Dissertation

- **Design of pedagogical scenarios: Adapting the MISA method to the IMS LD specification**

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Design of pedagogical scenarios:
Adapting the MISA method to the IMS LD specification.

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Abstract

This research supports the choice of a Design and Development Research approach for the creation and validation of ID methods, thus providing a theoretically-grounded and pedagogically-inclusive method for designing reusable pedagogical scenarios. It also presents a framework for articulating a generic instructional design theory with a coherent instructional design method, and hence, it contributes to augmenting the instructional design knowledge base.

This dissertation presents a research divided into four main phases of development and validation.

The first phase grounds the research in a theory of instructional design that aligns it with other related design disciplines, and decomposes the design problem into layers of artifact functionalities. This theory corresponds to software-engineering-infused instructional design methods also known as courseware engineering.

The second phase explores ways to integrate an educational modeling language within an instructional design method for enabling the representation of pedagogical scenarios of computational facture. To reflect and experiment on this issue, we have chosen to study the MISA instructional design method developed at the LICEF research center and the IMS LD specification.

The third phase presents an initial developmental solution, which is tested in a case study. We studied the introduction, into the MISA method, of a new technique supporting the design of a MISA pedagogical scenario according to IMS LD constraints. The aim was to test an 'economic' solution that would not require further modifications to the MISA method. We therefore conducted a case study where a technique for the representation of a conformed to IMS LD pedagogical scenario was applied to the transposition of a MISA pedagogical scenario by an expert instructional designer.

The fourth and final phase exends the development and validation of a solution by way of a two-round Delphi method. We requested the participation of four experts. This developmental step included a selection and introduction of minor modifications of a set of MISA documentation elements identified as crucial for the design of IMS LD compliant pedagogical scenario. The Delphi enabled agreement on an adapted version of the MISA method that fulfills the design purpose. The final outcome of the design process is a pedagogical scenario with all the information required to run an IMS LD-like pedagogical scenario organized in a semi-formal manner and capable of translation into a structured markup language for running in a compliant learning management system. In this sense, the pedagogical scenario results in a document that can be understood as an intermediate state between a blueprint and an executable UoL.

Communications and publications

This research has been presented in conferences and published in a journal and a book chapter. A new article is ready for submission by the time of presentation of this dissertation.

Maina, M. (2005, November). *Towards an instructional design method for the design of IMS-LD compliant units of learning*. Poster presented at the 2nd Annual Scientific Conference – I2LOR 2005, Vancouver, Canada. Awarded.

Maina, M. (2007). Modeling learning scenarios for delivery: lessons from an instructional designer case study. *Proceedings of the Colloque Scénario 2007 Scénariser les activités de l'apprenant : une activité de modélisation* (pp. 121-128). Montreal, Canada: LICEF. ISBN 978-27624-4518-3

Maina, M. (2009). A toolkit for learning design: Methods and languages. In M. Prieto Mendez, S. Sánchez-Alonso, X. Ochoa, & S. Pech Campos, S. (Eds), *Recursos digitales para el aprendizaje, Proceedings of the Conferencia conjunta Iberoamericana sobre tecnologías para el Aprendizaje* (pp. 61-70). Mexico: Universidad Autónoma de Yucatán.

Maina, M. (2009). Designing ready to deliver Units of Learning: A case study. *Journal of Learning Design, 3(1), 21-33.*

Maina, M. (accepted, to appear in 2011). Developing a method for the design of sharable pedagogical scenarios. In N. Aziah Alias & S. Hashim(Eds.), Instructional Technology Research, Design and Development: Lessons from the field. IGI publishing.

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Chapter 1

Introduction

The problem, the questions, and aims of the study

Chapter 1

Introduction

Overview of this chapter

This introductory chapter addresses the issues that form the background of the research. We begin by declaring the purpose of the study and stating the problem we have identified. Following, we pose our research aim, present the research questions associated to the outlined problem, and enumerate the research objectives; all of previous contributing to guide our research throughout the whole process and serving as baselines to contrast our progress and keep on focus. Next we explain the research approach adopted and the methodology that follows. For a better comprehension of the research in its specificities and linking to personal concerns, we also introduce the context in which the study takes place and the motivations that lead to its realization. In the next section we present a table that gives an overview of the thesis and the structure of this document. Finally, we introduce a short terminology where crucial terms for the understanding of the work are defined.

1.1 Purpose of the study and statement of the problem

The research presented in this dissertation is based on the assumption that sharing pedagogical know-how (Daziel, 2008) improves teaching practice, and, therefore, learning experiences. Facilitating the sharing of pedagogical know-how supposes finding ways to make it explicit in a comprehensible manner, thus assuring communicability of the design generated. This issue can be framed within the field of instructional design with special attention paid to the design outcome.

When made explicit, the planning of a teaching and learning situation may be documented in different ways according to the preferences of the teacher or designer. The concept of a pedagogical (or learning) scenario tries to capture main aspects of the envisioned situation. A pedagogical scenario describes a process of interaction between teachers and learners within a specific social setting and learning situation. Each participant in their role performs a series of activities directed towards learning, using resources and evidencing acquired knowledge and competencies. Formalized pedagogical scenarios are also interpreted as learning flows, a concept that explains teaching-and-learning process through concepts of workflow management: actors, roles, goals, activities, resources, rules of progression, and outcomes (Klebl, 2006; Mariño, Casallas, Villalobos, Correal, & Contamines,2007).

Studies about the 'actual practice' of instructional design (Rowland, 1992; Henri, Gagné, Maina, Gargouri, Bourdeau, & Paquette, 2006; Ertmer, Stepich, York, Stickman, Wu, & Zurek, 2008) contend that both expertise and theory are applied in the planning of learning solutions. The former is almost entirely the domain of the teacher, while the latter is usually found in specialized literature that requires a significant amount of effort and skill for translation into concrete educational solutions. Either eliciting professional knowledge or instantiating theory into easy-to-(re)use pedagogical scenarios supposes a considerable challenge.

Efforts have been made to develop languages for representing pedagogical scenarios. These 'educational modeling languages' (EML) are intended for the description of teaching and learning processes in a standardized way for sharing (Botturi, Derntl, Boot, & Figl, 2006). Moreover, EML was intended to be computable and, consequently, to produce pedagogical scenarios ready for implementation and execution in compliant learning management systems. Pedagogical scenarios expressed in a computational way could be published, adapted and improved upon. There has been much interest in EML and some of the languages developed include OUNL EML (Open University of the Netherlands) (Hermans, Manderveld, & Vogten, 2004), PALO (Rodríguez-Artacho & Verdejo Maíllo, 2004), E^2ML (Botturi, 2006), coUML (Derntl & Motschnig-Pitrik, 2008), poEML Caeiro-Rodriguez, Llamas-Nistal, & Anido-Rifón, 2007), and CPM (Nodenot & Laforcade, 2006). The IMS Learning Consortium, an international organization for learning standards, officially adopted the EML developed by the OUNL in 2003 and published it as the IMS LD specification (LD, for learning design) (Koper & Marderveld, 2004). IMS LD focuses on modeling activities based on a generic pedagogical metamodel built with EML (Educational Modeling Language), which enables the expression of various pedagogies. IMS LD is of interest to consortiums, researchers, and software developers around the world. Their efforts mainly materialize around applications that enable the representation and interoperability of Units of Learning (UoLs).

Despite much effort, the specification has not yet gained wide recognition among the teaching community at large. A wide and general implementation of the IMS LD specification is being sought by developing designer-friendly tools (Kinshuk, Patel, & Oppermann, 2006; Koper & Bennet, 2008) as well as add-ons for the IMS LD specification that would cover a wider range of learning situations (Botturi & Stubbs, 2008). However, all these developments don't provide features to enable designers to concentrate on actual design tasks instead of the specification itself. The available tools are intended to address specific and rather limited aspects of the design activity. Technological solutions have failed to adequately address the complex instructional design endeavor. A deeper understanding of the nature of educational design as a “design activity”, should draw a more accurate portrait of the design problem, and help guide the development of appropriate and coherent solutions. The design of pedagogical scenarios could be successfully brought about if addressed through a domain-specific modeling language combined with an instructional design method that provides guidance for its implementation.

The field of instructional design and technology has always evolved and grown, translating new knowledge in the learning and cognitive sciences into instructional principles, increasingly incorporating technological innovations into the design of educational solutions, and adapting to social changes (Reiser, 2007; Tennyson, 2005).

Sodhi et al. (2007, p.2) differentiate bottom-up from top-down IMS LD design approaches:

> The authors [designers] can start either from defining the lower process level details and refining the details up, till a learning design emerges (bottom-up), or commencing from selecting the type of education to be modeled and working down to the process level details, aided and guided in the application of learning design rules to capture their knowledge into effective, pedagogically sound UoLs (top-down). Traditionally, strategies for processing information and knowledge ordering, these approaches can also be used to characterize educational process modeling techniques.

This vision aligns to our position that the creation of reusable and interoperable IMS LD compliant UoLs is a significant instructional design issue.

In IDT, the formalized processes that guide the designing of learning solutions are known as instructional design models. ID models are abstract representations of processes guiding the design of learning systems (Andrews & Goodson, 1995). They “serve as conceptual, management, and communication tools for analyzing, designing, creating, and evaluating guided learning, ranging from broad educational environments to narrow training applications” (Gustafson & Branch, 2002, p. xv). Following Richey (2005), ID models may be categorized as conceptual and procedural. The former relate to theories of learning with a focus on the pedagogical/didactic dimension and the latter, more closely linked to system theory, cover a greater scope that usually includes development and managerial tasks. ID models aim to create a link between theories and practice, a lacuna that was identified more than a century ago (Dewey, 1900).

ID models can be closely linked to methods in software engineering; Developments in Courseware Engineering constitute the basis upon which it is possible to approach the field of ID from that of software engineering in a suitable and productive way. According to Spector and Ohrazda (2004), courseware engineering is an emergent practice that applies an engineering approach to the development of instructional systems and creates its own support tools and methods. In this sense it represents a strong attempt at formalization by providing “operational tools” or “companion tools,” usually lacking in ID models (Gustafson & Branch, 2002). For the purpose of simplifying terminology we will refer to the courseware engineering methods as instructional design methods.

MISA (French acronym for learning systems’ engineering method) is a consistent instructional design method developed at Télé-université (Paquette, 2004a). Since its creation, MISA has been improved and adjusted to technological innovations and advancements in professional ID practices.

To illustrate the MISA method as a whole, a bird’s-eye view first shows a “matrix” that guides the complex activity of instructional design. This high-level structure is composed of six phases of architectural development that intersect with four layers of design problem decomposition. In a closer view, MISA reveals its strength as a “method”; it provides a toolkit for “handling” the design process, which includes a rich design language, together with well described design techniques and procedures as well as detailed descriptions of a series of interrelated design documents that specify the decision making process and allow building a complete blueprint of a learning system. The MISA method is made up of 35 macro and micro design documents (Documentation Elements or DEs) that keep track of the design process. It bears mentioning, however, that the MISA method and its design language predate the emergence of educational modeling language proposals and of the learning objects paradigm, which characterizes it as a groundbreaking method in the instructional design field.

MISA’s vertical phases tackle the system design from an architectural perspective. A set of six “procedures” support the design of the learning system. MISA’s horizontal layers present an alternative and complementary design process; they entail a layered decomposition of the design problem into knowledge, instruction, media and delivery issues. Each layer is part of the model-driven approach to building the learning system.

The proposition of the MISA instructional design method as a solution for the design of IMS LD compliant pedagogical scenarios fits well with the top-down approach mention by Sodhi et al. (2007). The top-down approach is defined as holistic and made concrete through an explicit design process (based on design rules, learning theories, tools and templates, best practices, etc.) that provides sufficient and detailed guidance to the designer

1.2 Research aim

Provide a consistent framework for understanding the instructional design endeavor combined with a coherent set of artifacts supporting the design of reusable and interoperable pedagogical scenarios

1.3 Research questions

We situate this research in the instructional design and educational technology field. Due to the subject of study, which demands the immersion into software engineering body of knowledge, we want to highlight that the adopted approach rests on the instructional design field; our inquiry makes use of concepts and views from computer science in what an instructional designer or teacher in their role of design respects. These concepts are then borrowed and (re)interpreted within this framework of understanding.

Framing the problem within the instructional design field helped us formulate the following research questions

> Question 1: What are the theoretical foundations that provide for the development of a design method incorporating educational modeling languages in the design of pedagogical scenarios?
>
> Question 2: Which kind of methods of instructional design can incorporate formal languages for the expression of reusable and interoperable pedagogical scenarios?
>
> Question 3: What is a design method which is flexible enough to include all instances of the design process and which is specific enough to enable designers to integrate available design theories and expertise into their design practice?
>
> Question 4: Is MISA an instructional design method plausible of adaptation for the design of IMS LD compliant pedagogical scenarios?

1.4 Research objectives

The first research objective is to identify a consistent theoretical framework providing intelligibility and grounding to the design of reusable and interoperable pedagogical scenarios. The second objective is to develop a design method flexible enough to include all instances of the design process, and specific enough to enable designers to integrate available design theories and expertise into the design of pedagogical scenarios compliant with the IMS LD specificaiton. The third objective examines the application and testing of a methodological framework that provides a rigorous process for the development and validation of such artifacts.

Thus, the research objectives concern three dimensions:

Theoretical

To support the method on a coherent theoretical framework rooted in design nature and practice (related to our research question one).

Technological (related to our first research question)

To develop an instructional design method for the creation of reusable and interoperable pedagogical scenarios (related to our research questions two, three and four).

Methodological

To explore the potential of the Design and Development Research methodology for supporting the whole enterprise (a meta objective related to our research methodology and procedure).

1.5 Research approach

For the purpose of our study we have adopted a design and development research (DDR) approach (Richey & Klein, 2007), as it involves "the production of knowledge with the ultimate aim of improving the processes of instructional design, development, and evaluation" (Richey et al., 2004, p. 1099). We specifically search for the adaptation of an instructional design method with the aim of creating reusable and interoperable pedagogical scenarios. We frame this problem within the field of 'design' (Boling & Smith, 2008; Murphy, 1992; Rowland, 1993) and analyze the MISA[1] instructional design method for the creation of pedagogical scenarios expressed with a visual EML that is compatible with the IMS LD specification.

DDR focuses attention on the model, method or procedure itself, and over iterative cycles of development and validation produces outcomes of a generalizable nature. We have combined method development and validation as suggested by Richey and Klein (2007) and divided our research into four main phases. The first phase of theoretical grounding aims at positioning and establishing an explanatory framework for the research. The second phase of development grounding seeks to deploy a rationale for the integration of an EML into a concrete instructional design method. The third phase

[1] MISA: French acronym for Learning System Engineering Method.

presents a first developmental solution that is tested in a case study. The fourth and final phase of the research outlines the development of a solution and validation by way of a two-round Delphi method.

1.6 Context of the research and motivation

This research was undertaken as member of the LICEF (Cognitive Informatics and Learning Environments Laboratory) research center, Télé-université (Québec, Canada), and more specifically, as part of the LORNET (Learning Object Repository Network) research project.

My first contact with the LICEF center was in 1997, during my studies of a Master program. I participated in a research project (Global Prototype) about an online media-rich learning environment. During this period I had the opportunity to know many works develop at the Center, and in particular the first versions of the MISA method and MOT editing tool. Soon after my return to the Center, in 2004, I began to participate in the recently started LORNET[2] (Learning Object Repository NETwork) project. Within this large project involving sixth Canadian universities and coordinated by Télé-université, some people at the Center manifested a particular interest in studying the IMS L D specification, and I was one of them. We began exploring the problem, and I realized that it was the right moment to accomplish a professional goal of undertaking the doctoral studies. Since the very beginning I was interested in educational modeling languages, but my questioning was rather from an instructional design perspective than from technological 'specs'. I assume that this position is due to my professional background.

I then applied and obtained a fellowship granted by the Government of Quebec at the same time that I applied to the UOC PhD program. This program was unique in that it encourages an interdisciplinary approach to the research and it offers an e-learning branch of specialization. The international scope of the studies, the UOC research groups oriented to e-learning, and the international reputation of the institution (which I knew since 2000) decided me to enroll in the program. Once my research project was approved I started the journey of "research and development" in search of a possible solution to the matter of 'designing' reusable and interoperable pedagogical scenarios.

1.7 Overview of the thesis

The thesis is composed of seven chapters. A table (see Table 1.1) was built to give an overview of the chapters with driving concerns and intentions as well as the methods used.

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[2] LORNET project website: http://www.lornet.ca

The first chapter introduces the problem, presents the research questions and goals and makes explicit the motivations orienting the research. The second chapter presents the design and development research approach that was chosen to study and develop a solution to the stated problem, to answer the research questions and to achieve the research aim and goals. We also give a glimpse of the four phases of our research. Third to sixth chapters deploy in detail the four phases is which divides the adopted DDR approach. As DDR is iterative and builds on conclusions and lessons from each phase, conclusions of the research are introduced by the end of each of these four chapters. The seventh and last chapter presents general conclusions and guidelines to orient further research… and development.

Table 1.1
Overview of the thesis.

Chapter 1	**Introduction** Problem, context and aims of the study
Chapter 2	**Methodological framework** Design and development research approach
Chapter 3	**DDR Phase 1 – theoretical grounding: inquiring the domain and adopting a position** Literature review for framing and refining the research problem • Inquiry on design nature and design activity • Genealogical perspective of design inquiry developments in instructional design and design related fields • Generic theories of design and domain theories in the design of instruction. • Models and methods in design.
Chapter 4	**DDR Phase 2 – developmental grounding: conceptual analysis for MISA method and IMS LD specification compatibility** Comparative analysis of design languages: boundaries, commonalities and mismatches • MISA process, documentation and language analysis. • Identification of a MISA proprietary EML • Comparative analysis of MISA EML and IMS LD
Chapter 5	**DDR Phase 3 – development and testing of a first solution**

	Development	Case study
	Development within LORNET team of: 1) an extension of the MOT notation system to cope with IMS LD requirements, 2) the MOT editor tool in order to integrate the IMS LD compliant notation system, and 3) a new technique for representing a UoL with the extended notation system	Testing though a case study with an expert instructional designer. *Data gathering: Video environment recordings, screen recording, think aloud technique, observation notes, and debriefings.*
Chapter 6	**DDR Phase 4 – development and validation of an alternative solution** Development and validation by way of a two-round Delphi method • Development of an adapted version of MISA. • Validation with experts (1st Delphi round). *Data gathering: Six opened questions questionnaire.* • Analysis of experts' answers and further development of the MISA version. • Validation with experts (2nd Delphi round) *Data gathering: Sixty closed questions questionnaire.* • Definition of a MISA version for the designing of IMS LD compliant pedagogical scenarios.	
Chapter 7	**Conclusion** Conclusion, recommendations and further research	

1.8 Significance of the research

This research explores theoretical and practical issues that search to strongly relate the fields of design, instructional design and the developments in educational-intended technological innovations. With this interdisciplinary effort, we pretend to build a rationale which provides a coherent framework for integrating the complex nature of design (rational and creative aspects) with concrete operational tools for assisting the instructional designer's practice. This research presents first a theoretical inquiry for the conceptual grounding of the design of pedagogical scenarios formally expressed, and second, it pursues an empirical study aiming at developing an instructional design method capable of producing reusable and interoperable scenarios. Both efforts should contribute to strengthen the link between neighbor disciplines: instructional design to design- related fields, to software engineering. The developmental research should provide concrete solutions for the adaptation of the MISA method capable of supporting a design process of IMS LD compliant pedagogical scenarios. Lessons from this process of development and research follow also a double enterprise: to address the issue of interoperable pedagogical scenarios from an instructional design perspective and to reflect on the process of development itself.

1.9 Terminology

We introduce hereafter a short list of key concepts identified as crucial for understanding the study presented in this document. A detailed explanation, as well as more contextualized meaning of the terms, can be found within the chapters themselves. These definitions are presented here with the only intention to serve as an introduction to the subject and for rapid consultation. We have extracted the definitions from the authors' texts and quoted them where possible.

MISA

MISA stands for the French denomination 'Méthode d‟Ingénierie de Systèmes d‟Apprentissage' [Learning systems instruccional engineering]. The MISA method "supports the analysis, the creation, the production, and the delivery of a learning system, integrating the concepts, the processes, and the principles of instructional design, software engineering, and knowledge engineering" (Paquette, 2004, p. 56).

INSTRUCTIONAL MODEL (in MISA)

"The Instructional Model [in MISA] describes the learning events, learning activities and resources, and their interactions. It also describes the path the learners must follow to acquire knowledge." (MISA, 2000, p.26). It is equivalent to the notion of pedagogical scenario.

IMS LD

"The IMS Learning Design Specification (Koper and Olivier 2004) is a standardized learning design language that was based on the work on Educational Modelling Language (EML 2000; Koper 2001; Hermans et al. 2004; Koper and Manderveld 2004) at the Open University of the Netherlands." (Koper & Bennet, 2008, p. 140)

IMS LD "supports the use of a wide range of pedagogies in online learning. Rather than attempting to capture the specifics of many pedagogies, it does this by providing a generic and flexible language. This language is designed to enable many different pedagogies to be expressed. The approach has the advantage over alternatives in that only one set of learning design and runtime tools then need to be implemented in order to support the desired wide range of pedagogies. The language was originally developed at the Open University of the Netherlands (OUNL), after extensive examination and comparison of a wide range of pedagogical approaches and their associated learning activities, and several iterations of the developing language to obtain a good balance between generality and pedagogic expressiveness." (Official definition from the IMS LD website: http://www.imsglobal.org/ learningdesign/)

UNIT OF LEARNING (UoL)

A 'unit of learning' is an abstract term used to refer to any delimited piece of education or training, such as a course, a module, a lesson, etc. It is noted that a 'unit of learning' represents more than just a collection of ordered resources to learn, it includes a variety of prescribed activities (problem solving activities, search activities, discussion activities, peer assessment activities, etcetera), assessments, services and support facilities provided by teachers, trainers and other staff members. Which activities, which resources, which roles and which workflow is dependent on the learning design in the unit of learning" (Official definition from the IMS LD "IMS Learning Design Information Model" document (IMS 2003x): http://www.imsglobal.org/ learningdesign/ldv1p0/imsld_infov1p0.html#1495631). It is equivalent to the notion of pedagogical scenario.

