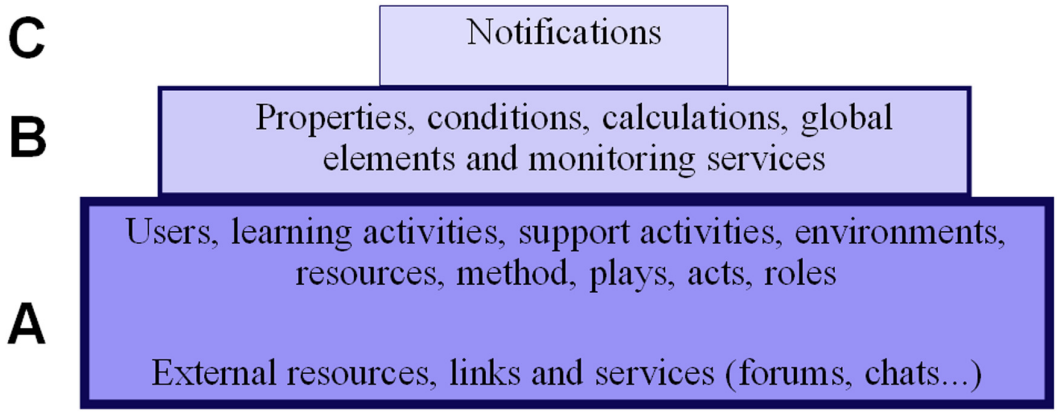

Figure 4 Three levels of IMS-LD

In addition to the basic structure of Level A, the elements in Level B and Level C are actually the key for more expressive UoLs (for instance, based on Adaptation or Collaboration), as they combine several features that encourage and make the content and the learning flow more flexible (Koper & Burgos, 2005; Specht & Burgos, 2006). Furthermore, the combination of these elements allows for the modelling of several classical adaptive methods (i.e. reuse of pedagogical patterns, adaptability, navigational guidance, collaborative learning, contextualized and mobile distributed learning, Adaptation to stereotypes), making use of different structural elements of IMS-LD, like i.e. Environment, Content, User groups and Learning flow (Burgos et al., 2006).

6.1.3 Tooling

Every single step between the creation and the use of a UoL needs an IMS-LD compliant tool. The UoLs can be created with general purpose editors or with specific IMS-LD editors–like XML Spy (Altova, 2006)– like CopperAuthor (Van der Vegt, 2005), Cosmos (Miao, 2005) or– , and they can be run with several–Reload LD Editor (Bolton, 2004) like CopperCore (Vogten–tools and engines & Martens, 2005), Sled (OUUK, 2005) or .LRN (Santos et al., 2007). There are also some integrative projects, like Alfanet (Santos et al., 2005) and netUniversité (Pacurar, 2005). However, current tools do not allow for an easy editing and a significant effort is still needed to create adaptive IMS-LD UoLs comprising level B and C constructs (Burgos et al., 2006). They make the creation of adaptive UoLs technically possible, but too difficult for a non-technical user. A higher level layer with a more visual metaphor is still missing, although some initiatives are being taken. For instance, the TENCompetence Project (TENCompetence, 2005) and Complutense University of Madrid (UCM, 2006) are both developing a visual LD Editor. The conception of these tools will ultimately rely on the domain concepts behind the specification, which are incarnated in the domain-specific XML binding. An additional challenge is that there are not so many Learning Management Systems able to handle and to play these UoLs; (Burgos, Arnaud, Neuhauser, & Koper, 2005). For instance, .LRN can execute Units of Learning modelled with Levels A, B (and C?); LAMS and Moodle play Level A both; MOT+ is able to export to Level A.

