Community platform management mechanisms to support integrated Learning Design

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La suerte no hay que buscarla,
o siempre andaremos un paso
por detrás de ella.

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ABSTRACT

This PhD Thesis contributes to the domain of Educational Technologies, and more specifically to the Learning Design (LD) research field, which focuses on supporting teachers in the creation of effective computer-supported learning activities considering the needs of their educational contexts. Research in LD has provided a myriad of tools and methods. Yet, existing tools lack collaboration support for communities of teachers engaged in learning (co-)design. Moreover, scope of tools is varied in terms of representations used, pedagogical approaches supported, and design phases targeted (from conceptualization to authoring and implementation). This diversity of tools contrasts with lack of articulation of their synergies to offer meaningful, manageable and integrated LD ecosystems for teachers and communities of teachers. This Thesis is framed in this problem area. Its guiding research question is: How can community platform management mechanisms support teachers in integrated learning design ecosystems? This question is addressed by more specific investigation towards addressing four specific research objectives.

The first objective is explorative, focused on understanding needs for management mechanisms in LD community platforms. The resulting contribution includes participation in building and evaluating LD community platforms (LdShake, Learning design Sharing and co-edition, and ILDE, Integrated Learning Design Environment) in the context of Spanish and European projects, and the identification of needs tackled in the following three research objectives. The second objective deals with enabling flexible management of learning (co-)design processes that involve use of several LD tools. The associated contribution is a model and implementation for LD Workflows, which shape orchestrated uses of selected LD tools that can be applied to LD Projects. The third objective focuses on supporting management of multiple learning design versions in scenarios of reuse and co-design. The contribution is a model and visualization strategy based on a family tree metaphor. The fourth objective concerns the need for interoperability between co-(design) tools and platforms, and in particular focuses on design patterns as structured LD representations of special interest because they collect repeatable good teaching practices. The contribution is a pattern ontology for computationally representing a pattern language (working case of design patterns in Computer-Supported Collaborative Learning) and a derived model together with an architecture for interoperable management of patterns across LD tooling. Contributions have been implemented in LdShake and ILDE community platforms, showing feasibility, enabling proof-of-concept in significant scenarios and user studies involving teachers.

RESUMEN

Las contribuciones de esta Tesis Doctoral se enmarcan en el ámbito de las Tecnologías Educativas, y más concretamente en el campo de investigación del Diseño de Aprendizaje (LD acrónimo en inglés). Este campo se centra en dar apoyo a los profesores en la creación de actividades educativas apoyadas por ordenador teniendo en consideración sus contextos educativos. La investigación en el campo de LD ha proporcionado gran cantidad de herramientas y métodos. Sin embargo, estas herramientas todavía carecen de mecanismos que posibiliten la colaboración en comunidades de profesores involucradas en el (co-)diseño de aprendizaje. Además, el alcance de las herramientas es muy variado en cuanto a las representaciones utilizadas, los enfoques pedagógicos utilizados, y fases de diseño a las que van dirigidas (desde la conceptualización, hasta la autoría y hasta la implementación). Esta diversidad de herramientas contrasta con la falta de articulación de sus sinergias para ofrecer ecosistemas LD significativos, manejables e integrados para profesores y comunidades de profesores. Esta problemática motiva la investigación realizada en esta Tesis. La pregunta de investigación que la guía es: ¿Cómo pueden apoyar los mecanismos de gestión de plataformas comunitarias dar soporte en ecosistemas de diseño de aprendizaje integrado? Esta cuestión se aborda en la investigación más concreta de cuatro objetivos específicos.

El primer objetivo es exploratorio, se centra en la comprensión de las necesidades de mecanismos de gestión en plataformas para comunidades en LD. La contribución resultante incluye la participación en la implementación y evaluación de las plataformas para comunidades en LD (LdShake, acrónimo en inglés de *Learning design Sharing and co-edition*, e ILDE, acrónimo en inglés de *Integrated Learning Design Environment*) en el contexto de proyectos españoles y europeos, así como la identificación de las necesidades abordadas en los tres siguientes objetivos de la investigación. El segundo objetivo busca permitir una gestión flexible de los procesos de (co-)diseño de aprendizaje que implique el uso de varias herramientas de LD. La contribución asociada es un modelo e implementación de los flujos de trabajo de LD (*LD Workflows* en inglés). Los *LD Workflows* se definen para permitir la representación de las herramientas de LD seleccionadas que se pueden aplicar a proyectos de LD (*LD Projects*, en inglés). El tercer objetivo se centra en el apoyo a la gestión de múltiples versiones de diseño de aprendizaje en escenarios de reutilización y (co-)diseño. La contribución es un modelo y una visualización basada en una metáfora del *árbol familiar (family tree,* en inglés*)*. El cuarto objetivo trata la necesidad de interoperabilidad entre herramientas de (co-)diseño y plataformas de LD, y en particular, se centra en los patrones de diseño como representaciones LD estructuradas de especial interés ya que recogen buenas prácticas docentes repetibles. La contribución es una ontología de patrones que representa computacionalmente un lenguaje de patrones (centrándose en patrones de *CSCL, del inglés: Computer-Supported Collaborative Learning*) y un modelo derivado junto con una arquitectura para la gestión interoperable de patrones a través de herramientas de LD. Las contribuciones se han implementado en LdShake e ILDE mostrando su viabilidad, ofreciendo la prueba de conceptos en escenarios significativos y estudios con profesores en entornos reales.

RESUM

Les contribucions d'aquesta Tesi Doctoral s'emmarquen en l'àmbit de les Tecnologies Educatives, més concretament en l'àrea de recerca del Disseny d'Aprenentatge (LD acrònim en anglès). Aquesta àrea es centra a donar suport als professors en la creació d'activitats educatives recolzades per ordinador tenint en consideració els seus contextos educatius. La investigació en l'àrea de LD ha proporcionat una gran quantitat d'eines i mètodes. No obstant això, aquestes eines no tenen mecanismes que possibilitin la col·laboració en comunitats de professors involucrats en el (co-)disseny de l'aprenentatge. A més a més, l'abast de les eines és molt variat pel que fa a les representacions utilitzades, els enfocaments pedagògics utilitzats, i les fases de disseny a què van dirigides (des de la conceptualització, fins l'autoria i la implementació). Aquesta diversitat d'eines contrasta amb la manca d'articulació de les seves sinergies per oferir ecosistemes LD significatius, manejables i integrats per a professors i comunitats de professors. Aquesta problemàtica motiva la recerca realitzada en aquesta Tesi. La pregunta d'investigació que la guia és: Com poden els mecanismes de gestió de plataformes comunitàries donar suport en ecosistemes de disseny d'aprenentatge integrat? Aquesta qüestió s'aborda en la investigació més concreta en quatre objectius específics.

El primer objectiu és exploratori, es centra en la comprensió de les necessitats dels mecanismes de gestió en plataformes per a comunitats de LD. La contribució resultant inclou la participació en la implementació i avaluació de les plataformes per a comunitats de LD (LdShake, acrònim en anglès de *Learning design Sharing and co-edition*, i ILDE, acrònim en anglès d' *Integrated Learning Design Environment*) en el context de projectes espanyols i europeus, així com la identificació de les necessitats abordades en els tres següents objectius de la investigació. El segon objectiu cerca permetre una gestió flexible dels processos de (co-)disseny d'aprenentatge que impliquin l'ús de diverses eines de LD. La contribució associada és un model i implementació dels fluxos de treball de LD (*LD Workflows* en anglès). Els *LD Workflows* es defineixen per a permetre la representació de les eines de LD seleccionades que es puguin aplicar en projectes de LD (*LD Projects*, en anglès). El tercer objectiu es centra en el suport a la gestió de múltiples versions de disseny d'aprenentatge en escenaris de reutilització i (co-)disseny. La contribució és un model i una visualització basada en una metàfora d'arbre familiar (*family tree*, en anglès). El quart objectiu tracta de la necessitat d'interoperabilitat entre eines de (co-)disseny i plataformes de LD, i en particular, es centra en els patrons de disseny com a representacions LD estructurades d'especial interès ja que recullen bones pràctiques docents repetibles. La contribució és una ontologia de patrons que representa computacionalment un llenguatge de patrons (centrant-se en patrons de CSCL acrònim en anglès de *Computer-Supported Collaborative Learning*) i un model derivat juntament amb una arquitectura per a la gestió interoperable de patrons a través d'eines de LD. Les contribucions s'han implementat a les plataformes de comunitats de LD LdShake i ILDE mostrant la seva viabilitat, oferint la prova de concepte en escenaris significatius i els estudis amb professors en entorns reals.

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CHAPTER 1. INTRODUCTION

This chapter introduces the main problems existing in Learning Design (LD) and Online Communities of Teachers research areas that motivated this PhD Thesis. The focus is on interest of LD ecosystems that consider myriad of existing LD tools and need for platform management mechanisms to flexibly support communities of teachers in the context of LD ecosystems. The chapter also formulates the global research question and the specific research objectives of the Thesis, while introducing main contributions associated to each objective and the methodologies applied. Finally, the structure of the dissertation is explained with a brief description about each chapter to be followed.

1.1 Introduction

The Learning Design (LD) field focuses on how to support teachers, teams of teachers and other stakeholders such as academic managers and students as designers and co-designers of technology-supported learning activities according to their specific educational needs and objectives (Conole, 2012; Mor, Craft, & Hernández-Leo, 2013; Mor & Winters, 2007). Previous research on LD has provided a myriad of approaches and tools (Persico et al., 2013; Prieto, Dimitriadis, et al., 2013) in this regard.

The variety of available tools is significant in terms of representations used, pedagogical approaches supported and support for possible tasks involved in LD process. These tasks include following teachers reflect about their context, sketch their pedagogical intentions, analyze profile of target learners, author the description of activities, its social aspects and configure the implementation aspects including the technological infrastructure that will be used to deliver and support the activities (Peter Goodyear & Carvalho, 2014; Koper & Tattersall, 2004; Mor et al., 2013; Pernin, Emin, & Guéraud, 2008).

However, from initial stages of this research work, the diversity of existent tools contrasted with the lack of articulation of their synergies to offer a meaningful and operational LD ecosystem for teachers (Conole, 2014). Only methodological approaches of LD offered indications about what combinations of design tasks and tools may be followed and used when designing for learning (Conole, 2014; Mor & Mogilevsky, 2012). Yet, the methodologies proposed were not supported with technologies that could facilitate its implementation. Moreover, the suitability of the methodologies depends on the context and requirements of an educational institution, the expertise of the teachers, the tools and technologies available, etc (Laurillard, 2012). This gives the necessity for flexible technology-supported articulations of the LD ecosystem.

LD approaches propose textual, graphical and computational representations to document the designs and enable its automatic interpretation by software systems (Derntl, Neumann, & Oberhuemer, 2011; Katsamani & Retalis, 2011). The use of explicit representations also enables its sharing so other teachers can reuse the learning designs in their own learning contexts. This idea is the basis of some LD tools that offer templates based on sound learning designs formulated as patterns (Griffiths & Blat, 2005; Harrer, 2006; Hernández-Leo, Asensio-Pérez, Dimitriadis, & Villasclaras-Fernández, 2010; Hernández-Leo, Harrer, Dodero, & Burgos, 2007; Mor et al., 2013) and of educational repositories collecting learning designs (Agostinho, Bennett, Lockyer, Jones, & Harper, 2013). A design pattern provides means of organizing information regarding a contextualized common problem and the essence of its broadly accepted solution, so that it can be repetitively applied (Peter Goodyear & Retalis, 2010). Patterns and structured representations in LD are of special interest because they collect knowledge of good practices in teaching and learning in easily reusable and applicable means by others and can act as scaffolds in design processes, facilitating cost-effective learning design (Calvo & Turani, 2010; Peter Goodyear & Retalis, 2010; Hernández-Leo et al., 2006; Laurillard, 2012).

The problem is that existing collections of patterns are not static, i.e., good practices can evolve with new sound knowledge/expertise and new patterns can be added (Hernández-Leo & Asensio, 2010; Laurillard, 2012). Moreover, these patterns and collections of existing patterns are normally isolated from each other (only available in a repository or a single authoring tool) and collections of patterns evolve independently (Peter Goodyear & Retalis, 2010). Moreover, there is no flexible interoperability between different repositories or pattern-based authoring tools (Agostinho et al., 2013; Bennett, Agostinho, & Lockyer, 2015; Emin, Pernin, & Aguirre, 2010; Hernández-Leo et al., 2006; Villasclaras-Fernández, Hernández-Leo, Asensio-Pérez, & Dimitriadis, 2013). Due to isolation, users of an LD authoring tool cannot acquire benefits of patterns available in other pattern-based tool of the LD ecosystem (e.g., repository or another authoring tool).

On the other hand, documenting learning designs is important as it enables the communication and alignment of multiple designers' perspectives and contributions (Scanlon et al., 2009). This encourages scenarios of social cooperation among teachers (and related stakeholders), where teachers collaborate in creation (or co-creation) and sharing scenarios (Carr & Chambers, 2006; Duncan-Howell, 2010). Social virtual spaces for teachers are denoted as Online Communities of Teachers by several authors (Jones & Preece, 2006). This notion of community is aligned with (Wenger, 1998) Communities of Practice, in which members (teachers in this case) share a concern for something they practice (teaching) and interact among them to learn how to improve such practice, e.g., by reusing and adapting co-designs created by other teachers or co-creating designs with other teachers (Carr & Chambers, 2006; Davis et al., 2010; Supovitz, 2002).

Yet, at the moment of starting this research work there was no online community platform of teachers focused on supporting sharing or co-creation of learning designs, with management mechanisms that facilitate a meaningful and flexible integration of tools and approaches in LD ecosystems and reusing learning designs among teachers and across tools.

1.2 Objectives

According to the issues identified in this dissertation, and introduced in the previous section, the global research question that guided this dissertation is:

GLOBAL RESEARCH QUESTION: How can community platform management mechanisms support teachers in integrated learning design ecosystems?

This global research question focuses directly on the gap identified in the literature by investigating how teachers can be supported when designing for learning in a context of a variety of LD tools and approaches and the relevance of collaboration and reuse within communities of teachers. This global question is addressed by more specific investigation towards addressing four specific research objectives. The context, both main and specific research objectives, and expected contributions are depicted in Figure 1. The figure shows how this global research question is decomposed into four specific research objectives.

SPECIFIC RESEARCH OBJECTIVE 1: Understand the needs for management mechanisms of communities of teachers in learning design ecosystems.

The first objective of the Thesis focuses on understanding the needs of communities of teachers in learning design ecosystems. To face this objective I reviewed the literature and participated actively in research projects focused on providing a community platform for sharing and co-edition of learning designs (LdShake[1] platform; Learn3 and EEE projects[2]) and an extended community platform integrating multiple LD tools (Integrated Learning Design Environment – ILDE[3]–, METIS[4] EU-funded

[1] http://ldshake.upf.edu/
[2] Projects funded by the Spanish Ministry of Economy and Competitiveness TIN2008-05163/TSI; EEE TIN2011-28308-C03-03
[3] http://ilde.upf.edu/about/
[4] http://www.metis-project.org

LLP Project). I was a member of the teams designing, developing and evaluating in authentic scenarios of both platforms; my participation in this research – related with the PhD Thesis –, already represent a partial contribution of Thesis, which needs to be understood in the context of a collective contribution.

The contributions of the work performed in LdShake has been published in the following journal and conference papers (Hernández-Leo, Moreno, Carrió, Chacón-Pérez, & Blat, 2015; Hernández-Leo, Moreno, Chacón-Pérez, & Blat, 2014; Hernández-Leo et al., 2011; Hernández-Leo, Carralero, et al., 2010)[5]. The collective work carried out with respect to ILDE has derived the following publications (Hernández-Leo, Asensio-Pérez, Derntl, Prieto, & Chacón-Pérez, 2014; Hernández-Leo, Chacón-Pérez, Prieto, Asensio-Pérez, & Derntl, 2013; Hernández-Leo et al., submitted).

Participating in these projects, together with the exploration of the literature, also enabled me to identify and understand relevant problem areas in the frame of the research question.

In particular, identified problem areas are: supporting flexible design processes involving diverse tools of learning design ecosystems (this leads to objective 2), supporting co-design and reuse scenarios that involve multiple versions of a learning design (this leads to objective 3) and supporting interoperable management of learning design patterns (this leads to objective 4).

Participation in the METIS Project is particularly relevant in this Thesis. In METIS, LdShake is extended to integrate multiple learning design tools (especially those provided by the consortium) and interfaces to enable their automatic implementation in Virtual Learning Environments. Moreover, METIS organized professional development actions aiming at training teachers in the use of learning design practice supported by ILDE.

[5] Moreover, we extended LdShake in the context of an EACEA LLP project involving the ICT and the Journalism departments at UPF, to serve as a collaborative learning environment (with teacher supervision) for Integrated Journalism courses. This work was published in a journal article (Chacón-Pérez, Da Rocha Fort, Hernández-Leo, Blat, & Alsius, 2014)

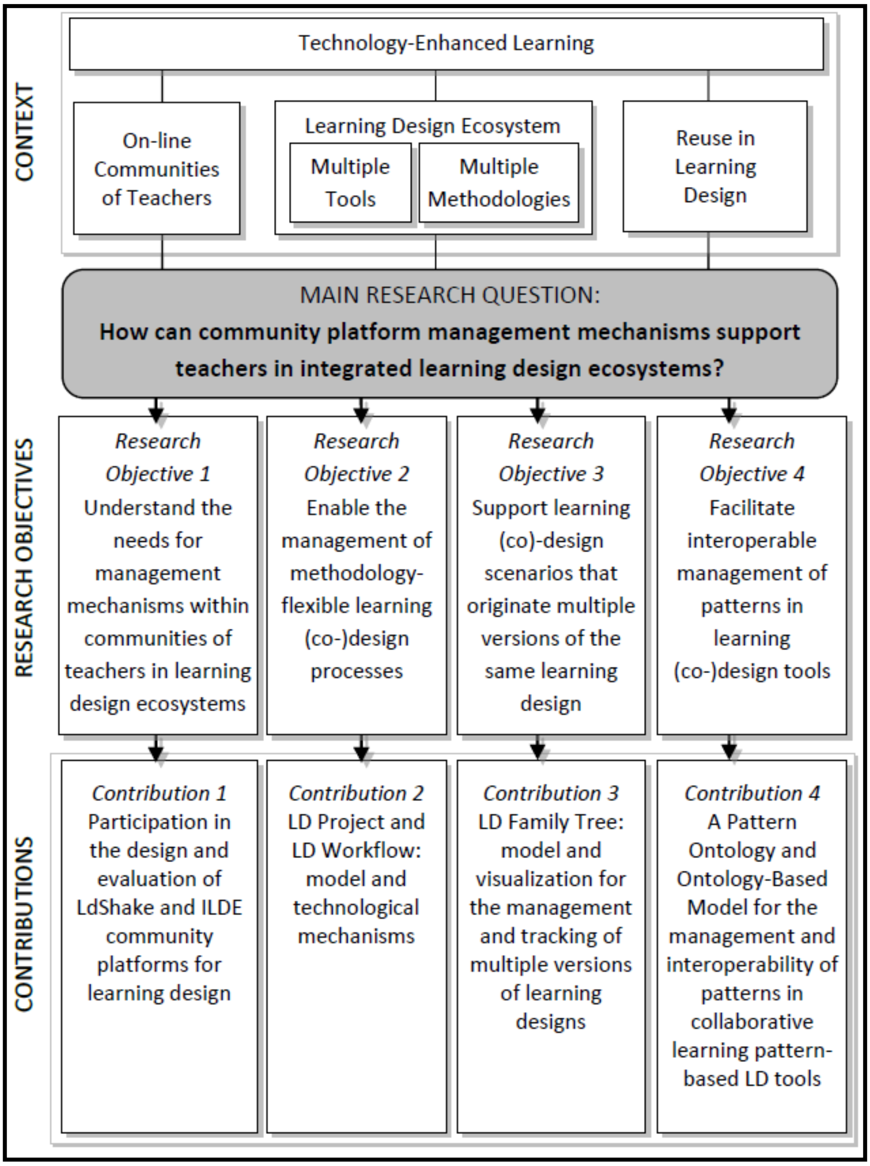

Figure 1: Schema of the research context, global research question, specific research objectives and contributions

Specific Research Objective 2: Enable the management of methodologically-flexible learning (co-)design processes

The integration of multiple LD tools in a community platform is not sufficient to offer teachers an articulated meaningful LD ecosystem. The incorporation of LD methodologies suggesting the use of a collection of tools shaping coherent (co-)design process would be an approach to tackle this problem. However, LD methodologies should also accommodate the needs of particular educational contexts. Guidance within an LD ecosystem should be flexible, editable by users (e.g., academic managers, experienced teachers, etc.) Support within a community platform should also enable teachers an easy application of the methodologies to their own learning design projects. We contribute with a model that conceptualizes management mechanisms that support flexible learning (co-)design processes in an LD ecosystem in the shape of what we call as LD Workflows. LD Workflows can be instantiated by teachers as LD Projects. This is still unpublished work but a journal manuscript is currently under preparation.

SPECIFIC RESEARCH OBJECTIVE 3: Support learning (co-)design scenarios that originate multiple versions of the same design solution

As mentioned in section 1.1, reusability is a relevant aspect in learning design and learning (co-)design scenarios. When reusable scenarios involving reuse were analyzed, it becomes clear that multiple versions of the same learning design need to be managed (e.g., identify which of the possible variations of a design is more interesting to be reused, see changes across refinements to a design originally ideated by a team of teachers, etc.) As contributions of the Thesis, we propose a model based on family tree relations metaphor, which simplifies the complexity of the relations between versions of a learning design; and provide visualization for the management and tracking of multiple versions of designs. The contributions related to this objective have been published in a conference paper (Chacón-Pérez, Hernández-Leo, & Blat, 2014) and later consolidated as a book chapter (Chacón-Pérez, Hernández-Leo, Mor, & Asensio-Pérez, 2015).

SPECIFIC RESEARCH OBJECTIVE 4: Facilitate interoperable management of patterns in learning (co-)design tools

In this objective we focus on facilitating interoperable management of patterns across pattern-based LD tools. As each LD tool has a purpose and is set in a particular environment, teachers may need to complement a design using different authoring LD tools over the same content (e.g., starting a brainstorming action with teachers' intentions, and later complement it using another LD tool with descriptions of the tasks). LD interoperability is a very complex problem when we try to cover all kinds of learning designs (Mandviwalla & Grillo, 1995; Muñoz-Cristóbal, Prieto, Asensio-Pérez, Jorrín-Abellán, & Dimitriadis, 2012; Vdovjak & Houben, 2001). To narrow down the problem, we choose design patterns as one particular interesting case of reusable structured learning design. Moreover, considering that patterns in the area of Computer-Supported Collaborative Learning (CSCL) design are especially well documented and interrelated within pattern languages (Hernández-Leo, Asensio-Pérez, et al., 2010), we have selected these patterns as the focus of study.

To address this problem, we claim that we can use semantic mechanisms to support interoperability between different pattern-based LD tools. Based on patterns' format, the Thesis contributes with an Ontology-Based Model for the management and interoperability of patterns in pattern-based LD Tools. The presentation of a pattern language as a pattern ontology is explained in a conference paper (Chacón-Pérez, Hernández-Leo, & Blat, 2011). Furthermore, the work is later extended with an architectural model published in another conference paper (Chacón-Pérez, Hernández-Leo, Emin, & Villasclaras-Fernández, 2014).

1.3 Research methodology

The research work of this dissertation is framed in the Educational Technologies field, with a perspective of offering computer-based platform management mechanisms to support Learning Design within communities of teachers. Therefore contributions to Educational Technologies are done mainly from an engineering perspective. Given this perspective, it was decided to conduct this Thesis using the Engineering Method (Adrion, 1993; Glass, 1995) as the overall methodological umbrella, see Figure 2. Then, for each research objective more specific methods are applied depending on the characteristics of each objective.

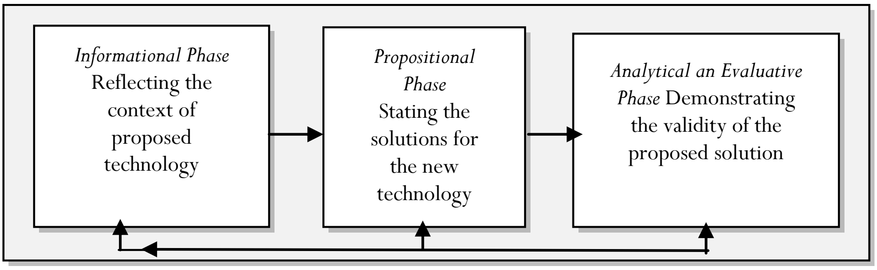

Figure 2: Engineering method proposed by (Adrion, 1993) described using the phases of (Glass, 1995)

The engineering method comprises the following phases according to (Glass, 1995): informational, propositional and analytical and evaluative phase.

- *Information phase*: This phase begins defining the problem that we want to study. Initial steps involve identifying information sources in order to become familiar with the state of the art and to identify practical problems observed when participating in building and evaluating learning design communities. Starting from a general context, the problem is progressively being limited until establishing a clear focus of the research. This phase is associated with research objective 1 and contribution 1 (see Figure 1) and the formulation of research objectives 2, 3 and 4.

- *Proposition phase*: Once we gather enough information about the topic, we propose how to formulate new technology we expect to contribute. In this phase, tentative contributions of the Thesis addressing research objectives 2, 3 and 4 are proposed, i.e., LD Project and LD Workflow model, the LD Family Tree model and the Ontology-Based model.

- *Analytical phase and evaluative phase*: Analyzing and exploring our proposed solution leading to formulation of the Thesis' contributions.

> Furthermore, an evaluation will be applied in accordance with methodologies selected for addressing each objective. Depending on the objective/contribution, we use descriptive/expressiveness methods based on scenarios (contributions 2, 3 and 4, see Figure 1), feasibility checking with technical implementation (contributions 2, 3 and 4), paper prototyping with users (contribution 4), questionnaires involving experts (contributions 2 and 3), evaluation of actual use with teachers in training sessions such as workshops (contributions 2 and 3), and a descriptive approach narrating the adoption of contributions in real scenarios (contribution 2).

The information phase will be specifically relevant during the first stage of the Thesis although it will continue to monitor the evolution of state of art throughout the whole Thesis. As part of this phase, we participate in design, development and evaluation of LdShake and later of ILDE (see contribution 1 in Figure 1). As aforementioned, this work involved participation in team research in the context of Learn3, EEE and METIS projects[6]. The processes followed to build both LdShake and ILDE are based on adaptations of the Design-Based Methodology (Amiel & Reeves., 2008; Barab & Squire, 2004; Hernández-Leo, Chacón-Pérez, et al., 2013; Hernández-Leo et al., 2011; Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007), with an emphasis in understanding and satisfying users' needs.

The propositional and analytical phases centered on research objectives 2, 3 and 4 also followed specific methodologies depending on the objective.

Due to innovative characteristics of models mentioned in contribution 2 and 3, that will produce mechanisms/artifacts to address specific problems, objectives 2 and 3 will be addressed following Design Science Research Methodology (Peffers et al., 2007) suggesting six different phases: i) identify problem and motivation, defining the problem and showing importance of the research; ii) define objectives of a solution; iii) design and

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[6] Moreover, these projects and the provided community platforms (LdShake, ILDE) have also offered us a relevant context and infrastructure for the evaluation of the solutions contributed to address the other research objectives of the Thesis.

development; iv) demonstration by finding a suitable context to test it; v) evaluation observing how effective, efficient is the proposed solution; vi) and communication by means of publications (in scholarly or professional publications). This methodology has been used in research projects in Educational Technology areas with an engineering emphasis, such as (Pérez-Rodríguez, 2013).

For contribution 2, the LD Project and LD Workflow conceptual model and definitions will be proposed for enabling management of methodology-flexible learning (co-)design processes. Following the design science research methodology, interest will be understood by inquiring teachers about how they perceive the support to LD Projects. Based on the initial results of the survey, proposals will be reformulated and refined until a satisfactory solution will be achieved, which will be implemented on ILDE. Following the methodology, the solution will be presented to observe its effectiveness and efficiency in potential use case scenarios. Later, it will be evaluated in three different teachers' workshops in the context of the METIS project.

For contribution 3, a conceptualization of a metaphor for support tracking and management of LdSs' versioning will be defined. In this contribution, the LD family tree model and visualization is going to be proposed. Following the design science research methodology, we will define objectives of a solution. Furthermore, a proper visualization will be implemented to apply the family tree metaphor and illustrate the relations between duplications. It will be demonstrated with a set of use cases. Both visualization and technical implementation for managing and tracking multiple versions of LdS are going to be evaluated in the context of METIS workshops.

For contribution 4, an ontology-based model is going to be proposed for facilitating interoperable management of patterns in learning (co-)design tools. Since the purpose of this contribution is to build a new system which serves as an intermediate point between existent repositories and tools, the Systems Development Research Process (Nunamaker Jr & Chen, 1990) is applied. This methodology is based on five phases: i) Construct a conceptual framework; ii) develop the system architecture; iii) analyze and design the system; iv) build the (prototype) system; v) and evaluate the system. The contribution will begin with computational representation of a pattern language by means of OWL language as the conceptual framework. Then, an ontology-based model for the management and interoperability of patterns in collaborative pattern-based LD will be designed in the form of architecture. Then, it will be implemented as a prototype (following the applied methodology) in ILDE. On the one hand, the pattern ontology will be evaluated in two phases: in the first phase, it will be evaluated with two real scenarios designed by teachers that describe two activities based on a set of patterns. Second, a paper prototyping experience will be conducted with different teachers, who will use the ontology to create new activities. On the other hand, the architecture will be initially evaluated by a set of given scenarios following the Systems Development Research Process (Nunamaker Jr & Chen, 1990), which illustrate diverse uses of the architecture around management and interoperable provision of design patterns in learning design tools.

Figure 3 shows a schema of overall engineering methodology followed in this Thesis, the main problems described in 1.2 and contributions proposed to solve them. The final column shows the main evaluation methods applied for each contribution.

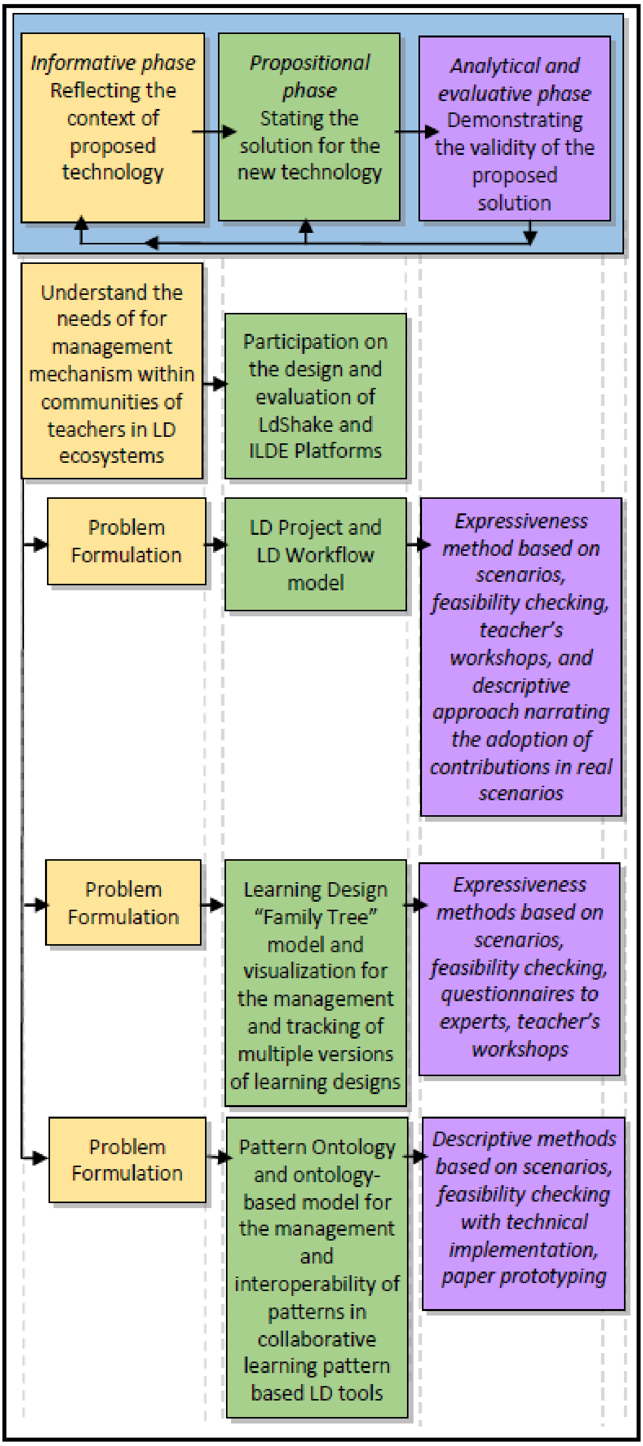

Figure 3: Schema of overall engineering methodology followed in the PhD Thesis

1.4 Structure of the dissertation

The remainder of this dissertation is structured as follows:

- *Chapter 2: Research Context: understanding the needs.* This chapter analyzes research areas involved in the domain problem tackled by the Thesis. The chapter starts providing an overview of the state of the art in online communities of teachers, Learning Design research field and Learning Design tools. A focus on reuse of learning designs is also discussed. Furthermore, the chapter describes the two community platforms in whose building I have participated (LdShake and ILDE) to understand the needs of community platform management mechanisms in learning design ecosystems. Finally, the chapter exposes problematic observations while teachers use the built community platforms.