PEDAGOGICAL SCENARIO

(learning scenario)

It is "a social setting dedicated to learning, education or training. It is a process of interaction between people in a specific learning situation using resources for learning within a designed environment. People in role of learners perform activities directed towards learning objectives using resources for learning. Learners may work on their own or in a group of learners. They may be supported by teaching staff." (Klebl, 2006, p. 226)

LEARNING FLOW It is "a formal description of a teaching-learning process within a learning [pedagogical] scenario that is based on concepts of workflow management. These concepts are actors, roles, tasks, goals, process elements, interaction, resources and outcome." (Klebl, 2006, p. 226)

DESIGN LANGUAGE "Design languages consist of design elements and principles of composition. Like natural languages, design languages are used for generation (creating things) and interpretation (reading things). Natural languages are used to generate expressions that communicate ideas; design languages are used to design objects that express what the objects are, what they do, and how they are to be used, and how they contribute to experience" (Rheinfrank & Evenson, 1996, p. 68)

NOTATION SYSTEM "An important quality of a design language is whether or not it has been coupled with a sharable, public, consistent notation system. A notation system is the set of symbolic, graphic, gestural, artifactual, auditory, textual or other conventions for expressing outwardly designs created using a particular design language" (Gibbons & Brewer, 2005, p. 118)

EDUCATIONAL MODELLING LANGUAGE "A semantic information model and binding, describing the content and process within a 'unit of learning' from a pedagogical perspective in order to support reuse and interoperability" (Rawlings, van Rosmalen, Koper, Rodríguez-Artacho, & Lefrere, 2002, p. 8).

> An information model is a representation of concepts, relationships, constraints, rules, and operations to specify data semantics for a chosen domain of discourse. The advantage of using an information model is that it can provide sharable, stable, and organized structure of information requirements for the domain context. An information modeling language is a formal syntax that allows users to capture data semantics and constraints. Tina Lee (1999, p. 315).

INSTRUCTIONAL DESIGN THEORY "Design theory is a body of theory about design making that can be considered independently of the specific fields in which the designs are made" (Gibbons & Rogers, 2009, p. 309)

"Design theory can be contrasted with the domain theories of specific fields of design, such as engineering design, computer and computer chip design, architectural design, manufacturing design, structural design, and others […]. We categorize instructional theories as domain theories. […] The theory domain of interest in instructional design is the acts that take place during an instructional conversation" (Gibbons & Rogers, 2009, p. 310).

"In our view *instructional theory* deals with the structure of instructional conversations, and *instructional design theory* deals with the manner in which the elements of those conversational structures are selected, given dimension, and integrated into a design. This suggests that one body of theory (instructional design theory) provides a framework within which the second body of theory (instructional theory) can be applied. In this perspective, the substance of an instructional theory consists of categories of design building blocks and the rules by which building blocks may be articulated to form different designs. The substance of instructional design theory, on the other hand, consists of methods for analyzing and decomposing design problems, classes of design structure, and principles for deriving design processes appropriate to different types of design problems. If instructional theory reflects a particular theorist's view of effective *instructional* structures and operations during instruction, then instructional design theory reflects a view of effective *design* structures and operations during designing" (Gibbons & Rogers, 2009, p. 308).

MODEL

(In INSTRUCTIONAL DESIGN TRADITION / in SOFTWARE ENGINEERING)

"Models, by definition, are simplified representations, and they are often idealized. Nonetheless, models provide structure and order to complex real life events that on the surface can seem chaotic. ID models are no different. However, as Andrews and Goodson (1980) noted, "The fidelity of the model to the actual processes it represents will diminish as the specificity of the model diminishes" (p. 3). In most cases, the use of an ID model calls for considerable interpretation and amplification to provide the detail required for specific applications. ID models can be used in a variety of ways. For the most part, they create standards for good design, but there are other common functions. Frequently, they are used as communication tools so that one can visualize and explain an intended plan. They can serve as marketing devices and as project management tools. They also can play a part in theory development and in translating theory into practice. There are two major types of ID models, both of which are candidates for validation. One identifies variables that impact the design process and shows their interrelationships. The second represents the recommended steps to follow in a design process (Seels & Glasgow, 1997). Richey (1986) called these two configurations conceptual models and procedural models, respectively." (Richey, 2005, p. 172)

ID models refer thus to procedures intended to help produce (input) the solution to a learning problem. Software engineering models, on the other hand, are abstractions of a reality or of the solution to a problem. They refer to the artifact to be constructed and not to the process to build it. Software engineering models represent components' blueprints of the artifact to be built (output).

METHOD

(in design and in INSTRUCTIONAL DESIGN)

"The main intention of new methods is that they attempt to bring rational procedures into the design process" (Cross, 2008, p. 46).

"New methods tend to have two principal features in common. One is that they *formalize* certain procedures of design, and the other is that they *externalize* design thinking. Formalization is a common feature of design methods because they attempt to avoid the occurrence of oversights, of overlooked factors in the design problem, of the kinds of errors that occur with informal methods. The process of formalizing a procedure also tends to widen the approach that is taken to a design problem and to widen the search for appropriate solutions; it encourages and enables you to think beyond the first solution that comes into your head. This is also related to the other general aspect of design methods, that they externalize design thinking, i.e. they try to get your thoughts and thinking processes out of your head and into the charts and diagrams that commonly feature in design methods.

This externalizing is a significant aid when dealing with complex problems, but it is also a necessary part of team work, i.e. providing means by which all the members of the team can see what is going on and can contribute to the design process" (Cross, 2008, p. 47).

Chapter 2

Methodological framework

Design and development research: four phases of iterative inquiry and development

Chapter 2

Methodological framework

Overview of this chapter

This chapter presents our methodological framework: Design and Development Research (DDR). We begin by explaining the DDR nature and scope. We then mention those kind of problems identified by the DDR approach that led us to recognize this methodological framework as consistent to our research objectives. After, we briefly introduce the phases in which develops our research (and development): the first phase of theoretical grounding, the second phase of developmental grounding, the third phase of developing and testing of a solution, and the final and fourth phase of development and internal validation of a design method. Each phase is presented in a detailed manner in each of the following four chapters.

2.1 The design and development research approach

Since the early beginnings of the 90's, there has been a growing interest in methodology innovation into the learning sciences and the instructional design and technology fields. The first attempts to name and conceptualize the new movement have been widely attributed to the works of Brown (1992) and Collins (1992) who introduced the term "design experiments". This still in consolidation and definition research framework is presented by Wang & Hannafin (2005)[3] in its variants under the common denomination of Design-Based Research[4]: design-based research (Design- Based Research Collective [DBRC], 2003), design research (Cobb, 2001; Collins, Joseph, & Bielaczyc, 2004; Edelson, 2002; Nieveen, McKenney & van den Akker, 2006), development research (van den Akker, 1999), developmental research (Richey & Nelson, 1996; Richey, Klein, & Nelson, 2004), formative research (Reigeluth & Frick, 1999; Walker, 1992), educational design research (van den Akker et al., eds., 2006), design and development research (Richey & Klein, 2007). Wang and Hannafin (2005, p.5) conclude: "The design-based research paradigm, one that advances design, research and practice concurrently, has demonstrated considerable potential. […] design-based research posits synergistic relationships among researching, designing, and engineering".

[3] Some new references have been added by us.
[4] Some journals in the field of learning and technology have recently published special issues on the subject: *Educational Researcher*, vol.32 (1), 2003; *Journal of the Learning Sciences*, vol.13 (1), 2004; *Journal of Computing in Higher Education*, vol.16 (2), 2005.

For the purpose of our study we will concentrate on a variant known as "design and development research (DDR)" mainly exposed in the works of Richey & Nelson (1996), Richey (1997), van den Akker (1999 – *development/developmental research*), Richey, Klein & Nelson (2004), Nieveen, McKenney & van den Akker (2006), Reeves (2006), Richey & Klein (2005, 2007 – *design & development research*).

2.1.1 The nature and scope of design and development research (DDR)

The tension between naming either design and/or development to the research approach seems to have the same roots on the discussion around the notions of instructional design and instructional development. Richey & Nelson (1996, p. 1214) explain that "the word *development* has a broader definition when it is used within the research context than it has when used within the context of creating instructional products. The focus is no longer only on production, or even on both planning and production. It also includes comprehensive evaluation" both formative and summative. Richey & Klein (2007) adopt the expression "design and development research" that define as follows:

> [Design and development research is] the systematic study of design, development and evaluation processes with the aim of establishing an empirical basis for the creation of instructional and non-instructional products and tools and new or enhanced models that govern their development (p. 1).

What is distinctive in DDR is that the processes of design and development are usually merged into a single one that operates throughout iterative phases, and in the case of being separated, a development has preceded the research phase (Richey, 1997).

The extent to which the DDR conclusions can be applied, either restraint to a specific context or, of generalizable nature, lets draw a line between two types of research projects that specify the definition given to developmental research: type I, with an emphasis on the study of a specific product, program or tool, and type II oriented to the study of design, development or evaluation processes or models. Type I conclusions describe the lessons learned form the specific product development together with the conditions that facilitate their use. Type II conclusions built on new or enhanced design, development and evaluation procedures and/or models; and they usually include identified conditions for the model or procedure implementation.

In the latest publication, Richey and Klein (2007, p.8) abandon[5] the denomination (even keeping their substantial distinction) into types and propose the research categories *Product and Tool*

[5] We prefer to keep, for our research, to keep the previous denominations of DDR type I and type II

Research (equal to type I) and *Model Research* (equal to type II). To give an idea of the state of the art of DDR, Richey et al. (2004) present an analysis of a cluster of representative type I and type II developmental research projects: 56 and 58 respectively, organized in four and five categories in turn, following the kind of conclusions addressed.

To better clarify the scope of developmental research and avoid misinterpretations Richey et al. (2004) enumerate the research activities that this approach does not encompass: “instructional psychology studies, media or delivery system comparison or impact studies, message design and communication studies, policy analysis or formation studies, and research on the profession” (p. 1103).

2.1.2 Sources of DDR problems related to our research

Into the sources of DDR problems, Richey and Klein (2007) mention those driven by the actual workplace settings needs, the technology impacting the practice of education, and the theoretical questions emerging in current theory.

We have undertaken our research based on two of these sources that we consider complimentary and mutually necessary to the understanding of instructional design.

A first source for DDR problem definition is related to the elaboration of theory. “While the practice of instructional design itself rests upon many types of theory (principally systems theory, and theories of learning, instruction, and communication), instructional design theory tends to relate to ID models and processes, designer decision-making, and emerging areas in which ID principles and theories are being applied (Richey & Klein, 2007, p.22)”.

Edelson (2002, p. 115) identified design methodologies (analogous to what we call method) as contributions to theory that results from the lessons learnt in constructing a design procedure:

> A design methodology is a general design procedure. […] A design methodology provides guidelines for the process rather than the product. A design methodology describes (a) a process for achieving a class of designs, (b) the forms of expertise required, and (c) the roles to be played by the individuals representing those forms of expertise.

This distinctive role of DDR for theory building, capable of “substantially expand the theory base of ID by reaching beyond the traditional foundations of teaching and learning research (Richey and Klein, 2007, p.14)”, claim for establishing a coherent framework to link up theory and the process of design. **Such demand unfolds in two interwoven concerns for our research: providing a theoretical explanation of the instructional design activity in combination with a more prescriptive framework of design making.**

Instructional design models or methods (formalized processes) validation are a way to collect empirical evidence to sustain the foundations of a design theory (Richey & Klein, 2007). The validation of instructional design models, in part or in whole, may be applied in two exclusive or complimentary ways: internal and/or external. While the internal validation refers to the components and processes of an ID model, the external validation focuses on the impact of the products of model use (Richey, 2005).

According to the previous definition, we adopt the internal validation approach for the adaptation of the MISA method according to new requirements emerging from the adoption of more formal languages for expressing the pedagogical scenario.

Another DDR problem source is that prompted by technology innovations. As Reiser (2007, p. 18) states, “two practices -the use of systematic instructional design procedures (often simply called *instructional design*) and the use of media [and technology] for instructional purposes-have formed the core of the field of instructional design and technology.” The characteristics of technology driven problems relate then to emerging and innovative technology and the most effective techniques and tools for producing technology-based products. The proliferation of computer technology is not indifferent to the instructional design field. There’s a growing interest in creating enhancing productivity tools that assist or even automate the entire instructional design process. The nature of these developments varies from intelligent tutoring systems, expert systems, job aids, performance support systems, etc. More recent research sources points to (Richey & Klein, 2007, p.21) “the feasibility of creating and maintaining reusable, scaleable, and distributed content. Some of this research has been devoted to the definition and organization of ‘learning objects’ or ‘knowledge objects’ (Wiley, 2000; Zielinski, 2000)”.

Concerning this technological innovation we explore possible implications in the adoption of educational modeling languages into the processes of designing instruction.

In summary, our research corresponds to the study of the processes of instructional design themselves. This study is not based on a specific project of design of a particular learning system but rather focuses on the development of a generic instructional design method enabling the creation of IMS LD compliant UoL. As our aim is an adaptation of the MISA method to take into account the IMS LD requirements, the object of the study is not the creation of a new instructional engineering method but rather the modification on an existing one. At the same time, the self-imposed enterprise of relating theory of design and a method of design, seeks to trace a consistent explanatory framework showing the process of design as an instance of a theory of design, thus providing evidence to substantiate the said theory.

We pretend through our work to contribute to the development of the instructional design knowledge base adding new evidences for theory development of instructional design, particularly to the instructional design theory of functional design.

2.2 Research methodology employed in our study

The DDR research methodology compose an array of research methods and techniques according to the research requirements, as it develops in “several distinct stages, each of which involves reporting and analyzing a data set” (Richey et al, 2004, p.1104). The most common research methods employed in DDR for model or design process research include (Richey & Klein, 2007): Literature Review, Case Study, Delphi, In-Deph Interview, Survey, Think-Aloud Method, Experimental, Expert Review, Content Analysis, Field Observation and Survey.DDR type II “typically does not involve a specific design and development project” (Richey et al, 2004, p.1112). DDR focuses attention on the model, method or procedure itself, and over iterative cycles of development and validation produces outcomes of a generalizable nature.

DDR type II is a ‘process’ in which we engage: The research plan is not completely traced at the beginning but unfolds throughout iterative phases guided by theory and based on evidence. The development and testing of plausible solutions involves examining, refining and/or adjusting to emerging issues revealed only during the carrying out of the DDR. The number of phases is based on the degree of satisfaction, which is measured both by accomplishment of the DDR main aim as well as the collected evidence providing support for the achieved state.

We have combined method development and validation as suggested by Richey and Klein (2007) and we decided to divide our research into four main phases. We introduce the phases as they took place, where the first and second phases where established at the research project design stage, and the third and fourth phases were outlined during the DDR process.

The first phase of theoretical grounding aims at positioning and establishing an explanatory framework for the research. The second phase of development grounding seeks to deploy a rationale for the integration of an officially recognized educational modeling language into a concrete instructional design method. The third phase presents a first developmental solution that is tested in a case study. The fourth and final phase of the research outlines the development of a solution and validation by way of a two-round Delphi method.

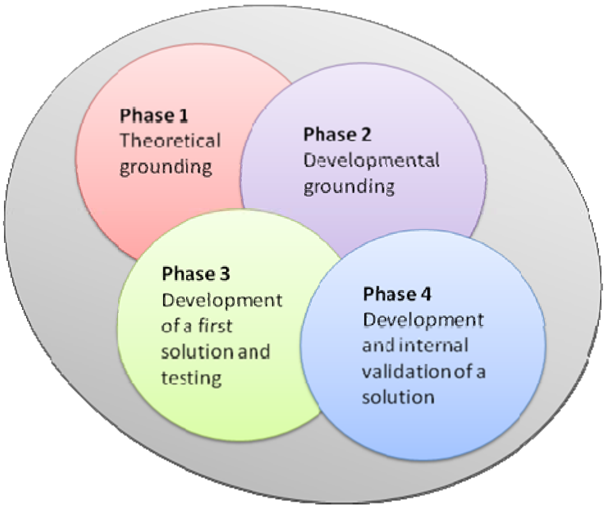


Figure 2-1. *DDR phases in our research*

We briefly introduce the phases here which are deployed in each of the corresponding chapters.

2.2.1 DDR PHASE 1: theoretical grounding

As is the case in most DDR, a literature review is used to identify and refine a research problem (Richey & Klein, 2007). We proceeded to elaborate on the matter in order to establish a rationale for the research, to frame the problem, and to trace the basis for the research continuity.

According to our research objectives we seeked in this phase to establish a theoretical grounding, an explanatory framework that strengthen the research validity in terms of an instructional design theory informing the design activity and supported by a coherent method of design; and as a technological pursuit, exploring instructional design formalized processes endowed with computable languages for expressing pedagogical scenarios.

We began asking ourselves about the pertinence of associating educational modeling languages (EML) to the instructional design activity. Is there any place for EML, and particularly for the IMS LD specification, in instructional design? How could it be integrated? Given the pedagogical inclusiveness and expressive power proclaimed by the developers of EML, which instructional design theory or conceptual explanatory framework could afford for such requirement?

We began examining the instructional design activity within a framework of design related fields (mainly architecture and engineering). A genealogical perspective of these fields of inquiry, and developments, helped identify main concerns about the nature of design, the design activity, the processes, as well as the artifacts supporting the whole design endeavor. This historical view, also traced within the specific field of instruccional design, provided evidence of equal or similar questioning and solution attempts. Linking instructional design to the other design related fields had the intention to search for a theory of design instruction of general scope. Next, we discussed about theories of instructional design, focusing on a specific instructional design theory inspired from design related fields. This design theory of generic nature and applied to the design of instruction articulates with local theories of instruction and detaches from specific pedagogical approaches. This theory proposes the functional decomposition of an instructional artifact into layers of concern. Within and in between layers apply domain theories and operate design languages, design processes and tools. This structure of the theory provided an insightful and concrete conceptual system for intelligibility and operability of our study. We could then draw a consistent framework for a design theory of instruction coherent with developments in design methodology as outlined by the courseware engineering approach, and we introduced the MISA instructional design method. This approach is particularly focused on tooling the design activity with a set of artifacts including methods, languages and technology-based instruments.

2.2.2 DDR PHASE 2: developmental grounding

The following step in our research was to establish a rationale for studying MISA and IMS LD, and to highlight a common ground for comparison. For this task, we built on two preliminary and related to our research works. On one hand an ontological comparison between MISA and IMS-LD (Paquette, 2004b) concluded that their underlying ontologies shared a common perspective as they “put a strong emphasis on the representation of pedagogical methods [scenarios] enacted as processes” (p.18). On the other hand, an exercise in transposition, by an expert researcher, of a MISA compliant instructional scenario into an IMS LD Unit of Learning (De la Teja, Lundgren-Cayrol, & Paquette, 2005) showed that “MISA is an ID method compatible with the IMSLD specification, because they share a lot of common conceptual elements permitting a harmonious binding” (p.13). Based on the previous results, we carried out a complimentary analysis of MISA and IMS LD from an instructional design perspective, comparing them both as design languages (Rheinfrank & Evenson, 1996; Seo & Gibbons, 2003; Gibbons & Brewer, 2005).

We began introducing the MISA method, its documentation elements as well as its attributes. We also analysed the MISA instructional design language and, specifically, the MOT modeling technique and notation system. We then concentrate on the instructional axis (layer) of MISA and proceed to a comparative analysis of MISA instructional model elements to the IMS LD units of leaning elements. This cross-examination enabled also the identification of specific IMS LD required elements within other MISA documentation elements pertaining to other axes. A comparative table traces the discussion about terminology and semantic correspondences and mismatches. Conclusions are presented in a table within the chapter. We completed this study through the analysis of a set of requirements that must meet any educational modeling language as proposed by Koper and Merderverd (2004), and a set of dimensions that help identify design languages specificities following Gibbons and Brewer (2005), that we completed by adding complementary language dimensions as presented by Botturi (2006).

The identification in MISA of a proprietary EML favoured our DDR aim as it proved to be part of the already existing set of tools assisting the instructional design activity. A detailed comparative analysis of the EML in MISA and in IMS LD, aimed at identifying specificities and commonalities, helped foresee a possible adaptation of the MISA method for the creation of pedagogical scenarios compliant to IMS LD.

2.2.3 DDR PHASE 3: developing and testing a solution

Phase 2 was crucial to establish a possible gateway from the MISA method to the IMS LD specification. The fact that both MISA and IMS LD describe pedagogical scenarios in terms of learning flows (actors, resources, activities and coordination and progression rules) opened the door for the development of a possible solution. Supported by the evidence that the MISA method encompasses a rigorous process of design of a pedagogical scenario semantically equivalent to a UoL, the first alternative solution, explored in this phase, pointed to the development and validation of a new MISA technique for the design of a IMS LD compatible pedagogical scenario. This enterprise was carried out within the LORNET[6] group with researchers as well as software developers of the LICEF research center at Téléuniversité.

2.2.3.1 Developmental step

For this study it was necessary 1) to develop a new technique in MISA for the purpose of supporting the creation of IMS LD conforming pedagogical models, and 2) to extend the MOT editor tool capabilities in order to include new graphical symbols enabling the computerized representation of IMS LD language specificities. The technique incorporates the IMS LD terminology as language primitives that follow the visual representation of the MISA notation system. Thus, the technique represents a special case of the MISA EML preserving common terminology between this EML and IMS LD and borrowing some additional elements for the last one.

2.2.3.2 Testing: the case study

As Richey et al. (2004, p. 1112) explain: “Case study techniques are sometimes employed in Type 2 research, which includes a description of the actual design and development processes

[6] LORNET (Learning Object Repository NETwork) project: http://www.lornet.ca

followed in the creation of a particular product or in the demonstration of a particular process." Eight documented research projects are mentioned in Richey et al. (2004) handbook chapter: King & Dille (1993), Wreathall & Connelly (1992), Piper (1991), Nadolski, Kirschner, van Merrienboer, & Hummel (2001), Roytek (2000), Tessmer, McCann, & Ludvigsen (1999), Shambaugh & Magliaro (2001) and Visscher-Voerman, (1999).

Case studies have a long recognized tradition and application in instructional design related research. Reigeluth and Frick (1999) states the pertinence of the case study approach as part of the more general framework of formative research, a "type of DDR" (Richey & Klein, 2007), that is "intended to improve design theory (or models) for designing instructional practices or processes" (Reigeluth and Frick, p. 633). Later on the same text the authors add that using formative research "as the basis for a developmental or action research methodology for improving instructional-design theories is a natural evolution from its use to improve particular instructional systems. It is also useful to develop and test design theory" (p. 636).