6.2 Types of Adaptation with IMS-LD

In a literature study, we identify eight different kinds of Adaptation being carried out in eLearning systems (Burgos et al., 2007): Interface based, Learning flow based, Content based, Interactive problem solving support, Adaptive information filtering, Adaptive user grouping, Adaptive evaluation, and Changes on-the-fly (Brusilovsky & Paylo, 2003) (Baeza-Yates & Ribeiro-Nieto, 1999; Van Rosmalen et al., 2006) (Merceron & Yacef, 2003; Romero et al., 2003; Van Rosmalen & Boticario, 2005). All of them use various inputs provided during the learning process and aim to tune the activities and actions of the learner to get the best learning experience as possible (Butz et al., 2003). A wide and consistent set of rules of dependencies among users, methods and learning objects is needed to describe these eight types of Adaptation, and moreover their

possible combinations (Karampiperis & Sampson, 2004). If we categorize all these types of Adaptation, we can group them in three clusters:

Traditionally, three types of Adaptation have been proposed:

1. Interface-based (also called adaptive navigation and related to usability and adaptability) where elements and options of the interface are positioned on the screen and their properties are defined (colour, size, shadow, etc.) (Ahmad et al., 2004); this is closely related to general customization and supporting people with special needs which influence personalization, such as colour blindness or poor hearing, for instance (Chin, 2001).
2. Learning flow-based, where the learning process is dynamically adapted to sequence the contents of the course in different ways. The learning path is dynamic and personalised for every student, but even also for every time that the course is started (also called run or instance), so that the student can take a different itinerary depending on his performance.
3. Content-based, where resources and activities dynamically change their actual current content, as in Adaptive and Intelligent Web-Based Educational Systems based on adaptive presentation (Brusilovsky & Miller, 2001; De Bra et al., 2004). For instance, the information inside a learning activity can be classified in three levels of depth, and every level is shown based on a number of factors.

The first block of Adaptation types become the base for the following ones. Additional kinds of Adaptation are (Brusilovsky & Paylo, 2003):

4. Interactive problem solving support, which guides the student on the next step to take in order to get the right solution to a problem. The guidance could come from an on-line or off-line tutor or from a predefined set of rules.
5. Adaptive information filtering, taking care of appropriate information retrieval that provides only relevant and categorized outputs to the user (Baeza-Yates & Ribeiro-Nieto, 1999). Although this type provides adaptive information, it could be considered as an external facility linked to a learning activity and not as a real part of that learning activity itself.
6. Adaptive user grouping that allows ad hoc creation of user groups and collaborative support on carrying out specific tasks. For instance, as a result of a pool of questions, two groups with beginners and advanced students are made.

We extend the classification further with:

7. Adaptive evaluation, where the evaluation model, the actual content and the running of a test can change depending on the performance of the student and the guidance of the tutor (Van Rosmalen et al., 2006).
8. Changes on-the-fly, the possibility to modify/adapt a course on-the-fly by a tutor or the author of the course in run-time (Van Rosmalen & Boticario, 2005), moving beyond the previous types which are set up and defined in design-time (Merceron & Yacef, 2003; Romero et al., 2003).

We now examine how IMS-LD can be used to represent each of the eight types of Adaptation aforementioned. A combination of the following proposals on Adaptation could support the performance of every role in an eLearning process (Cronbach, 1957; He et al., 2002). Taking the first block (which consists of the three main types), IMS-LD is able to model Adaptation:

- Adaptation based on the interface

Interface based Adaptation is quite different to content based Adaptation. Content Adaptation is based on the information inside an activity that is shown and handled. Interface Adaptation is based on options, navigation and visualization facilities. Interface Adaptation is not possible with today's tools for IMS-LD, such as CopperCore Player, Reload LD Player and Sled. As long as the Adaptation of the interface is based on the tool and not on the Unit of Learning that is interpreted by the player, this is still true. Today's players do not yet provide facilities to change the size or the position of the navigation panels, or even open and close the working areas in the player. Either, these tools cannot change the style sheets related to a HTML file, part of the content, and any of the linked features, as font-size, font-type or background colour, for instance. Although the CopperCore engine provides the appropriate infrastructure, no player uses it so far. Nevertheless, some kind of adaptive interface is possible, using DIV layers and environments.