- *Chapter 3: Supporting flexible Learning Design projects.* This chapter is devoted to address the need for flexibly articulating LD processes that involve the use of diverse LD tools according to varied methodologies and frameworks. In particular, the chapter introduces the concepts of LD Project and LD Workflow and a model for their implementation. Furthermore, it also describes how the model has been applied to develop a feature for flexibly managing LD projects that has been incorporated in ILDE. Finally this chapter includes the evaluation carried out: descriptive/expressiveness methods based on existent LD methodologies, evaluation of actual use with teachers in training actions (METIS workshops) and descriptive narratives about its adoption in third-party contexts.

- *Chapter 4: Supporting Learning Design versioning.* This chapter addresses the need for managing multiple variations of a learning design in context of reuse and co-design. The chapter proposes a model and a visualization strategy based on the Family Tree metaphor for LD versioning. The chapter also presents implementation of the model and associated visualization in ILDE and the evaluation carried out with experts and in training workshops (METIS and third-party workshops, scenarios of use and feedback from users).

- *Chapter 5: Supporting interoperability in pattern-based Learning Design tools.* This chapter explores the challenging need of interoperability across LD tools focusing on the specific case of LD patterns in the area of

CSCL. The approach taken is based on ontologies. The chapter formulates a pattern ontology and an ontology-based model that is applied to an architecture for interoperability of LD pattern-based tools. The architecture has been partially implemented to show feasibility. The chapter also presents a proof-of-concept scenario involving a selection of representative tools.

- *Chapter 6: Conclusions and future work.* In this chapter main conclusions are discussed. Furthermore, it also summarizes main contributions and future work derived from this dissertation.

- *Supplementary material:*

  - Contributions to LdShake [7] and ILDE [8] software code are available in GitHub. Technical and user manuals, including community platform management mechanisms contributed by the Thesis, are also available online[9] and compiled in a METIS deliverable (Hernández-Leo, Chacón-Pérez, Abenia, Asensio-Pérez, Prieto, Hoyos, & Derntl, 2015).

  - Organization, running and evaluation of METIS workshops are described in METIS deliverables (Brasher et al., 2015; Pozzi, Ceregini, Persico, Sarti, Brasher, Chacón-Pérez, et al., 2015; Pozzi, Persico, Sarti, et al., 2015; Rudman et al., 2015)[10].

  - A technical report (Chacón-Pérez, 2013) listing descriptions of project management tools in diverse fields, which are analyzed in Chapter 3.

[7] https://github.com/GTI-Learning/LdShake
[8] https://github.com/METIS-Project/ILDE
[9] http://ilde.upf.edu/v/f4o - see ILDE global features (powered by LdShake) manuals -
[10] I contributed to the work presented in these deliverables mostly by supporting workshop facilitators in the configuration of ILDE as required for the workshops and co-leading adult education workshops.

CHAPTER 2. RESEARCH CONTEXT: UNDERSTANDING THE NEEDS

The aim of this chapter is to frame the research context of this PhD Thesis. Domain problem is situated in the intersection of online communities for teachers, existent multiplicity of LD tools and methodologies, and relevance of reuse in LD. The chapter explains the work carried out to address first research objective of the Thesis focused on understanding needs for management mechanisms within communities of teachers in LD ecosystems. This work involves participation within LdShake designing team and ILDE community platforms, and evaluating their usage in several contexts. Sections 2.5 and 2.6 reflect contributions of the work performed in objective 1, based on work published in journal articles (Hernández-Leo, Chacón-Pérez, et al., 2013; Hernández-Leo, Moreno, et al., 2015, 2014; Hernández-Leo et al., 2011; Hernández-Leo, Asensio-Pérez, et al., submitted, 2014).

2.1 Introduction

The diffusion of Internet shifted the way people communicate and interact with each other. Besides, Internet has become a repository itself of immeasurable dimensions where people can find any different kind of information. The Internet made online education increasingly accessible. Moreover, Information and Communication Technologies (ICT) enabled greater and faster human communication and collaboration, while supporting information sharing and communication between people which had been previously unfeasible (Harasim, 1990).

In the Educational field, Internet is also shifting the learning paradigm for both learners and teachers. On the one hand, a student may use resources available in Internet to complement their classes. Doing so, student can clarify or expand concepts learned during their courses or explore totally news areas. On the other hand, the way teachers are preparing their teaching is shifting from offline environments where they prepare their classes based on their own previous experience (Bennett et al., 2015), to online communities where teachers can share and explore other educational methodologies (Harasim, 2000). Thereby, areas such as Learning Design (LD) appeared for supporting educators to design their innovative content (Conole, 2012; Laurillard, 2012; Mor et al., 2013).

Specifically, online communities are being increasingly used by teachers for professional support during the preparation of their own teaching classes (Duncan-Howell, 2010). Moreover, these online communities of teachers are acting as real repositories of activities. However, to allow teachers to benefit from experience and practices of others is difficult. Their expertise should be reflected into activities and we may plan carefully the guidance through those resources.

This chapter explains the work carried out to address first research objective of the Thesis focused on "understanding needs for management mechanisms within communities of teachers in LD ecosystems". To address the objective, the chapter revises state of the art framed in the research context and includes participation in research work around the design and evaluation of two online community platforms for teachers (LdShake and ILDE).

The chapter is structured as follows, section 2.2 introduces Online Communities of Teachers; section 2.3 describes the Learning Design research field; section 2.4 explains the challenges of reuse in LD repositories; section 2.5 introduces LdShake as an example of an online platform for communities of teachers; section 2.6 describes ILDE, an environment that builds on top on LdShake and also includes LD-based tools that cover the whole LD life cycle from conceptualization to implementation on Virtual Learning Environments (VLE) with students; section 2.7 concludes this chapter with the identification of problems areas that are tackled during this Thesis.

2.2 Online communities of teachers

Educators must be constantly adjusting their teaching to accommodate change (Riding, 2001). Furthermore, as technology advances they are under constant pressure to learn new technologies and update their knowledge. Once this new knowledge and skills are mastered they need to apply it successfully into their classroom practices (Richardson, 1990). Traditionally, schools offer teachers training courses or workshop sessions in order to learn these new skills. However, there are several examples in literature claiming that these small sessions do not encourage full development of new skills productively (Boyle, While, & Boyle, 2004; Guskey, 2002).

On the one hand, they need to personalize what they learnt in order to adapt it to their specific teaching needs. Although each educator needs to learn these new competences, they will apply it for different teaching practices. Moreover, examples of use and real scenarios close to their practices will facilitate them to reuse absorbed new practices. On the other hand, teachers need longer time frames for learning new skills, allowing educators to learn and reflect on their learning practices (Boyle et al., 2004).

Internet provides teachers with suitable environments to collaborate and reflect with other teachers and experts, supporting individuals to interact, learn and access knowledge and resources within a social space (Schlager & Fusco, 2003). This social space is commonly known as online communities of teachers. According to (Jones & Preece, 2006) an online community is defined as “a group of educators who work together for a common goal or to satisfy a set of common requirements; inside the community”. In a way, this notion of community is aligned with (Wenger, 1998) Communities of Practices, in which members share a concern for something they practice and interact among them to learn how to improve such practice (Carr & Chambers, 2006; Davis et al., 2010; Supovitz, 2002).

These online communities create a sense of disconnectedness where worldwide educators find a place that they have the opportunity of online communication by synchronous and asynchronous mechanisms. Moreover, these environments provide a forum for teachers to discuss and compare ideas. Further, this forum provides a place to learn from others on applying their ideas in classroom. Another aspect about online communities is the absent of time constraint. As the content is online participation may flow from high to low activity over longer periods of time.

An example of an online community of teachers is eTwinning (Vuorikari, Gilleran, & Scimeca, 2011). It facilitates a space for teachers from different schools to collaborate using ICT tools, meet virtually, set up projects and sharing ideas and practice examples. Other examples of platform for online communities include: Cloudworks (Conole et al., 2008), where teachers can share, find and discuss learning ideas and experiences; and EdShare (Davis et al., 2010), where teachers found an online environment for teaching and learning resources. However, these kinds of existent communities of teachers share a common constraint: their main features only support communication. Thus, it does not support the co-edition of learning design, and LD tool support inside the platform is limited. What is needed are sets of tools articulating an LD ecosystem in those environments to offer flexible approaches that scaffold teachers in designing for learning.

2.3 Learning Design ecosystem

In this section the *Design* concept is presented to denote how important is to plan carefully the design process in the Learning Design (LD) Field. Cambridge dictionary [11] defines Design as "the process to invent and prepare a plan of (something) before it is built or made". Oxford dictionary[12] defines design as "a plan or drawing produced to show the look and function or working of a building, garment, or other object before it is made". In these regards, designing involves an agent who performs the

[11] Design [Def. 1]. (n.d.). In Cambridge Dictionaries Online, Retrieved September 2, 2014, from http://dictionary.cambridge.org

[12] Design [Def. 1]. (n.d.). In Oxford Dictionaries Online, Retrieved September 2, 2014, from http://oxforddictionaries.com

specification of an object that intends to accomplish goals in a particular environment, satisfying a set of requirements. However, design can have different connotations in different fields.

In the field of software engineering design is part of the engineering process. This process involves a number of steps like defining the concept of the product, doing research and analyzing the user's needs, requirements gathering and some of them in an iterative process of design, producing, testing and re-designing again. Furthermore, design is a part of many engineering methodologies and processes in order to define new software products (e.g. Rational Unified Process (RUP) (Kruchten, 2004)). For instance when developing a new cash-machine interface for a bank, the design for this interface has to be carefully prepared in order to be easier to use by customers. In industrial design, it implies the process of studying a product in order to improve the aesthetics, ergonomics, functionality and usability. In this field they define design as the process of taking something from its existing state and moving it to a preferred state (Coelho, Silva, & Simao, 2011). For example, when producing a new automobile the design of each of its parts must be planned: proper aerodynamics, security issues and also a proper look and feel to sell it to customers. Another example is the field of architecture. Here the design refers to the layout of spaces and includes mathematics involving dynamics and physics that builders has to take into consideration when building (Alexander, Ishikawa, & Silverstein, 1977).

Albeit different connotations of design in different fields, all of them have the design as a process in common that must be planned in order to succeed in designing or re-designing a product. This reasoning is also applied in learning when preparing new educational activities, where it is also important to consider and plan accurately the design process, as aforementioned, the research field that focuses in methodologies, theories and processes of designing learning activities is known as Learning Design (LD). The LD field support teachers within design, sequence and managing of learning design activities. Previous research on LD provided a myriad of tools and approaches (Persico et al., 2013; Prieto et al., 2013), allowing teachers to be designers of sound educational activities from small-scale activities up to whole teaching plans (Guri-Rosenblit & Gros, 2011; Mor et al., 2013). Moreover, these activities are enhanced with effective conditions for learners to learn. Aim of this field is to support teachers as designers during the whole learning design process to improve teaching quality and create innovative and more effective activities. In these regards, training in LD is becoming a necessary investment to support teachers improving their teaching quality. Furthermore, there is evidence in literature that shows that is relatively easy to adapt learning designs to contextual changes, and incorporate technology-enhanced educational materials and learning platforms (Garcia, Gros, & Noguera, 2010; McKenney, Kali, Markauskaite, & Voogt, 2015; Svihla, Reeve, Sagy, & Kali, 2015).

Regarding ICT support for learning design, a rich set of tools have been developed, providing support for different tasks, such as OULDI templates (Cross, Galley, Brasher, & Weller, 2012). With respect to authoring tools, Collage (Hernández-Leo et al., 2006) and Web Collage (Villasclaras-Fernández et al., 2013) proposes a pattern-based design approach for collaborative learning; CADMOS LD (Katsamani & Retalis, 2011) proposes a visualization tool that helps teachers to design a unit of learning in two layers: conceptual and flow, OpenGLM (Derntl et al., 2011) enables the graphical creation of learning designs following diverse pedagogical approaches. Another repository which however do not support co-design, is AUTC ("AUTC," 2012). Interestingly, the LAMS (Dalziel, 2003) suite shows the feasibility of closing the life-cycle of authoring and enactment. With respect to enactment, we need to consider VLEs such as Moodle, .LRN, etc. These VLEs are widely used, but they lack features to facilitate the deployment of learning designs. This issue has been tackled by systems such as GLUE!-PS (Prieto, Muñoz-Cristóbal, Asensio-Pérez, & Dimitriadis, 2012), which provides interoperability between several authoring tools and VLEs. These systems cover the needs to create and run learning designs with ICT support. However, teachers may need a sort of guidance for using these tools. Furthermore, some of the tools need to be used in a particular stage of the learning design process.

LD methodologies try to define a set of steps to be followed using a particular group of tools in order to define specific kind of resources or activities. For instance, the 7Cs of Learning Design methodology (seven Cs from: conceptualize, capture, create, communicate, collaborate, consider and consolidate) is especially useful for teachers and educators who want guidance and inspiration for more effective, imaginative and creative uses of a virtual learning environment such as Moodle and the web, to enhance the learning process for learners. Furthermore, this also helps teachers to make the learning experience more interactive and engaging for learners at different levels of granularity (from a basic activity to the whole course). In order to support teachers to adopt this methodology the 7Cs developer team provides the 7Cs of Learning Design Toolkit (Conole, 2014). This toolkit provides links and descriptions to more than 20 templates, tools and resources.

Another example of methodology is the Learning Design Studio (LDS), which is needs-driven inquiry-based framework for collaborative professional development of educational teachers. Teachers, educator's leaders, policy makers and developers often find it hard to apply the outputs of research and innovation in education and technology to their practices. The theoretical structures seem abstract and remote, thus resist application in real life settings. Many examples seem rooted in a specific and unique context, making them hard to transfer to novel situations. The LDS confronts this challenge by engaging teachers in a process of Design Inquiry of Learning. This process combines the iterative structure of educational design research with the principles of inquiry learning. Participants follow a cycle of: defining their project, investigating the context in which it is situated and identifying appropriate techno-pedagogical theories, reviewing relevant cases and theories, conceptualizing a solution, implementing a prototype of that solution, evaluating it and finally, reflecting on the process (Mor & Mogilevsky, 2013).

Both methodologies and tools are important and support teachers in different ways. However, what is needed next is to try to combine these elements dynamically, by means of a learning design ecosystem. In these regards, we define the set of LD methodologies and LD tools a teacher may use inside an online community of teachers as a «Learning Design Ecosystems», in a way that any resource will be concise, comprehensive and accessible for teachers and learners to adopt more learning-design-based thinking and practices (Conole, 2013).

Although evidence proved by research the affordances of LD has not widely impacted teaching practice yet. Recent studies, focusing on understanding how teachers work and prepare their classes, found evidences for lacking of adoption of LD methodologies and LD tools. Bennet et al. (2015) highlighted that learning design tools need to be more flexible. Depending on teachers' disciplines and teaching contexts the way teachers define their activities may vary. Mor et al. (2013) pointed out LD tools lack support to enable teachers to document with instructions their learning decisions explicitly, and at the same time these LD tools use those instructions to automatically prepare the technological learning environment to be used by students. (e.g. adapting a VLE such Moodle by using the instructions depicted during the LD process). Finally, Voogt et al. (2011) and Bennet et al. (2015) confirm the importance of the social perspective in LD. It is becoming more common that teachers design in teams, hence the need of online communities where teachers can share their designs and experiences. However, the support to sharing and co-creation of designs is very limited in the context of LD tools (Hernández-Leo et al., 2011).

2.4 Reuse in Learning Design

The sharing of learning designs facilitates scenarios of reuse, which become especially relevant when the designs reflect good practices in teaching and learning. Supporting creation of potentially effective learning designs is a relevant topic in TEL (Goodyear & Retalis, 2010). ICT are being introduced in schools progressively and teachers are being encouraged to create material and design new practices using these technologies. However, the process of designing activities with technology is not an easy task for teachers. Not all of them are familiar with technology itself. In order to facilitate this task the solution proposed is to adopt the "designing by reusing" approach, which has already proved to be useful in the literature (Hernández-Leo et al., 2007). This approach proposes to start reusing already existing and proved-to-be-good material instead of starting from scratch. Doing so, teachers neither familiar with technologies nor LD approach can have a solid help to design their own activities.

The TEL literature has applied and studied different levels of reusability (Harrer, 2006; Hernández-Leo et al., 2007). According to these studied levels of reusability, we focus on design patterns that can be provided as templates or building blocks, since they have proved to be appropriate reusable components for the creation of potentially effective designs (Hernández-Leo, Jorrín-Abellán, Villasclaras-Fernández, Asensio-Pérez, & Dimitriadis, 2010).

By adopting design by reusing approach, teachers are assisted in the creation of designs based on existing patterns. When those designs are patterns in the form of templates or building blocks, then reusable elements represent sound didactic ideas. Teachers only need to select the set of patterns that better fits the needs of each educational situation. However, without a guide to select patterns, teachers may end up with a set of isolated patterns that does not fit harmonically with each other.

2.4.1 Learning Design patterns

Pattern Languages (PL) were proposed to address the problem of isolated patterns, since those are a collection of interconnected (related) patterns which enable the generation of a coherent whole (Peter Goodyear & Retalis, 2010). Furthermore, pattern languages interconnect patterns using natural language. Thus, each pattern within a pattern language includes a description indicating which other patterns could be used to complement or complete it.

An example of a broadly accepted Patten Language (PL) is the Computer-Supported Collaborative Learning (CSCL) scripting PL presented in (Hernández-Leo, Asensio-Pérez, et al., 2010). CSCL is a field in TEL that focuses on how people can learn together with the help of computers (Stahl, Koschmann, & Suthers, 2006). The CSCL scripting PL is organized in four different levels: Collaborative Learning flow, Activity level, Resource Level and transversal to all of them Roles and common CL mechanisms level. Nonetheless, the most commonly used are the Collaborative Learning Flow Patterns (CLFPs), a particular type of patterns that capture good practices regarding the structure of an activity and the involved communication between participants in the form of groups. Examples of patterns regarding this category will be Jigsaw (see Table 1), Pyramid, Brainstorming or Simulation.

Jigsaw pattern supports teachers in the kind of activities where groups of students face resolution of complex tasks that can be easily divided into sections or independent sub-problems. Then the class is divided in jigsaw groups of a particular number of students, each student from a jigsaw group work individual around a particular sub-problem. Then, the students of different groups who study the same problem meet in an expert group for exchanging ideas. These temporary focus groups become experts in the section of the problem given to them. At last, students of each jigsaw group meet to contribute with its expertise in order to solve the whole problem (Hernández-Leo, Asensio-Pérez, et al., 2010). An example of the fields for a Jigsaw pattern included in a pattern language could be seen in Table 1. This learning design patterns are implemented into LD authoring tools available in online repositories.

Table 1: Pattern fields included in the pattern language

Field	Description
Category	category in which the pattern is included (CLFP, activity, role, resource, space, group formation, …)
Pattern Name	Name of the pattern
Alias	Other names for the pattern
Problem	Learning problem to be solved by the pattern
Applicability	Situations in which the pattern is usable; the context for the pattern, general environment in which the pattern could be applied
Intention	Educational benefits of the pattern, intentions about learning improvements (attitude, capacity, knowledge) with the pattern
Solution	Description of the proposal by the pattern for solving the problem
Actors	Actors involved in the collaborative activity described by the pattern
Example	A real-world learning activity capable of being structured according to the pattern
Diagrammatic Representation	A graphical representation of the pattern (schema, image…)
Sample Code	An illustration of how the pattern can be used in an interoperable language (IMS-LD, SCORM…)
Consequences-Risks	A description of the results, side effects, risks and tradeoffs caused by using the pattern
Is Completed By	Related Patterns which *complete* this pattern, refined this pattern with a second pattern that adds further design ideas than those already proposed by the initial pattern.
Is Complementary With	Related Patterns which *complement* this pattern as these patterns together form a larger whole
Types and structure of Groups	Description of the types of groups of learners identified and how they are related
Flow	Structured sequence of activities with phases, Types of tasks, together with their sequence, performed by the actors involved in the activity.
Application guidelines	Description of how to use the pattern, advices

2.4.2 Pattern-based Learning Design tools

The relevant role of pedagogical patterns in LD can be recognized in multiple of available LD tools. There exist general repositories of LD ideas that also include patterns, such as Design Principles Database (Kali, 2006) – among others-, and specific tools focused on collection of patterns, such as the Pedagogical Pattern Collector (Laurillard, 2012). Moreover, several authoring tools provide templates based on explicit patterns (as for instance inquiry based learning), enabling their direct refinement (and sometimes also combination) by editing and particularizing the templates (Laurillard, 2012b; Prieto et al., 2013). Among the existing tooling, in particular those proposed in a collective paper (Prieto, Dimitriadis, et al., 2013) comparing a same scenario expressed through different tools as lenses, some examples are Web Collage, ScenEdit and LdShake.

The first tool, Web Collage is a web learning design graphical authoring tool that supports teachers who are familiar but not experts in learning design to design their own CSCL scripts (Prieto et al., 2013; Villasclaras-Fernández et al., 2013). Web Collage allows teachers to structure CL activities using one or several patterns, the tool suggests ideas about structuring collaborative learning activities. Furthermore, Web Collage manage automatically the creation of roles, phases and activities that later may be completed and refined.

The second tool is ScenEdit, this tool is a graphical authoring environment dedicated to the design of blended learning scenarios (Emin et al., 2010; Prieto et al., 2013). ScenEdit is based on the ISiS framework (Intention, Strategies, and interactional Situations). This framework aims at capturing teacher's intentions and strategies to have better understanding of scenarios written by others teachers (Pernin et al., 2008). ScenEdit allows teacher-designers to structure their own scenarios designs by including their intentions, strategies and interactions included in the ISiS framework. ScenEdit foster sharing and reusing practices by providing patterns for each type of component (intention, strategy and interactional situations) elaborated from best-practices found in the literature or within communities of practice.

The third tool is LdShake, which includes patterns and Learning Design Tools (including pattern-based authoring tools). The following section describes in detail opportunities offered by this tool to understand the needs of management mechanisms in online communities of teachers.

2.5 LdShake, Learning Design sharing and co-edition

LdShake is a web tool for social sharing and co-edition of learning design solutions (Hernández-Leo, Moreno, et al., 2015, 2014). The name "**LdShake**" stands for "**L**earning **d**esign **s**olutions – **Sh**aring and (**k**)co-**e**dition" and uses the "*shake*" metaphor to emphasize that the tool aims at facilitating teachers to *shake their hands* with other educators in their social network by collaborating with them in the co-edition of joint learning design solutions, to *shake their way of working* by sharing designs with other teachers, and to *shake different learning design solutions* shared by others to elaborate new designs in order to *shake the students* (see Welcome page for LdShake logged users in Figure 4).

Figure 4: Welcome page to LdShake
(LdShake is available online at http://ldshake.upf.edu)

Teachers or learning designers registered in LdShake, who are referred to as LdShakers, can create and edit different types of educational materials and activities (Lockyer & Patterson, 2008) that are generally termed as Learning design Solutions (LdS). Though future plans include enabling the creation of standard-compliant learning designs, such as IMS LD, the current version of LdShake allows authoring LdS whose body is a collection of HTML documents, so that they can be enriched with any kind of embeddable multimedia element present in the Internet. An LdS consists also of some open metadata and parameters that describe it and define its usage, such as description tags, an indicator of how ready it is for classroom use (full-fledged resource vs. refinable template, (Hernández-Leo et al., 2007)), or its sharing options.

LdShake implements read/write Web technologies, as they have been proved to address the problems of co-user-authored content in communities of teachers (Cifuentes, Sharp, Bulu, Benz, & Stough, 2009), and combines them with commenting support (Neuwirth, Kaufer, Chandhok, & Morris, 1990). LdShake sharing options allow granting access rights to the LdS so that pointed LdShakers can be readers or co-editors of such LdS. Readers can read and add comments to an LdS, while co-editors can also modify or extend the LdS. In this way, the LdS acts as a shared social object (Knorr-Cetina, 1997) that connects an educator with other LdShakers, creating automatically and transparently their social network. Users can also create named collections of LdShakers (e.g., "Biology teachers"), which are visible just for them, and share their LdS directly with the members of these collections. With this functionality the platform facilitates group work; sharing an LdS with a group is a matter of selecting the group name in the LdS options. A group can be also modified and subsequently the access permissions of all of the LdS shared with this group are automatically updated. Therefore, each LdS is associated to a team of LdShakers that are capable of working on its authoring, and a group of LdShakers that can only see the design solution. These teams of LdShakers can be also "all logged in users". Creator of the LdS acts as the coordinator and manager of the LdS life cycle, including the definition (and change) of its sharing rights and the number of HTML documents it comprises.

Discoverability of LdS is supported with an approach based on simple user-generated tagging. This mixture of folksonomy and provision of structure together with the use of clear terms that relate to the teaching practice seems to be an appropriate approach in Web2.0 platforms where educators are the end-users (Conole et al., 2008; Davis et al., 2010; Lockyer & Patterson, 2008). In LdShake, metadata associated to each LdS is generated from the title, its description, the discipline and the pedagogical approach tags.

In the LdS section of the site, users will find three different listings of their social objects: Their own LdS (those created by them), the designs that they can edit, and all the LdS they can view, see Figure 7. While the first two listings act as a shared and remote file system for LdS, the last listing acts as a repository viewer. As it is typically supported in co-authoring editors, such as wikis (Cifuentes et al., 2009), along the text of an LdS users can navigate through a revision history of its contents, seeing who has made each modification and when was it made.

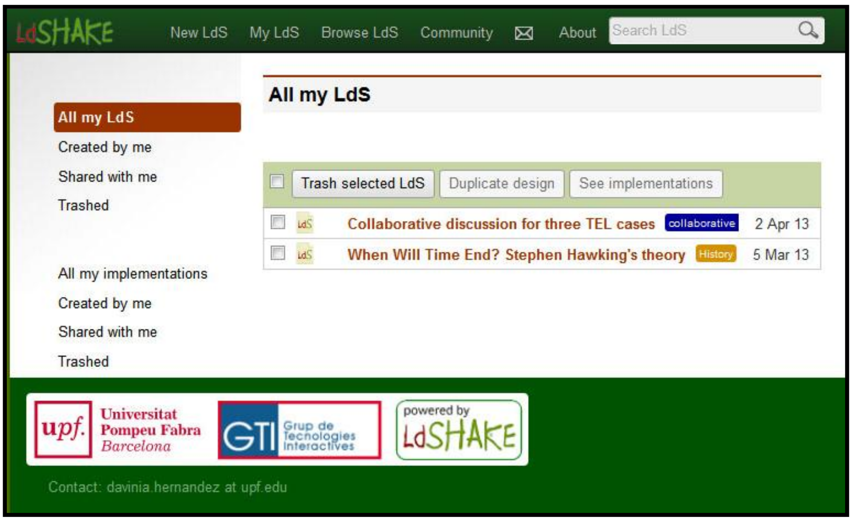

Figure 5: LdS organized into "All LdS", "Created by me" and "Shared with me"

Given the myriad of course management systems that exist nowadays, it was seen as useful to be able to (openly) publish a finished LdS through a unique URL, which can be easily referenced or linked anywhere (e.g., the learning management system that is used by the students). The creator of an LdS can publish it, and its associated public URL becomes visible for all the LdShakers that can read the LdS. Having this URL, any user, even those not logged into the system, can view the LdS (though they cannot comment it). The owner of the LdS can later decide to unpublish the LdS in order to make it no longer available out of LdShake.

Technologically speaking, LdShake is built on top of the Elgg platform. Elgg is an open source social networking engine written in PHP (Sharma, 2008). It offers a comprehensive set of functionalities for social network sites, ranging from contact management tools to an internal messaging module. Internally, Elgg treats all the information published in the site as entities with associated metadata. By having this data homogeneity, Elgg-based sites are very easily enhanced; likewise adding new modules to them does not require extra coding. There is a numerous community of contributors behind Elgg, who are frequently releasing new modules, as well as updating the engine's core. The counterpart of this modularity is that having such a generic data model goes at the expense of scalability, but Elgg has been seen as a good option for a rapid building of ready-to-use social networking tools such as LdShake.

LdShake reuses an existing module to create wikis in the platform to implement all the core LdS-related functionalities. However, other functionalities such as tag clouds, importing and exporting tools and LdShake-specific LdS management are located in independent modules that can be activated or disabled from an administrator control panel. The idea behind this architecture is that it must be easy to personalize LdShake according to specific requirements of a particular group of users. LdShake is built as a generic tool that can be used for the creation of any learning design type. However, it can be also customized according to the needs of institutions or teaching units using specific didactic methods.

Following example demonstrates the situation of an integrated-course design of Biology, where teachers from Human Biology degree of Pompeu Fabra University apply Problem-Based Learning methodology (PBL)

(Barrows, 2002). Its curriculum includes a set of so-called "integrated-courses" based on problems whose resolutions require knowledge of different biomedical disciplines that have been previously coursed by students (Carrió, Larramona, Baños, & Pérez, 2011). Main challenge around preparation of this integrated-course is managing the collaborative authoring of interdisciplinary problems by teams of teachers with different backgrounds such as Evolution, Biochemistry, Anatomy, Physiology, Statistics, etc. The coordinator of the integrated-course would ideally want that all teachers involved in the creation of problems are aware of them. So, teachers would know in what problems contribute and coordinator may check if teachers have the proper rights to co-edit them.

The "Integrated Biology" scenario poses two main challenges that have been identified in the literature to cope with this concern. The first challenge is focused on fostering cooperation between educators in teams where they can actively participative in collaborative co-creation of designs (Cifuentes et al., 2009; Dodero et al., 2007; Koper & Tattersall, 2004). The second challenge is centered on facilitating the sharing of relevant designs so that other educators can reuse them in their own educational settings (Hernández-Leo et al., 2007; Wichmann, Engler, & Hoppe, 2010). In this context, LdShake has been designed as an approach that faces the two challenges, sharing learning designs and cooperation between teachers in the creation of new solutions. The novelty of the proposal relies on the combination of features adopted from the areas of co-authoring support, small communities' repositories and social network platforms. LdShake supports the creation of learning design solutions based on any pedagogical approach. However, particularized versions of the system can be instantiated so as to provide design structures formatted according to specific didactic methods (Hernández-Leo et al., 2011).