In order to test the pedagogical technique which makes use of an extension of the the MISA EML notation system to to IMS LD requirements, a case study was conducted with an instructional designer with expertise in MISA, MOT and knowledge-modeling but little background in IMS LD and related technical knowledge. The participant was an instructional designer and cognitive modeling expert with 12 years of experience. He also had 7 years of expertise using the MISA method and 10 years using various versions of MOT[7] software. He had designed 4 full-fledged online courses applying MISA and MOT, and had also worked as an online course facilitator.

This case study focused on a transposition of a MISA collaborative pedagogical scenario designed for a graduate course in information technology and cognitive development (Basque, Dao, & Contamines, 2005). The pedagogical scenario is based on the metaphor of a virtual scientific conference where learners are encouraged to participate through the elaboration and presentation of a poster summarizing their research project. Our research followed Yin's (2003) four-stage case study recommendations of designing, conducting, analyzing and developing conclusions.

The case study has followed the procedure outlined by Yin (2003) which comprises a four-stage procedure:

1. Design the case study, specifically by establishing the case objectives, the case situation, the participant profile and the case protocol.

[7] MOT is an object-oriented modeling software tool.

2. Conduct the case study, based on a detailed case implementation protocol including multiple data collection techniques and logistic case development explanations.
3. Analyze the case study evidence, through data processing and triangulation.
4. Develop the conclusions, recommendations and implications for the MISA method and research continuity.

In our case study, we focused on two main aspects: (1) clear identification of MISA elements and processes to be modified and (2) verification of the appropriateness of the principles guiding the MISA ID process with regard to the design a UoL.

The case study sessions consisted of a half-hour introductory session and two subsequent three-hour work sessions. Sessions took place at the LORIT[8], a distance learning research laboratory at LICEF/Télé-université.

During each session, we gathered data using the LORIT's equipment and services. We recorded the designer's work environment (from three different angles) and the video screen signal from the computer in order to keep track of the designer's use of the modeling software tool. We also employed a think aloud protocol (Ericsson & Simon, 1980, 1993) and recorded the designer's verbalizations and explanations of the ongoing activity. This data was supplemented with notes from the observation of important events that we identified. After the end of each session, we kept copies of the designer's work in progress (i.e., files with the different stages of the MISA pedagogical model, reorganized as a UoL in progress). Each session was concluded with a debriefing.

We divided the analysis of data into two sections: (1) a comparison of the MISA Documentation Elements (previously produced by the participant) with the documents created by the participant as a result of the sessions; and (2) the analysis of the UoL representation *process*.

The purpose of the first section was to identify, within the MISA DEs and the course itself, the attributes and values that were reused to represent the UoL. We were careful to note which DE elements were consulted by the participant during the sessions We then proceeded to conduct deeper analysis, so as to be able to later compare these elements with the documents resulting from the sessions.

Based on this analysis, we identified syntactic and semantic correspondences and non correspondences between the elements describing the "two types of scenarios", i.e. the

[8] LORIT stands for "Laboratoire-Observatoire de Recherche en Ingénierie du Téléapprentissage."

elements from the sessions' outcomes and those from the MISA DEs previously provided by the participant.

The identification of DE attributes and values is not sufficient in itself to isolate all the elements that are common to MISA and IMS LD. How they are organized and structured and how decisions are taken must also be examined. We explored these questions through process analysis, a dynamic view, which is complementary to the rather static analysis of the artifacts produced by the participant, based on the case scenario.

The purpose of the second section (analysis of the representational process) was to identify critical elements that can provide guidelines, in regards to the MISA design process, leading to the modeling of a UoL.

In order to reconstruct the participant's activity, we created a table clearly differentiating the *prescribed* tasks from the activity actually carried out by the participant. The "reconstruction" of the participant's procedure is based on the information gathered through the video and audio recordings, observation notes, debriefings, and final interview.

We could draw some conclusions from the solution explored above regarding the boundaries of the technique at the same time that supply enough information for decisions on the research continuity. Positive outcomes of this phase are the extension of the MOT visual instructional design language together with a software editor tool for the representation of IMS LD compliant pedagogical scenarios. However, the new pedagogical technique was found to be more suitable for the technical profiles of teachers or designers comfortable with software engineering approaches, which is quite a narrow target group.

2.2.4 DDR PHASE 4: further development and internal validation of the design method

Phase 3 was a first attempt at a solution focused on the extension of the MOT notation system to fit in with IMS LD requirements and the development of a MISA ad-hoc technique. Even though the notation system was adapted satisfactorily, the technique for the representation of the UoL proved to be overly complex to the designer. This first attempt privileged IMS LD and focused on its integration into the MISA method. The technique revealed highly focused on the process of "representation" of the pedagogical scenario. It overemphasized a controlled procedure for composing with the scenario elements to fit the IMS LD metaphor at expenses of the designer's support of a pedagogical reflection and, ultimately, of the design activity.

In Phase 4 we decided to turn our attention to the MISA method as an entire process, trying to minimize MISA modifications while at the same time exploring complementary aspects of the design endeavor. In order to accomplish this goal, we implemented a two-round Delphi research method for the development and internal validation of a MISA version supporting the design of IMS LD compliant pedagogical scenarios. In DDR type II, the expert review serves for internal validation of the design model, method or process during its development. Internal validation focuses on the integrity of the model or method and searches for validation of for example: the inclusion of all the required steps, the sequence logic and flexibility, the scope of the model or method in terms of design and development, the profile of users of the model or method, the kind of outcome the process supports, the context of application, and so on (Richey, 2005).

Model or method validation, either the complete design and development process, or a particular part of the process, may be "constructed in a variety of ways, including […] arriving at a consensus of opinion of respects experts in the field using Delphi techniques (Richey et al, 2004, p.1116)". Two dissertations using the developmental research type II framework and the Delphi technique are given as examples: Tracey's (2002) and Adamski's (1998).

2.2.4.1 The Delphi technique

The Delphi technique originates in the RAND Corporation in the 50's developed by Norman Dalkey in an U.S. Air Force sponsored military project. The Delphi is used "as a judgment or forecasting or decision-aiding tool" (Rowe & Wright, 1999, p.353). Linstone & Turoff (1975, p.3) explain that "Delphi may be characterized as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem". The Delphi technique is primarily employed "in cases where judgmental information is indispensable, and typically use a series of questionnaires interspersed with controlled opinion feedback. (Okoli & Pawlowski, 2004, p.16)." In order to accomplish this 'structured communication' and respond to the Delphi technique requirements, four key features must be respected: "anonymity, iteration, controlled feedback, and the statistical aggregation of group response. Anonymity is achieved through the use of questionnaires (Rowe & Wright, op.cit, p.354)". The controlled interaction "appears to be more conducive to independent thought on the part of the experts and to aid them in the gradual formation of a considered opinion. (Dalkey & Helmer, 1963, p.459). This moderated communication then should provide: "some feedback of individual contributions of information and knowledge; some assessment of the group judgment or view; some opportunity for individuals to revise views; and some degree of anonymity for the individual responses (Linstone & Turoff, op. cit.)." The controlled feedback "informs the participants of the other participant's perspectives, and provides the opportunity for Delphi participants to clarify or change their views" (Skulmoski et al., 2007, p3.).

In a recent search through the ProQuest Digital Dissertations database (Skulmoski et al., op. cit.) found that "at least 280 dissertations and theses [ranging from 1981 to 2003] used the Delphi method in their research. The majority of the research projects were from either education or healthcare (p.8)". In a previous article, Clayton (1997, p.377) enumerates a large number of studies in education that employed the Delphi technique for different purposes raging from curriculum development, to identifying features of effective practices, to foreseeing policies in education.

In terms of the number of participants required to a Delphi, this varies according to the research goals. Brockhoff (1975) carried out some tests comparing face-to-face and the dynamics of the Delphi communication and regarding group performance and expertise. He concluded that groups as small as four can perform satisfactorily.

In most of Delphi studies, rounds' number varies between 2 to four. The number of rounds is disputed in literature but according to Delbecq, Van de Ven and Gustafson (1975) a two or three iteration Delphi is sufficient for most research. Schmidt (1997) prevents that "too many rounds would tax the researcher's resources and waste the panel members' time" (p.764). Walker and Selfe (1996) warn that "repeated rounds may lead to fatigue by respondents and increased attrition" (p.680).

2.2.4.2 Our Delphi specificities

A Delphi mainly relays on the expertise of the participants engaged in the process. In our experts selection we followed Adler and Ziglio (1996) recommendations of the four requirements for 'expertise': 1) knowledge and experience with the issues under investigation; 2) capacity and willingness to participate; 3) sufficient time to participate in the Delphi; and, 4) effective communication skills.

As our Delphi concerned a non conventional pedagogical engineering method as MISA and a relatively new learning specification as IMS LD, we requested the participation of four experts that highly fulfilled the required knowledge and expertise. We have addressed this issue by establishing criteria for their inclusion in the study based on their: knowledge of the MISA method in terms of years and more specifically by their implication in the creation and upgrading of the method, the research undertaken and communicated both in publications and seminars, their experience as teachers of the method itself or their use in the designing of educational solutions. Similarly, we also asked about their knowledge of the IMS LD specification measured in their implication as researchers, teachers, and designers according to the learning specification. These roles into the more specific arena of the MISA and IMS LD as an imbricate problem were also subject to consideration (see Appendix 2-A).

We have limited the Delphi to 2 rounds as our starting research point was well advanced. We argument our decision of a two preplanned rounds based on the fact that we began the expert consultation after three significant phases that had let us advance the research: phase 1 and 2, where we established the pertinence and adequacy of the research, and phase 3, where a shortcut solution proved to be insufficient for the MISA method adaptation. If during the Delphi development evidence showed that a 'reliable consensus' (Dalkey and Helmer, 1963) was not achieved we were prepared for a third additional round.

Our Delphi cycle consisted then in: 1) a first round where we presented to the experts an up to moment state of the art of our research development together with six opened-questions, 2) a second round containing an analysis and synthesis of the experts' round-one responses together with a series of closed-questions, and 3) a final feedback to the experts with the resulting consensus around the MISA method modifications for the designing of IMS LD compliant UoL.

First round serves as "the cornerstone of soliciting specific information about a content area from the Delphi subjects" (Hsu & Sandford, 2007, p.2). The first round of the Delphi consisted of a set of documents sent to the experts by e-mail. The set included: 1) an introductory letter with the schedule and directions for the Delphi study together with the questions to be answered, 2) the overall research problem statement, research general methodology and up-to-the-moment research findings, and 3) the results of the first and second phase of the research. In round-one, questions were directed toward the validation of the adapted version of MISA from a principled perspective (how modifications could compromise MISA principles) and a procedural perspective (throught the selection of a set of mandatory documentation elements). It also pointed to some terminology issues.

We then followed additional advice from Hsu & Sandford (op. cit.): "After receiving subjects' responses, investigators need to convert the collected information into a well-structured questionnaire. This questionnaire is used as the survey instrument for the second round of data collection." We proceeded with round two, which consisted of a questionnaire of sixty closed questions based on a five-point Likert-scale, this time addressing detailed changes to MISA to support the design of IMS LD compliant pedagogical scenarios. For analysis we have distinguished the measure of 'convergence' from that of 'approval' in order to meet Delphi requirements. While approval allows us to choose which modification proposals to implement, convergence refers to the establishment of a reliable consensus for ending the iterative expert consultation.

2.2.5 Overview of our research methodology

We introduce hereafter (table 2-1) a summary table of the DDR as used in our research.

The detailed explanation and presentation of the methods employed, the data, and the analysis is introduced in the corresponding following chapters. As DDR builds upon conclusions of the previous phase, each chapter finishes with the findings made during the each one which provide the bases for decisions to take for the research continuity.

Table 2-1
Summary of the DDR phases

DDR Phases	Method	Strategy
Phase 1 Theoretical grounding: inquiring the domain and adopting a position	Literature review for framing and refining the research problem	• Inquiry on design nature and design activity • Genealogical perspective of design inquiry developments in instructional design and design related fields • Generic theories of design and domain theories in the design of instruction. • Models and methods in design.
Phase 2 Developmental grounding: conceptual analysis for MISA and IMS compatibility	Comparative analysis of design languages: boundaries, commonalities and mismatches	• MISA method language analysis. • Identification of a MISA proprietary EML • Comparative analysis of MISA EML and IMS LD
Phase 3 Development of a first solution and testing	Development based on previous evidence. Case study	• Development within LORNET team of: 1) an extension of the MOT notation system to cope with IMS LD requirements, 2) the MOT editor tool in order to integrate the IMS LD compliant notation system, and 3) a new technique for representing a UoL with the extended notation system

		• Testing though a case study with an expert instrucitonal designer
Phase 4 Development and internal validation of a solution	Development based on previous evidence. A two-round Delphi method	• Development of an adapted version of MISA. • Validation with experts (1st Delphi round) • Analysis of experts' answers and further development of the MISA version. • Validation with experts (2nd Delphi round) • Definition of a MISA version for the designing of IMS LD compliant pedagogical scenarios.

In this chapter, we have explained and justified the adoption of the DDR methodology for our research. For a better comprehension of the research design and methods employed, we have briefly explained the four main phases of our study: 1) a first phase of theoretical inquiry aiming at establishing solid basis for explaining the instructional design process as well as the conceptual and technological artifacts involved in the design practice of a teacher or instructional designer; 2) an analytical phase exploring and positing a common ground for composing with the MISA method and the IMS LD specification; 3) a third phase of development and testing by means of a case study of a tempted solution for providing an instructional design method supporting the design of interoperable pedagogical scenarios, and 4) a phase of reorientation of the research, expanding the development of the said ID method through a Delphi technique of expert consultation.

Chapter 3

Theoretical grounding

Instructional design and design-related fields: issues, concerns, developments

(DDR Phase 1)

Chapter 3

Theoretical grounding (DDR 1)

Overview of this chapter

This chapter begins by exploring design-related fields concerns about the nature and practice of design, and particularly, with regards to the instructional design field. An historical perspective shows, that even though if the instructional design field has evolved separately, it shares basic interests, challenges and even generic solutions with the other design fields. This shift in the view of the instructional design field enabled us to explore theoretical developments in instructional design in search of a specific design theory of general scope. As a result, we introduce a theory of design applying to instruction that goes beyond the numerous local theories of instruction and embrace them into a coherent framework. This theory of functional design, inspired by theoretical developments in design-related disciplines, provides authoritative explanation to the design nature of instructional design as well as working concepts for exploring the design activity and design artifacts. We then introduce the notion of models of instructional design to assist the designer's practice and we discuss their strengths and weaknesses, and the way they were indented to be used. We explore also the notion of design methods as proposed in courseware engineering. This first phase of the DDR approach presents then an effort in linking the instructional design activity to other design-related fields. This alignment of the ID field to other design ones spawns the available conceptual and artifactual developments for both explaining and tooling the instructional design field of inquiry and development, and ultimately, it contributes to the growth of the instructional design knowledge base.

3.1 Design and Instructional design

Murphy, D. (1992, p. 279) poses two noteworthy questions: "Is the use of the word 'design' appropriate in the context of instructional design? Are instructional designers really engaged in a design activity?"

Lots have been written about the 'instructional' facet of the instructional design, the qualifier, less attention has been given to the qualified "design".

Recognizing such activity as design in nature (anchored in "design") has a strong impact on the perception, understanding and studying of the field. Moreover, this accent on the design traits let align the instructional design field with a more general framework of the design activity as recognized in other disciplines and professions like engineering (in their different expressions: mechanical, industrial, software, etc.) and architecture (Rowland, 1993).

Goel & Pirolli (1989) propose the term *generic design* to denote two related ideas: "it suggests that design as an activity has a distinct conceptual and cognitive realization from nondesign activities and that it can be abstracted away from the particulars of the knowledge base of a specific task or discipline and studied in its own right" (p. 19).

3.1.1 Design inquiry timeline

As a social concern, "the origins of the emergence of new design methods in the 1950s and 1960s lay in the application of novel, 'scientific' methods to the novel and pressing problems of the Second World War […] and in the development of creativity techniques." (Cross, 1993, p. 63). In a latter text, Cross (2001) cites the 'radical technologist' Buckminster Fuller that proclaimed the '60s as the 'design science decade' and advocated for a 'design science revolution' based on science, technology, and rationalism to overcome the human and environmental problems that he believed could not be solved by politics and economics. This interest in design gave birth to a 'design methods movement' that organized around a series of conferences like the 1962 Design Methods conference, the 1965 The Design Method, and the 1968 Design Methods in Architecture.

> "Design was understood as a process and a systematic view of design stemmed from these discussions. The notion of design research emerged at this time. Bruce Archer's collections of essays emphasized design as an activity that is common to many disciplines. Systematic approaches to problem solving were developed, informed by computing technologies and management theory. " (Cross, 2007, p.19)

A marking point at the end of this decade is the publication of Simon's 1969 classic book *The sciences of the Artificial* and his postulate about a 'science of design' as "a body of intellectually tough, analytic, partly formalizable, partly empirical, teachable doctrine about the design process (p. 113). "Typical design research included: prescriptive models of the design process, what it should be like, how you should design, management-like models that consider information gathering and specification. Systematic methods to rationalize decision-making were developed" (Luck, R., 2006, p.19).

This effort to 'scientisize' design and sticking it to an engineering perspective triggered a refusal reaction that spanned during the '70s, mostly from the supporters of an architecture-creative indissoluble interpretation of design. They caricatured the design methods as an "attempt to fix the whole of life into a logical framework" (Jones, 1977, cited in Cross, 2007, p. 2). In 1973, Horst

Rittel proposal of “generations of methods” will solve this controversy by accepting constraints and inadequate dimensions of first generation methods and opening the door to the development of new ones. New methods would take into account the “wicked” nature of design problems, emphasize the weight of the designer in the process of design, and recognize as a valid condition a design solution qualified of satisfactory or appropriate (Simon, 1969).

The 1980s is a period of significant development of engineering design methodology (Hubka, 1982; Pahl & Beitz, 1984; French, 1995; Cross, 1989; Pugh, 1991). It is a decade where design research consolidates through the celebration of conferences on the subject (Jacques & Powel, 1981), the appearance of specialized journals (Design studies in 1979, Design issues in 1984, Research in engineering design, 1989) as well as of grounding books recording the developments in design methodology (Cross, 1984) and presenting studies on design cognition (Cross, 1984; Lawson, 1980; Rowe, 1987).

Since the 90s up to today is considered a period of expansion. New journals (just to cite a few) like *Journal of Engineering Design* (1990), *Design Journal* (1998), the *Journal of Design Research* (2001), *CoDesign* (2005), and *International Journal of Design Engineering* (2007) give testimony of the growing number of research associated to design. New conferences (DRS, the Design Thinking series, etc.), and postgraduate programs focusing on the subject draw evidence on the continuous growing of the field across disciplines.

3.1.2 Instructional design timeline

The analogy of the instructional profession with others like architecture dates back to Reigeluth (1983):

> “The result of instructional design as a professional activity is an ‘architect's blueprint’ for what the instruction should be like, [therefore], instructional design as a discipline is concerned with producing knowledge about optimal ‘blueprints’-knowledge about diverse methods of instruction, optimal combinations of methods (i.e., whole models), and situations in which each of those instructional models is optimal”(p. 7).

Tracing a parallelism between the evolutions of design related disciplines (presented above) and the instructional design field, let identify common concerns, developments and controversies. Reiser (2007) narrates a short history of instructional design that gives testimony of a certain delay in the developments and applications of design methodologies due to inner field circumstances. This text and others (Wallace, 2005; Willis, 1998) show also a lasting controversy (with ramifications until the present days) around a (mis)interpretation of the instructional design process. This debate seemed to have subsumed the field for far too long and provoke certain stagnancy in the development of design methods

Dick (1987) mentions the first efforts to formalize procedures for the design of instructions during World War II. The focus of attention was the development of instructional materials where psychologists and educators played a key role applying “principles derived from research and theory on instruction, learning, and human behavior” (Reiser, 2007, p. 24). It is in the late 1940’s and all along the 1950’s, mainly in military contexts, that was outlined a systematic view of the instructional design process, including detailed task analysis as well as design and evaluation procedures (Gagné, 1962).

In the transition from the 1950s to the mid 1960s, the works of (to name the most significant) Skinner (1954) on the developments of teaching techniques for reinforcement and programmed instruction, of Mager (1962) on the need for defining educational objectives, of Bloom (1956) on taxonomy of educational objectives, and of Gagné (1965) on the conditions of learning and the nine events of instruction, will nourish the idea of planning instruction based on scientific principles. They will also highlight the procedural aspects of the design activity.

The 1970s show an exponential growth in the number of “instructional design models” of systemic nature. This particular interest in the systematic design of instruction can be seen in the adoption of Branson and others (Branson et al., 1975) instructional design model by the United States military. It is also manifested by the efforts of faculty on improving instructional materials quality by following specific systematic procedures (Gaff, 1975; Gustafson & Bratton, 1984), and of industry adopting the approach with the aim of improving the quality of training (Mager, 1977; Miles, 1983). Graduate programs on the matter, the appearance in 1977 of the *Journal of Instructional Development* documenting the advancements of the field, and an international projection (Chadwick, 1986; Morgan, 1989) illustrate the burgeoning of the systems approach.

The 1980s is a decade of sharp contrasts between, on one side, the public schools and higher education institutions in the United States, where the systems approach interest decrease, and on the other side, the military (Chevalier, 1990; Finch, 1987; McCombs, 1986), the business and industry (Bowsher, 1989; Galagan, 1989), and the international level (Ely & Plomp, 1986; Morgan, 1989), where the adoption of systematic procedures continues to grow.

The focus of attention of public education institutions turns around how to apply principles of cognitive psychology in instructional design processes (Bonner, 1988; Divesta & Rieber, 1987; Low, 1980; Winn, 1990), even if there was not much evidence of a real effect of this enterprise (Dick, 1987; Gustafson, 1993). The developments in microcomputers capture also the attention of how to use them with instructional purposes, resulting in a series of early computer-based instruction solutions (Dick, 1987; Shrock, 1995). The advent of computers propels not only the developing of models of design that give account of the interaction capabilities afforded by this new technology (Merril, Li, & Jones, 1990a, 1990b) but also the development of tools that support the process of designing instruction itself (Merril & Li, 1989).