- Adaptation based on the learning flow

The modification of the learning flow as the Unit of Learning is being executed is one of the most often used types of Adaptation. Taking the flow as a base, the Unit of Learning provides different activities, resources and services, depending on these four inputs during execution (user's behaviour and performance, user's decision, teacher and set of rules). The activity structure in an IMS-LD UoL is defined using plays, acts, activity structures, learning activities, support activities and environments. We can also use the property of visibility to hide and show these elements and to adapt the learning flow. In these cases the property works as a flag, switching on and off the elements referred to We now show five scenarios and their related implementations of learning-flow based Adaptation focused on the several possible inputs. The pseudo XML code shown is an abstraction of the IMS-LD original source, concentrating on the key elements of the specification needed for a more self-understandable explanation.

- Adaptation based on the content

We know that a learning flow is mainly focused on the sequence of the activities in a Unit of Learning. However, content based Adaptation is focused on the information of every activity, and on the activity itself. There are two main approaches for content based Adaptation: Flag properties and content of properties.

6.3 Elements in Levels B and C to model Adaptation

The elements in Level B and Level C providing support to Adaptation in Units of Learning are categorized as a) properties, b) conditions, c) global elements, d) calculations, e) monitoring services, and f) notifications (Burgos & Specht, 2006; Koper & Burgos, 2005)

1. Definition, set-up and use of properties: Properties are taken as variables to store values. There are several types of properties: local, local-personal, local-role, global-personal, global. There is also a property-group that is able to compile a number of the others.
2. Conditions: IMS-LD is able to define a basic structure if-then-else, or multiple structure with several chained basic if-then-else in a row, for instance to change the value of a property or to show and hide one element.
3. Global elements: Global elements provide a communication flow between the imsmanifest.xml, where the different levels of IMS-LD are set-up, and other XML files. Mainly, they can get an input from the user and they can show a value of a property. Furthermore, they can manage DIV layers in XHTML, for instance to show and hide specific content.
4. Calculations: IMS-LD is able to make some basic arithmetic's (sum, subtraction, multiplication and division) and some combination of a number of them in a row, to get a more complex formula, like a simple average, for instance.
5. Monitoring service: The specification allows monitoring any kind of property assigned to a user or a role, for instance. In order to start this action, firstly the component monitor must be set-up inside an environment and later the property can also be monitored.
6. Notifications: An action is automatically launched depending on the state of a property or a previous action, i.e., when a student ends an assignment an email is sent to the tutor.

7 Modelling pedagogical strategies and techniques with IMS-LD

IMS-LD is a very expressive specification able to model different types of pedagogy. However, it is never been used to model Adaptation before as we do in GRAPPLE, with so much fine grain granularity. The main challenge aims at making the translation from theoretical strategies and techniques to run-able Units of Learning. Following, we show a visual approach on modelling pedagogic guidelines with IMS-LD.

7.1 A visual approach on modelling pedagogy with IMS-LD

In order to provide a re-usable approach on Adaptation (that could be used in GRAPPLE and outside) we work on a set of conceptual representations with dependencies, relationships, and modules, from the theoretical concept to the in-practice modelling with IMS-LD, step by step. The theoretical background underneath can be found in the previous section. The main objective of this approach is to improve the re-usability and stand-alone use of every single module.