Another scenario is the "Biologia en Context" community of teachers. "Biologia en Context" is the Catalan name meaning "Biology in Context", which is an officially recognized by the government of Catalonia. This community comprises teachers from 20 high schools distributed around the provinces of Catalonia. The teachers belonging to this initiative share motivation of enhancing their teaching via joint design of innovative activities fostering the situated learning of Biology topics. This community aims to bringing Biology activities up to date continuously. Therefore, teachers need new tools which facilitate their virtual collaborative work and co-edition to improve their efficiency. In this context, LdShake was extended and customized according to the needs of the “Biologia en Context” community (Hernández-Leo, Moreno, et al., 2015).

Moreover, LdShake was used in two different teacher-related contexts. On the one hand, the first context is that of a Master degree where a total of 27 participants with educational and media communication backgrounds used LdShake to create one or two learning designs. The designs were explicitly requested to be innovative. Participants were encouraged to share their designs with some of their colleagues so that they could collaborate toward the (co-) creation of more creative and richer designs. They had a total of 10 days to complete this activity virtually (online and at a distance), without any previous training in LdShake. On the other hand, the second context corresponds to a research team on interactive technologies composed of 20 members (3 senior researchers, 7 junior researchers, 10 research assistants) using LdShake in the co-devising of research ideas. 75% of them attended a short presentation about the tool and were invited to use it as long as they wanted to. (Hernández-Leo, Moreno, et al., 2014)

Finally, LdShake has been used in the implementation of the Integrated Learning Design Environment (ILDE). Inside ILDE, LdShake provides social networking features and management of integrated access to designs and tooling.

2.6 Integrated Learning Design Environment

The Integrated Learning Design Environment (ILDE) is being developed in the context of a European Project called METIS (see section 1.2). METIS aims at promoting the adoption of learning designs by providing integrated support to teachers throughout the whole design and implementation process (or life cycle). In the context of the METIS project we defined as different phases that an LD activity goes through as «Learning Design life cycle», see Figure 6. The LD life cycle is composed of three different phases: from early stages in the analysis of context and *conceptualization* of learning design ideas to their complete *authoring* and to *implementing* setup in VLEs to use with students. We use these three different phases: conceptualization, authoring and implementation to classify the different LD Tools (Hernández-Leo, Chacón-Pérez, et al., 2013).

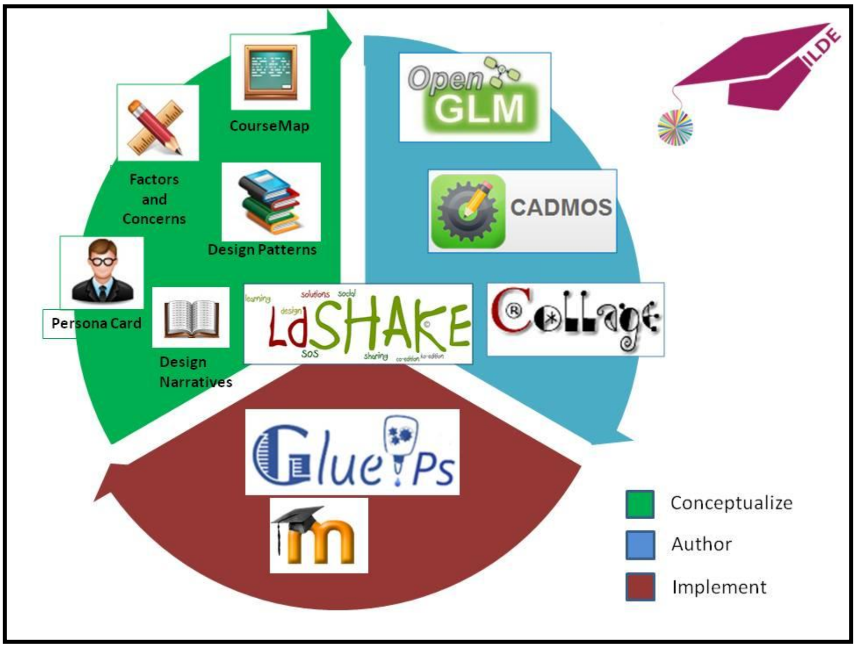

Figure 6: Life cycle phases and tools

ILDE integrates existing free –and open– source LD tools that include: co-design support for teachers communities; learning design editors following different authoring and pedagogical approaches; interface for deployment of designs and mainstream Virtual Learning Environments (VLEs). ILDE supports cooperation within "learning design" communities in which their members share and co-create multiple types of learning design solutions covering the complete life cycle (Hernández-Leo, Asensio-Pérez, et al., 2014). This has been achieved by the integration of a number of existing learning design tools (Figure 7), supporting:

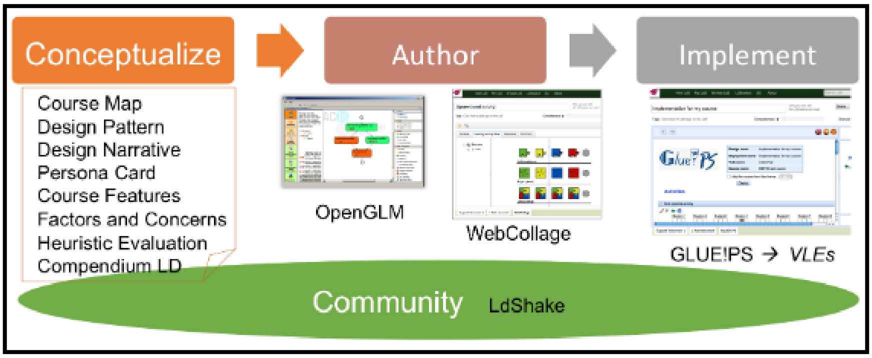

Figure 7: Schema of tools integrated in ILDE

Community: ILDE is built on top of LdShake to support co-design, sharing, and peer-review evaluation of learning design solutions (Hernández-Leo et al., 2011). As elaborated in previous section, LdShake provides social network features, including sharing designs with different access rights, public comments to designs, private messages, exploration of shared designs, exploration of community members' activity, etc. Thus, it also acts as a repository, controls the access to designs, and embeds in its web space conceptualization, authoring and implementation tools; all in all, offering an integrated user experience.

Conceptualization: Before starting with the actual creation of learning designs, it is important to reflect about the characteristics of the context in which designs will be applied (e.g., Personas, Factors and Concerns), sketch ideas for the design (e.g., Course Features, Course Map) and reflect about abstract descriptions (e.g., Design Pattern, Design Narrative). ILDE integrates a number of design templates and tools facilitating conceptualization of learning design solutions, most of them derived from the OULDI project (Cross et al., 2012).

Authoring: Authoring is a key step between often sketchy conceptualization of an LdS, and their implementation in a VLE that provide the runtime environment for design artifacts. This requires the production of a detailed definition of a learning design that can be deployed and executed with a specific group of learners. There are several tools available for this learning design stage. Most of the tools allow visual authoring of learning designs, yet each tool provides its own authoring approach. For instance, Web Collage (Villasclaras-Fernández et al., 2013) allows learning design modeling in the web browser based on design patterns; being a web-based application, Web Collage is directly integrated within ILDE's workflow. OpenGLM (Derntl et al., 2011) on the other hand, is a desktop application that can produce learning designs in a format understood by the ILDE, which can be used for implementation of such detailed designs. To integrate with the ILDE, OpenGLM offers search in, import from, and export to ILDE within its desktop user interface. Generally, ILDE allows the attachment of arbitrary file types to design solutions, some of which can be used further for implementation–e.g., IMS Learning Design[13] compliant packages.

Implementation: This phase includes a first step in which an authored learning design is particularized for a concrete learning situation, e.g., a "course" in a specific VLE. It involves creating groups with students enrolled in the VLE, assigning groups to different learning activities, and selecting learning tools to support those activities (both tools provided by VLE itself, or external third-party web 2.0 tools that are integrated in the VLE using the GLUE! System (Alario-Hoyos et al., 2013). For carrying out this particularization of the designs, ILDE makes use of the GLUE!-PS system (Prieto et al., 2013). GLUE!-PS translates learning designs, represented with computational languages of different authoring tools, into a common internal representation or "*lingua franca*". Teachers use GLUE!-PS's graphical user interface, then can manipulate these representations. In a second step, once all details of the particularized design are worked out, GLUE!-PS "deploys" it into the VLE, i.e. it sets up and configures all the VLE elements that represent the learning design (e.g., activities, groups, tools, ...). Thus, for instance, a Web Collage authored learning design can be automatically transformed into a Moodle course ready to be accessed by the participating students.

ILDE has been developed within the context of the METIS EU-funded project. Several groups of teachers (user groups, from now on) from

[13] IMS Global: Learning Design. Available at http://imsglobal.org/learningdesign (2003)

different institutions were involved in METIS project, representing three different educational sectors: Higher Education (HE), Vocational Training (VT) and Adult Education (AE). A total of five educational institutions were involved, based in different European countries (Spain, Greece and United Kingdom). Besides, additional teachers from diverse educational sectors were openly approached at intermediate stages of the research to understand more widely the interests beyond the METIS user groups. Part of the professional development actions consisted of "collaborative learning training (CL) workshops" in which participants were instructed about CL fundamentals, practiced in co-conceptualizing and co-authoring collaborative learning activities, and were finally guided through the process of deploying their design into Moodle. All workshop activities were carried out using ILDE, including the sharing and peer-evaluation of the designs. A second subset of professional development actions included enactment of a selection of the designs with students in authentic conditions. These, enactments close the cycle of going from pedagogical ideas to their actual use with students, with the support of ILDE (Hernández-Leo, Asensio-Pérez, et al., 2014).

ILDE platform has been used and evaluated at the end of each training session in the context of the METIS Project (Pozzi, Persico, Sarti, et al., 2015; Rudman et al., 2015). Participants filled a questionnaire and were conducted some interviews with them. After the first training session all feedback obtained helped to propose guidelines for revision of the workshops and ILDE. Precisely, considering feedback from first training iteration posed a lack of guidance when using LD tools. The integration of multiple LD tools in community platforms does not guarantee an articulated meaningful LD ecosystem by itself.

For this reason, the participation on ILDE has been a key factor to understand the work of teachers in learning design ecosystems. The participation in ILDE, related with the first objective of the PhD Thesis and the collective work carried out has derived to the following publications (Hernández-Leo et al., submited) and deliverables (Brasher, McAndrew, Chacón-Pérez et al., 2015; Hernández-Leo, Asensio-Pérez, Chacón-Pérez,

& Prieto, 2013; Hernández-Leo, Chacón-Pérez, Abenia, Asensio-Pérez, Prieto, Hoyos, & Derntl, 2015; Hernández-Leo, Chacón-Pérez, Abenia, Asensio-Pérez, Prieto, Hoyos, Derntl, et al., 2015; Pozzi, Persico, Sarti, Brasher, Chacón-Pérez et al., 2015; Rudman, Conole, Dimitriadis, Asensio-Pérez, Pozzi, Brasher, Serrano, Chacón-Pérez et al., 2015; Pozzi, Ceregini, Persico, Sarti, Brasher, Chacón-Pérez et al., 2015).

2.7 Identification of problem areas

In this chapter we introduced the context of the dissertation around communities of teachers inside Learning Design ecosystems. This chapter also introduced LdShake, a social network oriented tool that provides an integrated environment for sharing and co-edition of learning design solutions by teams of teachers. LdShake goes beyond existing co-edition approaches since it is structured as a social network system specifically designed for teacher-centered creation and sharing of learning design solutions. LdShake has been used in real scenarios where groups of teachers with different backgrounds collaborated. LdShake was instantiated and particularized depending on the needs of each.

In this chapter we also presented ILDE, a community environment that offers teachers multiple conceptualization, authoring and implementation functions for the creation of learning designs and their automatic deployment in VLE's. Community functions include sharing and co-edition of designs and the creation of groups to organize collaboration among teachers. The design shared in the community can be browsed using diverse types of filters and visualization to facilitate their exploration and reuse. This collaboration of functions in a single environment tries to overcome obstacles for adoption (related to tooling) of learning design, calling for multiple design options and support for the whole learning design life cycle. To achieve such an integrated learning design environment, ILDE integrates existent free- and open-based research approach framing an iterative process with continual interaction between teachers and researchers.

The work on LdShake and later on ILDE, and the work and observations done during the workshops and evaluations of those online tools, helped me to detect current needs of teacher in learning design ecosystems.

First, the integration of multiple LD tools in community platforms does not guarantee an articulated meaningful LD ecosystem. Cases such as Integrated Biology where teachers need to collaborative authoring interdisciplinary problems; or the "Biologia in Context" case where teachers need to work on teams actively participating in collaborative co-creation of designs, brought to light a lack of guidance when using several possible LD tools. Furthermore, this lack of guidance has also observed while working on ILDE workshops in the context of METIS project. For those scenarios, we observed that for each educational center a particular combination of LD tasks and different tools were used. So, in each educational center the coordinators design their own methodology to be followed by participants. This poses the need of flexible and editable LD Methodologies within the platforms to accommodate their particular needs. In these regards, there is a general problem of management of the design processes involving diverse tools of the learning design process, which motivates the second objective this Thesis: to enable the management of methodologically-flexible learning (co-)design processes.

Second, as mentioned in section 1.1 and extended in section 2.4, reusability is a relevant aspect in learning design and learning co-design scenarios. In order to facilitate the creation of new activities, teachers tend to reuse existent material and adapt it. In these sense, when reusable scenarios such as "Integrated Biology", "Biologia en Context" or workshops in the METIS project, it becomes clear that multiple versions of the same learning design need to be managed. For example, in the case of Integrated Biology is interesting to see changes across different refinements to a design originally created by a team of teachers. Or in "Biologia en Context" as designs repository is becoming larger is appealing to see which of the possible variations of a design is more interesting to be reused. In these regards, there is a general problem to manage facilitation of existing design reuse, which motivates the third objective of this Thesis: to support learning (co-)design scenarios that originate multiple versions of the same design solution.

Third and finally, as aforementioned in section 2.4.1 we focus on fostering the reuse of design patterns as these can be provided as templates or building blocks, since they have proved to be appropriate reusable components for the creation of potentially effective designs. As noticed during the METIS workshop in Agora, teachers that used patterns expected these to be interoperable managed between pattern-based tools. As each LD tools has a purpose and is set in a particular environment, teachers may need to complement a design using different authoring LD tool over the same content (e.g. in agora teachers started filling information in a design pattern template on ILDE; later they used an authoring pattern-based tool and they expected data streamed naturally and automatically from design template to the authoring tool). This example illustrates the problem of management of interoperable learning design patterns, which supports the motivation motivates of the fourth objective of this Thesis: to facilitate interoperable management of patterns in learning (co-)design tools.

CHAPTER 3. SUPPORTING FLEXIBLE LEARNING DESIGN PROJECTS

This chapter introduces the problem related with management of design processes that involve the use of diverse tools in the learning design ecosystem. Particularly, contribution in this chapter helps to support teachers when they need to apply existent methodologies that propose the use of LD tools in a given order. The chapter introduces a model that proposes and conceptualizes the concepts of LD Workflow and LD Project to facilitate application of LD methodologies. Thereby it presents a technological facility implementing this model as part of ILDE. Usage and evaluation of this facility in different contexts illustrate its application and flexibility as well as teachers' appreciation of its utility and usability. Contribution of this chapter comprises the core of a manuscript under preparation that is to be submitted to a journal (Chacón-Pérez et al., under preparation).

3.1 Introduction

As introduced in section 1 and later extended in section 2, LD is a research field dealing with teachers' fundamental mission of devising good arrangements for their learners to learn (Conole, 2012; Laurillard, 2012). Since the importance of design, teachers need to plan accurately the definition of new designs. Creation of new designs may follow an LD life cycle. In the life cycle proposed by METIS project, teachers can work in three different phases: from conceptual issues where teachers should reflect about context, their intentions and also the kind of participants who are going to perform designs; to authoring phase where teachers have to define their particular activity; to final implementation with real users in a learning environment (Hernández-Leo, Asensio-Pérez, et al., 2014).

Learning Design field has provided a myriad of available free and open source learning design editors following different authoring and pedagogical approaches and supporting different phases of design life cycle. As a consequence, in order to create a full design the author may use different LD tools (Bennett et al., 2015; Hernández-Leo, Asensio-Pérez, et al., 2014). There are methodologies that support teachers to design deep, engaging and enjoyable learning experiences for learning by following a set of steps and tools (Conole, 2014). However, teachers are not familiar with those methodologies, it is difficult for teachers to access relevant tools mentioned on methodologies, or they have difficulties to manage them in a coherent and usable way. Certainly, conditions for selecting one tool or set of tools depend on desired learning design objectives and requirements of particular contexts (Mor et al., 2013).

In this sense, there is a lack of guidance and support in management of design processes that involve diverse tools in Learning Design ecosystem. Moreover, management of these educational tools or design artifacts can be a particularly complex problem for interested but not experts in ICT teachers. Moreover, the suitability of a methodology depends on context and requirements of an educational institution, the expertise of teachers, the tools and technologies available, etc. (Laurillard, 2012). This gives the necessity for flexible technology-supported articulations of the LD ecosystem.

This chapter aims at working on objective 2 of this Thesis: "Enable the management of methodology-flexible learning (co-) design processes". We coined a schema of action where designing for learning involves a selection of learning design tools that should be used in a recommended order as a «Learning Design Workflow». We define a specific action of design for learning, based on a workflow as a «Learning Design Project». So, any time a new educator wants to create a new LD Project in order to produce or starting to produce a new activity or set of activities (e.g. a course) they could select an existent workflow to follow.

This chapter is organized as follows: section 3.2 introduces the methodology applied for the second contribution; section 3.3 helps to understand broad interest on this second objective; section 3.4 presents the model proposed to face this contribution; section 3.5 shows model implementation in ILDE; section 3.6 presents how this model covers existent methodologies; section 3.7 relates how this model is applied in real scenarios; section 3.8 features the evaluation; and section 3.9 includes the main conclusions related to the second contribution of this Thesis.

3.2 Methodology

For the second contribution, design science research methodology (Peffers et al., 2007) is applied by following different activities described in the methodology, see Figure 8. Using this methodology we design the system in an iterative approach with early feedback from user groups, openly surveying the interest in the use cases supported, and iterative refinements with intermediate preliminary pilots.

In this sense, we start identifying the problem during the experiences in designing, implementing and evaluating LdShake and ILDE. As described in chapter 2, during the work on ILDE and LdShake we identified the problem of management of design processes involving diverse tools of the learning design ecosystem. As a second step, we include two questions in a survey by the European METIS project that sought to have an initial assessment of certain educational characteristics about the LD process by teachers. Thus we take the opportunity to assess the interest of teachers in having available this mechanism. Then we define objectives for the solution, in this activity from the methodology we introduce the conceptual definition. Once the model and terms are coined successfully and described, follows the implementation of the technological features, as described in activity 3 from methodology.

During activity 4 of the methodology we demonstrate how the technological facility is both effective and efficient in a set of described use case scenarios. Based on initial results of the demonstration we reformulate and refine the proposals until the final solution proves to be superior to the existing one. Later, it is implemented in ILDE and is used in three educational sectors (five different contexts, which include teachers from different educational levels: Higher Education, Vocational Training and

Adult Education). Furthermore, it is used a MOOC course in the context of the HANDSON project, and in the MSF foundation. Finally, it is evaluated during activity 5 of the methodology following extended TAM model (Chuttur, 2009; Davis, Bagozzi, & Warshaw, 1989; Pozzi, Persico, & Sarti, 2015) to understand satisfaction of usability and utility perspectives in the context of the METIS project and the MOOC course.

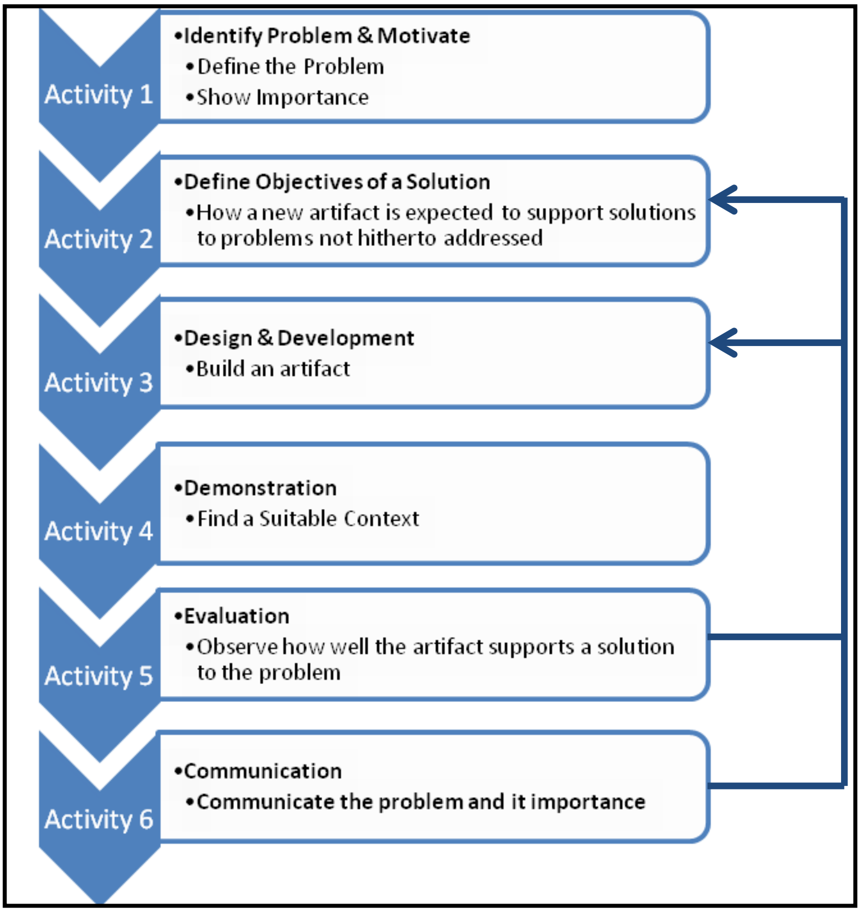

Figure 8: Design Science Research Methodology (Peffers et al., 2007)

3.3 Understanding broad interest

It is important to understand to what extent teachers and educational managers coming from diverse sectors (Higher Education, Adult Education and Vocational training) perceive "organization of designs" as relevant. As a consequence, a survey was carried out in the context of the METIS project. The survey included two identical *Likert* statements with 1-5 scales devoted to identify if teachers creates and organize several LD artifacts associated to design of activities or courses (i.e. this does already “happen”) in their institutions and to what extent that is or will be “desirable”. The statement in the survey was “Educators organize several conceptualized/authored/implemented learning design artifacts related to the same learning design scenario (e.g. in design projects or folders)”.

Likert scale related to the statement “happens” goes from 1 (never) to 5 (always happens). *Likert* scale related to know if the above statement is desirable for them goes from 1 (very undesirable) to 5 (very desirable). A total amount of 75 data entries were collected from more than 20 different countries by using a survey translated into 4 different languages: German, Italian, English and Spanish. We can visualize in Figure 9 that, teachers that answered the survey do not tend to organize their design artifacts when they are working in a learning design scenario, 24% have never done it, and 33 only do it rarely. If we first look to the data collected from teachers we obtain an average mean score of 2.46. So, they usually do not organize their designs (tends to “rarely”). In addition, we can see in Figure 9 their desire to be able to organize their artifacts, 43% of them want it and 23% mark it as very desirable. In conclusion, teachers who do not organize their design artifacts (answered never, or rarely in Figure 9), desire to have some mechanism to organize them, and teachers who actually organize their designs answered neutral when requested about desirable or not.

With a mean score of 3.77 in the desirable statement, results of the survey pointed those teachers desire for a mechanism that to organize their LD artifacts. Therefore, they need flexible LD methodologies that allow teachers to organize resources, tools and environments, and support them during the design process of new designs. For that reason, this Thesis is proposing a model for supporting teachers to organize those LD artifacts while providing support for guiding them through the application of LD methodologies.

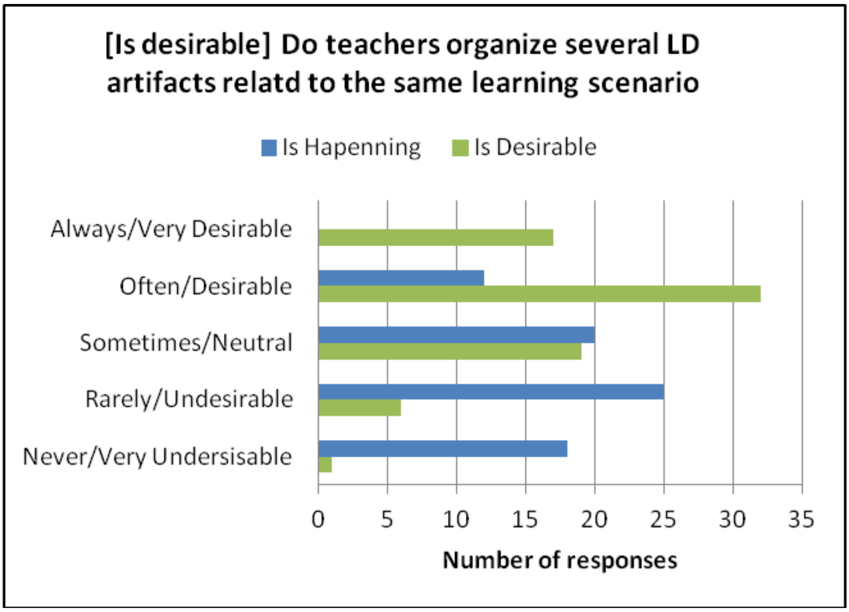

Figure 9: Participants' opinions about organizing LD artifacts

Furthermore, in the METIS project we organized two rounds of training within three different contexts groups. In total we carried out 5 different workshops: two in adult education: one in Agora and one in Valladolid's adult education school; two in higher education: one in OU and one in Valladolid University; and one in vocational training in KEK EUROtrainning. In each workshop participants must fill a questionnaire at the end of the workshops and we conducted some interviews with them. Moreover, we did some tracking of participants: taking notes by an observer plus the participants' actions done automatically by ILDE. After the first training session all feedback obtained helped to propose guidelines for revision of the workshops and ILDE. Precisely, considering feedback from first training iteration, and with the spirit of improving both usability and guidance of teachers through the transition between tools and design phases, ILDE was extended with LD Project and LD Workflow mechanisms. The feature enables users (especially those with profile of academic managers in institutions) to depict an LD Workflow reflecting a design process or methodology that involves the use of a selection of tools. In the previous iteration, it was seen that all the tools integrated in ILDE may not be required for specific projects or institutions, and that users are sometimes lost when selecting tools among the list provided by the ILDE. With the new mechanism, user can create an LD Project making it compliant with a specific LD Workflow. As a consequence, they will automatically see the selection of conceptualization and authoring tools that will have to use (in the proper order) in the creation of their design.

3.4 A model for LD Workflows and Projects

As described in section 3.1, when teachers want to engage in a learning design process they can simply use a learning design tool or consider an LD methodology which proposes the use of a combination of tools. To flexibly manage the second situation, we propose the definition of the LD Workflow and LD Project concepts.

3.4.1 Definitions

> *Learning Design Workflow (LD Workflow)* as a schema of action where designing for learning involves a selection of learning design tools that should be used in a recommended order.
>
> *Learning Design Project (LD Project)* as a specific action of design for learning, based on an LD Workflow, which may lead to production of conceptualizations, authored and implemented designs related to the same learning situation.

By those definitions, any time a new a teacher wants to create a new LD Project in order to create a new design they could select an existent LD Workflow to follow. The workflow not only will suggest the steps but also needed tools ready to use. Moreover, as we support teachers with a step by step guide, they do not necessarily need to be experts on LD or ICT pedagogies. They only need to learn to use the tools and templates. The learning curve at first may be high due to the amount of tools to use, in the case of complex LD Workflows. However, the use of these tools is simple and mastery is achieved in a few practices (Hernández-Leo, Asensio-Pérez, et al., 2013). Furthermore, teachers which advance knowledge of LD, or teachers who want to share their expertise with others for the creation of new designs, may define their own LD Workflows. As teachers gain expertise, they may decide to design or adapt existent methodologies adding or removing steps, or even updating the process with different tools. Once terminology is defined and requirements are clear, we propose a conceptual model for applying these concepts to practice.

3.4.2 Conceptual model

To support creation of LD Projects and LD Workflows, we propose a model for formulating flexible methodologies, which can be seen in Figure 10. In the top center of the model there are three main elements of a LD Workflow: the step number, the tool associated to the step, and the template. In Figure 13, an LD Workflow groups a number of steps sorted in a particular order, where each step corresponds to the use of a particular tool or framework, which at the end is one of the multiple types of LdS. Furthermore, teachers can add a template to a specific step. So, when teachers create an LD Project using this LD Workflow will find examples or pre-filled templates in those steps For example, one Learning Design Workflow can be described using this model as a composition of steps such as LD Workflow Jonathan that includes: step 1, Persona Card; step 2, Design Narrative, attach a template with some prefilled data; step 2 Design Pattern (we can attach different tools to the same step) and step 3, Web Collage. In that way teachers will fill and adapt those steps easily.

On the one hand, once a LD Workflow is defined, teachers can create as many as LD Projects as needed. On the other hand, teachers may adapt any existent LD Workflow to its needs. In this sense, teachers can add and remove as many steps as needed from any tool of the different phases of the LD life cycle, defining a flexible and adaptable approach for the management of LD methodologies.

Using UML syntaxes we related those three objects: Step, LdS and Template with a ternary association. Every time an LD Workflow is defined a ternary is defined with at least one step and the related LdS. Optionally, a teacher may attach an existent LdS to the Step-LdS association as a template or example of use (i.e.: a teacher adds a persona card LdS as the third step of the LD Workflow, and decides to attach an existing persona card LdS with data about the typical users for her/his designs). Finally, each time a teacher wants to apply an LD Workflow for her/his personal project, they instantiate a new LD Project. In this case, the UML relation between LD Workflow and LD Project is a generalization hierarchy relationship. In this regard, any LD Project is initially a specification of an LD Workflow.

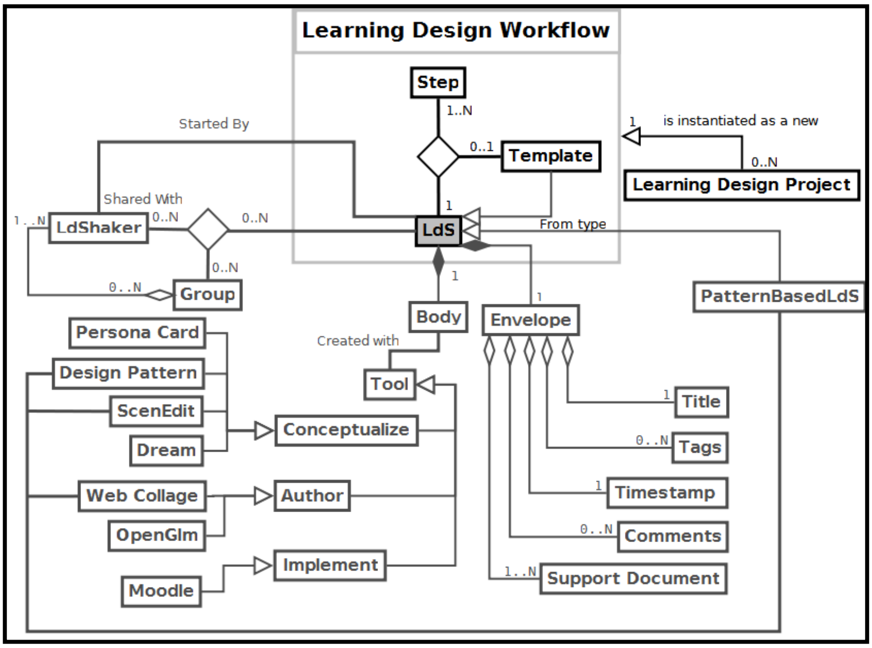

Figure 10: Model for the flexible management of LD projects for community platforms with integrated learning design ecosystems

3.4.3 Use cases

Taking into consideration the observations about how teachers organize themselves while using LdShake and lately ILDE implementation and the work with teachers in different workshops organized in the context of the METIS Projects, HANDSON MOOC and MSF, we defined a total of 9 use cases that would be helpful for teachers when defining their own LD Projects, see Table 2.