Since the beginning of the 1990s until these days there has been a variety of factors that have influenced the way the instructional design field has evolved. There is a movement focused on human performance technology moving apart and emphasizing business results and on-the-job performance instead of learning (Sugrue & Kim, 2004). On the other hand, a growing interest in constructivism put strong emphasis on designing authentic learning tasks and building real-learning environments that replicate the complexity of the real world (Driscoll, 2000). Some authors present constructivism as antithetical and irreconcilable with instructional design (Gordon & Zemke, 2000), while other see it as enriching the instructional design knowledge base and enhancing the design practices (Coleman, Perry, & Schwen, 1997; Dick, 1996; Lebow, 1993; Lin et al., 1996). A third major trend influencing the instructional design field is the continuous evolving technology field and related developments: online learning, reusable learning objects, knowledge (Rosenberg, 2001) and learning management systems, the web 1.0 and 2.0.

3.2 Framing the instructional design activity

Murphy (1992) analyses the instructional design activity from the categories outlined by Lawson (1980, 90; also in 1997 and 2005 editions) in “his attempt to present an overall picture of both the work of designers and the nature of design” (Murphy, 1992, p. 280). This enterprise is undertaken by examining separately design problems, design solutions and the design process. The conclusions of this study correspond also with the findings of Goel and Pirolli (1992) about significant invariants in the task environments of prototypical design situations.

We introduce the main attributes raised by Murphy that characterize a design problem and solution, as well as, a design process. We complete the portrait with conceptual developments from other authors that studied the subject.

3.2.1 About design problems

- Design problems cannot be comprehensively stated, they are Ill-defined, ill-structured, or 'wicked' (Rittel & Webber, 1973). Budgen (1995) elaborates on the ‘wicked’ facet of the design problem as those that has no stopping rule; its solutions are not true-or-false, but good-or-bad.

- The information required to define them is not completely available to the problem-solver, not even through an exhaustive analysis (Cross, 2006).

- Design problems tend to be organized into clusters. They need to be treated in conjunction with the subject matter, the course requirements, the available resources, and so on.

- "Design problems are often both multi-dimensional and highly interactive" (Lawson, 2005, p. 58). For example, the instructional design outcome has to convey educational objectives as well as promote learner engagement. Other issues as costs, context constraints, organizational purposes, etc. play all together and intervene in the problem definition.

- The problem perception relays in part on the instructional designer's background and experience, as this, it is constraint to subjective interpretation.

- Complexity and incommensurability of factors make the problem not entirely susceptible to exhaustive analysis, therefore, there can never be guarantee the one and only 'correct' solutions can be found for them. Goel and Pirolli (1989) explain this trait in terms of nomological and conventional constraints. The former consist of unchangeable laws and the latter refer to social, political, economic, and so on negotiable issues.

- Complexity also refers to numerous component parts. As design problems are not well defined, its decomposition relays on the practice and experience of the designer. Their interconnection are more contingent that logical. (Goel & Pirolli, 1992).

3.2.2 About design solutions

- There are an inexhaustible number of different solutions. Not only different instructional designers could propose distinct solutions, even the same instructional designer may think about alternative valid propositions. This highlights the more heuristic, rather than pure algorithmic nature of instructional design.

- There are no optimal solutions to design problems as the start point may differ: e.g. available resources may vary, designer's expertise and experience is particular. "Each acceptable solution involves compromise in some form." Murphy (p. 281)

- In terms of strategy, a solution-focused strategy is usually preferable to a problem-focused one. The 'problem' is subject to continuous refinement, as the solution arises.

- "It is only in terms of a conjectured solution that the problem can be contained within manageable bounds (Hillier and Leaman, 1974). […] What designers tend to do, therefore, is to seek, or impose a 'primary generator' (Darke, 1979) which both defines the limits of the problem and suggests the nature of its possible solution" (Cross, 2006). Gibbons understands this concept as a synonym of Alexander's 1979 'pattern' definition and of Polanyi's 1958 'operational principle'.

3.2.3 About the design process

The above highlighted distinctiveness of the twofold nature of the instructional design endeavor, a poor defined problem which becomes better delineated at the stage of exploring alternative solutions, let outline some specificities of the encompassing design process. This process meets the above mentioned more heuristic than algorithmic nature of the design activity. The process can be described according to the following characteristics:

- The process is endless: there is always a different way to improve or change the design output.
- There is no infallibly correct process: the heterogeneity of contexts in which instructional solutions may be implemented is highly improbable to be covered by one unique process.
- The process involves finding as well as solving problems: the process must go in both directions, nourishing both dimensions in a back-and-forth manner.
- Design inevitably involves subjective value judgments: even if pattern solutions may be identified, both the designer and the particular context of implementation of any given solution call for an individual intervention based on expertise and experience.
- Design is a prescriptive activity: the "project" orientation of the design activity is based on at least a set of procedures that support the process.
- Designers work in the context of a need for action: designers don't have "all the time" to define a problem, they need to take decisions and make propositions within limited resources and periods of time.

3.2.4 Design space in instructional design

There are several studies of the instructional design practice that reinforce the design space framework traced above. Actual practice of instructional design shows:

- A balanced problem-solution approach based on an iterative and refining process of design (Allen, 1996; Henri, Gagné, & Maina, 2005; Holcomb, Wedman, & Tessmer, 1996; Rowland, 1992; Wedman & Tessmer, 1993).

- A decomposition of the design endeavor in a set of interrelated clusters or functions (Gibbons, 2003b)
- A difference in the way novice and expert designers design. Novices tend to interpret prescriptive models of design literally, overemphasizing the problem definition, while expert designers rely more on past experience and feel comfortable with ill structured problems (Ertmer, Stepich,York, Stickman, Wu, Zurek, et al., 2008; Pérez, Fleming Johnson, & Emery, 1995; Rowland, 1992; Pieters & Bergman, 1995; Rowley, 2005; Uduma & Morrison, 2007).
- A complex set of tasks that demands a vast expertise in multiple domains, from learning and instructional theories, to managerial, communicational, and technological skills (Cox & Osguthorpe, 2003; Kenny, Zhang, Schwier, & Campbell, 2005; Kisrchen, Carr, & van Merriënboer; Klein & Fox, 2004; Liu, Gibby, Quiros, & Demps, 2002; Richey, Fields, & Foxon, 2001).
- A designer personal type of reasoning and preferences that differentiate in four categories ranging from those applying formal processes with emphasis in analytical aspects of the problem, to those relaying on pure personal intuition with emphasis on trial and error search of solutions. In between there those more open to work in a team and project based approach, and those more “developers” to whom prototypes as the entry points of the design process (Visscher-Voerman & Gustafson, 2004).
- A theoretical informed solution or alternative solutions relying on scientific principles but used as heuristics more than in a direct and strict manner (Rowland, 1993)

3.3 Defining instructional design

Instructional design is mainly presented in the specialized literature as a process, and this dating since the early 1940s with the appearance of focused procedures, and then blooming during the 1970s until nowadays with the major influence of system theory. A few up to date definitions from prominent scholars in the instructional design and technology field reinforce this vision. Most of the times the term *instructional design* and *instructional system design* are used as synonyms and in an interchangeable way. Hereafter a selection of these definitions:

- “Instructional design (ID) is a systematic process that is employed to develop education and training programs in a consistent and reliable fashion. Instructional design is a complex process that is creative, active, and iterative.” (Gustafson, & Branch, 2007, p.11)

- "Using a systematic design process is termed instructional design (often abbreviated as ID). It is based on what we know about learning theories, information technology, systematic analysis, educational research, and management methods." (Morrison, Ross, Kemp, & Kalman, 2007, p.6)
- "The term instructional design refers to the systematic and reflective process of translating principles of learning and instruction into plans for instructional materials, activities, information resources, and evaluation." (Smith & Ragan, 2005, p.4)
- "An instructional system may be defined as an arrangement of resources and procedures used to facilitate learning […]. Instructional System Design (ISD) is the process of creating instructional systems. It is both systematic and scientific in that is documentable, replicable in its general application, and leads to predictable outcomes. Yet, it also requires creativity in identifying and solving instructional problems […]. ISD includes systems theory and problem-solving methodology, which constitute the basic paradigm for describing and producing leaning environments for training and education. ISD also incorporates knowledge of the principles of learning and instruction from learning science and instructional psychology that will optimize learning environments and learner achievements to achieve the goals of the system." (Gagne, Wager, Golas, & Keller, 2005, p.18)

These definitions put an emphasis on an organized process that is both scientifically informed and flexible enough to give place to the "creative" aspects of a design activity. They also establish a certain scope that the design process supports. Even if labeling the term 'instructional' with 'design' or with 'development' is at the origins of long discussions (Gustafson & Branch, 2002), both expressions refer, depending on the author, to the extent to which the process of conceiving learning solutions is covered. There seems to be an agreement that the generic ADDIE[9] model (Gagné et al., 2005; Molenda, 2003a, 2003b; Peterson, 2003; Bichelmeyer, 2003) gives account of the required set of major activities involved in the instructional design endeavor: "(1) analysis of the setting and learner needs, (2) design of a set of specifications for an effective, efficient, and relevant learner environment, (3) development of all learner and management materials, (4) implementation of the resulting instruction, and (5) both formative and summative evaluations of the results of the [design] development" (Gustafson & Branch, p. iv).

Another important issue present in the definitions of instructional design is its conception as a practice informed by a composite of theories. Theories of instructional design will either inform

[9] Analysis, Design, Development, Implementation and Evaluation

the process or explain the process. ID theories are traditionally explained as being "supported or informed by theories of learning, cognition, and motivation" (Reigeluth, 2004, p. 54) as well as theories of system design and project management (Reiser, 2007; Smith & Ragan, 2005).

3.4 Theories informing instructional design

Reigeluth (1999) posits that "instructional-design theory is a knowledge base that guides educational practice [about] how to facilitate learning" (p. 16). This knowledge base need to be continuously enriched and updated to inform the instructional designer and the teacher on how to better design learning solutions and incorporate up-to-date theoretical and technological developments.

Richey (2007) adds intelligibility to the instructional design knowledge base explaining two views of the instructional design theory and hence, its practice:

> (a) the design of particular lessons, products, or programs, and (b) the implementation and management of the overall design process. The former is guided by design principles for selecting and sequencing instructional strategies that are richly supported by learning theory and teaching-learning research (Ragan & Smith, 2004). The latter is typically guided by instructional system design (ISD) models which have not been tested to a great extent using research (p. 6).

Understanding instructional design theory or better said, theories, directs our attention to different moments and held positions on the matter within the field. As early as the 1900, John Dewey, acknowledging the difficulties in applying learning theory to educational problems, evidenced the need of a "linking science" between learning theory and educational practice. Many attempts to fill this gap have been proposed from different perspectives. Traditional instructional (design) theories[10], prescriptive-oriented, are generally rooted in learning theories, descriptive-oriented. This view of instructional design put an emphasis in the relationship with the learning theories in their three main philosophical frameworks they apply: behaviorism, cognitivism, and constructivism (Smith & Ragan, 2005).

Seels (1997) proposes a classification of these instructional (design) theories in:

- Taxonomic: Egdar Dale's Cone of Experience(Dale, 1946); Boom's taxonomy of learning objectives (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956); Krathwohl revised taxonomy of learning objectives (Krathwohl, 1994); Clark's taxonomy of media

[10] Since now on we will simple label these kinds of theory as instructional theories. A deeper explanation of such decision is presented later on in this same chapter.

attributes (Clark, 1975); Fleming and Levie's principles of message design (Fleming & Levie, 1978, 1993); Jonassen's mapping of IT concepts (Jonassen, 1989); Seels and Richey's domains of instructional technology (Seels & Richey, 1994),

- conceptual frameworks: Reigeluth's elaboration theory (Reigeluth & Stein, 1983); Hannafin's ROPES model (Hannafin & Rieber, 1989); Kaufman and English's organizational elements model (Kaufman & English, 1979), and
- theoretical systems in instructional technology: Merril's component display theory/instructional design transaction theory (Merril, 1983); Keller's motivation theory (Keller & Kopp, 1987); Rogers' diffusion of innovations theory (Rogers, 1962, 1983, 1995); Gagné's conditions-based instruction (Gagné, 1985).

Even though the three kinds of theories link concepts, taxonomies mostly specify categories and their relationships, conceptual frameworks provide clues for interpretation of the relationships within a model, and theoretical systems gain in explanatory power adding propositions and principles to categories and models. Nachmias and Nachmias (as cited in Seels, 1997, p. 18) presents this classification of theories in a continuum process of theory development where "concepts gain empirical meaning from operational definitions and gain theoretical meaning within the context of theory within which they are employed" (1981, p. 39).

The instructional design field has developed also adopting and adapting other theories like communication theory, system theory, and management theory. They all make up the instructional design knowledge base (Richey, 1986, 2007; Smith & Ragan, 2005, Reigeleluth, 1997, 2004).

Interest in communication theory began as soon as the first theories were developed. The communication process is one of the main focus or early models (Shannon & Weaver, 1949) as well as feedback control (Weiner, 1969) accompanying the mass communication phenomenon. Other approaches like interpersonal communication (Schramm, 1956), semantics (Barthes, 1954), and semiotics (Eco, 1976) are at the basis of theories of instructional radio, television, and later computers and networks, as well as message design and audiovisual and multimedia learning materials design.

The origins of a general systems theory are usually referred to the works of Ludwig von Bertalanfly (1930). In this view a system is defined as "a set of interrelated and interacting parts that work together toward some common goal" (Smith & Ragan, 2005, p.24). This theory inspired the development and multiplication of instructional design systematic models as reported in Andrews and Goodson (1991), and Gustafson and Branch (2002).

3.5 Towards a design theory in instructional design

Richey (2007) acknowledges the need for complementing what the field has already acquired from the "psychological and learning theory, instructional and teaching-learning theory, and communication and message-design theory" with a 'design and development theory'. What is being put forward is that up to now most of the efforts in the instructional design and technology theoretical developments have been devoted to the "instructional" facet of the instructional design, disregarding the "design" nature of the whole enterprise.

This claim goes in line with Bichelmeyer (2003) when she posits: "We need to recognize that instructional design is not the same as instruction. We need to care about instructional design theory. We need to address it intentionally and explicitly" (Conclusion section, para. 2).

Edmonds, Branch, and Murkherjee (1994, p.58) propose overcoming the situation though the development of a metatheory: "Another important reason for the lack of broad and comprehensive instructional design theories can be attributed to the absence of suitable metatheory." This idea is also expressed by Clarck (1989):

> We must begin to sort out the many theories of IDD [instructional design and development] and reduce them to those few that offer clear alternative explanations of the same phenomenon. Only in this way will we allow the systematic nature of programmatic research to support necessary evolutionary advances in our understanding of IDD. (. . .) Rather than competing, many theories may simply offer design prescriptions for different types of tasks. If this is the case, future research will tend to combine them into larger and more comprehensive theories, rather than letting the weaker theory replace the stronger for all types of tasks (p. 60).

Gibbons (2005) elaborates in the definition of a more general theory of instructional design, this one close to more general developments in other related design disciplines that share common background with the instructional design field. Gibbons begins by establishing specificities and complementarities between instructional-theories and instructional-design-theories. This effort demands a strong reinterpretation and redefinition of the traditional view of instructional design theories. In this perspective, the cognitive-and-learning-related instructional design theories are straight forward understood as 'instructional theories', or 'local theories'. The expression 'instructional-design-theory' is then reserved to name a design-focused theory of broader scope:

> In our view *instructional theory* deals with the structure of instructional conversations, and *instructional design theory* deals with the manner in which the elements of those conversational structures are selected, given dimension, and integrated into a design.

> This suggests that one body of theory (instructional design theory) provides a framework within which the second body of theory (instructional theory) can be applied. In this perspective, the substance of an instructional theory consists of categories of design building blocks and the rules by which building blocks may be articulated to form different designs. The substance of instructional design theory, on the other hand, consists of methods for analyzing and decomposing design problems, classes of design structure, and principles for deriving design processes appropriate to different types of design problem. If instructional theory reflects a particular theorist's view of effective *instructional* structures and operations during instruction, then instructional design theory reflects a view of effective *design* structures and operations during designing (Gibbons & Rogers, 2009a, p. 308).

The design theory proposed by Gibbons, also presented as "functional design", is an attempt to differentiate from the dominant view of design as pure process. It pursues also the articulation of two different bodies of theories in a coherent and complementary manner: a design theory detached from a specific knowledge, learning or instructional theory.

Design theory is theory about 'making design' that can be general enough to be considered field-independent. This idea is expressed by theorists like, to name a few, Simon (1999), Alexander (1964, 1979, 1996), Edmonson (1987), Cross (2001, 2007), Schön (1987). Simon (1999) portrays the underlying logic of the design activity as the formation and exploration of theory-driven alternative solutions that must satisfy constraints and criteria, and choosing one based on a prioritizing rule. Theoretical guidance is put forward to avoid "brute combinatorics and blind search" (Gibbons & Rogers, 2009a, p.310). Design theory provides guidance for use in structuring and synthesis (Gibbons, 2003c).

Domain theories are specific to each field and apply differently. In instructional design the domain theory describes the acts that take place during an instructional conversation. The works of Bruner (1966), Gage (1964), Gagné (1985), Oswald (1989, Reigeluth (1999), Merril and Twitchell (1994), Snelbecker (1985) and others, are examples of instructional theories that can operate with the generic design framework of structures.

As this, the substance of instructional theories consists of "categories of design building blocks and the rules by which building blocks may be articulated to form different designs" (Gibbons & Rogers, 2009a, p 308), while the substance of instructional design theories consists of "methods for analyzing and decomposing design problems, classes of design structure, and principles for deriving design processes appropriate to different types of design problem" (ibid). Instructional theories and instructional design theory differ as the first explains a particular point of view of effective instructional structures and operations during instruction, the second focus on them at design time. This embracing notion of instructional design theory relates to the learning and cognitive derived/informed instructional theories as well as to the system related design theories in a new manner.

Gibbons and Rogers (2009b) present a set of propositions at the basis of their design theory:

- Design problems are complex and their solving entails their decomposition into a set of sub-problems of solvable size (Simon, 1999; Schön, 1987; Alexander, 1979).
- The design problem decomposition is based on the principle of functions that are supported and carried out through the artifact being designed. This decomposition is also presented by Schön (1987) in terms of “domains” and by Gibbons (2003) in terms of “layers”.
- The design problem decomposition in terms of the artifact functions allows also the designer to concentrate in solutions bounded to each sub-problem, and at the same time relating and keeping coherence between sub-problem solutions and the whole.
- Each layer comprises languages that provide inner terms appropriate to the solving of sub-problems and building of solutions.

This operational view of an instructional design theory derives from a functional analysis of a generic instructional artifact which provides a detailed set of composing sub-categories. This alternative to the dominant generic design process (ADDIE) decomposition scheme allows identifying different layers of artifact functionalities that decompose the design problem and are supported by design languages. It also serves as a framework to compare different instructional theories against a common background.

3.5.1 Design layers

The composite view of design is prompted by the works of Brand (1994) architectural description of buildings in terms of (six) multiple coordinated and integrated sub-designs problems or *layers*. The important part of Brand’s conceptual development to instructional design is that layers: a) age and change at different rates, but they should be conceived and intertwined in a relative independent and nondestructive way, b) represent set of different design skills that tend to “harden into lines of labor division, especially as technical sophistication of tools and techniques increases (Gibbons, 2003b)” , c) pursue different goals, tuned to specific sub-problems, d) may have their own agendas, e) create adaptive designs facilitating the update to new situations, f) correspond with a set of design heuristics, rules of thumb, practical considerations, and lore.

Previous works have shown that the instructional designs can be conceived as the integration of various layers of decision making (Gibbons, Nelson & Richards, 2000), thus mashing up at a convergence zone that give them actual existence and embody them into an artifact (Duffin & Gibbons, 2001; Gibbons, Lawless, Anderson, & Duffin, 2001). Layers integration and articulation are a crucial aspect of the design endeavor:

> The alignment of design layers during the design process is an important factor that strongly influences product qualities such as speed of operation, maintainability, and skill and effort of construction. A good match between layers is indicated by a clear and direct correspondence between design constructs at one layer and those of other layers. Mismatch is indicated by the need to modify the design at one layer in a way that degrades the design at that layer in order to accommodate connections with other layers. It is also indicated by the need to build new, intermediary layers into the design to connect other layers (to align crossed functional boundaries).
>
> Layer mismatch can have negative influence on the execution of within-layer designs by constraining one of the layers, can increase the complexity of inter-layer connection, and can negatively affect the skill level required to execute the design. In this way, layer mismatch can increase the construction, integration, and maintenance costs of a design and create elements that are not portable and have only one use (Gibbons, Nelson, & Richard, 2000, p.13).

The decomposition of instructional design problems let identify a set of representative instructional design layers of concern (Gibbons, 2003b; Gibbons & Rogers, 2009a, 2009b) as follows:

- Content layer: A design must specify the subject-matter to be learned or knowledge to be mastered by the students. This ‘content’ should also, in turn, be divided into units with the explicit description on how they are made available to instructional functions performed by the other layers. The identified design processes associated to this layer are: Task Analysis, Cognitive Task Analysis, Rule Analysis, Content Analysis, and Concept Mapping.
- Strategy layer: A design must specify the organization of the learning environment in a broad sense (according to different modalities of delivery) and learning scenario of event structures and hierarchies including roles, resources, goals, activities, time distribution,

types of interaction though which the learner can experience the content units. The identified design processes associated to this layer are: Strategy planning, Problem planning, Challenge formation, Activity planning, and Exercise design.

- Message layer: A design must specify a tactical language that formalizes the communication of content-derived information to the learner in a conversational manner according to the defined instructional experience. This layer defines the conversation from the human or automated counterpart to the learner. The identified design process associated to this layer is: Message design.
- Control layer: A design must also specify the way in which the learner expresses the messages and communicates actions to the source of the learning experience. The identified design processes associated to this layer are: Flow planning, Control walk-through, Diagramming.
- Representation layer: A design must specify the kind of representations that make message elements perceptible: visible, audible, or haptic. It includes also the formal languages for representation as well as media and channels for delivery and interaction. The identified design processes associated to this layer are: Display design, Formatting, Display event sequencing, Media channel synchronization, Media channel assignment.
- Media-logic layer: A design must specify the structures of execution of sequences by which the representation are enacted by information systems or human facilitator to the learner. The identified design processes associated to this layer are: Program design, Program construction.
- Data management layer: A design must specify the data generated during the learning experience that should be captured and archived for analysis, interpretation and reporting. The identified design processes associated to this layer are: Management planning, Implementation planning, Evaluation planning.