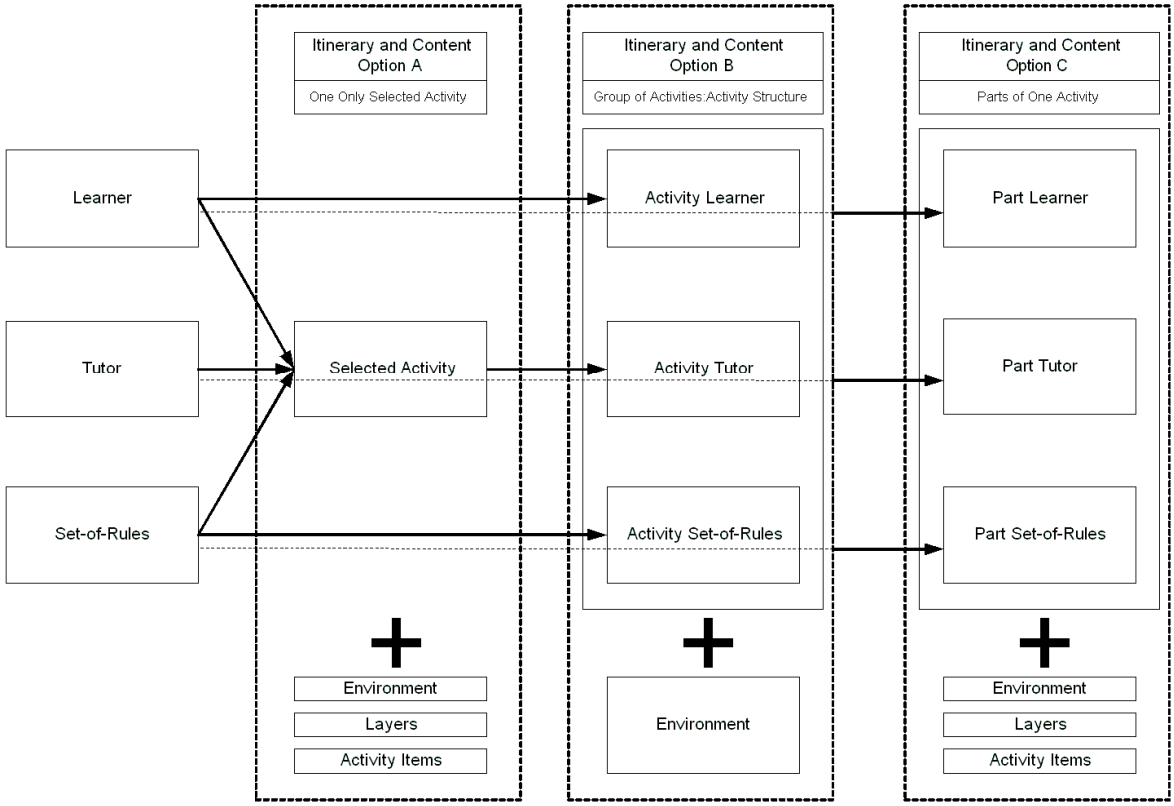

Figure 5. Personalisation of activities with IMS-LD

The approach is depicted in three different diagrams. Figure 5 shows the different possibilities to personalize activities with IMS-LD, depending on the role that plays the activity. We define three basic roles (teacher, student and set of rules) and each dotted block illustrates how Adaptation could take place. The first block (Option A) allows any role plays a new activity (self-chosen or automatically assigned). Every role has assigned a new isolated activity with no relation to the others. Option B shows how every role could play an activity inside of an activity structure (group of activities). In doing so, every role is autonomous although all of them deal with the same next step, meaning the activity structure. Option C shows how every role could play one only part of the same activity. In this case, the same activity glues together the different parts for every role. At the same time, each solution could make use of a few resources, i.e., environments, layers and items.