Those use cases represents interactions between teachers and different artifacts to define, edit, and work in a LD Project or LD Workflow. In case

#C1, a teacher wants to define a new LD Project following and existent LD Workflow. In #C2 a teacher wants to define a set of tools and artifacts to create her/his own methodology within an LD Workflow. In C#3 a teacher may want to share their own methodology to others. Furthermore, use case #C4 presents a situation in which a teacher may attach existent LdS to a particular step, reusing existent material (such as a persona card related to different LD Projects). A teacher may want to create a new LdS inside an existent LD Project, case #C6. Moreover, it is also important for facilitate search of LD Projects. Thus, a teacher may want to predefine a collection of tags to be used for describing the LD Projects use case #7. In use case #C8 we depict a situation where an LD Project is created and the creator wants to share it with other partners. Finally, #C9 introduces a situation where we want to alert somebody to work in a specific step of the LD Workflow.

Table 2: Desirable use cases for working in LD Projects

Case	Description
#C1	I want to follow a suggested LD Workflow in an LD Project
#C2	I want to plan my LD Workflow for my LD Project
#C3	I want to suggest an LD Workflow
#C4	I want to associate an LdS to my LD Project
#C5	I want to know in which LD Projects I have to participate
#C6	I want to create a new LdS inside an LD Project
#C7	I want to predefine Tags for my LD Project
#C8	I want to share, view and/or edit my LD Project with other participants
#C9	I want to assign task to participants of my project according to the LD design process

Using those use cases, we analyzed tools from different areas of knowledge which worked on managing project design. We analyzed how these tools can cover above presented use cases (see Table 2). Moreover, we explored and noted which mechanisms of these tools were useful to support LD Projects.

3.4.4 Study of project design tools

As introduced in 3.4.2, the project concept exists in other areas of knowledge. Therefore, we have explored other areas of knowledge to find out how artifacts and tools are sorted when defining a new project. Thus, we wanted to see within those areas which mechanisms were used to sort different tools and artifacts inside a project. It was also important to find how they manage those tools and artifacts and how other people collaborate and work within a project, in those areas of knowledge. For instance, in computer engineering there are some methodologies defined to be followed in order to produce a new program. Furthermore, there are tools that facilitate the mechanisms to plan or to collaboratively program a new application (Lesyuk, 2013; Mandviwalla & Grillo, 1995).

Tools that support programmers to program and develop such applications were analyzed. Some initial tools that were investigated related to this context are Redmine (Lesyuk, 2013), Asana[14] o JIRA[15] . We also look for educational tools, that despite of not directly solving the problem poses solutions that may be useful to us, such as Learning Designer “LDSE” (Laurillard et al., 2013).

Analysis of the tools helped us to set limits to the problem, which can be found in a technical report at (Chacón-Pérez, 2013). In conclusion, it pointed us some aspects to considerer in both: design and implementation of new features. Furthermore, we realized that one of the solutions closest to our problem was JIRA. This tool presents a solution that can serve as inspiration to design our solution. JIRA offers different workflows that can be followed; allows the user to customize the design process, and also to make minor modifications to the existing steps. However, it does not allow you to attach documents to the existing methodology. Neither, it does

[14] Asana, https://asana.com/
[15] Atlassian, https://www.atlassian.com/software/jira

facilitate them as templates to other experts, nor can design our own workflows and share them with other users.

After preparation of intended use cases that should be supported and the analysis of tools, led to propose a new design for the solutions and start implementation of the new feature.

3.5 Implementation in ILDE

As a member of the development team of LdShake and later in ILDE, we tested those learning design ecosystems in different projects, as introduced in section 1.1. Therefore, we had the opportunity to implement and integrate the Learning Design Project feature in ILDE, in order to face the management of design processes involving diverse tools of the learning design ecosystem. As described in section 2.3.1, we follow an iterative approach for developing the tool. The LD Project tool is divided into two different features: first, the tool that allows teachers and experts to define their own methodologies creating new workflows or personalizing existent ones, the LD Workflow editor; second, the tool for creating a particular LD Project based on existent LD Workflows, which includes the visualization of the project with all its elements to teachers, the LD Project display.

For the design of the LD Workflow editor, two different aspects have been taken into account. First, we considered ILDE as the platform where we are performing integration. ILDE has an API enabling the integration of LD tools in the community platform. Following the API[16], any tool has to be included into an *iframe*. Furthermore, on the top of the *iframe* there is a set of common aspects: a name for the LdS, a list of tags for searching purposes, and sharing and saving options. It is important to follow the API and then implement the proper mechanisms to allow the communication between ILDE and the tool to be integrated. So, when the user clicks on save and close button, the tool need to receive a message for closing and saving the design. As a conclusion, we get a nonfunctional requirement: our

[16] The API documentation can be found in http://ilde.upf.edu/api/html/

application must be framed within ILDE platform and therefore width and height within ILDE are limited. Second, the analysis described in section 3.3.1 pointed some elements we may consider for the design of the feature. For instance, it may have a clear space for defining the methodology or a panel with the available tools.

In Figure 11, we can see a draft from the tool framed in ILDE, where *iframe* acts as tool container. The LD Workflow is divided into two spaces: the tool panel and the canvas. In the tool panel we include all the available tools in ILDE for creating new LdS.

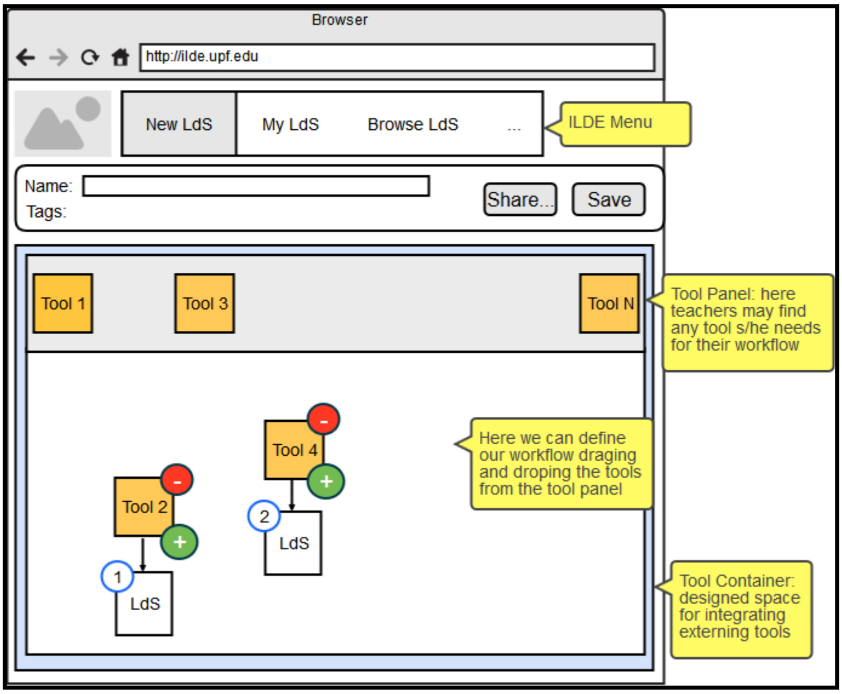

Figure 11: LD Workflow editor design of first prototype.

In the canvas, teachers can drag and drop any available LD tool. Any time a tool is dropped in the canvas it assigns an empty LdS with a number inside a blue circle. We use these circles to define the number of the step when this LdS has to be filled. Moreover, it also appears both: a red and a green circle. We can click on the red for turning the tool back to the tool panel, or we can click on the green one for adding a new LdS from the same type. For instance, we want to have two different LdS from the type “Tool 2” for our workflow.

This first prototype has been implemented and tested in a set of workshops as part of the METIS project; some of these workshops will be described in section 3.4. As a result from this testing, we develop a new prototype, see Figure 12, using the feedback we obtained with teachers.

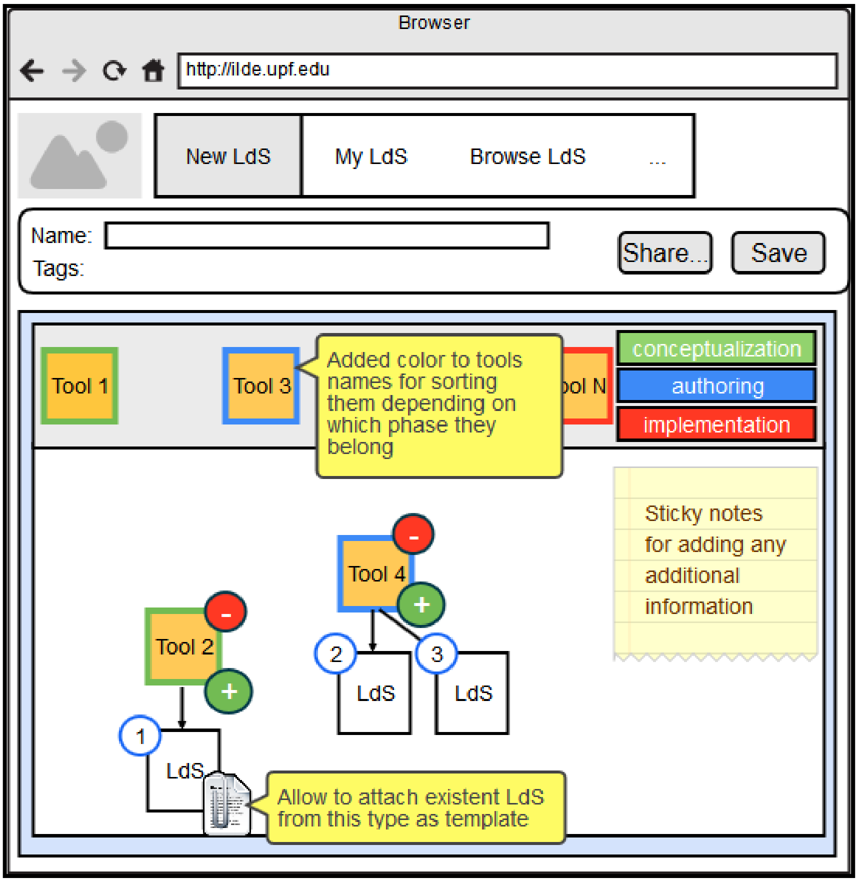

Figure 12: LD Workflow editor design of final prototype

For this second prototype we included some news add-ons. First, each tool has a colored border to identify which tools belongs to each of the different phases described in the METIS life cycle: green stands for conceptualization, blue stands for authoring and red stands for implementation. Furthermore, in this second version we included sticky notes as the solution for the teachers' query about a mechanism to add notes and explanations. Finally, teachers wanted to reuse existent material in the platform as templates for their workflows. So, we included an option to attach existent LdS to any of the tools.

The final prototype of the LD Workflow editor has been implemented in ILDE, see Figure 13.

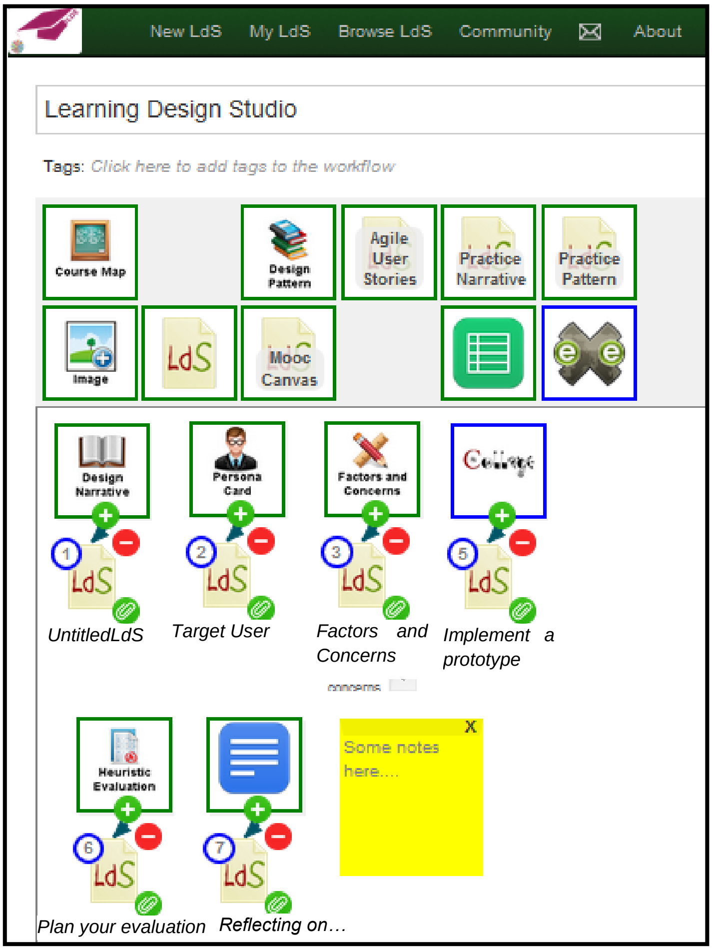

Figure 13: LD Workflow edition implementation in ILDE

The LD Project display was developed following ILDE's aesthetic. In these regards, when we want to create a new LD Project, we click on "New LdS" from ILDE upper menu. Then, a new page is opened where we can navigate through all the existent workflows defined in the platform. However, we only will see the ones with public access rights or private ones shared with us, see Figure 14.

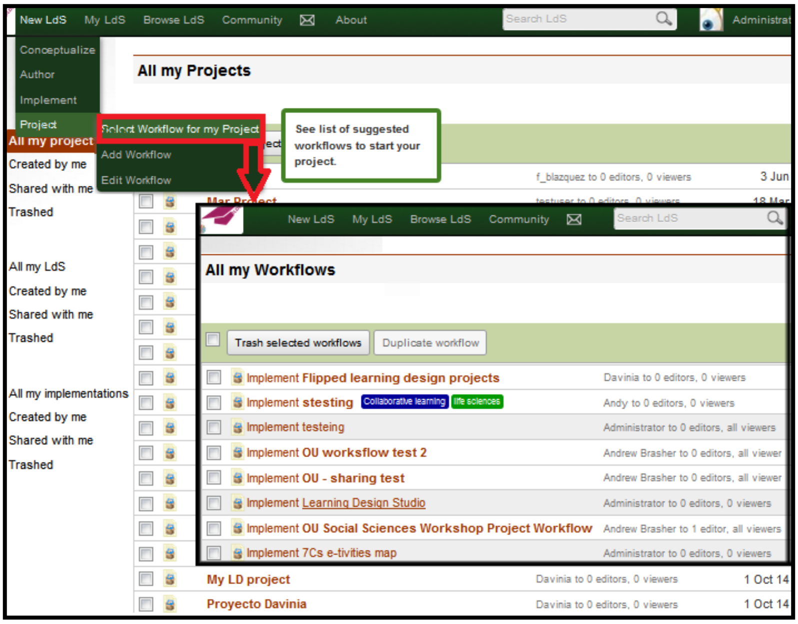

Figure 14: Creating a new LD Project selecting LD Workflow to be followed

Once the workflow is selected, we name it and we start working on our new learning project. As an example, selecting the workflow described in Figure 13 will produce the LD Project within Figure 15. Once we have final implementation of LD Project tool, next step was to check if this new feature is able to represent existent methodologies as LD Workflows.

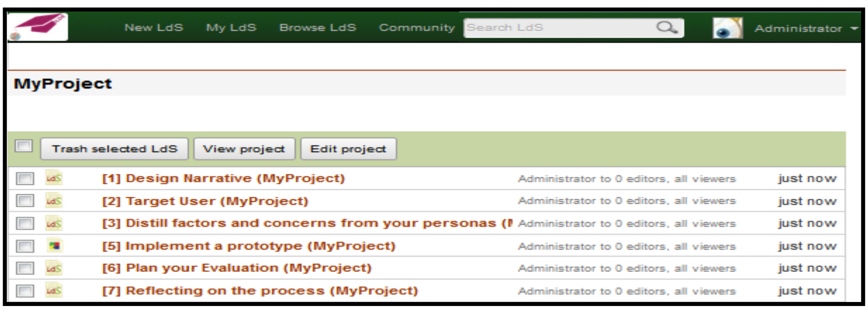

Figure 15: LD Project visualization screen

3.6 Application to existent LD methodologies

In this section we show how the use of implemented technological feature allows to represent existent LD methodologies, following the Activity 4 of (Peffers et al., 2007).

In Figure 16 there is an example of an LD Workflow called "Flipped learning design projects". In this particular LD Workflow the creator defined the following steps: step 1 reflect and define about your target user on Persona Card template, step 2 use Compendium LD, step 3 define Factors and Concerns, step 4 is a combination of 5 different tools, upload and image, Google excel sheet, Web Collage, eXe Learning and Google doc. Steps 1, 2 and 3 included only tools from conceptualization phase. However, in step 4 the author of the LD workflow included tools from both phases: conceptualization and authoring.

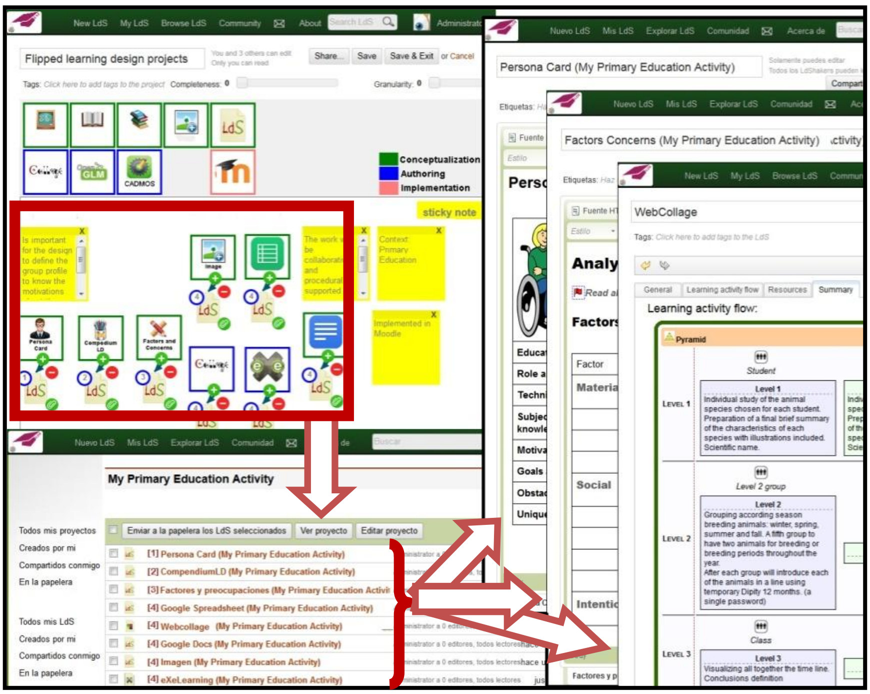

Figure 16: LD Project created following an existent LD Workflow, and some examples of templates created

The visual representation of the described LD workflow can be seen in Figure 16 left-top part of the image. In the left-bottom part of the image there is the representation of an LD Project created by using the previous LD Workflow and called “My Primary Education Activity”, which includes a list of the tools already configured for starting working on the new LD Project. Furthermore, in Figure 16 the right part includes some examples of the tools described within LD Project that will be opened when the user starts to work on that particular step.

In the following sections there is the first attempt to represent the use of new feature by representing in a LD Workflow the 7C’s Methodology (see section 3.6.1). The second example represented is the LD Studio methodology in section 3.6.2.

3.6.1 LD Workflow based on 7C’s methodology

The 7Cs of Learning Design methodology (seven Cs from: conceptualize, capture, create, communicate, collaborate, consider and consolidate) is especially useful for teachers and educators who want guidance and inspiration for more effective, imaginative and creative uses of a virtual learning environment such as Moodle and the web, to enhance the learning process for learners. Furthermore, this concept helps to make the learning experience more interactive and engaging for learners at different levels of granularity (from a basic activity to the whole course). In order to support teachers to adopt this methodology the 7Cs developer team provides the 7Cs of Learning Design Toolkit (Conole, 2014). This toolkit provides the links and descriptions to more than 20 templates, tools and resources.

In the toolkit there is a tutorial for learning how to design your own 7Cs activity. Inside the tutorial there is a “7Cs e-tivities map[17]”, this activity includes the design of a whole workshop for learning how to use 7C’s design toolkit, which contains links to all the “e-tivities”, along with a short purpose statement for each one describing the whole example. Then, in

[17] All the information about the Toolkit and the 7C’s activities can be found there: http://www2.le.ac.uk/projects/oer/oers/beyond-distance-research-alliance/7Cs-toolkit/the-7cs-e-tivities-map

Figure 17 there is a workflow representing the "7Cs e-tivity map", which includes the main "e-tivities" and in described order. Most of the "e-tivities" described in the 7C's are guides and templates. Those "e-tivities" have been included in the LD Workflow by means of Google docs tool. First, 6 LdS describing the different "e-tivities" are created using Google doc within ILDE. Then, those Google docs are attached as templates in the LD Workflow to the corresponding step of the methodology. In the case of **Figure 17**, there are attached to steps: 1, 2, 3, 4, 6 and 7. In total it includes 7 new templates supported within Google docs, 2 design patterns and 1 course map. Every time a teacher will use the LD Workflow described in **Figure 17** for creating a new LD Project, they will receive a project with 9 LdS in total, which includes 6 copies of the 6 Google docs created by the LD Workflow's author.

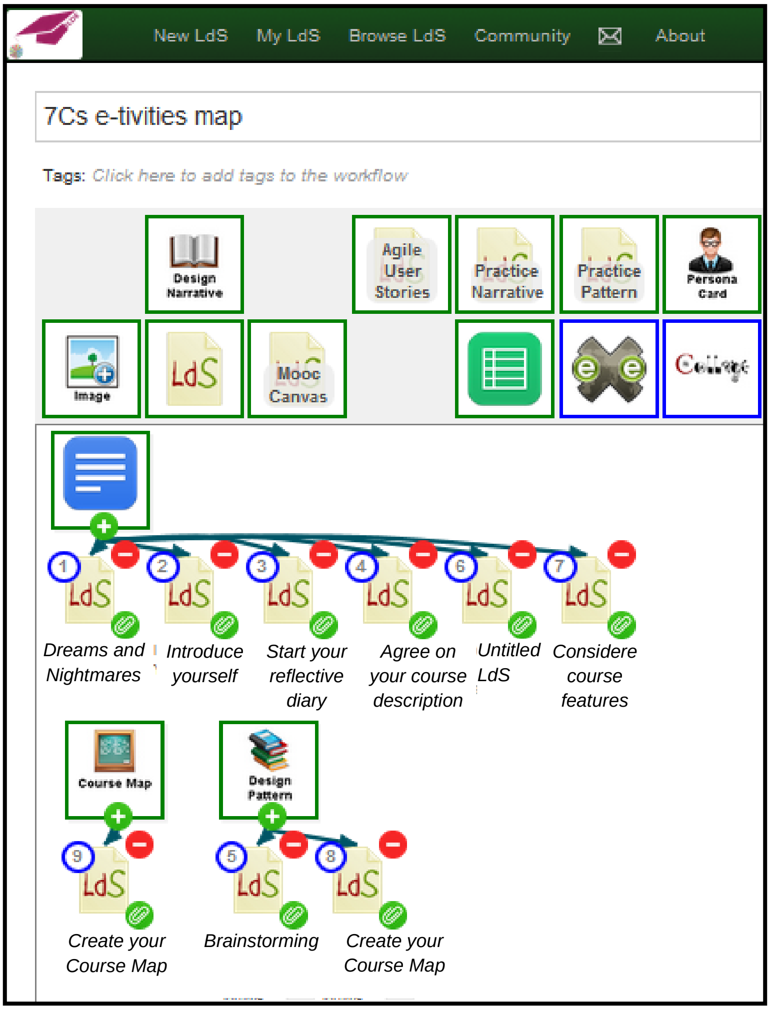

Figure 17: LD Workflow defining the first 9 steps from the "7Cs e-tivities map"

3.6.2 LD Workflow based on LD Studio methodology

The Learning Design Studio (LDS) is a needs-driven inquiry-based framework for collaborative professional development of educational teachers. Teachers, educator's leaders, policy makers and developers often find it hard to apply the outputs of research and innovation in education and technology to their practices. The theoretical structures seem abstract and remote, thus resisting application in real life settings. Many examples seem rooted in a specific and unique context, making them hard to transfer to novel situations. The LDS confronts this challenge by engaging teachers in a process of Design Inquiry of Learning. This process combines the iterative structure of educational design research with the principles of inquiry learning. Participants follow a cycle of: Defining their project, investigating the context in which it is situated and identifying appropriate techno-pedagogical theories, reviewing relevant cases and theories, conceptualizing a solution, implementing a prototype of that solution, evaluating it and finally, reflecting on the process[18] (Mor & Mogilevsky, 2013).

In Figure 18 there is represented an example of an LD workflow created using tools and templates proposed by the LDS. Specifically, those are: design narrative, persona card, factors and concerns, implementing a prototype using WEB collage, Heuristic evaluations and a Google doc for reflection. Most of the tools and templates used in LDS are already included explicitly in ILDE. However, it is not included the template for reflecting at the end of the process. As in section 3.6.1, for those templates not included in ILDE we use a Google Doc LdS for include them. Once the LdS from Google doc type is created and filled with the instructions for reflecting, we attach that particular LdS to step 7.

[18] The Learning Design Studio definition and examples could be find there: http://www.yishaymor.org/

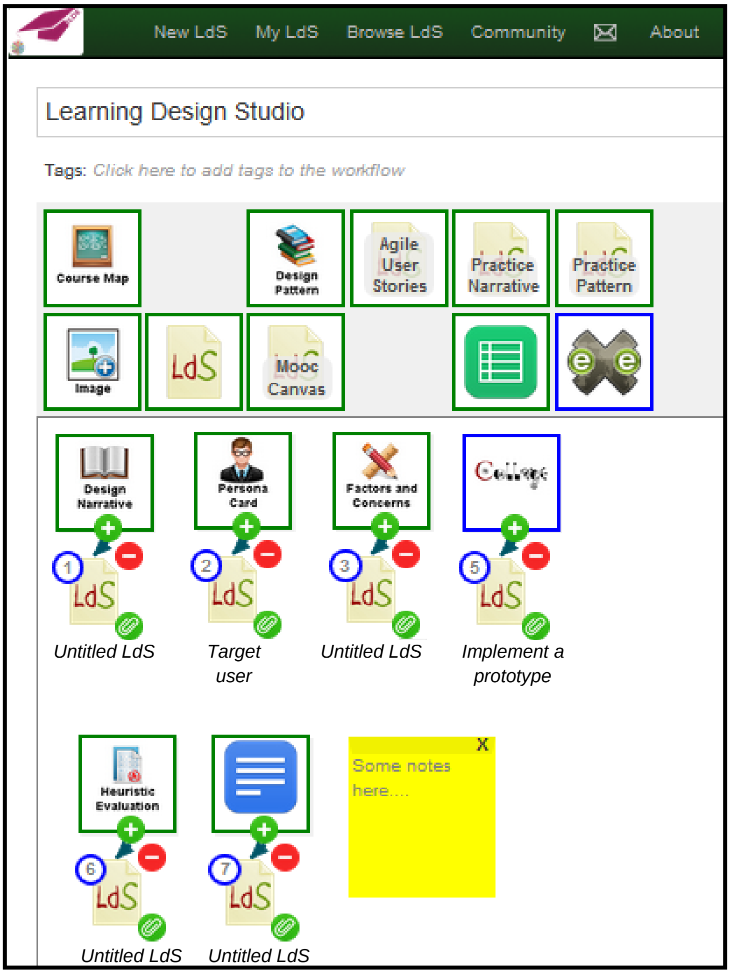

Figure 18: Workflow defining the Learning Design Studio framework

3.7 Application in authentic settings

In this section we describe a set of studies where teachers adopted the use of LD Projects by following Activity 4 from design science research methodology (Peffers et al., 2007), service showing its validity. It includes a preliminary study with a group of pre-teachers, and the real use of the feature which has been adopted in three different contexts: METIS project, Hands-On MOOC and the eLearning department in Barcelona from Doctors without Borders (MSF acronym in Spanish).

3.7.1 Preliminary uses

First, while designing and implementing within ILDE the feature to support LD Projects within ILDE, we run a preliminary study involving 10 pre-service educators being trained in the context of a Master course. A beta version of the LD Project feature was used during a 4-hour morning session where the participants were asked to play the role of an eLearning Unit Head of a given organization (educational center, NGO, company). The task proposed was to plan the methodological workflow to be used within their institution in the creation of LD Projects. As part of this activity we showed a beta version of the learning design workflow application. Once, they decided which set of tools, templates and resources they need for their particular case study, we show them how to define and create a general workflow. Then, they had some time in order to use the tool for define their own particular workflow. Even considering the limitations of a beta version, we asked teachers their assessment and the responses were positive and encouraging about this new feature, whose implementation was finalized in the direction planned to be evaluated in METIS workshops.

3.7.2 METIS workshops

As introduced in section 1.1, and extended in chapter 2, the METIS project is focused on fostering teachers' adoption of innovative pedagogical approaches. In this line, the METIS project worked with different educational institutions: adult education, vocational training and higher education. In particular, they worked with Agora, KEK EUROtraining and the Open University (OU). As part of the project we organized a set of workshops in the different educational institutions for training them within the ILDE platform with related tools for creating activities (Hernández-Leo, Chacón-Pérez, Abenia, Asensio-Pérez, Prieto, Hoyos, Derntl, et al., 2015). Those workshops serve for evaluating purposes following activity 5 of the methodology.

The main workflow of the workshop was defined by the whole METIS project consortium. Besides, for each educational institution there is at least one facilitator who has to adapt the main workflow to their group of teachers and educational style, and run different workshop sessions.

Therefore, each of the facilitators ended up adapting the workflow as an LD Workflow on ILDE, where their participants must use it for creating the activities during the workshop (Brasher et al., 2015; McAndrew, Brasher, Prieto, & Rudman, 2015).

We were directly involved in the development of the Agora's workshop for adult education teachers. Since their style of education is based in creating activities by discussing them between all the teachers involved in the courses, we adapted the METIS workshop workflow to a discussion style with collaborative activities where they have to meet, discuss and define activities by groups of teachers. Furthermore, they involved students in the process of development of their activities. Thus, in the workshops there were teachers, learners and also school's responsible personnel. Due to this mixture of profiles it was also beneficial to work in groups of people instead of standalone.

Agora workshops were divided into three half-day face-to-face sessions of three hours each. The first session was intended as a sort of warm-up to the actual workshop contents, so that Agora's learning community could discuss among them and be convinced that the contents and learning goals of the workshop were aligned with their own interests. Thus, this session contained a lot of collaboration and sharing work to reflect on how learning about learning design and collaborative learning can be important for the learning community of Agora. Then, session two completed the conceptualization stage of the design of concrete collaborative learning activities, which was initiated in the first session, and also peeked into the later phases of the learning design cycle (authoring and implementation). Finally, in the third and last session of the workshop, participants got feedback about their designs so far (from peers and facilitators), and they finished their first LD life cycle by going over the Authoring and Implementation tools (Web Collage and GLUE!-PS), until they had a ready-to-run course in Agora's VLE Moodle server.

In the Agora workshop, we co-designed (with members of the Agora community) an LD Workflow which involves four different steps: first, persona card with profiles of designs' participants. For facilitating the adaptation of this new tool for participants we attached a pre-filled persona. So, participant has already an example with data they can substitute easily. Then we move to Design Narrative, where teachers may prepare the narrative of their designs. Then, in the third step we used a tool from the authoring phase of the life cycle, Web Collage. Here teachers applied a pattern for their design: setting the activities, resources (videos, documents, slides, etc.), participants and groups, see Figure 19. Finally, we used Glue!-PS for setting the activity in a Moodle course using Web Collage.