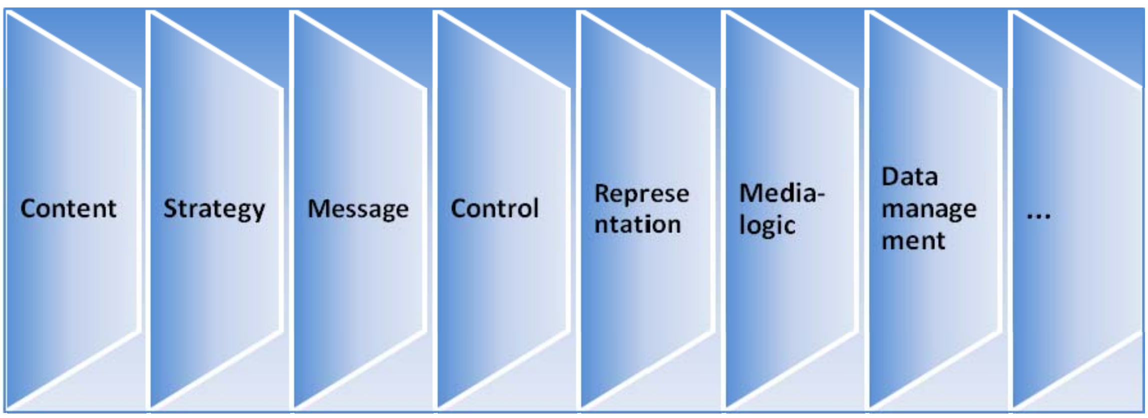


Figure 3-1. Artifact functional decomposition into layers of design concern.

These layers are not exclusive or unmodifiable, but the result of an analysis of the functional properties of instructional designs in general (Gibbons, Nelson, & Richard, 2000). This is a dynamic view of layers, which existence is first established by contextual and specific constraints, and they may emerge as the design process advances.

> This way of decomposing the design problem offers the designer flexibility in planning the order of design decisions and includes in the design process only those decisions that pertain to the constraints, criteria, and resources of the specific design problem. Problem constraints (such as the requirement that the product use video) may automatically include certain layers (and languages) into the design while excluding others. (Gibbons & Brewer, 2005, p. 127)

This view of design decomposition presents the advantage of linking with existent design process models and instructional theories. Gibbons (2009, p.4) highlights that:

- "Layer definitions have a rough correspondence with processes from the traditional instructional design process model, suggesting that valuable elements of that model need not be discarded.
- Layer definitions correspond closely with practical aspects of the design, including the classes of initial constraint that exist for virtually every project.
- Layer definitions correspond with subdivisions of instructional theory, making the application of theory to different parts of the design more straightforward."

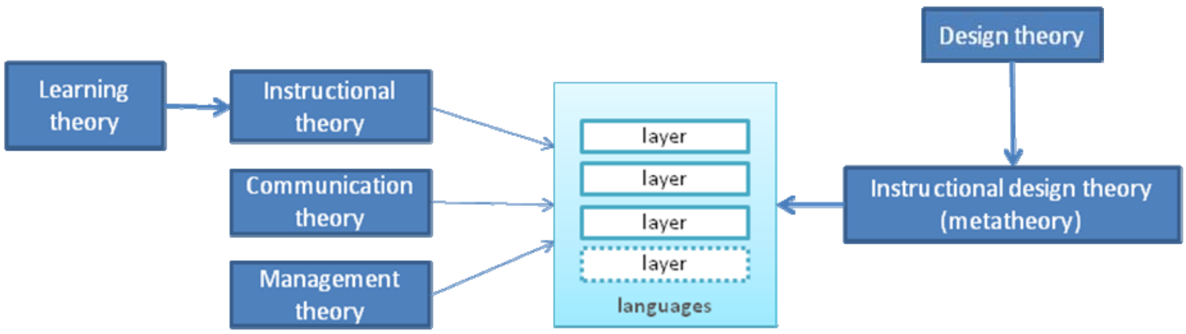


Figure 3-2. Informing theories in instructional design from a layered perspective of functional design.

Functional design allows decomposing the overall design problem into a set of layers specific to each design and according to the designer's preference, the instructional theory put forward, the available resources, the constraints of the design space, the participants involved, the stakeholders, and so on. Design layering also allows multiples "entrances" to the design process, and it reveals very dynamic throughout the course of design: unfolding or clustering layers occur during design time, they "evolve and change based on design decisions, constraints, criteria, resources, tools, new technologies, construction (development) methods, and available designer skills and awareness" (Gibbons & Rogers, 2009a, p. 309). Gibbons (2003b) acknowledges the implications of a design layering and the growing complexity of instructional design as a whole enterprise:

> A layer often corresponds with a set of specialized design skills with its own lore, design heuristics, technical data, measurements, algorithms, and practical considerations. The boundaries of these skills over time tend to harden into lines of labor division, especially as technical sophistication of tools and techniques increases (p.24).

"Separate, independent, interoperable, free-standing engines can be constructed for each of these layers. Internal to most current authoring systems, engines for some subset of the layers operate as semi-independent routines, procedures, or object suites" (Gibbons, Nelson, & Richard, 2000, p.13).

For a better understanding of layers and their specificities, see the figure 3-3, based on Gibbons, 2003b), and presenting:

- a set of design goals unique to the layer,
- a set of design constructs (selected and used on the basis of theoretical principles)
- a set of design and development tools, and
- a set of specialized design processes.

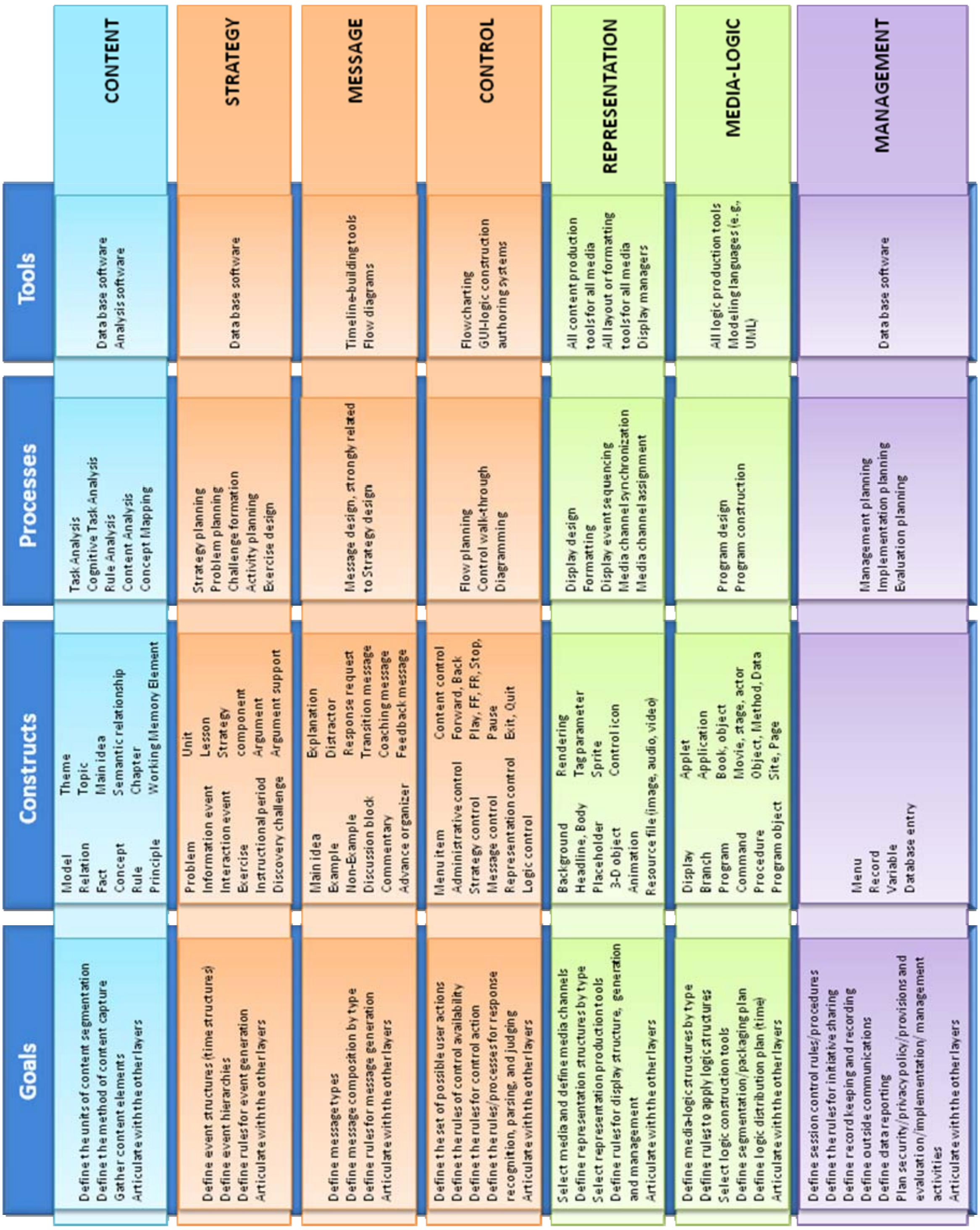


Figure 3-3. Layers' engines.

3.5.2 Design languages

Gibbons & Brewer (2005) explain in his theory of design layering the existence of different design languages supporting *the structures and structuring rules needed to complete designs" within each layers* (p. 112). The relationship between layers and languages in design is outlined by Schön (1987). The author works on an example based on architecture. The design problem is decomposed into layers (or domains, as called by Schön) within which operate design languages: "Elements of the language of designing can be grouped into clusters […]. These design domains contain the names of elements, features, relations, and actions and of norms used to evaluate problems, consequences, and implications. (pp. 58-60).

Rheinfrank & Evenson (1996) are one of the pioneers in attempting to explain the notion of design languages based on the natural language analogy:

> Natural languages consist of words and rules of grammars, and are used to create meaningful utterances. Design languages consist of design elements and principles of composition. Like natural languages, design languages are used for generation (creating things) and interpretation (reading things). Natural languages are used to generate expressions that communicate ideas; design languages are used to design objects that express what the objects are, what they do, and how they are used, and how they contribute to experience (p.68).

In this sense, Seo and Gibbons (2003) explain that a design language, like a natural language, is used to communicate ideas and structural relationships among elements, in other words they "supply a basic vocabulary and a set of guidelines for forming design expressions" (Seo & Gibbons, 2003, p.46). But there are differences between natural and design languages. Gibbons and Rogers (2009) highlights these differences on what typifies a natural language a set of primitives, a syntax, and a semantic (Berlinski, 2000; Cooke, 2003; Jackendoff, 2002).

> The terms of a natural language tend to evolve from usage, as objects and events are encountered repeatedly in everyday experience, sufficiently to where an abstraction of them is formed and given a name or symbol. General social use of the terms over time brings them into the language. Design languages exist as tools for problem solving and design synthesis. Their expressions have meaning only within the domain of problems for which they were created (Gibbons and Rogers, 2009, p. 316)

Table 3-1

Natural languages and design languages compared in terms of primitives, syntax, and semantics.

	Natural Language	**Design Language**
Primitive terms	Centered in everyday things and events; abstractions of experience	Centered in tools, processes, technologies, theories, or best practices
Syntax	Based on words as a medium of expression in which linear or positional order is critical	Dependent on the medium of problem solving and solution; sometimes spatial or view-oriented
Semantics	Derived from the world as it is experienced and things that can be, or are desired to be, communicated	Derived from the problem domain and the context of problems in the domain

Note: Adapted from "The architecture of instructional theory," by A. Gibbons and C. Rogers (2009). In C.M. Reigeluth & A. A. Carr-Chellman (Eds.), Instructional-design theories and models, volume III: Building a common knowledge base. NY: Routledge, p. 316.

Design languages serve as mental tools (Botturi, Derntl, Boot, & Figl, 2006) for externalizing thinking and allowing the expression and representation of blueprints, but also, if shared, they provide ways to exchange and communicate designs with others. Although design languages are common in the architecture and software development domains, they have become a focus of concern in the instructional design field only in recent times (Waters & Gibbons, 2004; Gibbons& Brewer, 2005; Boot, 2005; Botturi, 2005; Botturi et al., 2006; Reigeluth & Carr-Chellman, 2006). Reigeluth and Keller (2002) raised a long standing problem within the instructional design field in what they called the 'tower of babble', "referring to the lack of clear and unambiguous definitions of terms that designate instructional constructs, methods, techniques, and types (Gibbons & Brewer, 2005, p.126).

Overcoming this situation should mean an effort in establishing a standard for defining design language terms with more explicit and technical properties, and should

> "be accompanied by the development of what Stolurow (1969) called *grammars of instruction*: rules describing how the terms of a given language can be combined to form meaningful expressions. Such rules can form the basis for the development of generative grammars for instruction. Stolurow's use of the term generative implies that the languages and their rules will not only classify surface forms of expression but will have deep structures to expressions that allow design expressions to be transformed through the application of transformational rules that preserve meaning, even when surface structure is altered" (Gibbons & Brewer, 2005, p.126).

Winograd (1996) emphasizes the communication aspect of design language among a team or group of work or into a community with common interests: [Design languages are] “visual and functional languages of communication with the people who use an artifact” (p.64).

> Design languages, formal or intuitive, lie at the heart of all design and development processes and tools. Instructional designers tend to be unaware of the multiplicity of design languages they use. This is not surprising because in most fields the use of design languages to improve precision and productivity is relatively new. However, the identification and use of design languages in many design and manufacturing fields has greatly benefited growth and maturation over a very short span of years. Instructional design will also benefit from this trend as designers and theorists become aware of the existence and use of design languages and their related notation systems. (Gibbons & Brewer, 2005, p.111)

Instructional design languages formalization and adoption should lead to the reduction of arbitrariness and the constraining of interpretation in the use of terms thus enhancing communicability of instructional designs for discussion, refinement, and reuse. Awareness on this subject is addressed from different angles by researches in the field. Rickey et al. (2001) elaborate on the communication skills that instructional designers must exercise: visual, oral and written. These skills are at the heart of a successful instructional process as it involves a group of people from different expertise that need to work together. Shared design languages are crucial to the success of the design enterprise. Rothwell & Kazanas (2004), in accordance with this position, add a series of ‘methods’ that instructional designers should use to interact with others in an efficient way: *techniques for establishing reports with others* (p.xxix). Other authors in the field, like Smith and Ragan (2005), highlight the instructional system design approach for its power as “a common language” (p.12), offering a framework for progressing through design and providing a set of constructs for producing the design blueprints or artifacts. Seels & Glasgow (1998) share this view when they explain the ISD processes represented as flowchart process models: “Flowcharting has a language of its own” (p. 47), expressed by generally accepted conventions for their representation. The need for formalization and agreement is put forward also by Wilson (1997) who claims that “”ID needs a richer language, a deeper conceptual framework for classifying instructional strategies” (p. 74). At the heart of this concern are the conceptual developments of Reigeluth and Keller (2009) that provide a “flexible framework for organizing constructs about instruction” (p. 28) and instructional theory to help build a common knowledge base in instructional design.

To mention an example of this idea, Merrill (1994) recognizes that:

> Like other theories of instruction, CDT [component display theory] is a language on one level and a set of prescriptions on another level. As a language, it is a set of concepts that describes the conditions, methods, and outcomes of instruction. This language is perhaps more complete and comprehensive within its domain than that of other models and theories. Hence, it provides a useful medium for analyzing and understanding those aspects of other theories and models that deal with the same domain. As a set of prescriptions, CDT attempts to indicate what set of method components (i.e., what model) is most likely to optimize achievement of the desired outcomes under the specified conditions (Merrill, 1994, p. 106).

This position is consistent with Gibbons and Rogers proposition of an instructional design theory providing a framework within which instructional theories can be applied. Instructional theories provide a "set of specialized, mutually consistent design languages, consisting of terms the theorist defines, that are distributed across multiple design layers which are defined by an instructional design theory" (2009, p. 319).

Multiple languages within each layer provide the opportunity for variations within each layer and define the design building blocks designers are likely to use as they design. (Gibbons & Brewer, 2005, p. 112).

All seems to point to the need, for instructional designers and the educational field, of more formal and consensual design languages that can be specifically qualified of instructional design languages. The generic construct "design language" is at the origin of different expressions and definitions depending on the discipline and research interest. That's why in specialized literature we find expressions like instructional design languages, instructional languages, visual learning design languages, educational modeling languages. There's also a key concept associated to them, which is if they are coupled or not with a "notation system". "Instructional design languages are proposed as a conceptual tool to achieve more creative design solutions and to enhance communication in design teams" (Botturi, et al., 2006, p. 1217).

Identifying, analyzing and evaluating design languages is facilitated trough a series of dimensions presented by Gibbons and Brewer (2005). They are not exclusive, but rather help define and understand the language specificities. The author proposes six different dimensions that can apply to a language:

- **Complexity**: it refers to the set of terms and grammars that compose a design language. The composition of terms forms categories and establishes rules. As Gibbons (2005, p.115) add: "the most sophisticated and complex design languages possess many, clearly defined, independent and exclusive categories. In addition, they posses clear unambiguous rules for forming design expressions that include these terms- in other words, a grammar."

- **Precision**: it's a quality of a design language defined by the measurability and exactness of its terms and relationships. The purpose is to reduce appreciably ambiguity in terms meaning. Cole (1971) cited in Gibbons (2005, p. 116) states that a language precision and flexibility "differ correspondingly between a general language that can be used for a variety of needs being adapted for multiple tasks and a specific language that has a single use and purpose."
- **Formality and standardization**: it is related to the general adoption of a language by a community that shares the same terms and meanings.
- **Personal versus shared**: it highlights the individual or collective use of the language. Evidence from the practice of design show that designers use their own design languages or that they adapt design languages to do their task. A symbolic notation system in required when a language is intended to produce designs that can be shared and communicated to others (Waters & Gibbons, 2004).
- **Implicit versus explicit**: personal languages that exist on the individual mind are the implicit ones, they are those that cannot be well verbalized but that reside inside the designer and it is use to take decisions about design. Those design languages whose terms and rules have been completely specified correspond to the denomination of explicit languages.
- **Standardized versus nonetandardized**: in the last year a growing interest into the e-learning field has created standardized languages with a detailed formal terminology and rules of usage for the "learning object" approach. We can mention the IMS Global Learning Consortium (including the IMS LD specification), the Aviation Industry and CBT Consortium, the Advanced Distributed Learning Initiative, the IEEE Learning Technology Standards Committee. This criterion is intimately related to the **interoperable** character of a design language.
- **Computability**: the degree of formalization and precision of some design languages allow computer programs testing the designs without having to build the actual product. Terms describing the product are able to be translated into a machine code, interpreted and executed by computer programs.

Another important dimension of design languages, understood as a mental tool, is proposed by Botturi et *al.* (2006). The authors present two axes of analysis. The first axis concentrates on the "communication" aspects of the design language whether (1) Reflective (personal): in this case as a tool for personal creative thinking, or (2) Communicative, in order to interact with other designers or stakeholders. The second axis relates to the design language in its "creativity" aspects for the generation of design solutions, whether they are (1) Generative, supporting the exploration, creation and refining of design solutions or (2) Finalist, as a way to *formalize and freeze the final design solution.* (p.1219).

All the above mentioned dimensions let understand that there are numerous languages assisting design at different levels with distinctive purposes. For example, Gibbons, Botturi, Boot and Nelson (2008) explain how the languages pertaining to the content layer have evolved over the past five decades: beginning with behaviorism (subject matters in term of *operants* and *operants change* – Gagné, 1965), through information processing (Gagné, 1985), to subject matter in terms of production (if-then rules) and working memory (semantic) elements (Anderson, 1993; Anderson, Corbett, Koedinger, & Pelletier, 1995), or situated learning (content within communities of practice - Lave & Wenger, 1991; Wenger, 1998).

3.5.2.1 Notations systems

Design languages are a set of categories or terms that composed according to specific rules for articulation and represent intentions or plans. Designs languages are abstract and have no outward expression; they can only be tangible if represented with drawings, sounds, symbols, or words. This external expression corresponds to a notation, that when reaches a certain level of development, organizes into a system. The notation system brings support to a formal representation of the design artifact and enables communication with regard to the design. There is an interplay between design languages and notation systems that supports a mutual growth and improvement.

> "Once a consistent notation system is established, it can become: (1) a tool for remembering designs, (2) a structured problem-solving work space where designs can take form, and (3) a laboratory tool for sharpening and subdividing abstract design categories. Through a continuing cycle of refinement, both design language and notation system grow in parallel, and more sophisticated design ideas result." (Gibbons et al., 2008, p. 642)

Known and shared design languages that are useful to illustrate this concept are used in architecture, music composition, writing choreography, mathematics, and computing programming (Waters & Gibbons, 2004; Gibbons, 2005).

Notations systems can be classified according to dimensions similar to those that apply in design languages: intuitiveness (the visual similarity to mental images), complexity, computability, precision, recording speed (i.e. during an event), transitionalness (association with other notation system), support for improvisation, acceptance of interpretation (i.e. a theatre piece vs a cockpit blueprint), inclusion of roles, context awareness (the correlation with multiple art or technology forms), and inclusion of emotional content and mood (i.e. emoticons).

Within the field of instructional design, it is well known the use of sketches, charts, diagrams, storyboarding and of mock-ups to communicate designs. There is a relatively recent interest in developing visual languages for instruccional design (Botturi & Stubbs, 2008). They highlight the effort for providing a notation system and they are mostly intended for the representation of teaching and learning processes. Most developers of these languages are also concerned with the computational aspects of these visual languages expressing pedagogical scenarios. Botturi et al. (2006) mention examples of these languages qualified as “visual” that allow different representations and views of pedagogical scenarios: E^2ML consisting of multiple interrelated diagrams, PCeL pattern initiative (Derntl, 2005) based on a profile UML (Unified modeling language), POEML integrating workflows and groupware aspects for modeling (Caeiro-Rodriguez, Andino-Rifon, & Llamas-Nistal, 2006), AUCT project (AUCT, 2003) providing generic templates with examples, and the UML (Booch, Rumbaugh, & Jacobson, 1999) itself providing notation for the representation of different diagrams.

Stubbs & Gibbons (2008, p. 363) remark that: “a common visual language for conveying design ideas has facilitated progress in many other fields of design. The lack of such as medium in ID may be a roadblock to improving the practice of ID.”