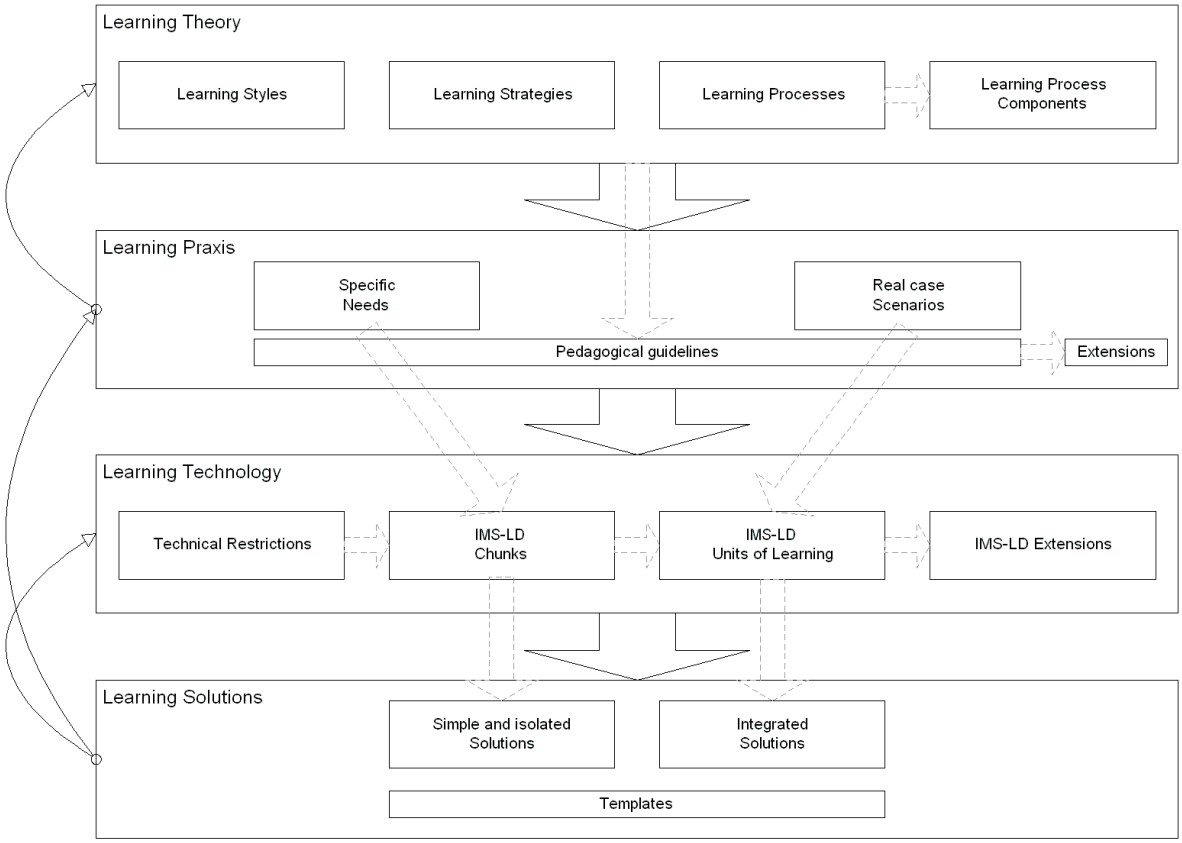

Figure 6 Different layers from theory to practical solutions

Figure 6 illustrates the different phases of the already mentioned process between theoretical background and in-practice solutions. There are four main layers: 1) Learning theory, it leans on styles, strategies and processes and provides process components; this first layer feeds 2) Learning praxis, where there are specific needs and real scenarios from daily life; all these together report on pedagogical guidelines; 3) Learning technology, it makes use of several resources and techniques, i.e., Units of Learning or code-snippets (chunks); and it provides the need input to 4) Learning solutions, it inherits both, pedagogical guidelines and technology, to provide stand-alone and integrated solutions; these solutions could describe templates to be used and extended by practitioners. In turn, 2) and 3) could report on extensions to carry out solutions that are not feasible, or hardly possible to realize, so far. These layers show several round-trip dependencies amongst them.