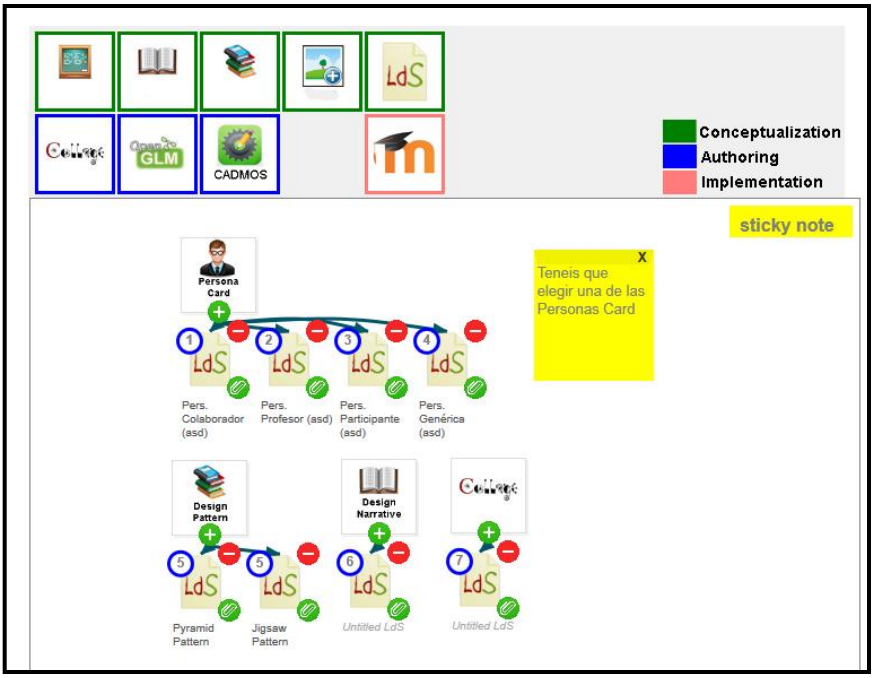

Figure 19: LD Workflow defined for Agora's workshop

For the OU workshops they prepared one full day of work of seven and a half hours. As in other workshops previously described, they introduced the terms and main concepts to teachers of higher education. During the workshop they work on teams of teachers and worked on the three phases of the life cycle: conceptualization, authoring and implementation. For this workshop, the facilitator prepared this particular LD Workflow, see Figure 20. Teachers started filling a Heuristic Evaluation prepared an LD Workflow called IET H800 who included 5 steps. Furthermore, they used Google Docs tools for adding LdS for providing a space for teachers to include heuristics from previous designs. Then, they finished the conceptualization phase with Compendium LD tool. In the authoring phase they included OpenGLM, and used Moodle too as their VLE.

Figure 20: LD Workflow created by the facilitator of OU

The full description from structure and activities performed plus the heuristics evaluations about the workshop sessions from Agora, KEK and OU could be found at (McAndrew et al., 2015).

The University of Valladolid also performed two workshop sessions in the context of the METIS Project: one for adult education's teacher and another for higher education's teachers (Asensio-Pérez, Dimitriadis, Hernández-Leo, & Pozzi, 2015). The workshop based on adult education sector was performed in a four hour session for teachers from Valladolid. This workshop was a summarized version from the workshop's session defined by the consortium. During this session teachers could get an overview of the whole life cycle and from some of the tools. For this workshop, the facilitator prepared an LD Workflow with following steps and tools: 1) Design narrative with a course description they want to design 2) persona card about a teacher, 3) a persona card about a representative student and 4) the course design authored in Web Collage, see Figure 21. Then, these settings has been implemented in a Moodle prepared for them using Glue!-PS.

The second workshop organized by University of Valladolid based on higher education consisted of two sessions from six hours each for teachers from the same University. This workshop is an extended version of the adult education workshop. In these sessions the facilitator prepared an LD Workflow with 3 steps, where steps 1 and 2 were optional and includes persona cards templates with data about teacher and student; and step three include a Dream template, see Figure 22.

Figure 21: University of Valladolid LD Workflow for adult education's teacher's workshop

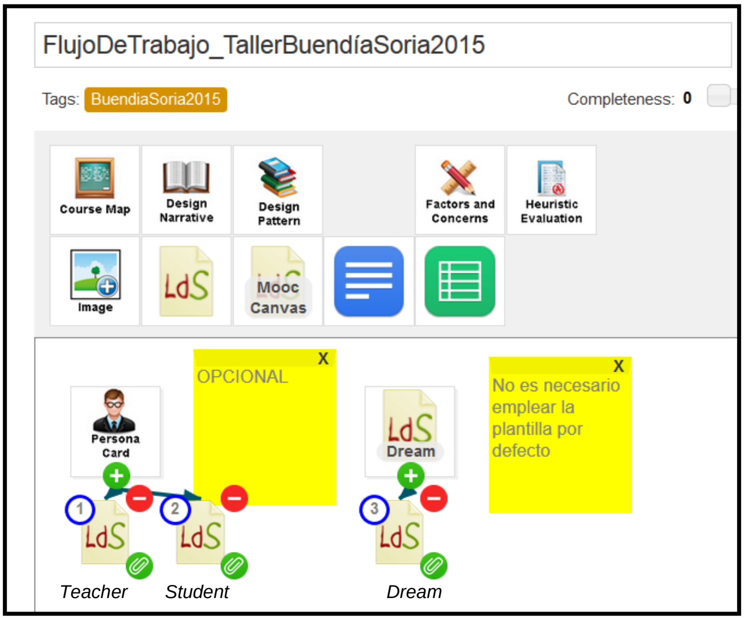

Figure 22: Valladolid's University workshop for higher education's teachers

3.7.3 HANDSON MOOC

The HANDSON MOOC is a Massive Open Online Course (MOOC) to support teachers' professional development in the use of ICT in class. The MOOC use the Learning Design Studio methodology as a pedagogical framework (Mor & Mogilevsky, 2013), ILDE as the design infrastructure (Hernández-Leo, Asensio-Pérez, et al., 2014) and Moodle and Canvas as delivery platforms.

The aim of the study is the general Learning Design Studio approach, the supporting technologies and the learning design tools as a mechanism to understand its probability for adoption by teachers and as indicators to assess the value of tools (Garreta-Domingo, Hernández-Leo, Mor, & Sloep, 2015; Garreta-Domingo, Aguado, et al., 2015). As part of the project they offered three Massive Open and Online Courses (MOOC), where they used a "lightweight" version of the Learning Design Studio methodology. In this adaptation, the methodology introduces learning design by leading participants through an LD Project of their own initiative, situated in their context of work. As a result, participants have intrinsic motivation to engage with the concepts and methods introduced, and can be bound to familiar situations. Facilitators of these MOOC defined a workflow which reflect the adapted methodology, see **Figure 23**.

The HANDSON MOOC LD Workflow defined includes the following steps: 1 define a dream, 2 reflect about the target audience for your designs, 3 factors and concerns, 4 define the learning objectives, 5 heuristic evaluation, 6 scenario described for the design, 7 define the design narrative, as seen in **Figure 23**.

Figure 23: HANDSON MOOC LD Workflow

3.7.4 MSF eLearning

Doctors without borders (MSF acronym in Spanish), has different locations around the world. When they have to define the protocols for the creation of new training courses, this information must be circulated among various offices across locations. In addition, in the case of MSF there are people who work in offices and people working directly in the field, hindering the collaborative process of design within the community. In the context of MSF they want a tool which allows them to define proper methodologies that could apply in different MSF offices for creation of new learning designs. Particularly, they want to define a game-based learning activity. We can see the workflow initially proposed for the induction game in Figure 24. This workflow includes 4 different persona cards; 4 templates defined by MSF: activity analysis, task analysis, course objectives and learning task; 1 Google document for an activity report; 1 image for attaching the prototype design; 1 Compendium LD and OpenGLM in the final step for authoring. It includes some sticky notes defining new steps and tools because it is still work in progress.

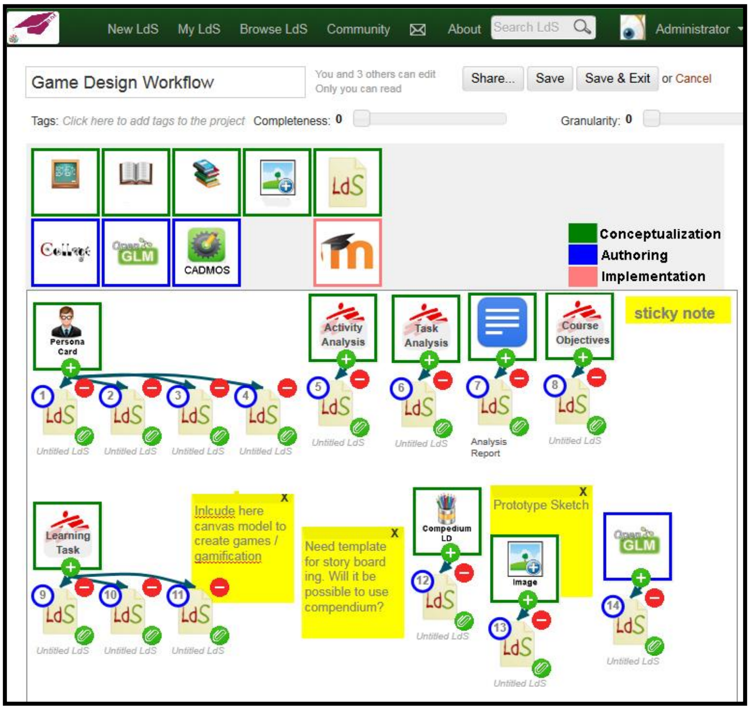

Figure 24: MSF LD Workflow defined by MSF staff members

3.8 Evaluation results

We evaluated the implementation of LD Workflow and LD Project model in ILDE by observing how efficient and effective was in a set of use case scenarios on METIS and HANDSON MOOC. Results from section 3.8.1 include data analyzed in (Pozzi, Ceregini, Persico, Sarti, Brasher, Chacón-Pérez, et al., 2015) in the context of the METIS project and additional data collected specifically for the Thesis (including HANSON MOOC, data from facilitators of METIS workshops).

3.8.1 METIS workshops

METIS project allowed a real use case scenario to evaluate the model for LD Workflows and Projects. The METIS goal was to study the feasibility of an approach aiming to foster the adoption of innovative and effective LD approaches and tools in real life environments. In this context, specific evaluation needs of METIS included: to measure acceptance of the proposed innovative technology (ILDE) and to verify the adequacy of the proposed workshops of target contexts (higher education and adult education for the particular case of evaluating LD Workflow and LD Project). Specifically, to evaluate the technology acceptance, we applied the Technology Acceptance Model (TAM) and its subsequent evolution (TAM2) (Chuttur, 2009; Davis et al., 1989; Pozzi, Persico, & Sarti, 2015), complementing it with observation notes and usage data tracked by the system itself.

Taking advantage of the questionnaire provided by the project, we added an item about LD Workflow and LD Project. The participants were asked to provide their opinion about ease-of-use (scale from 1=min to 5=max) and usefulness (scale from 1=min to 5=max) for the following statement: selecting an LD Workflow for their LD Project. Furthermore, they were offered an (optional) textbox for comments on their rating. In the second round of the training sessions, a total of 142 people attended the workshops. 107 people out of the 142 responded to our questionnaire (which is 76% of the overall population of participants). And 33 participants out of the 107 answered the item about Selecting an LD Workflow for their LD Project.

Besides, looking at the statistical analysis, even when tests could be applied, no significant differences among the contexts emerged, meaning that the LD Project and LD Workflow mechanism have been positively accepted everywhere. Moreover, the resulting evaluation is very encouraging, both in terms of ease-of-use and usefulness, see Figure 25 (all means >4.0 for ease-of-use; all means >4.3 for usefulness).

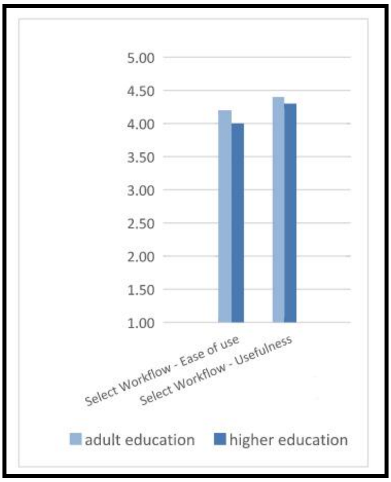

Figure 25: Participants' opinion about the functions to LD Projects on METIS Workshops (Pozzi, Ceregini, Persico, Sarti, Brasher, Chacón-Pérez, et al., 2015)

Taking into consideration the two different institutions that ran the workshops (Agora and OU) plus the organized from Valladolid University, we can subdivide responders per partner institution which organized the workshop. From Agora we got 24 respondents, 9 from OU and 32 from Valladolid. However, Valladolid organized two session one for adult education and another for higher education. Thus, we can organize the respondents sector (Higher Education and Adult Education). We got 34 from higher educator, 34 from Adult education and 8 from other sectors; see data displayed by sectors from participants who answered the item of Select LD Workflow for my LD Project in Table 3.

Table 3: Select LD Workflow for my LD Project
(Pozzi, Ceregini, Persico, Sarti, Brasher, Chacón-Pérez, et al., 2015)

	#actions tracked	Overall		Adult education			Higher education			p
		tot	SD	*tot*	M	SD	*tot*	M	SD	
Ease of use	57	*33*	.78	*13*	4.2	.72	*20*	4.0	.91	.662
Usefulness		*33*	.71	*13*	4.4	.77	*20*	4.3	.80	.724

In addition, main facilitators from AGORA, OU and Valladolid workshops were invited to answer the questions related to LD Workflow and LD Project from METIS questionnaire, their answers are reflected in **Table 4**. In this case we asked about: (1) selecting an LD Workflow for their LD Project, and included two new statements: (2) adding a new LD Workflow and (3) editing an LD Workflow. From facilitator point of view, resulting evaluation is very encouraging too, both in term of ease-of-use and usefulness, see Table 4 (all means >4.7 for ease-of-use; all means >4.3 for usefulness). Facilitators were asked to give their feedback about (1) any limitations found in the tool, (2) opinion about the features and (3) proposition of any improvement. Facilitator 1 (F1 in Table 4), commented about (1) that those feature were nicely integrated on ILDE and look like other features included. Furthermore, facilitator 1 said "the idea of LD Workflow is very useful because it facilitates and streamlines entire process of creating new projects". Facilitator 2 (F2 in Table 4), answered about (1) that he found difficult to add an example to a tool when defining new LD Workflow. Specifically, when any user wants to add an example at a tool they are requested to attach directly the original or a copy of it. However, facilitator 2 has not had clear if he was "attaching a copy by reference or a copy by value". Finally, about (3) facilitator 2 proposes a new mechanism to show specifically flow between tools, so it would be helpful for teachers, better than numbering it. Facilitator 3 (F3 in Table 4), support the features with comments such as "workflows are very useful to anticipate a customized learning design specific path" and "I think this feature is very useful. Not only for individual designers (or teams of them), but also for structuring professional development actions (it can help provide a narrower view of ILDE's functionalities, something of interest for novel users)". Furthermore, F3 proposes to group tools directly under conceptualization/authoring/implementation tools palette.

Table 4: Data collected from Agora and OU Workshops facilitators

Action Tracked		Select LD Workflow for my LD Project	Add LD Workflow	Edit an LD Workflow
F1	Easy-of-use	5.0	5.0	5.0
	Usefulness	5.0	5.0	4.0
F2	Easy-of-use	4.0	4.0	4.0
	Usefulness	4.0	3.0	4.0
F3	Easy-of-use	5.0	5.0	5.0
	Usefulness	5.0	5.0	5.0
Mdn	Easy-of-use	4.7	4.7	4.7
	Usefulness	4.7	4.3	4.3

Regarding data tracked by the system following the TAM/TAM2 approach (Chuttur, 2009; Davis et al., 1989; Pozzi, Persico, & Sarti, 2015), number of LD Workflows and LD Projects defined in each use case scenario were tracked. In the OU workshop, a facilitator defined 1 LD Workflow that has been used to define 7 different LD Projects. However, in this particular use case, the facilitator was the person in charge of preparing LD Projects for participants. Moreover, the facilitator created and adapted those 7 different LD Project for each particular group of participants. Thus, demonstrating that facilitator learned to apply successfully those new concepts.

In Agora, a facilitator defined one LD Workflow that each group of participants needs to apply to define a new LD Project. In this use case a total amount of 26 different LD Projects were defined by participants. Furthermore, from those 26 LD Projects created using the LD Workflow proposed by facilitator a total of 20 where fully developed and ended been implemented in a Moodle course. Initially, more than 75% of groups participating in the workshop achieved their personal goal and developed a ready to use activity. Analyzing data from the system, and considering the observation notes, the groups that did not implement their LD Project were due to the following reasons: a) 4 LD Projects belonged to groups that attended the first sessions but some of them did not attend the second session, so members of those groups where reallocated to other groups; b) 2 LD Projects had technical problems with the Moodle plug-in connector that could not be resolved in class. Finally, in the context of the UVA workshop 14 LD Workflows were defined. From those 14 LD Workflows, 8 were defined by participants of the workshop, and 6 by the facilitator. In this use case, participants worked individually or in groups of, which explains the total amount of LD Projects defined in this instance of ILDE: 44. Furthermore, 8 participants/groups created at least 1 additional LD Project by themselves. In this particular use case scenario more than 50 teachers learned about LD, fulfilled the activity satisfactorily and implemented their activities in Moodle courses (Pozzi, Ceregini, Persico, Sarti, Brasher, Chacón-Pérez, et al., 2015; Pozzi, Ceregini, Persico, Sarti, Brasher, Hernández-Leo, et al., 2015).

3.8.2 HANDSON MOOC

The MOOC is organized in weekly activities. Every week participants may fill a survey about specific feedback on activities completed and tools used. The MOOC proposed participants the use of a LD Workflow based on the LDS framework (see Figure 26). Moreover, they can explore and use all ILDE functionalities from the very beginning and until the very end of the MOOC schedule. Again, we included an evaluation question inside those weekly surveys. Same schema as in the METIS workshops described in section 3.8.1.

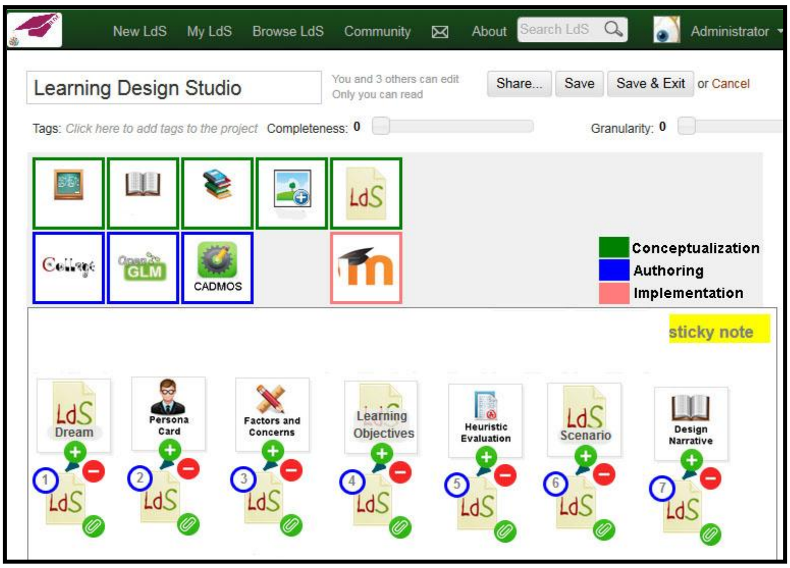

Figure 26: LD Workflow based on the LDS framework proposed by MOOC

A total amount of 25 participants replied the survey. However, only 12 participants answered the item related to LD Projects. The reason behind the low participation in survey could be either being an optional task or the kind of participants who enroll in MOOC courses. Analyzing the answers from the questionnaire plus notes from system's tracking feature, the LD Project function have been extensively explored and used. Furthermore, the resulting evaluation is again encouraging, both in term of ease-of-use and usefulness, see Figure 27 (all means >4.22 for ease-of-use; all means >4.4 for usefulness).

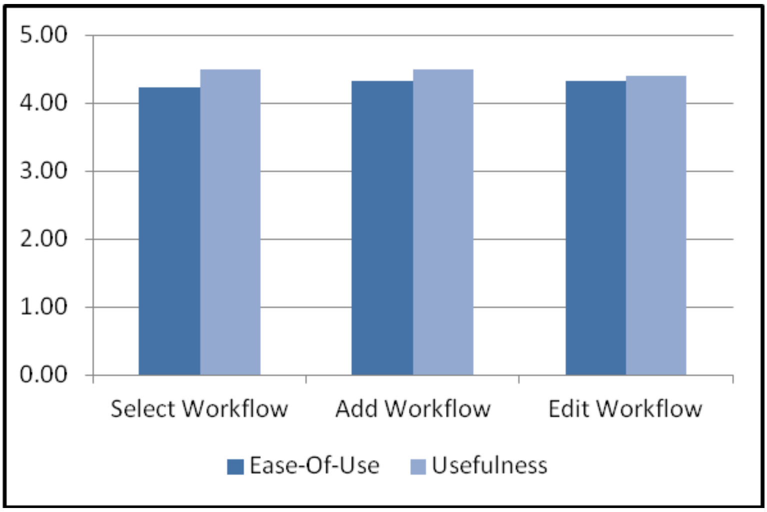

Figure 27: Participants' opinion about the functions to LD Projects on Hands-On MOOC

3.9 Conclusions

This chapter contributes to the adoption and fostering of LD methodologies aiming at assisting teachers with technological support for flexible learning design project definition. Those methodological approaches of LD offer indications about what combinations of designs and tools may be followed when designing for learning. For example, actual methodologies - such 7C's or Learning Design Studio - involve using several tools in a particular order to fulfill the creation of sound designs. However, methodologies proposed were not supported with appropriate tools that could facilitate its articulated implementation. Moreover, the suitability and particularizations of those methodological approaches depends on the context and requirements of an educational institution, teachers' expertise and technologies available. This gives the necessity for flexible technology-supported articulations of the LD ecosystem.

In this chapter we propose the use of LD Workflows. We define workflow as the schema of action where designing for learning involves a selection of learning design tools that should be used in a recommended order (i.e., a computational representation of an LD methodology). In a workflow we define a number of steps that must be followed to define a new activity. In each step we define the tool or set of tools that should be followed to complete it, and we include direct access to them. Thus, with an LD Workflow we provide methodological approaches of LD and resources and tools necessary for its implementation.

LD Workflow feature allows teachers to create and share their own methodologies based on tested and proved LD tools. Teachers can capture their design processes for creating new designs, including steps and tools to be followed. Moreover, they can share their LD workflows with other peers. Furthermore, teachers could see how others have applied own methodologies to specific uses, allowing teachers to take advantages of peer experiences. Apart from sharing, teachers may adopt new methodologies from other partners by using their LD Workflows. Teachers may adopt directly other LD Workflows, or may particularize them considering their educational institution requirements and technologies available. An illustrative use for an LD Workflow is when a teacher is responsible for defining the list of steps to create new courses inside his/her institution, and define the tools and the order any teacher may follow to create new designs.

When a teacher has an LD Workflow ready to be used, the teacher may create an LD Project using it. We defined an LD Project as a specific action of design for learning, based on an LD Workflow, which may lead to production of conceptualizations, authored and implemented designs related to the same learning situation. By creating an LD Project, a teacher may follow a set of sorted steps to create new designs according a predefined standard set.

LD workflow and LD Project features has been implemented in ILDE. This platform integrates a wide collection of LD tools. Hence, each step defined in an LD Workflow is directly related to the proper LD tool (or LD tools) needed. In addition, ILDE has provided a platform for carrying out the evaluation process of these proposed features in real environments. As aforementioned, ILDE has been used in the context of several projects in both national and European domains.

Evaluation presented in this chapter shows that support provided by proposed LD Workflow covers different existent LD methodologies, which is encouraging, and also has been adopted in several contexts. Moreover, results from using this mechanism in different use case scenarios pointed out encouraging aspects in ease-of-use and a useful feature. Furthermore, adoption of this tool supports guidance to novel teachers who are not experts in LD, so that they can easily follow step by step guides, which comes with appropriate tooling.

As the definition of new LD Projects may imply duplication of already existing designs, the amount of replicas of a particular design would increase. Management of multiple replicas and proper display of them to teachers in order to allow a visualization of the multiple versions is an interesting and challenging aspect addressed in next chapter.

CHAPTER 4. SUPPORTING LEARNING DESIGN VERSIONING

This chapter describes the problem of supporting learning (co-) design scenarios that originates multiple versions of same design solution. This chapter explains the work carried out to address the third objective of the Thesis focused on supporting learning (co)-design scenarios that originate multiple versions of the same learning design. Besides, this chapter introduces an LdS branching model to support those scenarios as well as a visualization to dig into versioning. The model is implemented in ILDE as a technological facility. Use and evaluation of this facility in use case scenarios demonstrate its application and flexibility as well as teachers' appreciation of its usability. Contributions related to this chapter have been already published in a conference paper (Chacón-Pérez, Hernández-Leo, & Blat, 2014) and later consolidated as a book chapter (Chacón-Pérez et al., 2015). Furthermore, evaluation of this functionality together with other functionalities of ILDE has been analyzed and reported in a journal article under review (Hernández-Leo et al., submitted).

4.1 Introduction

Learning designs have varied or multiple lives. Sometimes designs are created by an individual teacher for a single use with their students. But often, they are reused in the following years or by other teachers with minor adaptations (Harrer, 2006; Mor, 2013). Other times, designs are co-outlined by teacher teams and later refined by each teacher for their particular group of students, or they are co-designed involving students (Könings, Brand-Gruwel, & van Merriënboer, 2011). These scenarios can imply the creation of multiple replicas of the same design, which in turn may be duplicated and refined as new learning design. Thus, we define a collection of learning designs which were not started from scratch but by replicating (or duplicating) a particular existing learning design as a "learning designs' family".

Related to the third objective, we state that supporting the management and visualization of interrelated designs can back scenarios of cooperation and reuse in the context of design communities. Therefore, we propose a management mechanism based on an LdS branching model visualized following a family-tree metaphor as the third contribution. This new mechanism will support teachers within an integrated learning design ecosystem to dig within versioning. The model, and its visualization, has been implemented as a new feature on top of LdShake as part of the METIS project new ILDE platform. ILDE covers these reuse scenarios, since learning design solutions can be duplicated and modified within the platform. Tracking versioning of learning design solutions is interesting from a teacher perspective (inspiration by exploring variations of the same design) and educational research perspective (understanding how educators design and reuse).

Development of the feature consists of two main modules: one devoted to family-related LdS's management and another focused on their visualization. On the one hand, management module is in charge of storing LdS replicas' data, managing their interrelations, and retrieving a learning design family corresponding to a given LdS. On the other hand, the visualization module displays a learning design family as square-shaped icon representing LdSs, and its family-relations using arrows. Focusing on the third specific objective, we described how the model implemented in ILDE support scenarios that originate several versions of learning design solutions as well as the visualization offered to dig into the versioning. Furthermore, the usage is illustrated with three examples extracted from real practice in different contexts. This implementation of both the model and its visualization has enabled collection of feedback from learning technology experts. Evaluation was carried out online, 11 experts responded to our invitation to try the feature completing a set of tasks and an online questionnaire. Their opinions indicate that the feature is interesting and could significantly address relevant learning design and co-design situations.

They used the feature satisfactorily and also pointed out several suggestions to improve its usability and enhance its potential utility. The suggestions were used in a second iteration of the model and its implementation, which was used by teachers in METIS workshops.

This chapter is organized as follows: section 4.2 introduces the methodology applied for the second contribution; section 4.3 presents the model proposed to face this contribution; section 4.4 shows model implementation in ILDE; section 4.4 show some examples where replication is applied; section 4.6 introduce the evaluation with questionnaires of the feature; section 4.7 features the discussion; and section 4.8 includes the main conclusions related to the third contribution of this Thesis.

4.2 Methodology

For the third contribution different activities described in design science research methodology (Peffers et al., 2007) are applied (see Figure 8), as in second contribution.

As described in chapter 2, during experiences in designing, implementing and evaluating LdShake and ILDE, some problems were detected. Particularly, the second problem identified was lacking of support to learning (co-)design scenarios that originate multiple version of same design solution, defining activity 1 of methodology. Following activity 2 defined by the design science research methodology (Peffers et al., 2007), see Figure 8, objectives for the solution are defined, including definition of family-tree metaphor proposed for building the conceptual model. Once family tree model is successfully described, in activity 3 implementation of a technological facility follows. As part of this activity, a conceptual model is implemented on ILDE as a new feature. During activity 4 of science research methodology a demonstration proceed. In this activity, usefulness and usability factors are demonstrated in a set of described use case scenarios. Furthermore, we invited 13 learning design experts to try the new ILDE feature implementing the family-tree metaphor. Based on initial results of demonstration we reformulate and refine proposals until final solution is proved to be superior to the existing one. Later, it is used in an educational context of Adult Education as part of the METIS project. Finally, it is evaluated during activity 5 of methodology following extended TAM model to understand satisfaction with facility from usability and utility perspectives (Chuttur, 2009; Davis et al., 1989; Pozzi, Persico, & Sarti, 2015). Specifically, we invited 13 learning design experts to try the new ILDE feature implementing the family-tree metaphor

4.3 A Model to track Learning Design versioning

As described in section 1.1, and extended in section 4.1 reusability is a relevant aspect in LD. In scenarios involving reuse, it becomes clear that multiple versions of the same LdS need to be managed (e.g., identify which of the possible variations of a design is more interesting to be reused, etc.). We propose a model based on family tree relations metaphor, which simplifies the complexity of the relations between versions of a learning design; and provide visualization for the management and tracking of multiple versions of designs

4.3.1 Learning Design "family tree" metaphor

In our previous research (Hernández-Leo, Moreno, et al., 2014; Hernández-Leo et al., 2011), we saw that sometimes teachers hesitate when they have to modify the work done by starter or original designer, even if they have editing rights. Unsurprisingly, this finding depends on the type of learning design situation that contextualizes the position of teacher.

To approach the design of the feature, we considered using a metaphor to facilitate designers an overview of existing replicas of a design, and its relations. The use of metaphors is common in human computer interaction design (Hernández-Leo et al., 2007). Lakoff and Johnson (1980) describe the use of metaphors as a way of "understanding and experiencing one kind of thing in terms of another". They claim that metaphors are not only pervasive in language, but also they are fundamental part of our conceptual system of thought and action. Metaphors have been proved to help users understand how to use computers, applications, etc. (Imaz, B. Benyon, 2007). In particular, we have identified the Family Tree metaphor as an interesting metaphor to represent, manage and relate different designs within an online community of teachers. In this sense, we deal with a collection of designs interrelated as if it was a learning design family. As aforementioned, we define a collection of learning designs which were not started from scratch but replicas (or duplicates) of particular existing designs (exemplar or template) as a «learning design family». A "parent" design is the initial material created by teachers from scratch. A progeny or child is any duplication or replica of a parent design.

4.3.2 Conceptual Model to track LD versioning

In order to support duplication-for-reuse process we propose a model for managing and tracking multiple versions of learning designs, which can be seen in Figure 28. In the top-center of the model there is the concept of «Learning Design Family», which is a set of learning designs interconnected using the metaphor of a family hierarchy. We named a "parent" learning design as the original design created by teachers from scratch. Any duplication or replica from either a parent design or another child originates a child or progeny. However, distinction between a simple clone and a replica relies on whether there has been a process of refinement to suit individual needs (see «Cloned designs» and «Refined designs» in Figure 28).

Any learning design is composed of both a body and an envelope. Design body is created with a tool from a myriad of LD tools. Those tools support teachers in the phases of learning design lifecycle: conceptualize (e.g., Persona card), author (e.g., Web Collage) or implement (e.g. a deployment of Web Collage design into Moodle). Design's envelope may contain title, date for both when resource has been created and when it has been edited, a collection of tags of educators that categorize the resource, a support document where educators can specify any extra supplementary material related to the design (e.g., a guide on how to use the design properly, the resources needed to apply it, indications about their evaluation, etc.), and the comments and extra information.