This focus of visual languages cohabits with the development in educational modeling languages. Because of our special interest related to their central role in our research they are presented later in chapter 3.

3.6 Models in instructional design

There is a strong link between theories and models in instructional design: models are sometimes understood as synonyms of theories, other times as abstract depictions of theories, and other times still as a complement to the theories, in their prescriptive power so precious to the practice of design.

Silvern (1977) cited the AECT[11] definition of a model as a "graphic analog representing a real-life situation either as it is or as it should be"(p. 168). Similarly, Gustafson and Branch (2002, p.1) add that models serve as an aid to conceptualize representations of reality:

> A model is a simple representation of more complex forms, processes and functions of physical phenomena or ideas. Models, of necessity, simplify reality because often reality is too complex to portray. Since much of that complexity is unique to specific situations, models help by identifying what is generic and applicable across multiple contexts.

According to Richey (2005), models in the instructional design tradition express at least two main realities. The author classifies the models into conceptual and procedural, where the former are of a more abstract nature dealing with taxonomies (Dale's Cone of Experience, 1946; Bloom's taxonomy of cognitive objectives, 1956; Gagnés' domains of learning, 1972; Martin and Briggs' taxonomy of the affective domain, 1986), and the latter are more prescriptive presenting visual representations of a process. These procedural models are sub-classified as representing either specific aspects of design (Gagné's Events of Instruction model, 1992; Rothwell and Kazanas models for writing and sequencing performance objectives, 1998; Reiser and Gagné's flowchart model, 1983; Keller's ARCS model of motivational design, 1987; van Merriënboer model for training complex cognitive skills, 1997) or prescribing a more general process, usually variants of the generic ADDIE model (Dick, Carey, and Carey model, 2005; Smith and Ragan model, 2005; Morrison, Ross and Kemp model, 2007; Rothwell and Kazanas model, 2004).

Tracing a parallelism between the definitions of models as introduced by Richey (2005) and the notion of theories informing instructional design as presented by Seels (1997) (see section 3.4 above), models in instructional design are of different nature and of different purpose. Conceptual models can be considered abstractions and representations of more descriptive theories. Procedural models of narrow scope provide prescriptions on how to design a specific teaching-and-learning sequence, and, of broader scope, encompass a whole process that deals not only with learning solution but also with managerial, production and implementation design issues; these latter known as "instructional system design"

The definition of procedural models as ISD corresponds to that a more general one as applied across design disciplines. Clarkson and Eckert (2005) explain that the function of models of design processes is to provide an abstract description of general design processes including sometimes their corresponding activities. These models serve as checklists, a sort of reminders of what should be accomplished at any moment of the design process. They have

[11] Association for Educational Communications and Technology

communicative power based on their visual representation, thus assuring coordination and shared understanding among designers and managers or other actors involved in the design project. Some specific process models, addressing particular concerns, are usually assembled to a more generic model throughout common terminology and conventions.

Andrews and Goodson (1995) circumscribe the notion of model to that of system:

> A model is usually considered to be an abstraction and simplification of a defined referent system, presumably having some noticeable fidelity to the referent system (Hayman, 1974, p. 4; Logan, 1976, p. 3). This fidelity is expected whether the model is intended to describe, prescribe, predict, or explain elements of the referent system, and whether the model is based on a set of implemented procedures or theoretical constructs (p. 163).

The instructional systems design approach is acknowledged to provide assistance for the managing of the various theories that make up the instructional design knowledge base. To this matter, Morrison et al. (2007, p.6) posits: "a systematic design process […] is based on what we know about learning theories, information technology, systematic analysis, educational research, and management methods." Moreover, Gagné et al. (2005) explain that ISD includes systems theory and problem-solving methodology, as well as it "incorporates knowledge of the principles of learning and instruction from learning science and instructional psychology (p. 18)". In addition, ISD "is both systematic and scientific in that is documentable, replicable in its general application, and leads to predictable outcomes. Yet, it also requires creativity in identifying and solving instructional problems (ibid)". Smith & Ragan (2005, p. 4) define the approach as a "systematic and **reflective** process of translating principles of learning and instruction into plans for instructional materials, activities, information resources, and evaluation" (bold is ours). Schiffman (1995. p.131) posits that ISD is not only a model but a "field requiring a wide range of psychological, sociological, interpersonal, and managerial skills if it is to be skillfully and creatively practiced. (…) Professional instructional systems designers must be prepared to design for different system constraints, populations, content areas (often unfamiliar ones), and forms of media and technology."

It is intentional the citation of Briggs & Walter (1989) features of a system model for instructional design. This early document already describes a process and establishes the 'nuances', giving clues for its correct interpretation of an orderly but flexible process:

> "1. All components of the instruction are planned to work together to achieve the goals and objectives of the instruction.

2. Components are analyzed and developed in a planned sequence; although each is **reviewed again as new components are planned**.

3. The entire design process is **orderly but flexible**. There is both "**feedback**" and "**feedforward**" in **iterative cycles of work**.

4. The **procedures are based on research and theory when possible, supplemented by logic, common sense, and frequent review**.

5. Empirical data are gathered to test assumptions underlying the work, and to test the effectiveness of the designed instruction. These data are gathered while the instruction is being planned and first tried out, and also after the instruction has been field tested. These efforts are called, respectively, **formative evaluation and summative evaluation**.

6. There is a characteristic order of stages in which the work is accomplished

7. The specific functions to be performed by teachers, learners, materials, exercises, media, and tests are **planned jointly**.

8. A delivery system is developed to include all components needed to make it operate as planned, including: the physical environment, the characteristics of learners and teachers, and the instructional procedures.

9. The overall model of procedures is based on an intellectually **consistent set of key concepts**. This helps assure compatibility or congruence among the resulting designed components.

10. The model is planned to assure an honest and **open relationship among the designer, the teacher, and the learner**. The resulting instruction is thus humane.

11. The model is consistent with the concept of accountability for the value of goals adopted and for the effectiveness of instruction.

12. The model provides for setting criteria for evaluating the success of the instruction." (p. 4-5, *bold is ours*).

ISD have encompassed the growing of the IDT field since WWII (Reiser, 1997), when the need for education became massive in the United States. Previous research into the behaviorist sciences and communication theory, rapid developments in media technology (mainly radio and television) and a significant economical and industrial flourishing were, in combination, a fertile soil for the expansion of ISD. ISD appear at the moment of a shift in the vision on the field, as Reiser (2007, p.3) explains:

> Beginning in the 1950s, and particularly during the 1960s and 1970s, a number of leaders in the field of education started discussing instructional technology in a different way-rather than equating it with media, they discussed it as being a process.

The focus on the "process" will help emerge the need for models as a way to abstract and represent their main components. Models proliferate in a great extent developed by educators or enterprise related technologists.

3.6.1 Models comparison

Models in instructional design will develop adapting the continuous changes, from more linear to increasingly cyclic and iterative process descriptions. Their multiplication in number, variety and focus of attention was the object of some efforts for their study, comparison and classification. The complexity for their classification is intrinsic to their heterogeneous properties:

> Instructional design models have descriptive, prescriptive, predictive, and/or explanatory elements in varying degrees. That is, some models describe the components or activities of instructional design, but they are used as if they prescribe the necessary activities, and sometimes are presented as prescriptions. Implicit in the presentation of many models of instructional design (and explicit in some) is the prediction of effective instruction, that is, that intended learning will occur when the activities outlined in the model are followed. Finally, some models have such a strong basis in learning theory that they tend to explain instructional design in terms of the events of learning. (Andrews & Goodson, 1995, p.163)

A first comparative analysis of instructional design model dates back to Twelker, Urbach, and Buck (1972) with a study of five of them. A decade later, Andrews & Goodson (1980-1995) selected, from an inventory of over 60 models, 40 of them for analysis and comparison. The first step consisted in indentifying the tasks prescribed by each model against a list of 14 common ones built upon Gropper's (1977) list of 10 tasks, which the authors extended as they emerged from the models' analysis. The second step follow with a review of the 40 models, this time on the basis of four dimensions of analysis: a) origin: Either theoretical or empirical, b) theoretical underpinnings: Showing emphasis on learning, instruction, or system theory, c) purposes and uses: Aiming at teaching the design process, produce instructional products or reduce costs, and d) documentation: based on research and experience reporting of the model application. Main results showed that general tasks, although differing in the order, are always present and apply across different purposes, emphasis, origins, uses and settings.

Gustafson (1981, 1991, Gustafson & Branch, 1997, 2002) has been regularly updating a comparative analysis of instructional design models clustered in three main categories according to the kind of product they focus on: classroom-oriented, product-oriented and system-oriented. They all reveal a process that can be more or less expanded as well as flexible. Here below are some examples of them.

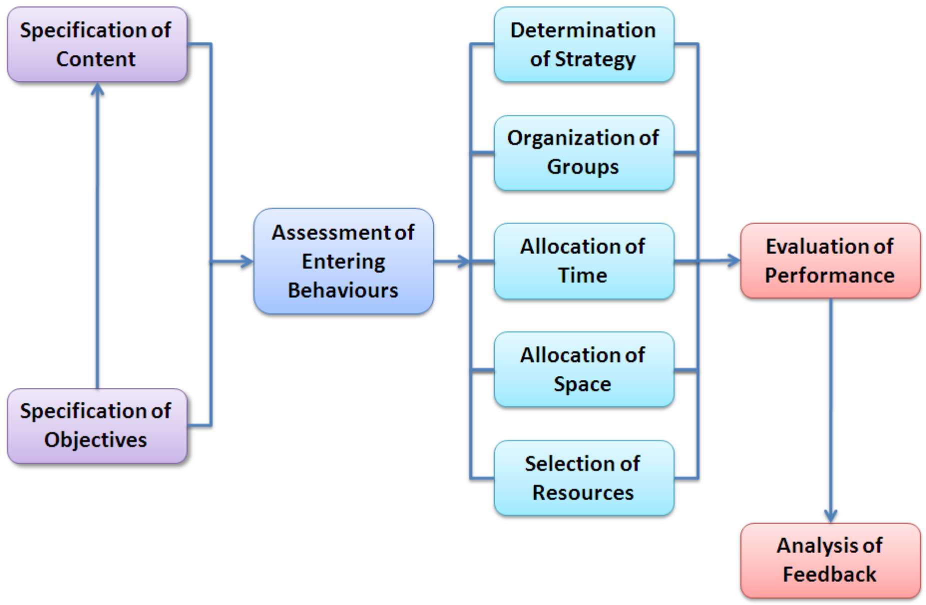


Figure 3-4. Gerlach and Ely classroom model. Adapted from "Teaching and Media: A Systematic Approach, (2nd ed.)," by V. S. Gerlach and D. P. Ely, 1980, Boston, MA: Allyn and Bacon.

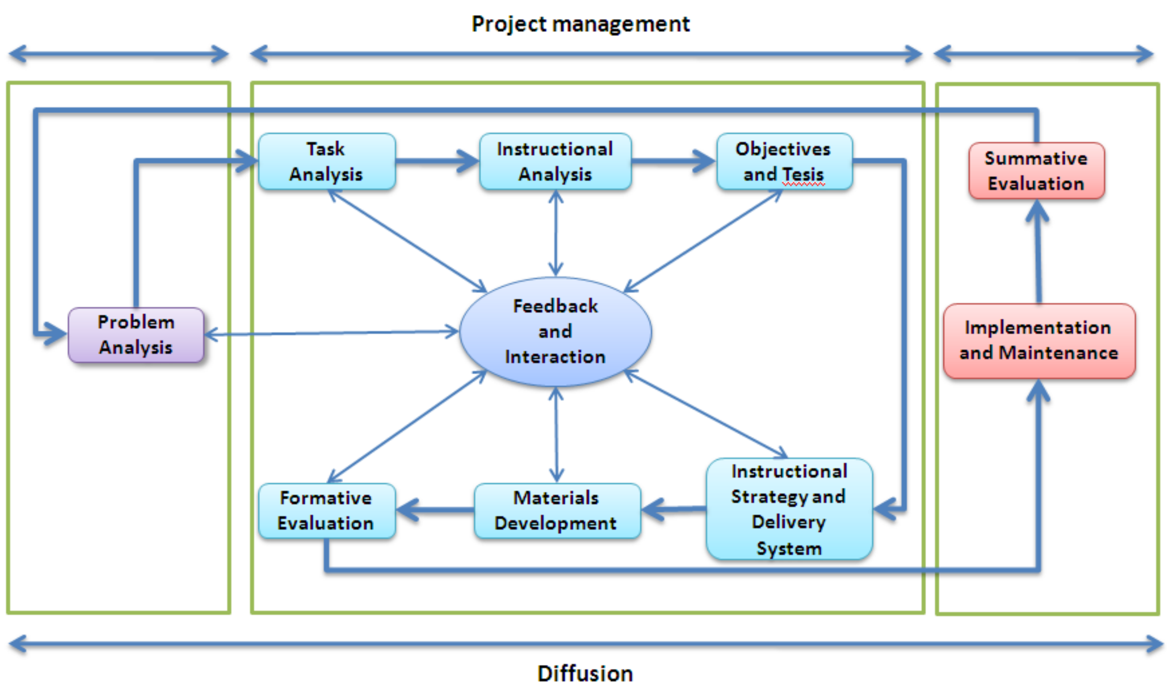


Figure 3-5. Seels and Glasgow product model: ISD Model 2 for Practitioners. Adapted from "Making Instructional Design Decisions (2nd ed.)," by B. Seels and Z. Glasgow, 1998. Upper Saddle River, NJ: Prentice-Hall, p. 178.

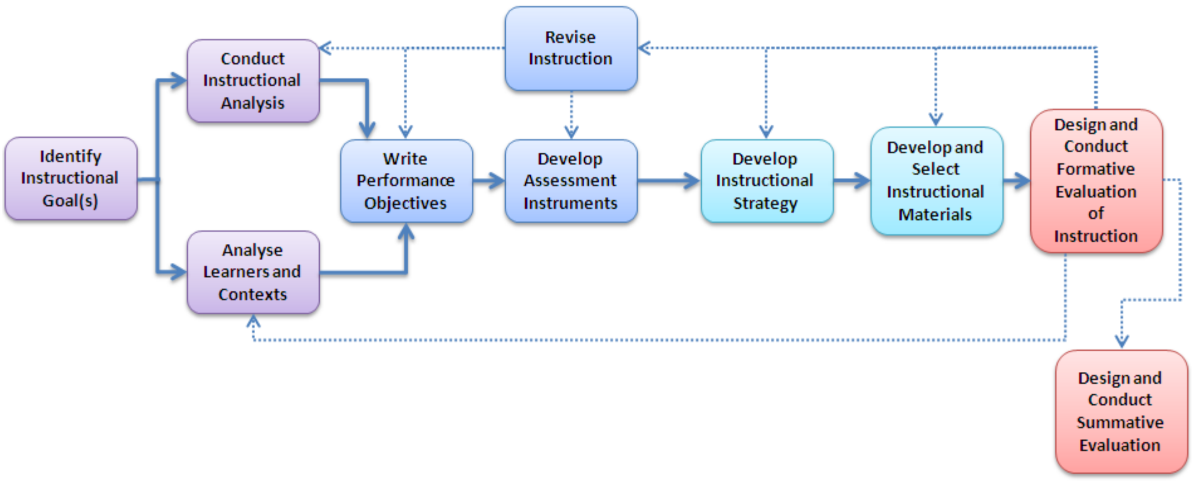


Figure 3-6. The Dick, Carey, and Carey system model. Adapted from "The Systematic Design of Instruction (6th ed.)," by W. Dick, L. Carey, and J. Carey, 2005. Boston, MA: Pearson, p. 1.

Based on the previous classifications and acknowledging a yet incomplete rationale capable to give account for divergent models, Edmonds, Branch, and Mukherjee (1994), outlined an ambitious common framework for models comparison. The resulting conceptual framework for ID models comparison they proposed is as follows:

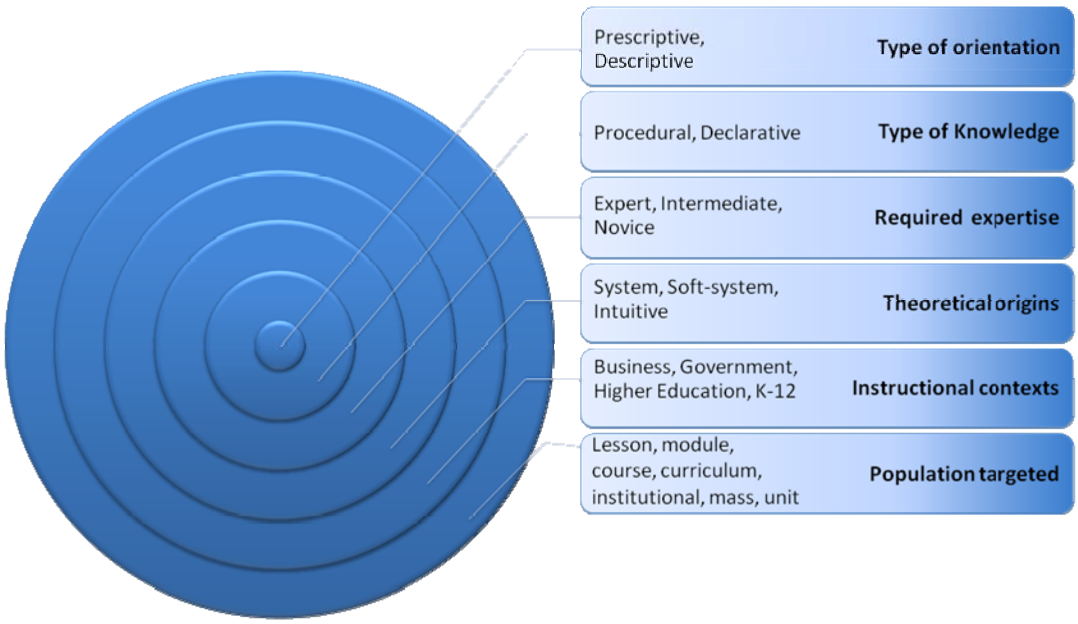


Figure 3-7. Conceptual framework for comparing instructional design models. Adapted from "A Conceptual Framework for Comparing Instructional Design Models," by G. S. Edmonds, R. C. Branch, & P. Mukherjee, 1994. *Educational Technology Research and Development, 42*(4), p.68.

Type of orientation: determines the purpose of the model in terms of the learning environment and their composing variables. While descriptive models speculate of how these variables could be affected by a given learning environment, prescriptive models outline how a learning environment can be constructed or modified in order to affect the variables to bring about a desired outcome. There are models targeting both orientations.

Type of knowledge: establishes the type of task the model is intended to support, either procedural, declarative, or both. Procedural supports how to reach a goal while declarative gives account of why such a goal should be reached. It mainly focuses on the instructional sequence design.

Required expertise: identifies the most suitable designer to the model in terms of expertise. Models of step-by-step descriptions are more appropriate for novice designers and vice-versa.

Theoretical origins: unveils theoretical underpinnings of the model in a continuum from hard system, through soft system, to intuitive approach. Hard systems are "mistakenly perceived as being governed by rigid formalized rules, procedures and routines while alternative approaches to instructional design contend to allow for a more flexible design based on site-specific needs (Edmonds et al., p.63).

Table 3-2
Instructional Design Models Comparison Matrix

ID Model	Orientation	Knowledge Structure	Expertise Level	Structure	Context	Level
Dick & Carey (1990)	B	A	D	A	A,B,C,D	A,B,C,D
Rapid Prototyping (1990)	C	C	A	B,C	A,B,C,D	A,B,C
Layers of Necessity (1991)	B	B	A,B	B	A,B,C,D	A,B,C,D,E,F
Diamond (1989)	C	C	A,B	B	B	A,B,C,D,E,F
Romizowski (1981)	A	B	A,B	D	A,B,C,D	A,B,C,D
	A. Prescriptive B. Descriptive C. Elements of both	A. Procedural B. Declarative C. Elements of both	A. Expert B. Intermediate C. Novice D. Suitable for all	A. System B. Soft-System C. Intuitive D. Aspects of each	A. K-12 B. Higher Ed. C. Business D. Government	A. Unit B. Module C. Lesson D. Course E. Institutional F. Mass

Note: Adapted from "A Conceptual Framework for Comparing Instructional Design Models," by G. S. Edmonds, R. C. Branch, & P. Mukherjee, 1994. *Educational Technology Research and Development, 42*(4), p.70.

Instructional contexts: stands for the appropriateness of the model to specifics contexts like K-12, higher education, business or government.

Population targeted: examines the models scope in terms of the design solution targeting the general public (a campaign for social awareness of a sensible subject), an institution (a company), or formal education like a course, lesson, module or unit.

Tennyson (1995) presents an evolutionary vision of instructional system design of historical relations between fundamental changes in theory and technology and their impact in the definition of models. This organization in generations of models responds to a dominant view of how the first ISD models were interpreted (that doesn't necessarily correspond to the intentions of their creators). It is based on four attributes that let distinguish the: a) system design, which identifies a continuum between linear to dynamic set of tasks, b) program evaluation, including formative and summative aspects of evaluation, c) learning theory, which identifies theoretical underpinnings for each generation beginning with behavioral approaches and progressively integrating advancements in cognitivism and constructivism, d) ID processes, from linear sequence of step-by-step procedures to more complex and dynamics processes of back-and-forth nature, e) ID author, from individual teacher work to highly specialized team work, and e) authoring activities, from poorly defined to increasingly specific and detailed.

Table 3-3

Attributes of the Four Generations of ISD

	Generations			
Attributes	**ISD[1]**	**ISD[2]**	**ISD[3]**	**ISD[4]**
System design	Linear	Flow-chart	Phases	Dynamic
Program evaluation	Formative	Formative / Summative	Feasibility Formative Summative Maintenance	Situational Feasibility Formative Summative Maintenance
Learning Theory	Behavioral	Behavioral	Behavioral (Cognitive)	Cognitive / Constructivist (Behavioral)
ID Processes	Step-by-step	Step-by-step	Phase-by-phase (simple)	Knowledge Base (integrated)
ID Author	Content Expert (system novice)	Technician (content novice)	ID Expert (content novice)	Content / System (tool) Expert
Authoring Activities	Ill-defined	Operational Definitions	Expert Defined	Explicit Rules
Model	Bloom's taxonomy (1956)	Dick & Carey (1978)	Diamond, (1989)	Crawford (1994) Willis (1995)

Note: Adapted from "The impact of the cognitive science movement on instructional design fundamentals," by R. D. Tennyson, 1995. In B. S. Seels (Ed.), *Instructional design fundamentals: A reconsideration.* USA: Educational Technology Publications, p. 114.