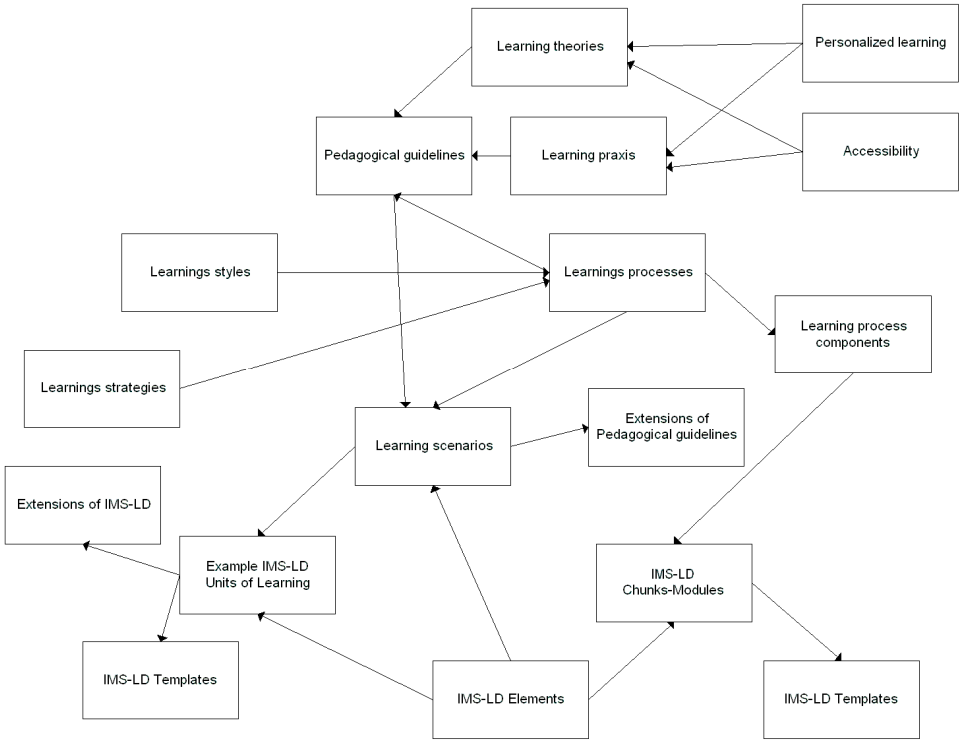

Figure 7 Relations amongst theory, practice and implementation with IMS-LD

Every layer is made of several modules that can be represented in a is-a node diagram, like in Figure 7, where we can show the different relationships amongst non-layer dependant modules.

8 Prototypes of Adaptation modelled with IMS-LD

As already depicted in former sections, re-purpose of templates and Units of Learning becomes one of the main objectives for many eLearning standards and specifications. In this section we explain a few examples of possible contexts where such resources could be used. Our drive is to model a set of actual supporting materials for practitioners, mainly teachers, according to GRAPPLE guidelines and CAMs. In this sense, we have decided to go from generic scenarios to specific ones. We do stress the Adaptation issues and types within these five scenarios.

In our view, this approach allows for a better understanding of what can be done with IMS-LD and how this specification could help while modelling Adaptation. Since the use of IMS-LD to express learning strategies on this topic is a quite new approach, there is a need for a step-by-step introduction to the potential target public when we want them understand and make use of it in an easy way.

Every scenario in this section is explained according to the several taxonomies, theories and guidelines provided before, which also analyzes the Conceptual Adaptation Models in WP3. In the **Annex Section** we provide the working spreadsheets used to develop the modelling solutions and templates. In addition, in the **Annex Section** there is an indication of which parts of IMS-LD are used in every scenario. For a more detailed description and use of IMS-LD, the full set of modelled learning scenarios (meaning the ZIP information packages, ready for execution with an IMS-LD compliant player) can be found at the Grapple site.

8.1 Scenario 1 Making a project proposal

Pedagogical focus: Adaptive mentoring

Roles: tutor, learner/s

Learning Categories: Understanding, Evaluating, Creating, Analysing

Learning Strategies: Monitoring and Regulating, Support from others, Elaboration, Study-environment

Name of the Unit of Learning: Free Style Assessment

Description: a group of Junior Consultants in an international company has been tasked to make of a new proposal for an EU FPVII project. They will work on peer basis with an Area Manager who will lead them on the right process of redaction

Learning flow:

1. Every Junior Consultant has to create a report following some guidelines
2. Every Junior Consultant submits his/her personal info and his first proposal to the tutor
3. The Area Manager checks the submission of all the Junior Consultants and close this first round
4. The Area Manager grades the assessment and provides his own remarks back
5. Every Junior Consultant reads the first remarks and can provide some feedback to make a second round. The Area Manager closes this second round
6. The Area Manager provides some feedback on the second round, taking into account the Junior Consultant's remarks, and assigns a qualification and a numerical mark, useful to evaluate the performance of the Juniors. The Area Manager closes this activity
7. Every Junior Consultant reads his dossier and can also have a look to the others´ results

8.2 Scenario 2 A new skill

Pedagogical focus: Self-evaluation, Learning path, Performance

Roles: learner, set of rules

Learning Categories: Understanding, Evaluating

Learning Strategies: Meta-cognitive, Elaboration, Rehearsal

Name of the Unit of Learning: Geo Quiz 3

Description: an officer of the Postal Office needs to learn how to use a new digital system that replaces the old analogical one. (S)he will use a set of quizzes to check his/her knowledge, based on previous information. Depending on the performance the learning path will be adapted to support the best study progress

Learning flow:

1. User name requested to personalised the later feedback
2. Five questions with three possible answers. Depending on the answer one or another value is provided (0, 1 or 2) with a maximum of 10 to the full test
3. Only when the learner has answered the five questions (s)he can go ahead to see the results
4. A total, a simple average and a percentage of accuracy are calculated
5. An adaptive feedback is provided depending on the average (less than 50, between 50 and 75 and more than 75)
6. The next activity delivered depends also on the feedback

8.3 Scenario 3 Human resources live

Pedagogical focus: personalised evaluation, Runtime tracking

Roles: learner, set of rules, tutor

Learning Categories: Evaluating, Creating

Learning Strategies: Cognitive, Meta-cognitive, Support from others, Planning, Effort

Name of the Unit of Learning: Quo Builder 2

Description: a human resources woman, who has to create a quiz for a course, has to adapt it as long as the course takes place (in the runtime). This system allows for a better Adaptation to the users´ needs along the learning flow. Since there is almost no distinction between design time and run time, learning goals, objectives and content can be easily adapted on the run

Learning flow:

1. Setting-up of the unit of learning with full personalization of questions, answers, right answers, ranges, points earned, messages of feedback and welcome, title, that can be adapted and re-published in runtime

2. Questions and related properties are local (loc-property) and keep the same value for all the users in the same run. However, personal answers and calculations are private and linked to every participant (locpers-property)

3. Five questions with three possible answers. If the answer is right, the participant earns the amount of points defined in the set-up

4. Only when you have answered the five questions you can go ahead to see the results

5. There are 2 roles, teacher and participant, and the learning flow swaps between them:

    a. First, the teacher sets-up the questionnaire and the participant waits for the opening of the course. The teacher can have a preview of the questionnaire before publishing

    b. Second, the teacher publishes the quiz and the participant answers the questions. The teacher monitors his/her progress

    c. Third, the participant finishes the quiz and receives two inputs: an adaptive feedback and a new activity, both based on the results

6. The logo and the next activities (Level 1, 2 and 3) can be easily changed in the ZIP file to fit them to personal goals of the teacher in an easy way

8.4 Scenario 4 Learning at the workplace

Pedagogical focus: personalised learning itinerary, Learning strategy

Roles: learner

Learning Categories: Understanding, Remembering

Learning Strategies: Meta-cognitive, Elaboration, Monitoring and Regulating, Organizational

Name of the Unit of Learning: Candidas II. The Great Unknown

Description: a young paramedic who has to learn on the run at the workplace about new treatments for diseases. The course consists of a series of sections with relevant information for his/her knowledge upgrade. The learner can choose the learning strategy that fits better with his/her behaviour and objectives, out of four different possibilities. Every choice deploys a contextualized learning itinerary

Learning flow:

There are five main parts:

Part I. An introduction about the topic

Part II-Part IV. Several aspects of Candidas to be studied

Part V. A general quiz about the contents

Besides, there are partial questionnaires after II, III and IV, and the answers can be checked in a last appendix