Additionally, every learning design is associated with an educator (initial author) that started the design and who may invite a set of co-authors (members of the platform community, a.k.a. LdShakers) to participate in the co-edition of the design.

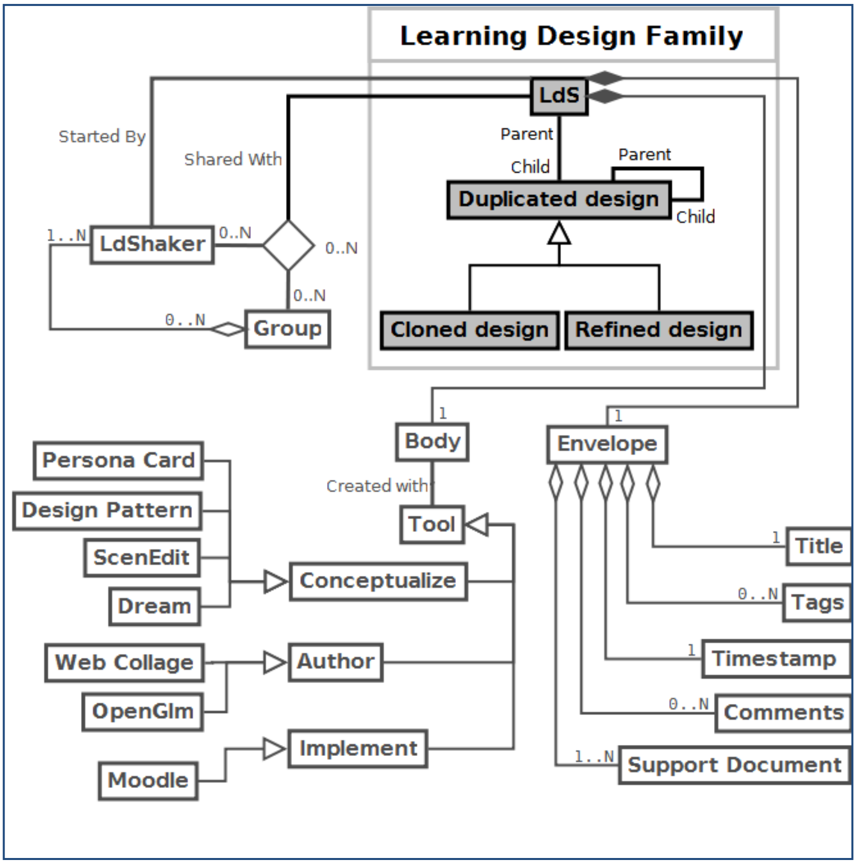

Figure 28: Model for tracking learning designs' versioning

Keeping duplications in form of learning design families enable tracking of learning design versioning for every single design. Educators can navigate through existing repository of designs within the community and replicate resources of their interest. However, before duplicating a particular design, an educator may be interested in exploring different versions of that particular design tracked by the model. This is enabled by the "family-tree visualization" of learning design versioning.

4.3.3 Use Cases

Table 5 summarizes a set of cases representing learning design situations where the aforementioned problem appears and additional situations that may benefit from supporting management of learning design replicas or duplications. By enabling learning designs duplication, we allow users to respect an original work. Moreover, if a teacher wants to reuse a design, they can duplicate, refine and adapt the LdS according to their needs and contexts. Furthermore, when a teacher duplicates a design, s/he gains full “ownership” of the design, as s/he is now the starter of the new design (reusing the design being duplicated). However, the management of the designs should still recognize the authors of the original design.

Table 5: Learning design situations addressed with the family tree model contribution

Learning design situations	
Case 1	Teachers reuse a design the following academic years with minor adaptations. It would be interesting for the teachers to keep track of the "design's life" across time.
Case 2	New teachers reuse previously existing designs for their new subjects with their particular adaptations. It would be interesting to keep track of the designs across time.
Case 3	A design is co-outlined by teacher teams and later refined by each teacher for their particular group of students. It would be nice to keep track of the original design and the multiple variations.
Case 4	When teacher views a design of her/his interest (for potential reuse), she/he would like to know if there are variations of the same (similar) design
Case 5	Some teachers don't feel comfortable modifying an existing design (even if they have been invited as co-editors) and prefer working on a "duplication" of the design.

There are additional aspects that motivate the relevance of this set of learning design situations presented in Table 5. Creation and design of learning designs is no trivial. There are evidences in the literature that show the challenges around teachers designing from scratch (Griffiths, 2005). A solution to face this problem is to support design process through reusing existing material to create new one (Hernández-Leo et al., 2007). In this context, all cases presented in Table 5 entail reuse of existing designs. A feature supporting duplication of designs back this type of reuse requirements. Furthermore, it also back situations of teachers reusing their own previous designs across time, and scenarios of teams of teachers applying the same design with multiple groups of students. Multiple duplications of a learning design may lead to scenarios with relatively high amounts of LdS replicas. We need a management mechanism within learning design ecosystems to manage this amount of LdS replicas and their relations in a user friendly approach to visualize and facilitate navigation through LdS.

4.3.4 Family tree visualization

As teachers reuse designs along time, number of designs versions increase. To enable a comprehensive representation of versioning for teachers, a feature that supports visualization of different versions of the design and their interrelations is needed. In order to solve this, a visualization based on a "family-tree" metaphor is proposed (Chacón-Pérez, Hernández-Leo, & Blat, 2014). This feature shows graphically an initial design, all their duplications and their relations in a user-friendly approach facilitating navigation through design versions. Both visualization and model have been implemented in ILDE. In particular, visualization of learning design versioning is available for each design (learning design is referred as LdS in ILDE) in "view mode". Next to «View duplicates» option, users can duplicate the design selecting «Duplicate this LdS».

The visual design of the family tree metaphor includes a box with LdS basic information as title and the picture of the educator (as configured in his or her LdShaker profile settings) who created the design (see Figure 29 A). Notice that the LdS that is used to open the Family-Tree Visualization is the one in the area B from Figure 29, while the other "relatives" of this LdS are colored different as seen in area A from Figure 29. If the LdS has an "ancestor", it is automatically showed on top of the actual LdS (Figure 29 A). There is a round button in every LdS which has been duplicated to expand or collapse their children, a «-» button for collapsing or «+» button for expanding (see Figure 29 A). Thanks to this option teachers are able to navigate through the tree without overloading the screen with LdS. Relationships are represented between LdS using a black line.

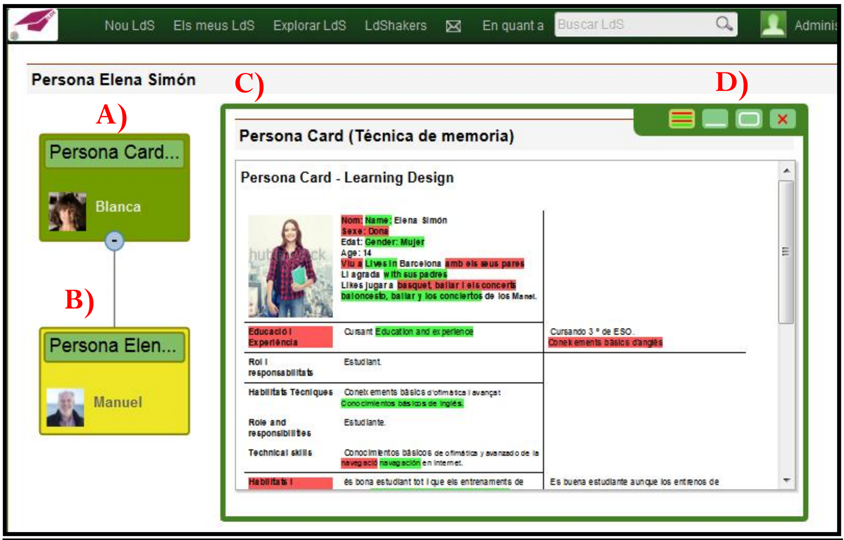

Figure 29: An example of the visualization of the model for tracking learning designs' versions

Clicking on the name of each LdS opens a new window showing LdS's view mode (Figure 29 C). Furthermore, in this new window educators can compare the text from original LdS with the replica. In order to activate this feature, teachers may click on compare button (Figure 29 D). When it is clicked, added or modified text is highlighted in green, while deleted text is marked in red.

4.4 Learning design branching tool implemented in ILDE

Besides learning design family tree visualization, we have implemented a module to manage, store and retrieve the information related to the replicas. Both visualization and management module have been implemented in ILDE, (Chacón-Pérez et al., 2015). In particular, the module has been integrated in LdShake platform and is accessible within LdS visualization section. In this way, when a user is viewing a particular LdS if only that user has editing rights, the user will see «Duplicate this LdS» (see Figure 30 A), and «View duplicates» options (see Figure 30 B). On the one hand, clicking on «Duplicate this LdS» system makes a replica of actual LdS and asks for a new name. Within the system, module stores relation between original LdS and the replica by tagging replica as offspring or progeny of original LdS. On the other hand, clicking on «View duplicates» option, triggers the load of a new screen where family tree visualization of actual LdS is displayed, see Figure 31. Data used to generate the family tree is extracted from ILDE platform and replicas generated within the design community.

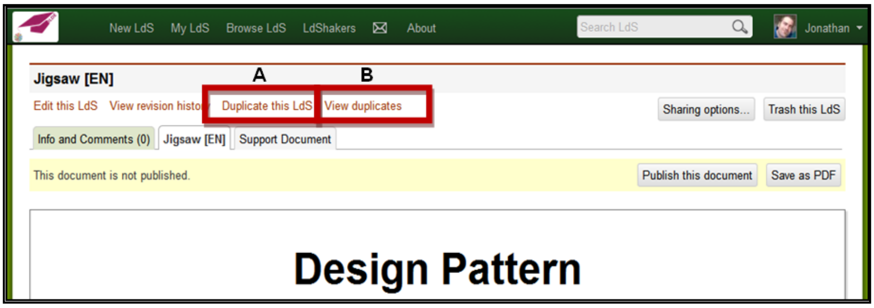

Figure 30: LdS's description view showing the inclusion of plug-in options

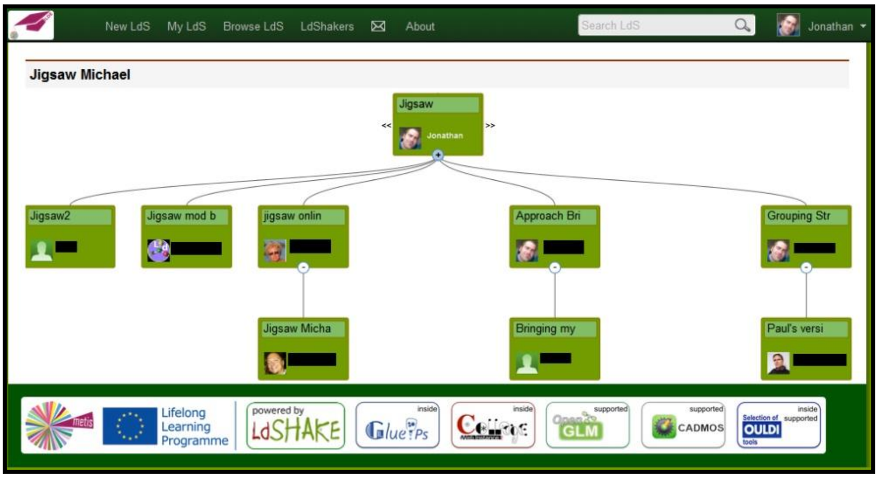

Figure 31: Family tree metaphor's visualization screen

The implementation has been planned in two iterative cycles. The first cycle covers a first implementation of the metaphor as a plug-in for the ILDE and the basics options (see Figure 31 for a general view of how it is visualized within the ILDE platform). Using this implementation, we have collected early feedback from LD experts and also gathered data from users to evaluate metaphor's utility, its implementation, and to identify lines for improvement in second phase. During the second phase, we refined first implementation according to feedback from first phase and extended the tool with advanced functionalities described in previous section. Resulting implementation in the second cycle was evaluated again with teachers in several educational contexts.

4.5 Examples of LD duplication and versioning

The LdS' duplication and versioning features implemented in ILDE are being used in different educator's communities, in the context of the METIS project, in a MOOC organized by the HANDSON project, and at several design workshops framed in the Learning Layers project. Following examples belong to contexts and illustrate diverse scenarios that benefit from these ILDE features: refinements of conceptualizations analyzing the target learners in adult education actions, duplications of authored designs to be implemented with different technologies with several groups of university students, and supporting ad-hoc design templates.

4.5.1 Refining versions of predefined persona card

La Verneda adult education school, run by Agora association, has piloted ILDE in the context of the METIS project. Association of Participants Agora is a non-profit association of adults who do not pursue any academic degree and are characterized by their intrinsic motivation to learn. Main goal of the association is to promote the educational and social inclusion of its participants grounded on democratic participation (Sánchez-Aroca, 1999). Agora / La Verneda offer a number of non-formal cultural and educational actions to the whole district of La Verneda in Barcelona (Spain) and are open to everybody, without any discrimination in order to promote equality. Most educators in this school are volunteers. It provides a daily educational setting for over 1500 participants and more than 100 volunteers. All the activities offered are free-of-charge and include language learning, basic literacy, information and communication technologies training groups, preparation for University access tests, preparation for driving tests, and dialogic literary circles among many other workshops. Volunteers share the educational materials, and when new educational activities are being planned, the process is open to all participants and volunteers to include all the different perspectives and possible contributions.

ILDE supports Agora's participants and volunteers in this process of planning and co-creation of educational activities for the school along the whole learning design lifecycle. Of course, participants also use ILDE to share designs with others within their community, or reuse other member's designs. Profiles of participants and volunteers are very varied. Some of them are experts on content topic (e.g., an introductory course to Microsoft Office), while others have a basic educational background, or they are collaborators that facilitate sessions and workshops, and even learners with strong opinions on what they would like to learn. All of them participate in the learning design actions fostered by the school, but since their levels of expertise in education varies, it was decided by the school committee together with ILDE providers to define a design methodology that any Agora participant could easily follow when creating their own activities.

A team comprising of Agora experienced participants and learning design experts defined a workflow in ILDE aligned with Agora philosophy and practices to guide learning design within the school. This Agora's workflow includes a selection of ILDE tools that support the different phases of the learning design lifecycle: a persona card (Nielsen, 2013), a pattern design and design narrative for the conceptualizing phase; Web Collage for the authoring phase; and Moodle as the institutional VLE where the activity will be implemented. Out of the many tools integrated in ILDE, Agora participants were suggested to use these specific tools to reflect about, document and co-create educational activities for the school.

To further facilitate learning design within school, it was decided to refine the proposed workflow by not using directly the original template of persona card but an elaboration of it in a way that it is very potentially suitable to all learning design projects in Agora/La Verneda. Refinement of persona card was, first, a duplication of the original template translated into Catalan (mother-tongue of most educators in the school). Then, the Catalan version of the persona card was used to create three pre-filled persona cards of typical Agora participants in their different roles (collaborator, learner, expert). To achieve this, the Catalan version of the card was duplicated three times and completed accordingly. Due to the fact that the three edited cards reflect the main profiles of participants, they can be reused in learning design projects within the school. These pre-filled cards were incorporated in the Agora workflow, and anytime the workflow is applied to create new learning designs the cards are duplicated so that the general descriptions of the Agora profiles are refined or adapted, if needed, in the context of the new design (e.g., immigrant learner, elder learner, etc.) This procedure leads to a persona card's versioning family tree of personas considered in Agora learning design conceptualization processes. One portion of section of the family tree originated can be seen in **Figure 32**.

Figure 32 shows translated version of persona card, at top of the tree. Then, in Level 1 there are duplications done by educators from the original version. Furthermore, there are three duplications edited with data of main profiles in Agora's School as previously defined in this section. In Level 2, there are parts of versions that educators did by duplicating and modifying the edited persona cards incorporated in Agora's LD Workflow. Furthermore, in level 3 there are duplications some educators did after navigating through the family tree of persona cards, selecting a refined persona and further adapting it to their context. So, there are educators who adapted or refined versions of what other educators already refined.

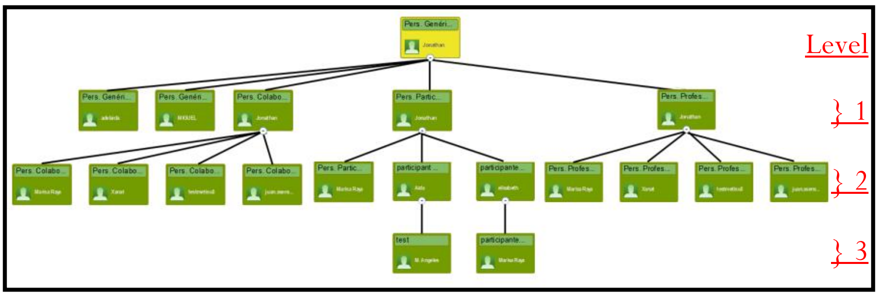

Figure 32: Persona card Family Tree versions tracked

Seven design projects have used the versioning feature in Agora/La Verneda: one about Spanish narrative, another as introduction to Photoshop layers, a chess course for beginners, and activity to learn about another cultures and cities such as Tegucigalpa capital of Honduras, a small course about Excel, the organization of a cooking course and a course about photography. Designs of these activities were created in teams. After completing a project, involved participants pointed that they found duplication and versioning as a very interesting and useful characteristic of ILDE. Some educators said that thanks to this feature they could adapt previous existing artifacts created by others easily and could create new activities faster. Another educator argued that this feature could be very helpful for duplicating and adapting activities from one design group to another. Finally, another educator pointed that this feature allowed her to analyze how other educators refined existing resources.

4.5.2 Versioning implementations

As already mentioned in section 2.6, at the end of the LD life cycle defined by METIS there is the implementation phase. This phase starts with a teacher specifying into with VLE will be implemented, and specifying which enrolled students will be enacted. Then, teacher can use available tools for configuring groups of students, as well as to include and configure the learning tools (available in the VLE) for their students. At the end of implementation phase, the teacher may "deploy" implementation. In this automatic process VLE will be set up and configured and selected learning tools will be included and prepared reflecting decisions specified by the teacher.

During the METIS workshops two main cases for duplication of LdS from implementation type were defined. Firstly in a training session for Higher Education teachers, one of participants wanted to enact same learning design with two different sets of students. In this case, activities, tools and even the social structure of students participating in those activities were almost identical. The only different was the list of participants. Secondly in a training session for Adult Educators, a teacher created a quite complex collaborative learning design using Web Collage authoring tool. The authored design was part of an introductory course on ICT tools within a program for adult education. Once everything is ready, the learning design could be deployed into the target VLE using GLUE!-PS. However, the drawback is that implementation edited with GLUE!-PS cannot be edited again with Web Collage, so eventual changes in the grouping of students was needed to be carried out within GLUE!-PS (which can be a burdensome process since this tool does not support grouping features as powerful as those provided by Web Collage). Thus, before deploy with GLUE!-PS a duplication of the implementation is recommended. So, if modification in the grouping structure was required, the teacher had to roll back to the duplicated implementation and do the editing with Web Collage (employing much less effort).

4.5.3 Supporting ad-hoc design templates

Another effective design practice afforded by the versioning facility was the creation and use of ad-hoc templates within learning design communities. ILDE included a set of templates for supporting teachers during the conceptualization of a new design. These templates were based on the representations developed by the OULDI project (Cross et al., 2012) and Learning Design Studio (Mor & Mogilevsky, 2013). Some examples of these templates are: course map, design narrative, design pattern, persona, factors and concerns and heuristic evaluation. However, in some cases design communities needed additional templates. The versioning feature, proved useful in supporting such scenarios: users could create a prototype LdS and instruct others to duplicate it. We present real scenarios that illustrate this use: the HANSON MOOC and the Learning Layers design workshops.

The HandsonICT project's aim was to aid teachers in the effective integration of ICT in their classroom practices, by guiding them in developing their learning design skills. One of the main instruments in the project used to this effect was a series of three MOOCs. In the second MOOC, the first activity consisted on a "Dreambazaar" activity, where each participant was requested to share their dream techno-pedagogical innovation by filling a set of provided fields. However, there was no template for dream descriptions on ILDE. Since it was unique to MOOC initiative context, it did not make sense to add a built-in template. Instead, the MOOC team created an LdS labeled "My dream…" and participants were instructed to duplicate it and fill it, see **Figure 33**. Indeed, participants produced hundreds of “dream” LdSs. Since the original “My dream” LdS was tagged as “dreambazaar”, all the duplicates had the same tag – making them easy to find and comment on in the collaborative phase of the activity.

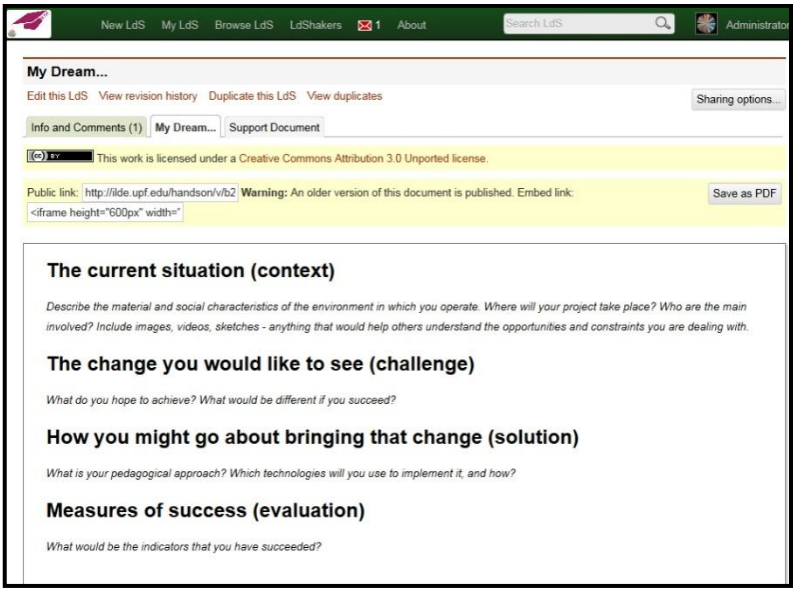

Figure 33: HandsOnICT Dream template

The second example in the context of HandsonICT is drawn from the Learning Layers project. This project develops tools and pedagogies to support informal learning in the workplace. In this project two workshops were conducted to conceptualize designs for new informal learning practices and the tools to support them. The team created several ad-hoc templates for capturing existing practices, describing user needs and making links between theory and practices. The templates were negotiated between the members of the project team. However, these templates were later modified in response to lessons learnt from their use. Thus, ILDE feature of versioning allowed the Learning Layers project to continuously reflect on its own design practice, and update templates by duplicating and extending them to best serve these as they evolved.

4.6 Evaluation with questionnaires

We evaluated the implementation of Family-tree model in ILDE by surveying 13 learning design experts to try this new feature on ILDE. Furthermore, observing how useful and usable was in a set of use case scenarios on METIS and HANDSON MOOC.

4.6.1 LD expert study

We invited 13 learning design experts to try the ILDE feature implementing the family-tree metaphor. Most of them were members of the METIS project, but none of them was involved in the design of the metaphor and its implementation. However, they were familiar with the ILDE system. 11 of them accepted the invitation (3 female and 8 male experts). Experts have more than 5 years of experience in the area of learning technologies and learning design. The evaluation was carried out asynchronously, from the distance. We sent experts the instructions on how to use the new ILDE feature using an e-mail message. The message included an introduction about the "learning designs' families" concept and the "Family Tree" metaphor. Then, instructions suggested them to complete a set of short tasks with the ILDE that had to do with the use of the new feature. Summarizing, we asked them to navigate through family tree visualization, to select an LdS and then try to duplicate and refine it. Part of resulting tree generated as outcome of this activity was displayed in Figure 31. Finally, we asked them to fill an online questionnaire in which experts must value relevance and utility of this feature to support LD situations (or cases) described in Table 5 as well as the usability of its implementation. The questionnaire included several *Lickert* scale questions and two open questions inviting experts to discuss the cases and the utility / usability of the proposed metaphor and implementation.

Table 6 shows results obtained for first two *Lickert* scale questions. First question inquired about the experts' opinions around relevance of cases listed in Table 5. We wanted to understand if they also see these cases as important situations that learning design research should address. They could rate each case in a scale from 1 "not relevant at all" to 5 "relevant" (the "not applicable" option (NA) was also offered). On the one hand, experts evaluated all of the cases as quite relevant (average rating from 3.8 to 4.5). They highlighted cases 1, 3 and 5 as most relevant cases (with a mean score of 4.5 out of 5, see Table 6), followed closely by case 2 (average rating of 4.4). These cases reflect practical situations of reuse across time and across teachers of a particular design and a situation of collaboration among teachers on a particular design. Lowest relevance rating was given to a case considering a situation in which a teacher willing to reuse a design may be interested in looking at variations of that design. Even though relevance of this case is less prominent than in other cases, its relevance rating is still positive (3.8) and supported by additional qualitative comments by experts like "A teacher might wish to see examples of use of a design/pattern to better understand how it works."

Table 6: Sampling scores of experts on issues regarding relevance and usefulness

(Scale de 1 – 5; where 1 means “no relevant at all” and 5 means “relevant”)

LD case	Relevance		Usefulness	
	Distribution of scores Score (# experts)	Mdn	Distribution of scores Score (#experts)	Mdn
Case 1	3(1)-4(4)-5(6)	4.5	4(4)-5(6)- NA (1)	4.6
Case 2	2(1)-4(4)-5(6)	4.4	4(3)-5(7)- NA (1)	4.7
Case 3	4(6)-5(5)	4.5	4(7)-5(3)- NA (1)	4.3
Case 4	2(1)-3(2)-4(6)-5(2)	3.8	1(1)-2(1)-3(1)-4(3)-5(4)-NA (1)	3.8
Case 5	3(1)-4(3)-5(7)	4.5	4(4)-5(6)-NA(1)	4.6

Experts are also positive about usefulness of implemented feature to support those learning design situations They rated usefulness of feature for each case using a scale ranging from 1 "not useful at all" to 5 "very useful". Usefulness of this feature is especially clear to them in cases 1, 2, 5 with an average rating of 4.6, 4.7 and 4.6 respectively. These quantitative ratings are also backed up with open comments, such as "It is a very useful addition to the ILDE,", “It’ll be very useful for those courses that involve many teachers and that require adaptations of the materials from one year to another. I'm a teacher of a Programming course that involves 10 teachers and around 250 students. Since the subject changes every year it is necessary to adapt some of the existing content. With this feature it would be possible to have an overview of the adaptation of these contents year after year at the same time that teachers could collaborate in the advance of these materials", and "I was using previous designs of my own course or I was adapting myself to the design created by the leading colleague of a course. In any case, reuse of previous designs is a common feature of my own practice (and probably of other teachers, as far as I know)." The usefulness of the feature to tackle case 4 is less clear. It seems that usability issues related to the information displayed for each design hinders an easy understand about variations across family-related designs.

Table 7: Sampling scores of experts on issues regarding Usability

(Scale de 1 – 5; where 1 means "fully disagree" and 5 means "totally agree")

		Distribution of scores Score (#experts)	Mdn
a	I could see where the design I was viewing was situated in the tree	2(2)-3(2)-4(4)-5(3)	3.7
b	Name, picture of main author and their name are enough information	1(1)-2(2)-3(2)-4(4)-5(2)	3.4
c	Possibility of different generations allow me to see multiple visions of the same work	3(1)-4(3)-5(6)-NA(1)	4.5
d	Elements within display are clear and easy to understand	2(1)-3(2)-4(4)-5(4)	4.0
e	Elements distribution give me feeling of a Family Tree visualization	4(2)-5(9)	4.8

Table 7 shows experts' ratings around usability issues. Given a set of statements on metaphor's design-implementation, we asked them to indicate their degree of agreement with each of them. Scale ranged from 1 "fully disagree" to 5 "totally agree" (and included "not applicable" option). In **Table 7** we can see that the "e" aspect was the highly rated with a mean score of 4.8 out of 5. The implemented visualization following a branching model offers users a feeling of a learning design family tree. In general, visualization is clear (d) and provides multiple visions of similar designs (c). However, there are different opinions regarding the comprehensiveness of the information provided in the visualization (b) and provided several suggestions on how to improve that aspect and the display of the design of which the user consulted the family tree (a).

4.6.2 METIS workshop evaluation

As described in section 3.8.1, METIS project allowed us a real case scenario to evaluate this feature. For evaluating this contribution in the context of METIS workshops we included an item in the METIS questionnaire provided to participants at the end of each workshop session. This item is about duplication and visualization of replicas. Similarly than in section 3.8.1, participants were asked to provide their opinion about ease-of-use (scale from 1=min to 5=max) and usefulness (scale from 1=min to 5=max) for the following statements (1) Duplicate an LdS and (2) View duplicated LdS. Furthermore, they were offered an optional textbox for comments on their rating.

Considering the different institutions that run the workshops: Agora, KEK, OU and Valladolid University, we can subdivide responders per partner institution which organized a workshop (see section 3.3). From Agora we got 24 respondents, 9 from OU, 32 from Valladolid and 42 from KEK. Thus, we can organize the respondents sector: Vocational training, Higher Education and Adult Education, see data divided by sectors in Table 8 and Table 9.

Looking at statistical analyses (Pozzi, Ceregini, Persico, Sarti, Brasher, Chacón-Pérez, et al., 2015; Pozzi, Ceregini, Persico, Sarti, Brasher, Hernández-Leo, et al., 2015; Pozzi, Persico, Sarti, Brasher, Chacón-Pérez, et al., 2015), even when tests could be applied, no significant differences among the contexts emerged, meaning that the family tree metaphor and visualization have been positively accepted everywhere. Moreover, the resulting evaluation is very encouraging, both in term of ease-of-use and usefulness, see Table 8 and Table 9 (all means >3.7 for ease-of-use; all means >4.0 for usefulness).

Table 8: Duplicate an LdS (Pozzi, Ceregini, Persico, Sarti, Brasher, Chacón-Pérez, et al., 2015)

Duplicate LdS	Overall				Adult education				Higher education				Vocat. training				p
	tot	Q1	Mdn	Q3	***tot***	Q1	Mdn	Q3	***tot***	Q1	Mdn	Q3	***tot***	Q1	Mdn	Q3	
Ease-of-use	***16***	4.0	4.0	5.0	***3***	4.0	4.0	--	***10***	3.7	4.0	5.0	***3***	4.0	4.0	--	.874
Usefulness	***16***	4.0	4.0	5.0	***3***	4.0	5.0	--	***10***	4.0	4.0	5.0	***3***	4.0	4.0	--	.802

Table 9: View duplicated LdS (Pozzi, Ceregini, Persico, Sarti, Brasher, Chacón-Pérez, et al., 2015)

View duplicated LdS	Overall			Adult education			Higher education			Vocat. training		
	tot	M	SD	***tot***	M	SD	***tot***	M	SD	***tot***	M	SD
Ease-of-use	***9***	4.3	.70	***4***	4.5	.57	***3***	4.0	1.0	***2***	4.5	.70
Usefulness	***9***	4.3	.70	***4***	4.5	.57	***3***	4.0	1.0	***2***	4.5	.70

4.7 Discussion

Learning design ecosystems such as ILDE assist teachers in co-design of their own educational activities and resources. Furthermore, ILDE acts as a repository of designs and their potential multiple versions (created by the same educator or team of educators or created by other educator or team of educators). Versioning is conceptually managed by ILDE as described in the model presented in this chapter, and visualized as a family attempting to facilitate tracking of versions when exploring, analyzing and reusing similar designs.