Another significant classification of models was proposed by Visscher-Voerman and Plomp (1996) based on the study of different design approaches in instructional design. They proposed a general framework of interpretation of design approaches that presents the two poles of a continuum, from problem-driven to solution-driven approaches. Problem-driven (Simon, 1969) emphasizes the scientific and analytical aspects of the design process, where a problem is decomposed into subproblems that are solved in particular taking into account the coherence with the whole. Solution-driven (Schön 1983), on the opposite, focuses on the design of solutions that are subject to continuous tests and refining. Visscher-Voerman and Plomp acknowledge that in educational design, designers "tend to combine specific ideas from both approaches" (p.23). In between the extremes of the continuum are the prototyping models of design where the product is either developed in part or in whole and tested overtime, and the rational models with a focus on implementation that take special attention to the context in which the solution is to be implemented.

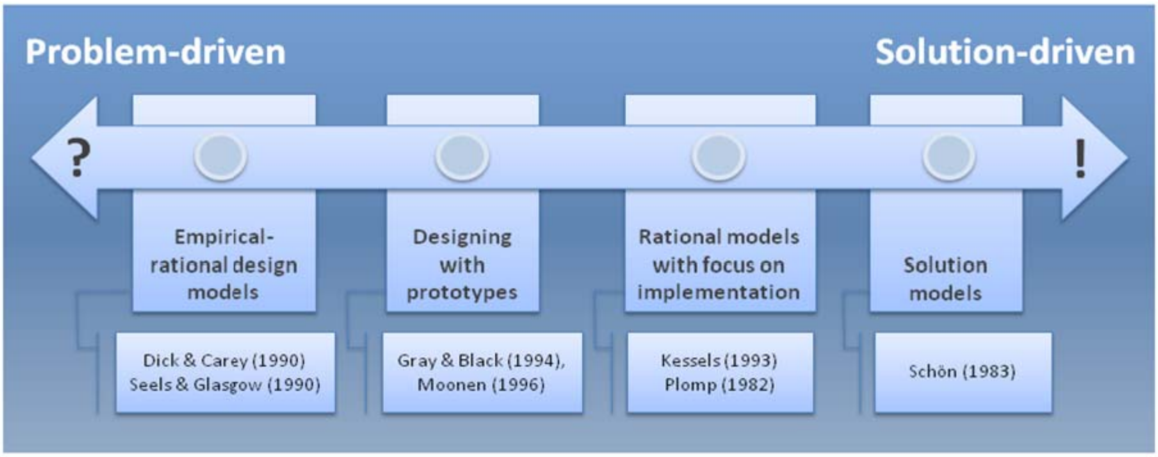


Figure 3-8. Design approaches continuum.

Yet, a recent effort to trace a framework for understanding models from a historical perspective and the confronting forces into the instructional design field is drawn by Willis (2009). Willis begins by differentiating what he calls the Pedagogical ID and the Process ID. Pedagogical ID interprets design as the application of knowledge of scientifically proven theories of learning, principles of teaching and pedagogical strategies that best much a given situation. There is an underlying assumption of a rational systematic procedure behind. Process ID, or better expressed, *constructive-interpretive process* (p.17), is concerned with a broader scope that involves the application of a set of theories borrowed from different disciplines. Process ID also uses phronetic knowledge (that of practical judgment or wisdom, common sense, contextually constraint) and technical knowledge and expertise. Process ID emphasizes social aspects of team design. This vision will conclude later in a proposition of four

Table 3-4.

Objective-rational and constructive instructional design models.

	Objective-rational models (procedural / pedagogical ID)	**Constructive instructional models (process / process ID)**
Epistemology	Positivism, postpositivism	Interpretivism, hermeneutics
Learning theory	Behaviorism, information processing theory, cognitive science, instructionism, direct instruction	Constructivism, social consctructivism, Deweyian progressive education theories
Designer's privileged knowledge	Theories of learning and instruction	Phronetic, technical, and experiential
Designer role	Manager, expert	Team member
Models	Dick & Carey (1978, 2005), ADDIE	Crawford (1994), Willis (1995)

Note: Adapted from "Three trends in instructional design," by W. Willis, 2009. In W. Willis (Ed.), *Constructivist instructional design (C-ID): Foundations, Models, and Examples.* USA: Information Age Publishing, p. 24.

This search for a rationale behind a highly productive instructional design community and the plethora of existent models shows that the tradition in the development of process models (at large) can be seen from a historical perspective, evolving from simplistic ID process descriptions to more elaborated systematic and systemic models.

The model trajectory reveals an increasing complexity in their representation, from more linear step-by-step procedures to increasingly cyclic and iterative process descriptions. These "arrows and boxes" (Gustafson, 2002) grew in complexity but also in more realistic representations of the ISD processes.

3.6.2 The status of the model

Developments in cognitive and constructivist learning theories and rapid advancements in technology such as interactive video, CD-ROM and the Internet strongly impact the IDT field (Gross, Elen, Kerres, Merriënboier, & Spector, 1997). Instructional design, in this way challenged, lived a period of questioning about its validity, accused of "old fashion behaviorism". The most significant criticism to the ISD approach is launched from the enterprise world by Gordon and Zemke (2000), that echoing some other voices, will "attack" arguing that ISD: focuses only on the problem, demands too much time for the analysis, is composed of fixed linear steps, it is outdated as it relays on behavioral sciences, and can conduce to ineffective solutions.

Spector and Muraida (1997) warns about a misinterpretation of ISD as only a model for prescription of a definite set of activities that should be performed in a orderly and strictly fashion. This misinterpretation is at the origins of a lasting controversy around the ISD approach. A study on the perception on visual representations of instructional designs process models (Branch, 1997) seems to confirm that diagrams, if simple as “boxes” or “ovals” flowcharts, are interpreted as more linear, rigid, and confusing, while if represented in a mixed format, grouping elements into bigger units, are perceived as more complex, conceptual, and cyclical. Spector and Muraida recall that the real value of the ISD model is that it “provides a meaningful organizing framework within which development activities can be described, discussed, actualized, and assessed. [It] provides heuristics for instructional development, and should be regarded as providing guidance, rather than as a rigid set of task prescriptions” (p. 61). In the same line, Broadbent (2002) criticizes the oversimplified vision of ISD as only flowcharts and proposes to rather understand it as a dynamic, flexible and multifaceted ‘way of thinking’. Hannun (2005) points out that the flowchart corresponds to a ‘representation’ of the ISD overall process but its enactment through the designers’ practice is ‘flexible, nonlinear and heuristic-not algorithmic’.

The evolution of the instructional design process models could be compromised if the discussion continuous to repeat the same arguments based on old fashion criticism that has consumed years in the field and which is mainly based on a set of misinterpretations:

1. A questionable position about the design process and activity that opposes rational to creative (Bichelmeyer, 2004; Hannum, 2005)
2. An historical reductionism of the ISD approach by confinement to the behavioral sciences and oblivion of system theory as well as subsequent theoretical reflections (Hannum, 2005; Wager, 2004)
3. A misconception of the ISD approach based on the simplified and literal interpretation (and application) of visual depictions of ISD models as pure linear procedures (particularly by novice instructional designers) (Dick, 1995; Martin, 2004; McCombs, 1986; Schiffman, 1995)

Efforts in translating learning approaches into prescriptive principles or guidelines for instruction will illustrate the pertinence of such approach (Ertmer & Newby, 1993; Greeno, Collins, & Resnick, 1996), even expanded also to include other perspectives such as hermeneutics, fuzzy logic, chaos theory and postmodern philosophy (Jonassen, Jo Hennon, Ondrusek, Samouilova, Spaulding, Yueh et al., 1997), the cultural studies, mainly in aesthetics (Parrish, 2005), semiotics (Bonnycastle, 2005), politics (Shutkin, 2005), and a special attention to 'motivation' (Main, 1993). This reveals that ISD is complementary and not concurrent with other approaches that focus or derive from different learning, knowledge and philosophical perspectives. More evidence comes from recent studies showing a real dialogue between the fields of research of the learning sciences and instructional design. Concrete links and complementarities have been put forward by Carr-Chellman and Hoadley in a special issue of Educational Technology (2004); moreover, a citation analysis (Kirby, Hoadley, & Carr-Chellman, 2005) of most prominent and representative publications of each field show that the connection between ISD and the LS is growing.

Based on the arguments and contra-arguments already presented, we do not think that continuing the 'attack on the ISD' approach is in any manner productive. Lessons learned from previous developments in models of instructional design point to the new models that allow for more flexible design and rapid prototyping, link knowledge and skill acquisition, provide enhanced support to the authoring process, and provide principled and effective use of ever emerging technologies (Gross et al., 1997). We estimate that new interpretations on what instructional design process models really account for, as well as an effort in inquiring the design activity, could lead to new findings and allow advancing the field.

Richey (2005, p.172) makes clear that "the use of an ID model calls for considerable interpretation and amplification to provide the detail required for specific applications". Andrews and Goodson (1980) explains that difficult balance between a model representation of the process and the actual process: as reality is overly complex and the model is a simplified version of it, "the fidelity of the model to the actual processes it represents will diminish as the specificity of the model diminishes" (p. 3). Bichelmeyer, Boling, and Gibbons (2006) explain how the ADDIE generic model, and by consequence, the ADDIE-like models, or better known of ISD variant models, are in fact "conceptual frameworks".

According to this notion of models as conceptual framework, from outside the specific field of instructional design, but within the field of design-related disciplines, Cross (2008; Cross & Roozemburg, 1993; Roozemburg & Cross, 1991) introduces a descriptive model of the design process that resumes a long lasting debate that echoes the one in the ID field: the rational versus the creative approach in the design process. After an analysis on both approaches, Cross introduces an 'integrative model' that subsumes the strength of both approaches and understandings of the design process. These poles have a lot of in common with Visscher-

Voerman and Plomp (1996) classification of problem-driven versus solution-driven models in instructional design.

The 'rational' perspective advocates for a model of the engineering design process as applied in the design of technical products (French, 1999; Jones, 1984; Pahl, Beitz, Felhusen, & Grote, 2007; VDI-2221-2222, 1993, 1997): It is a rational model that proceeds in a general systematic manner beginning with a first attempt of problem definition and decomposition. In this problem-to-solution path underlies the logic of analyses and synthesis. The design process is structured in two dimensions: the vertical dimension presents a set of stages (or phases) that correspond to the lifecycle of a product, and the horizontal dimension corresponds to the problem-solving process taking place in every stage. The vertical dimension is usually well described while the horizontal is not strongly represented and left to the designer, leading to unintended misinterpretations.

The 'creative' perspective adheres to a design process model as applied in architectural and industrial design: It is a heuristic approach to design based on conjecture-analysis, where the designer foresees and develops a preliminary solution that is analyzed, evaluated and corrected. This approach is solution-focused and based on the view of design thinking as "productive" instead of inductive or deductive, these two last appropriate to describe the evaluative and analytical types of a design activity (March, 1984). March bases his argument on Pierce's notion of 'abductive reasoning': "deduction proves that something *must be*. Induction shows that something *actually* is operative; abduction merely suggests that something *may be*." (Pierce, 1934/1960, Vol. 5, p. 171). The role of the ddesigner's own expertise and knowledge is put forward.

Both models present pros and cons: "a weakness of the engineering model is that it emphasizes problem-analysis and specification, perhaps at the expense of innovative solution-generation; and a weakness of the architectural model is that it emphasizes early solution-conjectures, perhaps at the expense of adequate problem clarification" (Roozemburg & Cross, 1991).

Cross (2008) advances a descriptive integrative model of the design process which takes into account that the designer explores and develops jointly problems and solutions. There may be a logical starting sequence of a minimal initial analysis understood as a first approximation to the problem. Even rudimentary and partial, it helps trace most evident constraints and acknowledges that design doesn't take place in the vacuum. This first portrait is often ignored and not made explicit because it is already internalized by the designer as part of its practice and knowledge of contextual constraints. The model also presents a hierarchical decomposition of problem into sub-problems and solution into sub-solutions. This simplified view tends to emphasize the dynamics and synchronicity between two poles that are constantly evolving and affecting one another. The anticlockwise representation of the movement within the model and the iterations between (sub)problem and (sub)solution, highlights the co-evolution aspects of the design process.

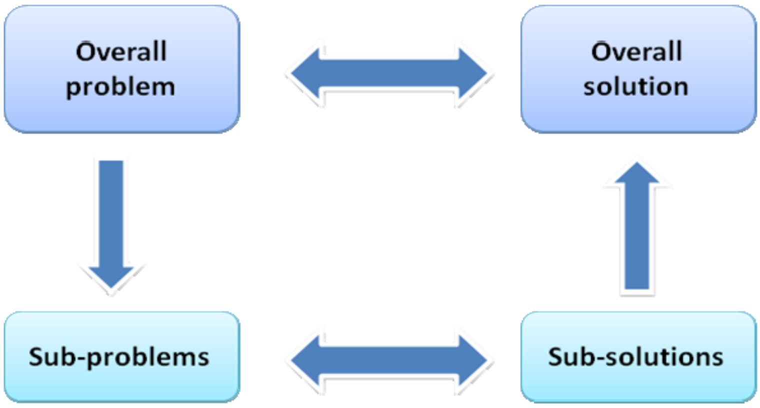


Figure 3-9. Integrative model. Adapted from **"**Engineering Design Methods: Strategies for Product Design (4th ed.)," by N. Cross, 2008. Chichester: John Wiley and Sons Ltd, p. 42.

This overall framework is highly abstract but tries to balance the importance of the analysis in the problem configuration and the nourishing aspects of creative expression in the design process. Design product must meet certain requirements and fulfills the user expectations, and all of that with a certain dose of amazement or curiosity to 'engage' the user.

We endorse a position where a "model" of design provides understanding of the double nature of the design process. At the same time, we acknowledge the need for a designer to count on more detailed specifications about the design process itself. Methods in design provide more detail and serve as operational tools that support and encompass the instructional design activity.

3.7 Models and methods

Although models provide intelligibility to the process of design, the design activity means doing and dealing with complex ill-defined problems subjected to evolving constraints. More specific guidance should benefit designers; particularly novice designers. Cross (2008) introduces another distinction very useful in the instruccional design field. The integrative model is mainly descriptive and conceptual. It pretends to explain the underlying logic of the design process and tries to endorse the double nature of design, as pivoting between rationality and creativity, problem and solution. A more comprehensive and clear set of procedures are required in order to better inform the designer on how to proceed. The author introduces the notion of "methods" as more prescriptive and detailed descriptions of procedures (also present in literature as activities, tasks, techniques, methods, etc.). The methods have in common two main features: "they *formalize* certain procedures of design, and (…) they *externalize* design thinking" (Cross, p.47). Formalization aims at avoiding oversights and overlooked factors at the problem definition stage, and widens the search for solutions by transcending a first spontaneous attempt to give a definitive answer. Externalization allows representing the thinking of solutions into concrete artifacts (drawings, charts, diagrams, etc.) of communicative and conversational power. "Design methods therefore are not the enemy of creativity, imagination and intuition. Quite the contrary: they are perhaps more likely to lead to novel design solutions than the informal, internal and often incoherent thinking procedures of the conventional design process" (p.48). Into the design methods the author mentions the creative and the rational methods: the first focusing in techniques for increasing the flow of ideas, removing mental blocks and widening the solution space (methods like 'brainstorming', 'synectics'-based on parallel analogies, 'random input'-an arbitrary triggering event, etc.), the second, supporting a systematic approach, intended to improve the quality of decisions and of the product. "Creative and rational methods are complementary aspects of the systematic approach to design. Rather than a straitjacket, they should be seen as lifejacket, helping the designer, especially the student designer, to keep afloat" (p.55)".

3.7.1 Instructional design and courseware engineering

As presented above, models in instructional design may serve different purposes and used in a variety of ways:

> For the most part, they create standards for good design, but there are other common functions. Frequently, they are used as communication tools so that one can visualize and explain an intended plan. They can serve as marketing devices and as project management tools. They also can play a part in theory development and in translating theory into practice (Richey, 2005, p.172).

But in general models are ill-equipped or represent high order descriptors of best practices, theoretical elaborations or processes. In great majority they represent useful organizers of the design activity, but they usually lack of enough additional recommendations and concrete specialized tools (hard and software) that assist the designer in the actual design of a blueprint and/or prototype.

The differentiation and correlation between models of instructional design and methods of design instruction has been tackled, at least in explicit and documented manner, by researchers from the field of instructional design acquainted with software engineering developments and by computer science specialists curious of the instructional design and the learning sciences fields. The common ground between instructional design and software engineering is clearly stated by Spector and Ohrazda (2004, p. 685):

> Merrill (1993, 2001) and others (e.g., Glaser, 1968; Goodyear, 1994) have argued persuasively that ID is an engineering discipline and that the development of instructional systems and support tools for instructional designers is somewhat similar to the development of software engineering systems and support tools for software engineers.

With the advent of computers and their ubiquitous adoption, the software engineering field was propelled to develop and challenged to respond to the explosive demand for software applications. The "processes" for developing software systems became the focus of attention. Well formalized methods began to emerge as a response to the need of more efficient cycles of development and team coordination. Software system development uses formal programming languages and developers built the system using standardized documents that describe the system expected behaviors together with the human supported activities.

The cumulated body of knowledge and expertise in the field of software engineering will nourish a way of understanding and undertake the "instructional design and development" process. Douglas (2006) highlighted the potential benefits of composing with both approaches:

> There is scope for instructional designers to use some of the body of research and experience in software engineering, especially as technology increasingly infuses learning systems. Goodyear (1995) and Bostock (1998) both refer to "courseware engineering," which represents the intersection of the fields of instructional design and software engineering. Other attempts to draw parallels between the two areas include Wilson, Jonassen and Cole (1993), who note how software engineering has largely moved away from the linear process model, still prevalent in instructional design, toward more iterative approaches utilizing prototyping (p. 28).

The term "courseware engineering" (CE) appears then with a double intention of, at the same time, approaching but differentiating the domains of instructional design from that of the software engineering (SE). De Diana and Schaik (1993) recognized that "SE and CE share an interest in developmental efficiency and in other aspects of the development process, for instance in design methods and in CASE [Computer Aided Software Engineering] tools (p, 191)." According to De Diana and Landhani (1998), CE may be understood both as practice and also as a research endeavor, giving then birth to an interrelated agenda of professional activity and scientific reflection:

> Courseware Engineering (CE) as a professional activity is concerned with the systematic design, development, implementation, use, and evaluation of courseware products. As a scientific field, CE studies the development, use, and evaluation of methods, techniques and tools for the design, development, implementation, use, and evaluation of courseware products. (p. 206)

Courseware engineering unveils itself at a first glance as a more technologic and formal approach, but it does not reduce to this framework. Goodyear (1995) highlights that the engineering approach: 1) is in contrast to the craft and artisan approach, 2) emphasizes the use of principled methods rather than intuition, 3) it values replicability of processes and results rather than idiosyncratic creativity, 4) due to the complexity of the product (system or learning material) there is a need for a multi-disciplinary team and thus it requires “shareable external representations of products and processes” (p.16) for team members’ communication, coordination as well as for quality control of the design process.

CE developed first with an attention on “automating” the design process and the delivery of instruction. Spector & Muraida (1997, p. 59) acknowledge the composite of the ID endeavor:

> The task of instructional design (ID) is complex for a variety of reasons. Designing student interventions that will be effective in stimulating recall of prior relevant knowledge, presenting new knowledge along with meaningful cues for storage and retrieval, constructing practice sets likely to enhance transfer of knowledge to future situations, and evaluating the effectiveness of learning are difficult and ill-structured problem-solving tasks. Complicating this already complex situation are a number of factors, including the following: (a) individual student differences, (b) variable instructional settings, (c) advanced instructional technologies, and (d) varying design goals and activities (e.g., intellectual skills, problem solving, etc.).

In order to be coherent with the complexity of human activity, especially in design activity, Goodyear (1994) claims that it is necessary to differentiate a ‘strong’ and a ‘weak’ definition of automation:

> The strong definition, takes automation to mean the replacement of human activity. The weak definition casts automation as support for a human agent, who is in control. It may be possible to reconcile these two views, by attending to the grain-size of the activity

> involved: replacing human agency in some sub-tasks of a process is a way of giving support. (p. 10-11)

Automating is perceived as an enhancer rather than a replacer of human activity, the aim is to support the design and development process in an 'intelligent' way. De Diana & Ladhani (op.cit., p. 206) explain that "authoring is still a human task based activity; authoring tools intend to support specific authoring tasks and authoring methods usually use task based scenario's or task (or action) based grammars (van Schaik, 1991) to describe (potential, intended, actual) behaviour of authors [designers]."

The automating trend allowed the emergence of a serious of CASE tools for development (authoring tools) and delivery (learning management systems). "However, although research has been done on automating analysis and design (Goodyear, 1997; Spector & Muraida, 1997), there are relatively few fully developed and widely used software tools in this category" (Douglas, 2006, p. 33).

Efforts in development of automation of instructional design (Uduma & Morrison, 2007, p. 537) "concentrated on the development of technological tools that would aid in the user's decision making and in the production of instructional materials. These efforts resulted in the development of job aids to support novice instructional designers in the military (Schulz & Wagner, 1981)." Kasowitz (1998) elaborating on the purposes of automated ISD tools differentiates four types of 'aid tools' that guide the instructional designers in through the process of creating instruction: (a) expert systems, (b) advisory systems, (c) information management systems, and (d) electronic performance support systems. Murray (2003) proposes 7 categories that cover a wider range, from design to implementation, and give account of advances in the field of instructional tutoring systems (ITS): curriculum sequencing and planning, tutoring strategies, device simulation and equipment training, domain expert system, multiple knowledge types, special purpose, and intelligent/adaptive hypermedia. These 'authoring' tools relate the design, development and implementation phases of computer-based instruction. Learning (content) management systems (LMS, LCMS) are another type of support tool for courseware engineering, focused mainly in the delivery phases, in the integration of the different components that make up a learning solution. Bajnai & Steinberger (2005, p. 168) explain that (bold is ours):

> Although LMS provide the courseware system engineer with a variety of predefined basic functionalities like file uploads, structuring of files to course structures, student administration, chat tools, forums or assessment tools they support only parts of the

> implementation process and the performing process of a courseware system. **Neither courseware system analysis nor design is supported by LMS**. In most cases also content authoring has to be done using other tools.