In parallel, some additional resources (not required) are provided as complements of main parts

There are four different itineraries to choose:

1. Sequential learning: step by step
2. Cluster learning: the play is divided in two different acts, one for assignments and another one for tests and feedback
3. Direct selection, all: any learning activity can be chosen, but all of them have to be completed, in order to finish the play
4. Direct selection, one: with just one learning activity finished, the play is finished

8.5 Scenario 5. Getting some expertise

Pedagogical focus: personalised learning itinerary, Self-evaluation, Learning style

Roles: learner, set of rules

Learning Categories: Remembering, Understanding, Applying, Analysing, Evaluating

Learning Strategies: Cognitive, Meta-cognitive, Study-environment, Organizational

Name of the Unit of Learning: Learning to Listen to Jazz

Description: a librarian needs to acquire some knowledge on Jazz Styles when (s)he is appointed to another position in the Music Section. A rich course with the requested information to get some important expertise on this topic is provided to the librarian. (S)he can adapt the learning itinerary according to his/her learning style and preferences. Related to every itinerary there are a set of self-evaluations that provide some formative and summative feedback

Learning flow:

1. The user can choose the learning itinerary out of two possible paths: Historic and thematic
2. The user can swap between both at three different points in the learning flow
3. The activities already done in one path remain in the same state when the user moves to the alternative path
4. Therefore, they are the same activities but with two different ways of study. In this case, the Adaptation comes from the user, based on a pre-design of the course by the author/tutor

9 Conclusions

The possibilities for Adaptation supported by IMS-LD are diverse. From the eight types of Adaptation described in this deliverable we identify three levels of support:

a) Learning flow, Content, Evaluation and Interactive problem solving support are well supported
b) User grouping, Interface Adaptation, Adaptive evaluation and Full modification of a course on-the-fly are partially supported
c) Some pending issues with no support at all are Dynamic modification of learning structure and method in run-time, and Adaptive information filtering and retrieval. Yet some of this lack of support leans on the current state of tooling, and not on the specification itself.

Nevertheless, with several types of Adaptation, like Content and Information retrieval, also it is possible to provide specific support on Adaptation, i.e. linking a learning activity to an external tool that provides a related service and keeping IMS-LD as a container for external Adaptation. To this extent, Adaptation comes from outside IMS-LD although the learning design acts as an integrator.

However, there is still a lot of effort needed to carry out such work,even more when non-technical end-users need to express psycho-pedagogic learning flows, guidelines and support. In order to get a balance between the theoretical framework, the actual needs and the technical restrictions we need to further progress on modelling with the specification, and to suggest modifications and extensions in order to get a better fit with Adaptation features. In addition, modelling resources (i.e., learning scenarios, templates) leading to fully operational Units of Learning have to evolve and try to meet expectations and needs of the theoretical merged approach.

In conclusion, with the appropriate support, IMS-LD can build Adaptation and rather flexible learning experiences for every stakeholder. In this deliverable, we model a number of learning scenarios that show Adaptation with the current resources that IMS-LD offers. In this sense, this research on IMS-LD will receive more input from WP3 progress. Something to be explored and released along with the forthcoming deliverables D5.3b and D5.3c.

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Annex: Spreadsheets to model IMS-LD Units of Learning

Following, we show the working spreadsheets used to modelled Units of Learning with IMS-LD. Every scenario shows one or several types of Adaptation, as described in this deliverable. This set of run-able learning scenarios wraps-up our initial approach, becoming a comprehensive bundle to be more in-depth researched and developed in the forthcoming months. In Month 24 we will release templates to be re-used (D5.3b), in Month 30 will be release a report with extensions and modifications of IMS-LD (D5.3c). Every scenario can be found at the Grapple site, and be executed by an IMS-LD compliant player.

Scenario 1. Making a project proposal

Scenario 2. A new skill

Scenario 3. Human resources live

Scenario 4. Learning at the workplace

Scenario 5. Getting some expertise