Features like versioning model and family-tree visualization feature implemented on ILDE has been used by educators from diverse communities, in particular addressing the specific third objective we elaborated three different scenarios that occur in four different context / communities. In Agora / La Verneda adult school seven design projects have used the versioning feature: one about Spanish narrative, an introduction to Photoshop's layers, a chess course for beginners, and activity to learn about another cultures and cities such as Tegucigalpa (capital of Honduras), a small course about Excel, the organization of a cooking course and a course about photography. For each of these scenarios, they reuse predefined personas cards already created in ILDE according to Agora context and did small refinements to completely reflect the personas (representing Agora participants) that will be involved in the delivery of the designs (as learners and facilitators). In this sense, Agora members involved in the definition of these learning designs can take advantage of previous existent material, making their own more coherent (aligned with the institution) designs. In Agora's case, participants acting as educators found this feature useful for re-using previously defined persona cards for their upcoming courses. For new Agora volunteers, reusing persona cards was also a formative process because they were able to reflect about typical profile of individuals involved in the school and the kind of learners they have to address the activities they were designing. It is interesting to note that participants reusing persona cards felt more comfortable adopting and adapting material that other Agora members defined previously than starting from scratch. Designs belonging to larger families were also of a higher overall quality.

In addition to scenarios involving duplication of conceptualization LdS (documents compliant with conceptualization templates), educators can also duplicate complex design solutions (diverse formats, e.g., IMS-LD) from the final phase of the learning design lifecycle. For instance, duplication of implementations enables their multiple deliveries with diverse groups of students and duplications of authored designs created with Web Collage to facilitate changes in social structures of collaborative learning activities that depend on particular implementation contexts. Specifically, in the case of METIS workshops teachers underlined in the interviews carried out after they enacted their designs with actual students, that during the design process they highly appreciated the possibility of duplicating implementations. They stated that the duplication feature saved them a lot of time/effort, especially taking into account the learning curve of implementation tools appeared to be significantly steep.

The cases of the HandsOnICT MOOC and the Learning Layers project illustrate a fortuitous side effect of the versioning mechanism. By making deliberate use of the LdS duplication functionality, these two projects could extend ILDE dynamically to meet their needs, by adding new templates to match their design practices. In the case of HandsOnICT the templates were pre-determined at the time of the MOOC design and production, and then used by hundreds of participants. In the case of the Learning Layers project, they evolved in tandem with the project team's emerging design practices.

Family tree visualization supports educators in exploring versions of LdS (conceptualization, authored or implemented designs). Family trees can reach up to quite large sizes, which challenge the visual representation of the trees and their navigation functions. The duplication and visualization features implemented in ILDE have satisfied the need of the explained examples. The family-tree visualization has been useful for educators when exploring what other teacher's designs and reflects about a potential adoption and adaptation to their cases. Yet, educators said that when there are too many branches in the tree, the LdS icons become too small hindering a proper exploration. Educators' feedback is currently being considered to improve the usability of the visualization.

4.8 Conclusion

The third contribution of the Thesis is a model for the management and tracking of multiple versions of learning design solutions of different types: from conceptualizations, to actual design of activities, to their implementation in VLEs. Furthermore, related with third specific objective, we proposed the concept of "learning design family" and the use of a branching model to implement the concept. The implementation manages and visualizes multiple replicas of a design following a family tree metaphor. Both the family tree metaphor and the LdS branching model solve problems related to replication of designs, such as: managing high amount of LdS and presenting the relationships of LdS in a comprehensible and profitable way to the teachers.

This model has been implemented in ILDE, a community environment that integrates a number of design tools supporting the different phases of learning design lifecycle. The family tree model and visualization approach backup reutilization of related scenarios in the context of teacher communities. The third specific objective considers several of these scenarios framed in diverse educational communities which show how the versioning mechanisms support refinements of conceptualizations, duplications of authored designs to be implemented with different technologies with different groups of students and the use of ad-hoc design templates. Cases described in Table 5 were evaluated by means of usefulness and usability by a set of experts from METIs project (see Table 6 and Table 7). Those cases show how duplication and versioning mechanisms support cooperation between educators, can save time and effort, may lead to design richest activities (inspired by variations of previous related activities) and support institutions and projects in structuring their own design processes by creating and replicating ad-hoc design templates. Additional scenarios include support to educational research, such as tracking versioning of learning designs can offer understanding about how educators design and reuse.

The replication of existent learning designs implies the reuse of existent material. Furthermore, the reuse of material may imply that a particular design could be edited by different LD tools (e.g.: reuse an existent design about an activity prepared using a jigsaw pattern, and complement it with users information with an authoring tool such as WEB Collage). Facilitating the interoperable management of designs in learning (co-) design tools is a important research challenge in the LD field.

CHAPTER 5. SUPPORTING INTEROPERABILITY IN PATTERN-BASED LD TOOLS

This chapter is centered on the problem of interoperable management of patterns in learning (co-)design tools. Particularly, this chapter provides insights to address the forth objective of the thesis focused on facilitating interoperable management of patterns in learning (co-)design tools. The focus of the thesis for this objective is narrowed to design patterns as one particular interesting case of reusable structured learning design. The thesis forth contribution consists in an ontology-based model for the management and interoperability of patterns in collaborative patterns-based LD Tools. The representation of a pattern language in the specific domain of Computer-Supported Collaborative Learning (CSCL) by means of a pattern ontology is explained in a conference paper (Chacón-Pérez et al., 2011). The work is later extended with an architectural model published in another conference paper (Chacón-Pérez, Hernández-Leo, Emin, et al., 2014).

5.1 Introduction

As introduced in section 1.4 supporting creation of effective learning designs is a relevant topic in TEL (Peter Goodyear & Retalis, 2010). Due to inclusion of ICT tools in schools, teachers are being encouraged to create innovative activities supported by these technologies. Because of teachers' novelty, s/he may reuse of good practices as starting points for their designs. Thus, the solution proposed is to adopt "designing by reusing" approach, which has already proved to be useful in the literature (Hernández-Leo et al., 2007). By adopting design by reusing approach, teachers are assisted in the creation of new designs based on existing ones.

LD is therefore far from trivial. Supporting the engagement of teachers in LD processes is challenging, not only because the process should solve pedagogical and technological gaps but also because of the time limitations faced by teachers activities (Griffiths & Blat, 2005). One aspect that facilitates the LD process is the use of design patterns as an approach to assist the creation of potentially effective learning designs. As already discussed in section 2.4.1 a design pattern provides means of organizing information regarding a contextualized common problem and the essence of its broadly accepted solution that it can be repetitively applied (Goodyear & Retalis, 2010). However, patterns should be managed and presented to teachers in suitable ways to facilitate their access and usability. There are multiple pattern initiatives: pattern repositories and pattern-based authoring tools, including patterns of different nature and different levels of granularity that can be connected or jointly used in a design. These patterns and pattern languages (or collections of existing patterns) are normally isolated from each other and each collection of patterns evolves independently from others. Moreover, there is no connection (interoperability) between different repositories or authoring tools, so users of an authoring tool cannot take advantage of patterns available in a different repository or provided by another authoring tool.

This chapter proposes a solution to enable the management and interoperable provision of patterns in learning design tooling (editors, repositories, etc.) (see fourth objective of the thesis in Chapter 1). The solution consists of an architecture based on a dynamic ontology of patterns that will allow different authoring tools to interoperate by using a common vocabulary, where they can import new patterns to their own collection of patterns. Additionally, the tools can export their patterns to the common vocabulary expanding the pattern language. We opted for an ontology for our common vocabulary due to their semantics characteristics (Uschold & Gruninger, 2004). The ontology could be used to interconnect different vocabulary with semantics techniques such as mapping that would serve positively for both: to import external knowledge to our pattern ontology and to export our knowledge to external repositories or tools.

This chapter is organized as follows: section 5.2 introduces the methodology applied for the fourth contribution; section 5.3 presents the architecture and the ontology-based model on top of which is built; section

5.4 presents the evaluation carried on; and section 5.5 includes main conclusions related to the fourth contribution.

5.2 Methodology

For the fourth contribution, systems development research process methodology (Nunamaker Jr & Chen, 1990) is followed, Figure 34. In phase 1 of the methodology the fourth objective of the thesis is fixed: facilitate interoperable management of patterns in learning (co-)design tools. As already discussed, this objective is motivated by the characteristics of the state-of-the-art LD ecosystems and by observations from the field, i. e. was arisen while working in real scenarios with LdShake and ILDE, which helped us to set up system requirements and to understand the processes that the architecture needs to include. In phase 2, we define functionalities for the system components and the relationships among them. During phase 3 an ontology-based model for the management and interoperability of patterns in collaborative pattern-based LD tools is designed. This model includes computational representation of a pattern language by means of OWL language, and act as knowledge database schema. Phase 4 serves to build a prototype in ILDE. Finally, in phase 5 pattern ontology is evaluated in two phases: in first phase with two real scenarios designed by teachers that describe two activities based on a set of patterns; in second phase, a paper prototyping experience is conducted with different teachers, who use the ontology to create new activities. The architecture is initially evaluated by a set of given scenarios, which illustrate diverse uses of the architecture around management and interoperable provision of design patterns in learning design tools.

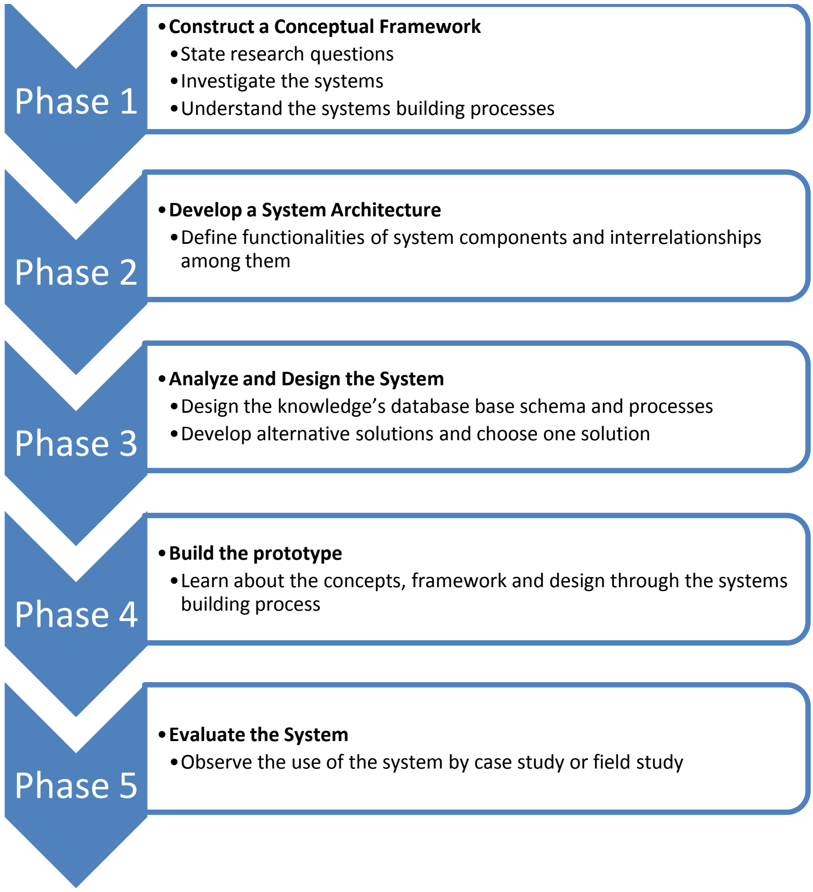

Figure 34: System Development Research Process

5.3 An ontology-based architecture

In this section we introduce the ontology-based model for the management of pattern-based LdS. Furthermore, this section describes the pattern ontology used to build the model. Finally this section presents the architecture built following the systems development research process methodology as explained in previous section.

5.3.1 Model for ontology-based management of pattern-based LdS

In order to support management of pattern-based LdS we propose a model based on a pattern ontology, which can be seen in Figure 35. In the top-left of the model there is the concept of pattern ontology. Pattern ontology is the computational representation of pattern language. Moreover, pattern ontology could include more than one pattern language, defining a language of languages, thanks to semantics of ontology. In this context, a pattern language includes a collection of interrelated patterns.

In this model an LdS has a subtype called «pattern-based LdS», which encloses all the LdS that has pattern information on it. Specifically, this pattern-based LdS encloses all designs created with pattern design template, Web Collage and ScenEdit tools. In this model all pattern-based LdS created by different tools are stored inside the pattern ontology, which acts as a database.

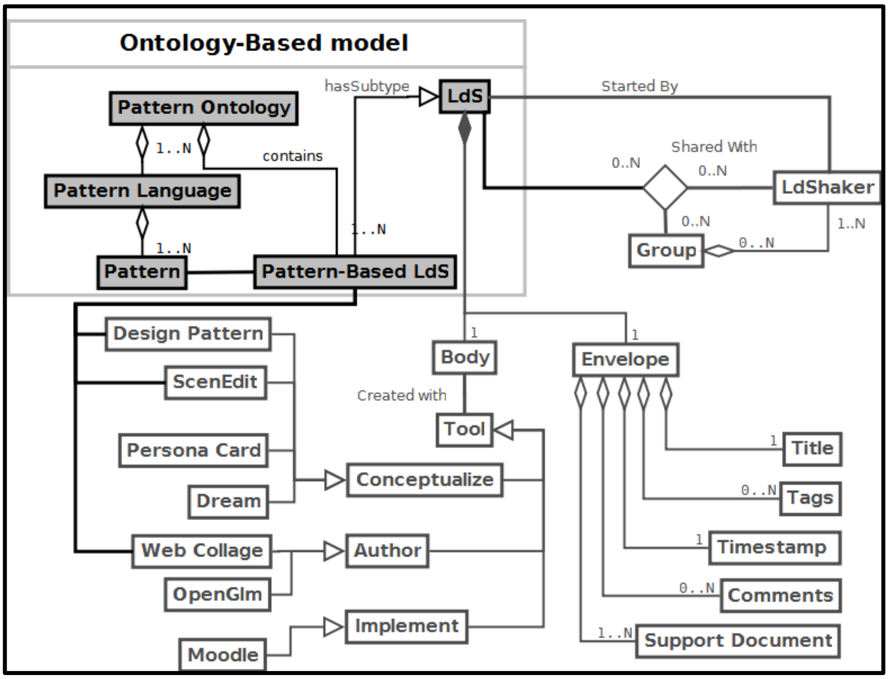

Figure 35: An ontology-based model for the management of pattern-based LdS

5.3.2 Pattern ontology, case of CSCL

To address the forth objective, an existing Computer-Supported Collaborative Learning (CSCL) pattern language is selected (Hernández-Leo et al., 2007). Moving from pattern language to pattern ontology enables the explicit representation of the meaning captured in patterns and their relationships as axioms, obtaining a formal semantic pattern language representation. The resulting ontology provides us a solid base, which we planned to extend with more patterns, such as (Villasclaras-Fernández, 2009), and linked reusable educational materials.

The selection of the ontology instead of other computational approaches such as databases (DB) is mainly justified because of their flexibility. Although databases are similar to ontologies regarding both: ontology axioms vs. DB schema, and ontology facts vs. DB data, there are several differences pointed out in Table 10 (Motik, Horrocks, & Sattler, 2009) that motivate the use of ontologies. As Table 10 shows, ontologies can deal with incomplete information while databases cannot. Furthermore, in ontologies individual elements may have more than one name, which is a critical property when establishing a common vocabulary.

Table 10: Databases vs ontologies

Database	*Ontology*
Closed World Assumption (CWA): missing information treated as false	Open World Assumption (OWA): missing information is treated as unknown
Unique name assumption (UNA): each individual has a single, unique name	No UNA: individuals may have more than one name
Schema behaves as constraints on structure data: define legal database states	Ontology axioms behave like implications (inference rules): entail implicit information

The pattern ontology resulting from the semantic formalization, using the OWL language (Horridge, Knublauch, Rector, Stevens, & Wroe, 2004) and the Protégé ontology editor, of the pattern language proposed in (Hernández-Leo, Asensio-Pérez, et al., 2010) can be graphically seen in Figure 36. According to the pattern language, the patterns are classified into four categories: *Flow Patterns* (e.g.: JIGSAW, see Figure 37), *Activity Patterns* (e.g: INTRODUCTORY ACTIVITY: LEARNING DESIGN AWARENESS), *Resource Patterns* (e.g.: ENRICHING THE LEARNING PROCESS), and *Roles and Common Collaborative Mechanisms Patterns* (e.g.:

FACILITATOR or FREE GROUP FORMATION). Extended descriptions of the levels and the patterns can be read at (Hernández-Leo, Asensio-Pérez, et al., 2010).

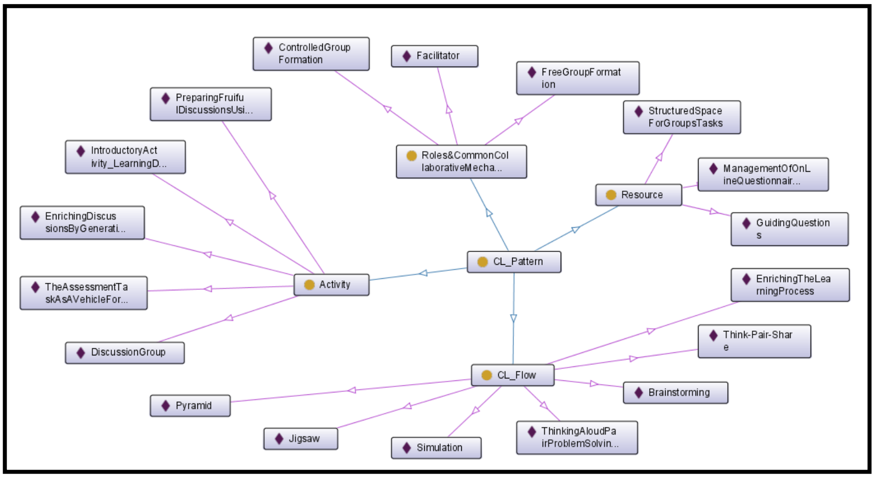

Figure 36: Tree radial view of Pattern Ontology
(only parent to child relationships is displayed)

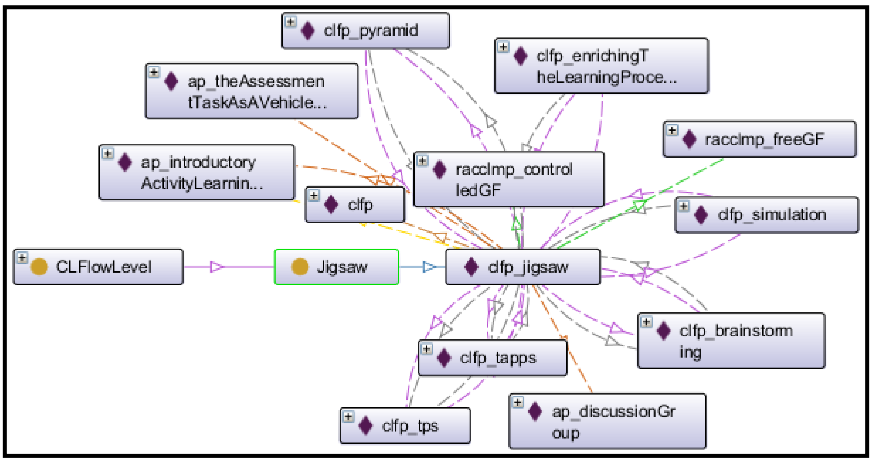

Figure 37: Pattern Ontology representation of a Jigsaw individual (center box)
and the relation with other patterns

Each pattern represented in our ontology has the following information: a pattern name, a category in which the pattern is included, a set of keywords that describes the pattern, a brief description about the problem it solves, the structure of the solution (especially in flow patterns, which propose sequences of activities and the group types associated to those activities), and a brief description with the intention they have to apply this pattern. Furthermore, each pattern has two lists: the first with a set of patterns which *complement* it and the second with a set of patterns which *complete* it. Here *complement* means that the patterns neither modifies nor refines the current one, but together form a larger whole; while *complete* means that the initial pattern is refined with a second pattern that adds further design ideas to those already proposed by the initial pattern. Both lists are set of recommendations that the user should follow once a pattern is selected, in order to complement or complete the pattern towards a coherent set of patterns suitable for a specific learning situation.

Table 11 shows an example of a pattern belonging to the adopted pattern language and which has been represented in the ontology. Part of this computational representation is shown in Figure 38.

The process suggested to educators when using the ontology in the selection of a set of patterns to be used in the creation of new design is as follows. Initially, educators are proposed to start selecting any flow pattern. Once they pick up their first pattern, the ontology recommends a set of patterns (of different categories) to complement or complete their selection. See the example in Figure 39, which shows how six patterns are suggested to be used in combination with THE ASSESSMENT TASK AS A VEHICLE FOR LEARNING pattern. This process can iteratively be followed (users can navigate through the visible patterns and each time they select a pattern a new set of recommended patterns will be shown) until the educators consider they have all the (interrelated) design ideas they need to create their own learning design.

Table 11: Example of a pattern belonging to the adopted pattern language and integrated in the proposed pattern ontology.

egory	*Flow pattern*
Name	JIGSAW
Problem description	If groups of students face the resolution of a complex problem/task that can be easily divided into sections or independent sub-problems, an adequate collaborative learning flow may be planned.
Problem Structure	Structure the learning flow so that each student (individual or initial group) in a group ("Jigsaw Group") studies or work around a particular sub-problem. Then, encourage the students of different groups who study the same problem meet in an "Expert Group" for exchanging ideas. These temporary focus groups become experts in the section of the problem given to them. At last, students of each "Jigsaw group" meet to contribute with its "expertise" in order to solve the whole problem.
Complement	PYRAMID, BRAINSTORMING, TPS, SIMULATION, TAPPS, ENRICHING THE LEARNING PROCESS, INTRODUCTORY ACTIVITY: LEARNING DESIGN AWARENESS.
Complete	PYRAMID, TPS, BRAINSTORMING, TAPPS, INTRODUCTORY ACTIVITY: LEARNING DESIGN AWARENESS, DISCUSSION GROUP, THE ASSESSMENT TASK AS A VEHICLE FOR LEARNING, FREE GROUP FORMATION, CONTROLLED GROUP FORMATION.

```
<Declaration>
    <NamedIndividual IRI="#Jigsaw"/>
</Declaration>
...
<SubClassOf>
    <Class IRI="#CL_Flow"/>
    <Class IRI="#CL_Pattern"/>
</SubClassOf>
...
<ClassAssertion>
    <Class IRI="#CL_Flow"/>
    <NamedIndividual IRI="#Jigsaw"/>
</ClassAssertion>
...
<SubObjectPropertyOf>
    <ObjectProperty IRI="#complete"/>
    <ObjectProperty abbreviatedIRI="owl:topObjectProperty"/>
</SubObjectPropertyOf>
...
 <owl:Class>
   <owl:unionOf rdf:parseType="complete">
     <owl:Class rdf:about="#Jygsaw"/>
     <owl:Class rdf:about="#Pyramid"/>
   </owl:unionOf>
 </owl:Class>
```

Figure 38: Fragment of the pattern ontology showing the definition of the JIGSAW pattern and its relationship

Thanks to the flexibility provided by the ontologies, educators can use the name under which they know a specific pattern, though this pattern may be also known under another title (i.e. PYRAMID is also known as SNOWBALL). Also, since ontologies are ruled by inferences, we can add new patterns and they will be properly integrated in the ontology by the reasoner.

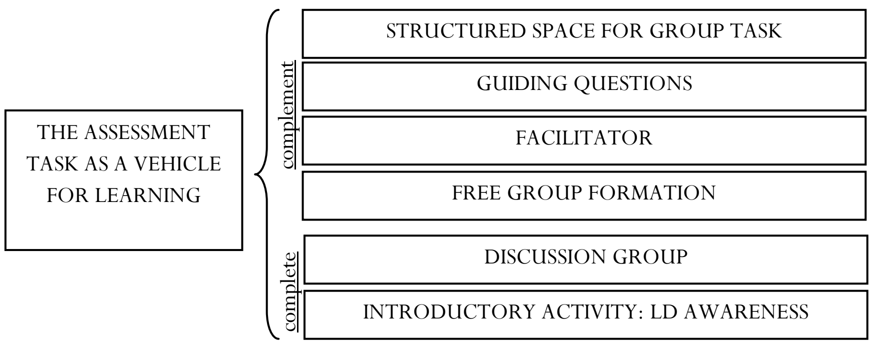

Figure 39: Pattern selected in the left and patterns recommended in the ontology to meaningfully complement or complete it.

As mentioned in section 5.1, the final goal with the pattern ontology is to provide a common framework, which mediated by computers, supports teachers in the edition of a particular patter by multiple LD pattern-based tools.

5.3.3 Proposed Architecture

In this section we describe the ontology architecture designed in order to create a common vocabulary for independent pattern-based learning design editors. As mentioned before, there are several pattern-based learning design authoring tools (Persico et al., 2013; Villasclaras-Fernández et al., 2013). These tools can be programmed in different languages and they use different structures of data (database, objects, etc.). Furthermore, the pattern description in any tool could be also coded in different languages: XML (following or not an educational modeling language such as IMS-LD, (Koper & Olivier, 2004)), OWL, RDF, JSON or represented as plain HTML or plain text. Developing a service in order to enable interoperability between all of these tools could be an exponential task. However, developing a small adapter for every tool in order to export and import the pattern description to a common vocabulary is a feasible task. The rest of this section describes the ontology, the proposed architecture, and some guidelines.

The core of this architecture is the pattern ontology that is described using OWL syntax. We use OWL in order to describe the pattern semantics in a machine-accessible way. This language allows mapping into logic, which can be used in formal semantics to support reasoning over the pattern ontology. However, a limited version and less expressive version of the pattern ontology is coded in RDF/RDFS. Allowing a RDF/RDFS codification will facilitate the integration of pattern-based learning design authoring tools that already work with RDF/RDFS or XML schemas.

In order to share the pattern ontology and allow others to increase our ontology repository, we designed an Ontology Web Service as a core part of our architecture, see Figure 40). We chose JSON in order to develop our parser prototype because of its characteristics. JSON is a lightweight data interchange format. JSON is easy to read and write by human and easy for machines to parse and generate. On the one hand, JSON is more convenient for tools when developing an OWL parser. On the other hand, JSON can be used to map OWL to other semantic languages or programming languages, such as Ruby, PHP or JavaScript.

The next piece in our architecture is the service part or service manager (the Ontology Web Service, Figure 40). We defined the API for this service with the following functions: *editPattern*, *addPattern*, *deletePattern*, *exportPattern*. Using these four functions any tool can add automatically their knowledge to the ontology. The process may be semi-automatic, when we consider scenarios in which modifications or extensions of the ontology needing expert approval.

In the same way, tools can export pattern knowledge from the Ontology Web Service to their repository. However, for the external tools to be able to access these functions, they need to adaptors implementing this access.

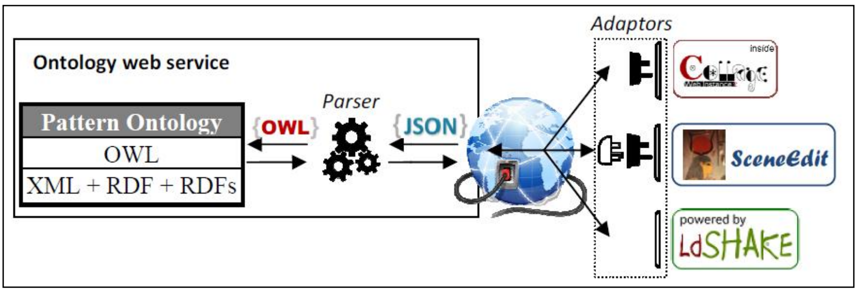

Figure 40: Architecture schema proposed

5.3.4 Adaptors

Depending on which language the pattern-based authoring tools are coded; a proper RESTFUL adapter or component must be implemented. This component must parse the new information to be added to the ontology and allow access to the JSON Code. Here we describe specific cases associated to the LD tool selected for the first iteration of the architecture. First, ScenEdit stores every scenario and pattern in a database, it can export the description of these scenarios (including all the patterns used to define it) with the patterns to an XML or a PDF file (Emin et al., 2010). The OWL to XML conversion only needs to map the RDF/RDFS description of patterns to XML. However the XML to OWL or to RDF/RDFS translation needs to be carefully done. Since XML does not impose rules for such a description and there are no ways to denote semantically equivalent elements, it becomes hard to reconstruct the semantic meaning from an XML document.

Second example Web Collage represents their patterns using Javascript objects and JSON. For this tool we need to map JSON description of the patterns into the patterns inside the pattern ontology. The benefit of using JSON in both sides is that any tool can take advantage from the whole semantic description of the OWL version from the pattern ontology. Although the conversion from OWL to JSON is possible and could be automated, JSON to OWL needs to be carefully planned. There are some initiatives to parse JSON to OWL such as SSWAP HTTP APPI. This API cover the majority of OWL characteristics using intuitive applications of JSON, but cannot be treated as a generic automatic JSON to OWL converter (Gessler et al., 2013).

Finally, in LdShake the adaptor is a plug-in developed in JENA. This plug-in access the pattern information stored in the pattern ontology. A simple HTML form can use the JENA plug-in to parse this new data inside the pattern ontology and to extract the data when needed.

5.4 Pattern Ontology Evaluation

As part of the methodology described in section 5.1 this section provides an evaluation of the pattern ontology. First, we present two real scenarios designed by teachers that describe two learning designs based on a set of patterns. In the description of the scenarios we show how the ontology is able to represent interconnections between the set of selected patterns so that it is meaningful for those scenarios. Second, we explain a paper prototyping experience with two other teachers, familiar with CSCL, who used the ontology for the creation of new scripts. Before creating new scripts, we proposed the teachers to read the description of the previously mentioned two scenarios without indicating the patterns but only main ideas that they considered when planning those scenarios (number of students, main goals, how they intended to structure the classes, how many sessions they had, the expected outcomes, etc.). Together with the scenario description, we also gave the teachers a separate sheet with sets of patterns that “solve” or “state the solution” to both scenarios. We gave the teachers some minutes to read the scenarios and look at the solutions. Then, we asked them to make a description of a similar (imaginary or not) course and to use a paper prototype of the ontology. They must select as many patterns as they think they could use to cover their course needs. Finally, we asked the teachers to complete a questionnaire in order to understand the benefits and limitations of the proposed approach as well as to learn lessons relevant for the implementation of the ontology in pattern selection tools.

5.4.1 Two examples computationally represented with the pattern ontology

The first example belongs to a “Computer Architecture” course, part of the core knowledge in the Telecommunications Engineering curriculum in Spanish universities. The whole course is defined as a project that develops along the semester. Its objective is to design and evaluate a computer system. The teacher defines five fictional clients and assigns each client to students grouped in dyads. This way, in each laboratory group, different clients are being studied through the course, following the principles of the JIGSAW pattern. The Jigsaw-based structure is completed with suggestions of the SIMULATION pattern where teacher plays the role of client. Furthermore, during the course the teacher becomes a FACILITATOR marking the milestones and presenting different assessment task to the students, as indicated by THE ASSESSMENT TASK AS A VEHICLE FOR LEARNING pattern. In each milestone, every laboratory group (“Jigsaw group” phase of the JIGSAW) holds a debate. This debate is arranged as suggested by PREPARING FRUITFUL DISCUSSIONS USSING SURVEYS and complemented with ENRICHING DISCUSSIONS BY GENERATING COGNITIVE CONFLICTS. At the end, a technical report is collaboratively produced among all dyads that have worked with the same client in each laboratory session (forming accordingly a PYRAMID). **Figure 41** shows the graphical representation of the patterns used in the scenario and their relationships according to the proposed ontological model.

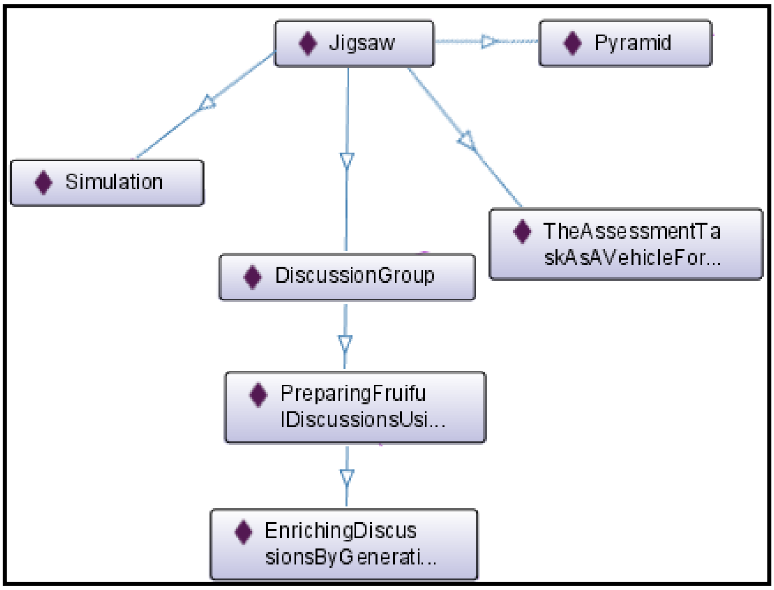

Figure 41: Patterns and their relationships according to the pattern ontology used in the Computer Architecture CSCL Activity

The second example is framed in a course on "ICT resources in Education". The global objective of this course is to allow students to create didactic units in collaboration. The course was structured as follow: during the first week they were introduced to the course and the general plan following the indications of the INTRODUCTORY ACTIVITY: EXPLANING THE LEARNING DESIGN pattern. The following weeks were planned according to a two-level PYRAMID: the first level of the Pyramid is, in turn, structured in accordance with a JIGSAW. Taking into account the FREE GROUP FORMATION pattern, the students are assembled in dyads.

In the "Individual phase" of the JIGSAW every dyad studies one of the 3 main topics of the course. Then, students have to summarize main ideas of their topic and elaborate a report not only for assessment purposes but also as a learning task (ASSESSMENT TASK AS A VEHICLE FOR LEARNING) which pushes them to reflect on a series of questions that they should answer in the report. These questions are explicitly provided by the teacher, as suggested by GUIDING QUESTIONS.

In the "Expert Group" phase of the JIGSAW, groups of six (or seven) dyads that have worked over the same topic join in a single large group to read and discuss the reports written by their partners. In the "Jigsaw Group" phase, new groups are formed. Every group comprises a pair of "experts" on each topic. In this phase, the students read and present the second report (outcome of the "expert group") and elaborate a new common report integrating the three different topics.

Finally, the second (and last) level of the PYRAMID is devoted to ENRICHING DISCUSSIONS BY GENERATING COGNITIVE CONFLICTS in a global debate where all students participate. Figure 42 shows the graphical representation of the patterns used in this scenario and their relationships according to the proposed ontological model.

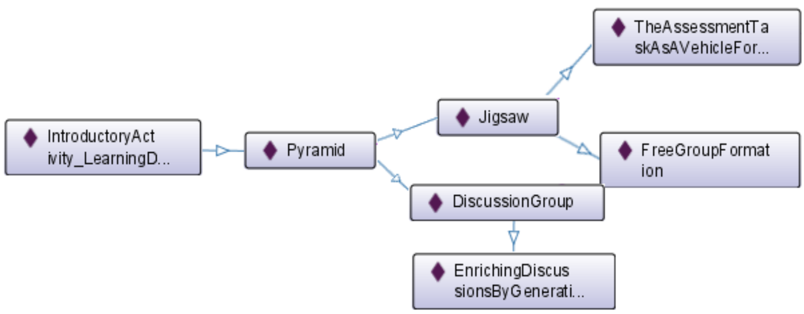

Figure 42: Patterns and their relationships according to the pattern ontology used in the ICT resources in Education CSCL Script

5.4.2 Paper prototyping with teachers: lessons learnt for the pattern ontology implementation

It is clear that a preliminary evaluation of the proposed pattern ontology approach is needed in order to provide insight about the proposal and its implementation in tools (Villasclaras-Fernández, 2009). So, in order to be able to test the approach and obtain a first feedback we selected to use the paper prototyping method. This approach allows us to present the pattern ontology to users who could perform realistic tasks by interacting with a pattern ontology paper version that is manipulated by ourselves as “computers” (Snyder, 2003). The paper prototyping was carried out with two teachers following the process described above.

For the paper prototyping we draw a total of eighteen charts, the number of considerations in the ontology. Examples of these charts are **Figure 39** and **Figure 43**. Each chart has a pattern in the center, representing the selected pattern, an all patterns related to it according to the ontology, in the periphery. We distinguish the different pattern category with a different shape: square shape for *Flow Patterns* (i.e.: JIGSAW in **Figure 43**), square shape with a plane corner for *Resource*, oval shape for *Roles and Common Collaborative Mechanisms* (i.e.: FREE GROUP FORMATION in **Figure 43**) and diamond shape for *Activity Pattern* (i.e.: DISCUSSION GROUP in **Figure 43**). Furthermore, we draw of the diverse types of relationships between patterns with different contour lines. We distinguish three different ones: solid lines for *complete* relations (i.e.: JIGSAW to DISCUSSION GROUP, bottom-right in **Figure 43**); dotted lines for *complement* relations (i.e.: JIGSAW to SIMULATION, top-left in **Figure 43**); and dashed-dotted lines to patterns that could be used for both, complement and/or complete (i.e.: JIGSAW to PYRAMID, center-top in **Figure 43**). We included a legend describing all this information.

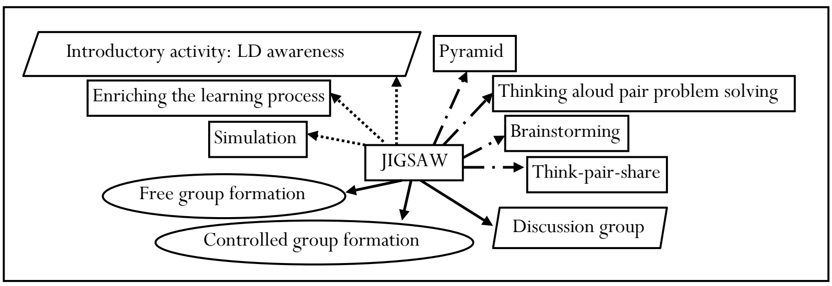

Figure 43: Paper prototyping example: JIGSAW flow pattern chart

During the sessions, each session took one hour long, we acted as the computer and any time teachers selected a pattern we marked it as selected and showed teachers another chart expanding the relations of this pattern with other patterns. Together with these charts we also gave teachers tables with the descriptions of the patterns, so that they could consult them if needed. See Table 11 to see a compacted version of JIGSAW pattern.

Analysis of the data collected in the questionnaires completed by the two teachers led to the conclusions shown in **Table 3.** As a positive feedback we obtained with our approach we foment the creativity of the teachers. According to the teachers' opinion, the ontology suggests relationships between patterns that made them to consider patterns in their designs otherwise they would not have included. Moreover, they were satisfied with the resulting design and said that designed script was well structured and considered strategies seem to have potential to enhance the collaborative learning of their chosen educational situation. Aspects for improvement suggested by the teachers were around the amount of information presented to the users (especially at the beginning). Besides, the teachers needed to read a lot while starting to be aware about the patterns and relate their already known patterns to the patterns suggested by the system. In some cases, it seemed that they were familiar to the design ideas captured in the patterns but the system was using different titles for the patterns. Finally, the teachers also pointed out that a more clear legend would be required to better explain shapes and line counters (described in the above section 4.2).

Table 12: Main positives and negatives aspects reported by teachers

Positive aspects	Aspects for improvement
• Variety of patterns and relations foments creativity • Relations between patterns lead to selection of extra design ideas that enrich the collaborative learning activities • The differences between pattern categories (at flow level, activity and resource) to guide the structure of the designs	• Too much information at the beginning • Visualization comprehension: arrows and figures meanings (clearer legend required) • Though the ontology guides selection of the patterns, it is necessary to read the descriptions of recommended patterns

The lessons learnt from the paper prototyping experience with teachers are being currently taken into account in the implementation of the ontology in

LdShake. In particular, the amount of information showed in screen when users start selecting patterns will only focus on flow patterns, then the user will be able to continue selecting the patterns that can be meaningfully combined with their selected flow pattern, complementing or completing it. Besides, we are designing an accurate legend that describes different figures representing different kind of patterns (learning flow, activities, resources and roles). Finally, summaries or graphical representations of the patterns will be visualized as small tooltips that support users in the understanding of the patterns' solutions when they do mouse over the patterns.

5.5 Architecture evaluation

The architecture is evaluated by a set of given scenarios following the system development research process (Nunamaker Jr & Chen, 1990), which illustrate diverse uses of the architecture around the management and interoperable provision of design patterns in learning design tools. Furthermore, the architecture is partially implemented to test its properties according to the forth objective of the thesis.

5.5.1 Scenario 1: adding new patterns

Adding new patterns into ontology is a key task for the proposed architecture. Thus, we need a procedure to add new vocabulary to our language to keep the pattern ontology dynamically growing. There are different ways of adding new patterns or knowledge to the pattern ontology. First, a pattern can be added into the ontology manually by filling a set of mandatory fields described in section 5.3.2. More interestingly, we should be able to import new patterns to the ontology from other pattern-based learning authoring tools. In that case, the adaptor must check in the ontology if there is a pattern that with same name, or alias, or a high number of common keywords. If the pattern does not exist it will be added to the ontology. Otherwise, the adaptor compares fields from both, and adds as much information as it can. The adaptor will add the extra fields as new optional fields for that pattern. An example of the implemented form in LdShake for adding a new pattern can be seen in Figure 44.

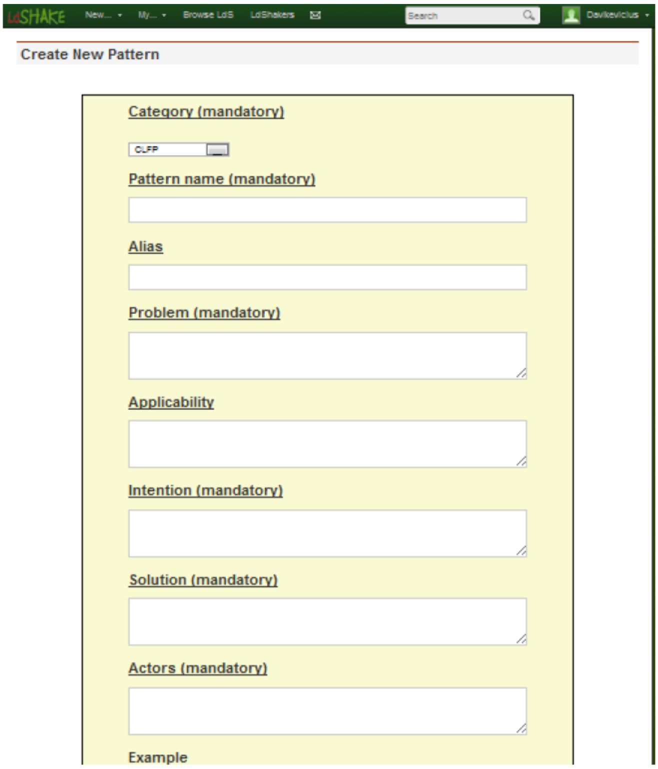

Figure 44: Form implemented on LdShake for adding a new Pattern to the Pattern ontology

5.5.2 Scenario 2: searching patterns

In a pattern repository, which we expect to be growing through time, is important to enable a mechanism in order to search from larger quantity of patterns. So, from any authoring tool we need to search through the whole pattern ontology. By default, the program will return any pattern whose name, alias or keywords match the keywords introduced by the user. However, this could be tuned in order to allow users to search in any particular field. We developed a semantic search engine and embedded it into LdShake, see Figure 45. This engine consults the patterns on the pattern language and retrieves them the user. Further it has been tested with real users in the context of the METIS project, where they found this application helpful.

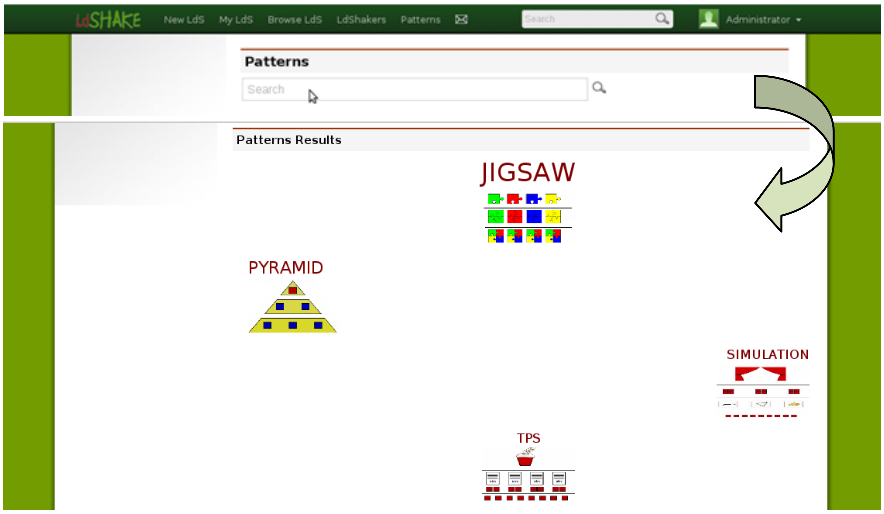

Figure 45: Pattern search included in LdShake

5.5.3 Scenario 3: modifying patterns

Patterns need to be modified to integrate more data. Any pattern-based authoring tool could have new specific fields for every pattern. In order to expand patterns with these fields we need a function to modify the previous knowledge in both cases: add new information, or modify it. Thus, any pattern would be modified any time when some pattern-based learning authoring tool exports a pattern into the pattern ontology and the pattern already exits (see section 5.5.2). Furthermore, any pattern can be loaded in any tool that supports an html form. Using a basic HTML form the user can modify the forms and export the modifications to the ontology.

In the implementation of this feature we define the fields that were mandatory for a pattern and codified it into an HTML form, see Figure 46. Moreover, once the user had filled the mandatory fields, they can select from a list which patterns complements, completes or mark if exist as an alternative to this pattern. This has been evaluated with small groups of users and some usability tests have been made.

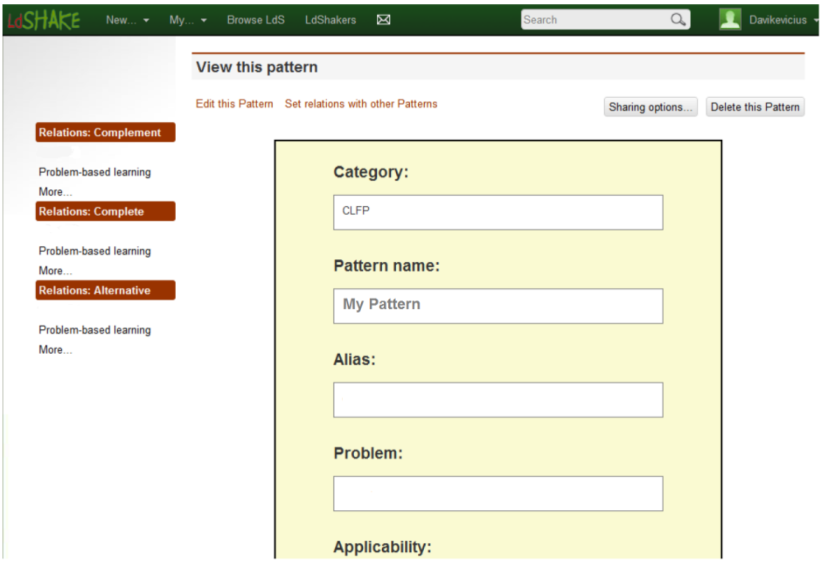

Figure 46 Pattern visualization form with editing options

5.5.4 Scenario 4: pattern families

In (Chacón-Pérez, Hernández-Leo, & Blat, 2014) we present the implementation of the family tree metaphor implemented in LdShake to visualize LD families, including pattern families. Any time a pattern is duplicated, we name the duplication as child of the original, and the original as its parent. Using this metaphor we manage all the pattern replicas in a visual oriented approach as pattern families. In this scenario we can import the patterns to our tool and then later export all the pattern variants to the pattern ontology enriching it with individuals. For example, given a version of the Jigsaw pattern in LdShake (exported from the ontology service), several CSCL experts may propose informed variations of the pattern and document them by replicating and modifying the original one. The result is a Jigsaw pattern family. The whole family tree can be imported to the pattern ontology enriching the knowledge about this pattern and their possible variations.

5.5.5 Scenario 5: interoperable access to patterns in different tools

In order to manage the pattern through different tools it is very important to allow interoperability through this common vocabulary. We illustrate this using the combination of these scenarios through different tools, as in the following examples. A teacher searches a Jigsaw pattern in LdShake. She duplicates it and performs minor changes in the structure. Later, she exports it into the ontology server, adding it to the pattern ontology. Finally the teacher wants to work with this pattern in ScenEdit. In this case, she can import this pattern to the tool and start working on it.

Furthermore, a teacher can add a new pattern to the pattern ontology using the LdShake HTML form. She can also relate this pattern to the existent ones. Later, the same pattern would be exported to Web Collage. In this tool she can attach a visual representation to the pattern in order to work with it visually inside the tool. Once the pattern is ready, the teacher can import back the pattern into the pattern ontology adding new information to the existing one to be ready for use in other tools.

As a conclusion we were defining the pattern life cycle, a pattern that can grow and be enriched with additional information from various and diverse tools. However, having the semantic description of a pattern, the information can easily be parsed to show only the relevant information of each tool.

5.6 Discussion and conclusions

Research presented in this chapter contributes to the design-by-reuse approaches aiming at assisting teachers by facilitating interoperable management of patterns in learning (co-)design tools, which is the fourth research objective of the Thesis. It focuses on patterns as design elements to be reused. Pattern languages collect a number of patterns and document relationships between them. However, these relationships are expressed in natural language and cannot be interpreted by software tools.

We propose to move from pattern language to pattern ontology in order to computationally represent the knowledge captured in an existing pattern language for the creation of new designs (specifically we focus CSCL pattern language). This pattern ontology can be implemented in tools so as to enable teachers, typically not experts in ICT, to creatively select a coherent set of interrelated patterns that suit the requisites of their particular learning situation. Moreover, if implemented in tools teachers could also flexibly use the ontology and extend its knowledge with more patterns or new meaningful relationships. The evaluation presented in this chapter shows that the support provided by the proposed pattern ontology is encouraging, and its implementation in tools, guiding the selection of patterns, is not trivial.

Using the pattern ontology, we presented an ontology-based model used for the implementation of an architecture that allows communication of isolated pattern-based learning design editors. By using the pattern ontology as a common vocabulary, the pattern-based learning designs defined in one LD pattern-based tool could be exported to other platforms and tools using this architecture. Allowing teachers to start working in one tool and using other tooling to complement and extend the design as needed. However, the adaptor implementation must be carefully planned in order to take benefits from the semantics definition of each pattern and its relations. Furthermore, the adaptor definition must contemplate both directions: specific tool-language to JSON and JSON to specific tool-language.

Next steps include a complete development of the adaptors for ScenEdit and Web Collage pattern-based tools. This is a limitation of the thesis and would have enable a stronger evaluation of the architecture. Yet, the developers of both tools confirmed feasibility in a process of designing the adaptor. Moreover, implementation and and testing in LdShake show that it is feasible to add new patterns to the pattern ontology and use the ontology to search patterns within LdShake. Additional lines of future work can be also formulated towards the vision that the ideas behind the ontology-based architecture to be extended with additional tools and more types of pedagogical design patterns.

CHAPTER 6 CONCLUSIONS AND FUTURE WORK

Throughout this dissertation we have tackled challenges around the research question of "How community platform management mechanisms can support teachers in integrated learning design ecosystems". This chapter presents a summary of the main contributions, including lessons learnt pointing out opportunities and challenges as well as the main directions of future work. To this end, the conclusions are organized into four sections corresponding to each specific research objective /contribution: i) understanding the needs for management mechanism within communities of teachers in learning design ecosystems, ii) mechanism for enabling the management of methodology-flexible learning (co-)design processes, iii) management mechanism to support learning (co)design scenarios that originates multiple versions of the same design solution, iv) mechanism to facilitate the interoperability management of patterns between learning (co-)design tools. Finally, the chapter lists future research directions derived from this dissertation.

6.1. Conclusions and main contributions

Throughout this dissertation we have tackled challenges around the research question of "How community platform mechanisms can support teachers in integrated learning design ecosystems". From this research question we oriented the thesis' first objective to understand the needs for management mechanisms of communities of teachers in LD ecosystems. Particularly, as an output from the first objective we narrowed down our research into three problem areas: management of design processes involving diverse tools of the learning design ecosystems; manage facilitation of existent learning design reuse; management of interoperable learning design patterns. Our position is that management mechanism should be flexible so they can be adapted to teachers' requirements depending on their particular educational situations.

In this context, current tools for supporting teachers during the LD process are still varied, complementary and costly to select and use in a meaningful articulated way for most teachers. We have observed that even providing teachers with an integrated environment with a collection of LD tools comprising an LD ecosystem, they still need guidance in their combined use and in the management of the design artifacts derived from their use. Furthermore, following LD processes may imply the reuse (and potential adaptation / refinement) of existent learning designs. We have identified several scenarios in which it is helpful to be capable of tracking multiple versions of a particular design. Finally, the use of several tools in the process of creating a learning design or the potential interest of reusing and refining designs using diverse tools derives interoperability management issues.

To overcome the aforementioned challenges, we proposed and evaluated a set of technological mechanisms. The use of the overall Engineering Method and the specific methodologies for contributions 2, 3 and 4, has allowed us to analyze validity with scenarios and collect feedback from users in several iterations, leading to refinements of the proposed mechanisms. As a result we proposed Learning Design Project and Learning Design Workflow as mechanisms for supporting flexible guidance and management during the learning design process involving multiple tools. Furthermore, we also contributed with the Learning Design Family Tree model and visualization for the management and tracking of multiple versions of learning designs. Besides, we contributed with a pattern ontology which computationally represents pattern languages, in the specific case of CSCL patterns, and an ontology-based model for the management and interoperability of patterns in collaborative pattern-based LD tooling. Finally, the three models contributed can be combined in a holistic conceptual model that encloses the three main contributions.

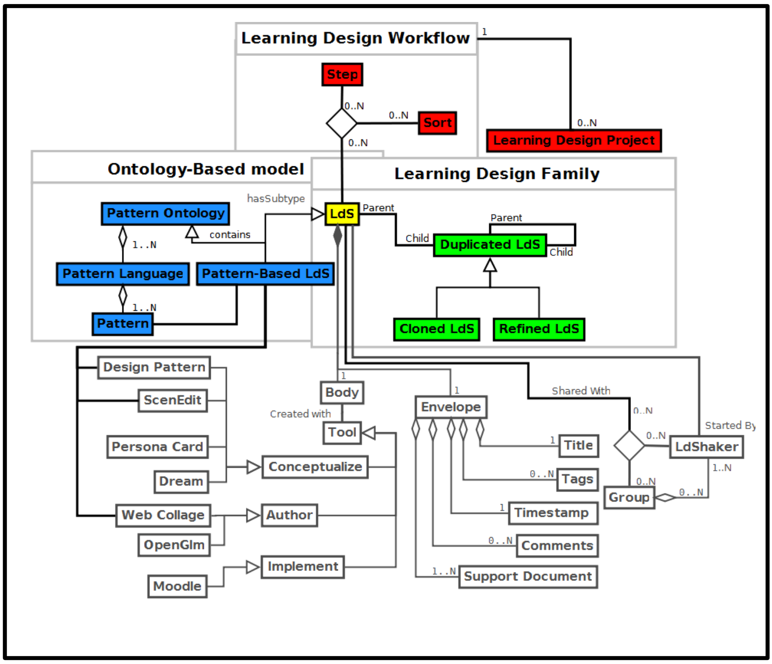

Figure 47: Integrated conceptual model of thesis' contributions

The remainder of the conclusion section is structured as follows: sections 6.1.1, 6.1.2, 6.1.3 and 6.1.4 focus on the four thesis' contributions. Then, section 6.2 presents a list of future research directions derived from this dissertation.

6.1.1. Conclusions on first contribution

This section discusses the main conclusions derived from the first contribution of this thesis: **Understanding of needs for management mechanisms of communities of teachers in learning design ecosystems.**

As explained in section 1.1 of chapter 1 to face this objective I reviewed the literature and participated actively in research projects focused on providing a community platform for sharing and co-edition of learning designs (LdShake platform; Learn3 and EEE projects) and an extended community platform integrating multiple LD tools (Integrated Learning Design Environment – ILDE–, METIS EU-funded LLP Project). As a member of the teams I participated into design and development processes.

Furthermore, I contributed in the process of developing and evaluating in authentic scenarios of both platforms.

The work on LdShake and ILDE in real settings helped me to detect needs of teacher in online communities of teachers. First, there is a general problem of management diverse tasks, tools and artifacts involved that can be involved in learning design processes. This management needs to be flexible to accommodate the diverse needs of educational contexts. Second, in order to facilitate the creation of new activities, teachers tend to reuse existent learning designs and adapt it. Reuse and adaptations of designs generate multiple versions of an original design, which need to be managed. Third and finally, direct reuse of designs across tools is an ambitious problem that we narrowed down to the particular case of learning design patterns.

The contributions of the work performed in LdShake has been published in following journal and conference papers (Hernández-Leo, Moreno, et al., 2015, 2014; Hernández-Leo et al., 2011; Hernández-Leo, Carralero, et al., 2010). The collective work carried out with respect to ILDE has derived the following publications (Hernández-Leo, Chacón-Pérez, Prieto, Asensio-Pérez, & Derntl, 2013; Hernández-Leo, Asensio-Pérez, et al., submitted; Hernández-Leo, Asensio-Pérez, Derntl, Prieto, & Chacón-Pérez, 2014)

6.1.2. Conclusions on second contribution

This section discusses the main conclusions derived from the second contribution of this thesis: **A conceptual model and a technological facility implementing the concepts of Learning Design Project and Learning Design Workflow as part of the Integrated Learning Design Environment platform**.

Our definition of Learning Design Project and Learning Design Workflow highlights the possibility of adopting, editing and defining (new) LD processes requiring the use of several tools by teachers. We define LD Workflow as a (computational) representation of those processes. A workflow defines the number of steps suggested be followed to create a new learning design, with access to the related tools of each step. Teachers can select a existent LD Workflow to create a new LD Project, which will result with a project with relevant steps defined and the proper tools and templates. On the one hand, thanks to this approach, teachers do not need to be experts on LD methodologies, but can follow existent workflows. Educational institutions can define the LD Workflows that suit better to their requirements and recommend teachers to follow them or variations of them. On the other hand, the creation of LD Projects provide an integrated access to design artifacts derived from the tools proposed in the selected Workflow, facilitating the management of those design artifacts.

The creation of new LD Workflows by teachers or LD experts, and the duplication and adaptation of existing ones will result in the creation of a repository of design practices. This means teachers will be taking advantage of the experience and expertise of their peers. Furthermore, based on the proposed conceptual model, derived mechanisms have been implemented in ILDE. Due to this integration, the mechanisms have been used by teachers in diverse contexts: several METIS workshops with different educational institutions: adult education, vocational training and higher education; it also has been adopted by users participating in the hands-on MOOC, and even in an initiative with MSF.

Contributions of this chapter comprises core of a manuscript under preparation that is to be submitted to a journal (Chacón and et al., under preparation).

6.1.3. Conclusions on third contribution

In order to support learning (co-)design scenarios that originate multiple versions of the same learning design solution, we contribute with **a model and visualization based on a family tree metaphor for the management and tracking of multiple versions of learning designs.**

To facilitate (co-)design scenarios the solution proposed is to adopt the "designing by reusing" approach. Reuse of existent designs facilitates the creation of potentially effective learning designs. However, reusing designs could be especially difficult when navigating through online repositories. Teachers must navigate through different learning designs by using a searcher for identifying designs relevant for their intentions. Furthermore, once the design is identified, it would be helpful to view if other teachers also reused it and what refinements they did to the design, if any.

In the context of this contribution, we proposed the concept of "learning design family" based on the family tree metaphor. A "learning design family" represents the collection of learning designs which were not started from scratch but by replicating a particular existent learning design. Moreover, we used a branching model to implement this concept of "learning design family".

Both the family tree metaphor and the branching support teachers to manage learning designs' replicas. Once a design is selected the visualization represents all the versions of that particular design. The model and the visualization have been implemented in ILDE which features those scenarios for reuse, since learning designs can be duplicated and modified inside the platform. It has been tested with real scenarios such as Agora workshop, Valladolid Adult Educational Workshop during the METIS project and was used in one of the first activities of the Hands-on MOOC, where the versioning tracking of learning design solutions has resulted interesting from teachers' perspective (inspiration by exploring variations of the same design) and educational research perspective (understanding how educators design and reuse). Besides, the use of several scenarios framed in diverse educational communities showed how versioning mechanisms support refinements of conceptualizations, duplications of authored designs to be implemented with different technologies, different groups of students and ad-hoc design templates.

Related contributions have been already published in a conference paper (Chacón-Pérez, Hernández-Leo, & Blat, 2014) and later consolidated as a book chapter (Chacón-Pérez et al., 2015). Furthermore, evaluation of this functionality together with other functionalities of ILDE have been analyzed and published in a journal article (Hernández-Leo, Asensio-Pérez, et al., 2014).

6.1.4. Conclusions on fourth contribution

Third contribution consists of a **pattern ontology and an ontology-based model for the management and interoperability of LD patterns in collaborative learning pattern-based LD tools**.

We focus on the use of design patterns for supporting teachers in the creation of learning designs. A design pattern provides means of organizing information regarding a contextualized common problem and the essence of its broadly accepted solution that can be repetitively applied. This patterns are collected into Pattern languages which document the relationships between them. However, these relationships are expressed in natural language and cannot be interpreted by software tools. In order to support this problem, we proposed the pattern ontology that allows having a computational representation of each pattern and its relations. This pattern ontology can be implemented in tools so as to enable pattern-based LD tools to use a common vocabulary.

We used the pattern ontology as the basis for defining an ontology-based model, which would allow the communication of isolate pattern-based learning design editors. Because of this common vocabulary in a pattern ontology form, the learning designs defined using patterns in one tool could be exported to other tools and platforms using the proposed architecture. The scenarios described in section 5.5 illustrate diverse uses of the architecture around the management and interoperable provision of design patterns in learning design tools.

The representation of patterns as a computational language represented by means of a pattern ontology is explained in a conference paper (Chacón-Pérez et al., 2011). Furthermore, the work is later extended with an architectural model published in another conference paper (Chacón-Pérez, Hernández-Leo, Emin, et al., 2014).

6.2. Future research directions

In addition to the aforementioned contributions and conclusions, this dissertation also has identified following future research lines:

- Implementation of a more usable and useful interface for the Learning Design Workflow editor. From the comments of participants during the evaluation of ILDE with its features related to this thesis, there are aspects that need to be revised. For instance, when teachers create several LdS from the same LD tool, the visualization may extend over the canvas, occluding visibility. Furthermore, a study has to be carried out to work on how to implement and visualize the flow between tools, beyond the numbering of steps. Finally, additional visualizations of progress along LD projects (e.g. a bar which shows to teachers how much of the LD Projects have been completed) and of work-plan details (e.g., milestones for the steps) would be interesting.

- The contribution about managing, tracking and visualizing of multiple versions of learning designs is based on a family tree metaphor. Longitudinal studies on the use of these mechanisms by communities of teachers would be relevant to further understand the supported scenarios and their limitations. Besides, it would be interesting to explore other possible visualizations and contrast them with the family tree metaphor.

- Extend the pattern ontology with other learning design patterns/pattern languages to facilitate this, it would be useful to set up an online design-pattern service with an API for allowing other researchers and teachers to import or export new design patterns, defining new knowledge.

- The problem of interoperability between tools is a very complex problem if it faces all the types of learning designs. As a consequence, we focus on CSCL patterns as a starting point, narrowing the focus of this problem area. Nonetheless, it would be relevant to explore if the ontology-based approach followed in the thesis could be applied to other types of learning design representations.

- The architecture defined using the pattern-based model needs to be fully implemented and evaluated with users. It will be interesting to complete the implementation the architecture and work on some of the pattern-based LD tools for developing their adaptors. Some of the adaptors have been drafted but not implemented.

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