Courseware engineering is a strong attempt at 'tooling' the design and development activity. De Diana and Schaik (1993) offer a classification of the different artifacts involved in CE, from design to delivery: "tools for developing courseware are called authoring tools, such as programming languages, authoring languages, authoring systems, and authoring environments" (p. 199). Spector and Ohrazda (2004, p. 697) enlarge this toolkit to professional habits and formal procedures:

> CE is an emerging set of practices, tools, and methodologies that result from an engineering approach to instructional computing systems. An engineering approach is in contrast to a craft or artisan approach and emphasizes the use of principled methods rather than intuition; an engineering approach values the replicability of processes and results rather than idiosyncratic creativity.

This turn introduces, without neglecting the software development focus, a special attention to the methods applied in the design of leaning solutions, the *soften* side of the *soft*ware-system development. The 'design activity', the 'methods', the 'authoring languages' and the 'programming' languages become a field of research… and development.

In conclusion, the developments in courseware engineering offer to the instructional design field a way of thinking design in terms of a set of artifacts including: methods and techniques, languages for authoring and programming as well as software tools for designing, developing and delivering learning solutions. The CE also opens a door for "including" methods for supporting different approaches in teaching and learning and focus on rigor in processes, standardization of languages, documentation of procedures, computability of certain design procedures, and outcomes as well as shortcuts in the design-development-implementation phases.

3.7.2 Instructional design methods

Cebollero, Lamas and Dodero (2006) notice that research and development focusing on 'design methods' that consider software engineering as a reference does not abound. These "methods of information systems engineering suggest a methodological division of a system into modules, phases or stages in order to improve the learning systems development" (p. 573).

In the literature we have found two documented methods that interlace instructional design and software engineering approaches: the CEM (Courseware Engineering Methodology, Uden, 2003) and the MISA (French acronym for Learning Systems Engineering Method) method (Paquette, 2004). The developments of these methods follow general principles of software engineering, with a special accent on instructional design issues. Uden defines the CEM as a combination of different disciplines such as “instructional design theories, software engineering principles, human-computer interaction and multimedia” (Uden, 2002, p. 50). CEM follows the courseware engineering tradition but incorporates up-to-date developments and reflections from the software engineering approach: 1) a selected state-of-the-art techniques including object-orientation and use-cases, 2) guidelines and methods for hypermedia and interface development and 3) a model-driven approach where “each partial model is an abstraction of the system, which enables the designers to make the necessary decisions at each level in order to move closer to the final model” (op. cit., p. 52). Paquette (2004c) introduces the notion of instructional engineering in similar terms, except that in the definition the author refers to instructional design, software engineering and knowledge engineering. In this definition, interface and multimedia issues are not made explicit but addressed within the mentioned interrelated disciplines. In both approaches there are core common conceptual basis for describing the methods structure and dynamics, but they differ mainly in the way of decomposing the design problem and of organizing the different design tasks.

For the purpose of simplifying terminology and of differentiating this approach from ISD, we will refer to it from now on as ‘instructional engineering design’ (IED). While the term ‘design’ connotes the ‘creative’ aspects of the activity, the term ‘engineering’ compose with the developments in courseware engineering as a whole enterprise compromised with tooling the designer with a set of artifacts that support the design activity. The qualifier ‘instructional” is used to circumscribe the whole enterprise to the educational field, and to insert these developments as evolutionary aspects of the instructional design tradition. For principles of economy, we will refer to the methods that follow this approach to ‘instructional design methods’, understanding that the term ‘method’ makes reference to the engineering approach.

Instructional design methods present two main intersected dimensions that compose a matrix of horizontal problem decomposition and vertical learning system development. This double-entry matrix allows representing an intertwined approach that mixes a model-driven and an architecture centric process for composing with the instructional design artifact.

Software engineering models are abstractions of the solution to a problem (output). They represent components’ blueprints of the artifact to be built. This model-driven approach in software engineering methods adds a new dimension that goes beyond the pure procedural approach of design. It introduces a different decomposition criterion of the design process into design artifact functions, conveying with the layered view of design as expressed by Gibbons & Rogers (2009). The models' building is based on a series of 'techniques' that are specific guiding procedures. Model (layered)-driven design is a 'conceptual' point of view of the instructional design activity that decomposes the design problem into sub-problems that are treated independently but in imbricate fashion, as sub-solutions contributing to the overall solution.

Instructional design methods are also 'architecture-centric'. "The process focuses on the early development and baselining of artifact architecture. Having a robust architecture in place facilitates parallel development, minimizes rework and increases the probability of component reuse and eventual system maintainability. This architectural blueprint serves as a solid basis against which to plan and manage component-based courseware." (Uden, 2002, p. 53). This view supposes an iterative and incremental process of design. Incremental refers to "a process that involves continuous integration of components into the system's architecture to produce releases, with each new release embodying incremental improvement over its predecessor" (Booch, Rumbaugh, & Jacobson, 1999, cited in Uden, 2002, p. 53). Iterative incremental denotes a process "based on successive enlargement and development of a system through multiple development cycles [where] each cycle tackles relatively small sets of requirements, and the system grows by adding new functions within each development cycle" (op.cit.). Throughout the iterative and incremental process of design, the different models are refined and adjusted.

For an overview of the instructional design methods we have elaborated two graphical representations that illustrate the approach in the two variants mentioned above (see figures 3-10 and 3-11).

Once again, instructional engineering methods act as robust and well detailed organizers of the design activity. The (layer) model-driven approach emphasizes the multiple possible entrances to the design problem, where their relative independency makes it flexible and adaptable to particular situations as well as customizable to the design project specificities and constraints. The iterative and incremental architecture building highlights the back-and-forth movement between sub-problem and sub-solution, and the overall-problem and over-all solution of the design artifact blueprint or prototype.

The instructional engineering design adopts a systemic and back-and-forth problem-solution approach and provides a "set of artifacts" that support the designing of learning solution alternatives.

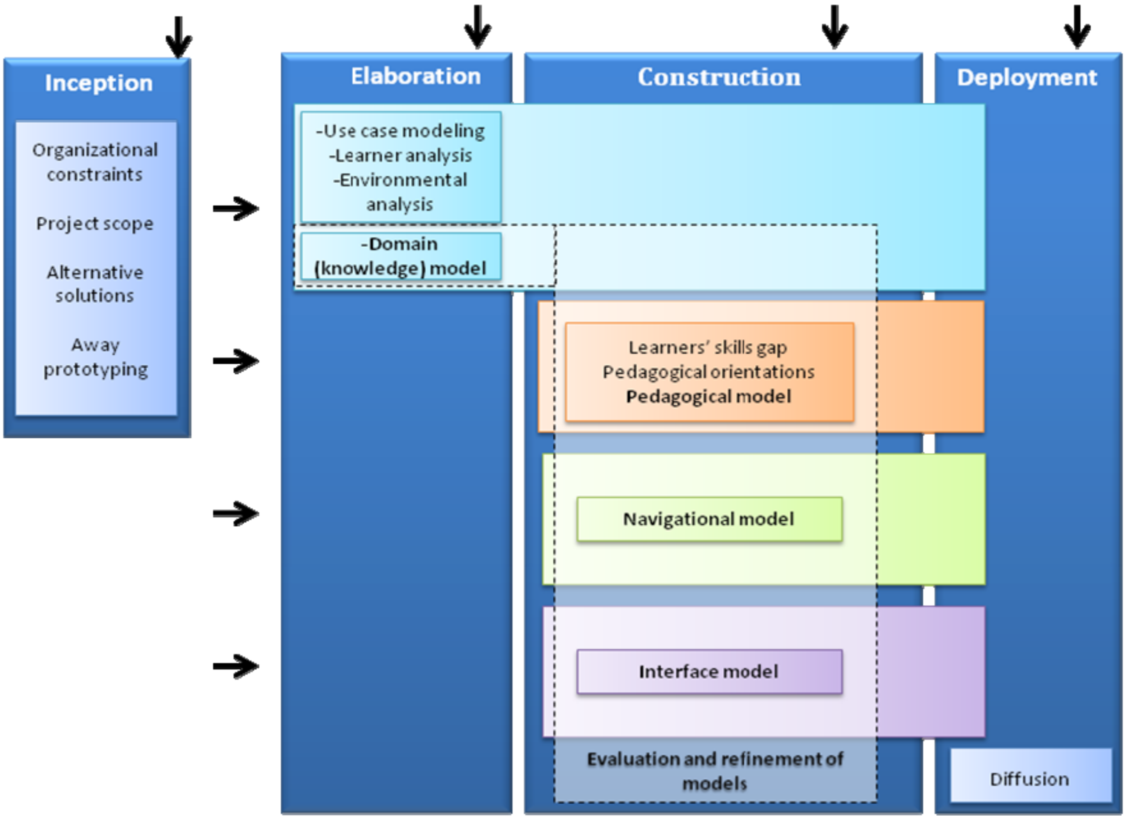


Figure 3-10. The Courseware Engineering Methodology (CEM)

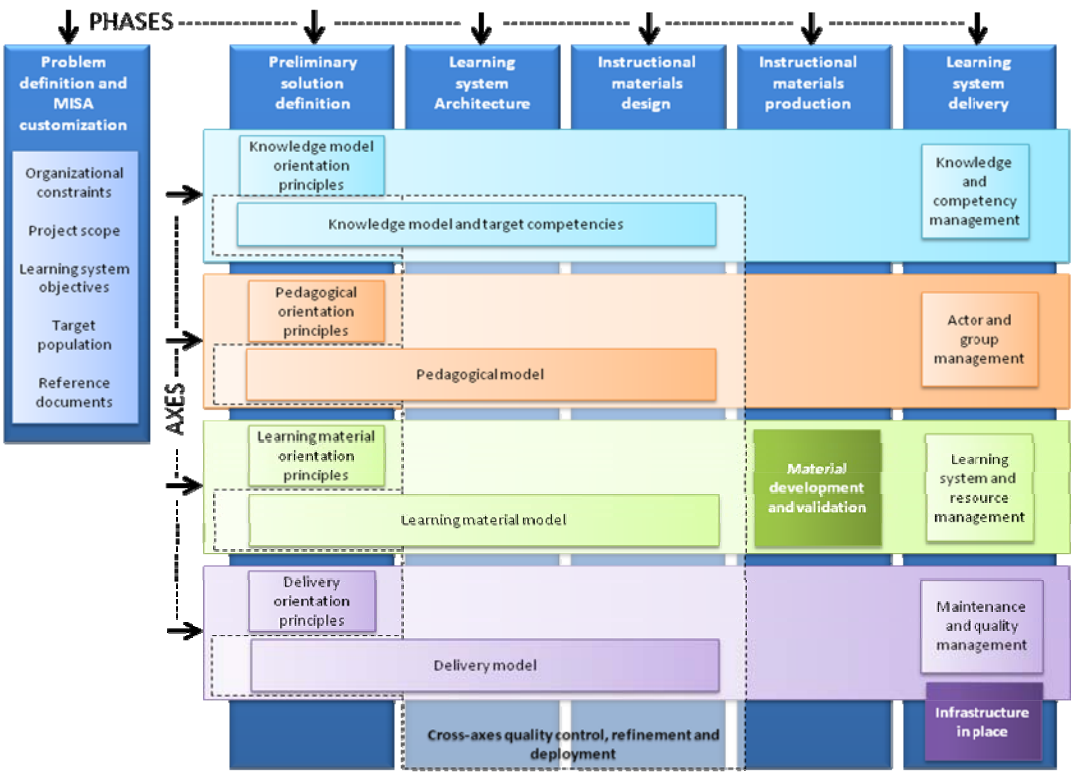


Figure 3-11. The Learning systems engineering method (MISA)

IED supports layered problem decomposition, specific techniques, process iterations, visual representational language, computability of design documents, and even ready-to-run learning systems. It results then in a merge-facilitator of design / development / implementation phases for testing and refining of the learning solutions, rejoining the rapid prototyping approaches (Li & Merrill, 1991; Rathbun, 1997; Tripp & Bichelmeyer, 1990). The instructional engineering design approach advocates for a more 'scientific' emphasis in the design of instruction, allowing integrating different local theories that inform each of the layers in with the design artifact is decomposed. It is also inclusive of the designers' expertise since it allows the eliciting of the tacit knowledge and their representation through the provision of formal languages coupled with notations system.

Towards DDR phase 2

The literature review and inquiry into design fields and theories allowed us to situate the instructional design activity in line with other design-related disciplines. The theoretical proposition of functional design aligns with developments in software-engineering-infused instructional design methods, also known as courseware engineering. Methods, even those of a prescriptive nature, can be seen as a support for the complex problem of design instruction. They usually provide tools to assist the designer in design practice, and (regarding our specific concern) conventional languages for externalizing, representing and sharing pedagogical know-how.

This first phase triggered the research in two ways: as a theoretical prerogative, finding explanatory frameworks to state the research validity; and as a technological pursuit, exploring instructional design formalized processes endowed with computable languages.

Chapter 4

Developmental grounding

On educational modeling languages and instructional design methods: MISA and IMS LD compatibility

(DDR Phase 2)

Chapter 4

Developmental grounding (DDR 2)

Overview of this chapter

In a previous chapter we have discussed the different notions of theory in instructional design. We have adopted the Gibbons proposition of a more general theory of instructional design as it applies in related design disciplines, and specifically defined this theory in terms of design layers and design languages. We have also discussed on the notions of models and methods and their relationships with the theoretical underpinnings.

As we stated in our research aim, we seek to develop a method for the creation of reusable and interoperable pedagogical scenarios. The following step in our research was to establish a rationale for a comparison of both the MISA instructional design method and IMS LD specification regarding the notion of pedagogical scenario, and to highlight what we found as a common ground for comparison. From a software development perspective, an ontological comparison (Paquette, 2004b) concluded that the underlying ontologies of both MISA and IMS LD shared a common perspective as they "put a strong emphasis on the representation of pedagogical methods [scenarios] enacted as processes" (p.18). Moreover, an exercise in transposition, by an expert researcher, of a MISA compliant instructional scenario into an IMS LD Unit of Learning (De la Teja, Lundgren-Cayrol, & Paquette, 2005) showed that "MISA is an ID method compatible with the IMSLD specification, because they share a lot of common conceptual elements permitting a harmonious binding" (p.13).

Based on the previous results, we carried out, in this developmental grounding phase, a complimentary analysis of MISA and IMS LD from an instructional design perspective, comparing them both as design languages (Rheinfrank & Evenson, 1996; Seo & Gibbons, 2003; Gibbons & Brewer, 2005) and identifying advantages and disadvantages regarding the potential support to the designer in the design activity.

We begin by introducing the MISA method and the IMS LD specification. We follow with an analysis of the MISA design language and compare MISA educational modeling language with IMS LD. Finally, we draw conclusions for the research continuity.

4.1 MISA: a learning systems' engineering method

The "learning systems engineering method" MISA (French acronym) is a concrete instructional design method based on the notion of instructional engineering, defined as: "A method that supports the analysis, the creation, the production, and the delivery of a learning system, integrating the concepts, the processes, and the principles of instructional design, software engineering, and knowledge engineering" (Paquette, 2004, p. 56).

MISA is the result of a series of research and development iterations through more than fifteen years at research center, LICEF (French acronym for Cognitive Informatics and Learning Environments Research Laboratory), of the Télé-université (Québec, Canada). Its development started in 1992 and the first version was released in 1994 together with a software support tool known as AGD (Paquette, Crevier, & Aubin, 1994). The method was applied by content experts and instructional designers, in nine organizations, and this implementation was subjected to a continuous process of validation (Crevier, 1996; Paquette, Aubin, & Crevier, 1999). The MISA method was developed in parallel with another tool for knowledge modeling known as MOT (Modeling with Object Types) (Paquette, 1996) that supports the design of some components of the learning system. These efforts concluded in versions 2.1 and then 3.0 of the MISA method, the latter including seventeen instructional design typologies (e.g.: knowledge models, taxonomy of skills, pedagogical scenarios, learning materials typology, and more) (Paquette, 1999; Paquette, Aubin, & Crevier, 1999; Paquette, Crevier, & Aubin, 1997). MISA was subsequently restructured, based on evidence from continuous feedback from its implementation, till the current version 4.0 released in 2001, where design tasks are distributed in six phases and four intersected axes (Paquette, 2001, 2002a, 2003, 2004).

The method has been and is being applied in universities[12], private and public companies[13] as well as in different organizations[14] that deliver education over the world.

[12] Télé-Université, Université de Montréal, Université Libre de Bruxelles, Université de Technologie de Troyes, Pontifícia Universidade Católica do Paraná (Brasil), Red de Universidades Nacionales de Chile (REUNA), UVirtual Chile), Universidad del Rosario (Colombia).

[13] Hydro-Québec, Tecsult-Eduplus, Is@li, U-Force/Netergy, ActivLearning, BFD Canada, Banque de Montréal.

[14] Défense nationale du Canada, Secrétariat international des infirmières et infirmiers de l'espace francophone, Dutch Police Education and knowledge Center, Collège communautaire du Nouveau-Brunswick, École de la fonction publique du Canada.

4.1.1 MISA basis

The MISA method builds upon four main bodies of knowledge and professional traditions:

- Instructional theories understood as conceptual and procedural frameworks that translate learning theories into concrete pedagogical scenarios, or in Gibbons (2009) view, theories that give shape to the conversational structures of an act of learning. The related theories are mainly exposed in volumes 1 to 3 of the "green books" of instructional design theories and models (Reigeluth, 1983, 1999; Reigeluth & Carr-Chellman, 2009).
- System theory, this taken from a systemic and sometimes systematic view of the process of designing learning systems as expressed in most of ISD models (Andrews & Goodson, 1980/1995; Gustafson & Branch, 2002).
- Computer science – software engineering methods: this discipline supporting the software life-cycle production, including the system documentation that describes its structure. It also adopts a systemic approach and provides tools for development, like methods and formal languages that compile with pure craft ways of designing learning solutions.
- Knowledge management and engineering: contributing to the system design understood as a knowledge-driven endeavor comprising techniques for knowledge eliciting, representing, communicating and computing.

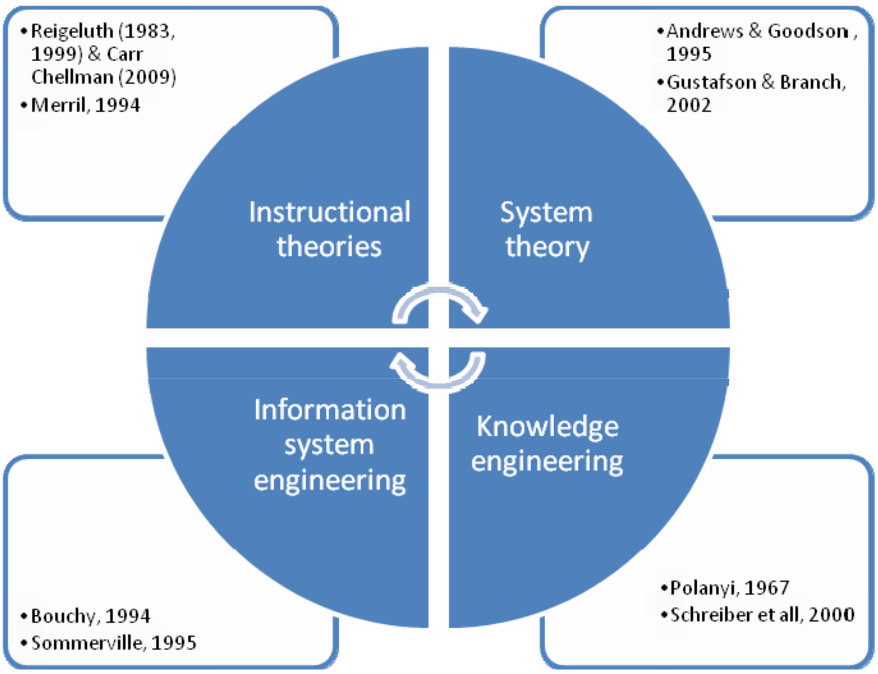


Figure 4-1. MISA theoretical and conceptual basis

4.1.2 MISA objectives

MISA addresses a series of issues that lay at the heart of the activity of designing a learning system:

- To systematize the engineering process without limiting the creativity inherent to the development of sound teaching strategies and effective media.
- To integrate the principles of scientific instructional design to the field of networked learning by broadening the focus of attention beyond the content and the learning materials to the pedagogical scenarios: the coordination processes between the actors involved in the learning situation and with all the available educational resources.
- To give structure and make explicit the instructional engineering process in order to allow the quality control of both the process and the outcomes.
- To maintain the overall coherence of the learning system between their main composing dimensions: content (knowledge and skills), pedagogy, learning materials and delivery options.
- To facilitate communication and consensus building among members of a design team through the integration of operating principles based on those of software engineering.
- To integrate knowledge modeling techniques into processes, products and operating principles.
- To facilitate the design of emergent or open learning systems allowing the building of personal learning paths either traced by the teacher or the students.
- To support the reuse of the whole or in part of the learning system in all dimensions that make it up.

4.1.3 MISA as a model and as a method

To illustrate the MISA method as a whole, a bird's-eye view first shows a "matrix" that guides the complex activity of instructional design. This high-level structure is composed of six phases of architectural development that intersect with four axes of model building. From this point of view, MISA is consistent with the notion of models in instructional design, understood as a "conceptual and communication tools that can be used to visualize, direct and manage processes for creating high quality instruction" (Gustafson & Branch, 2002, p. 1). However, again according to these authors, models also assist the designer in the selection or development of "appropriate operational tools and techniques." In a closer view, MISA reveals its strength as a "method"; it provides a toolkit for "handling" the design process, which includes a rich design language, together with well described design techniques and procedures as well as well detailed descriptions of a series of interrelated design documents that specify the decision making process and allow building a complete blueprint of the learning system. The MISA method is made up of 35 macro and micro design documents (Documentation Elements or DEs) that keep track of the design process.

MISA's vertical phases tackle the system design from an architectural perspective. A set of six "procedures" support the design of the learning system: the definition of the training problem, the definition of a preliminary solution, the building of a learning system architecture, the designing of the instructional materials, and the production and validation of the materials.

MISA's horizontal axes present an alternative and complementary building process of a layered decomposition of the design problem into knowledge, instruction, media and delivery issues. Each layer is part of the model-driven approach to building the LS: knowledge, pedagogy, learning materials, and delivery.

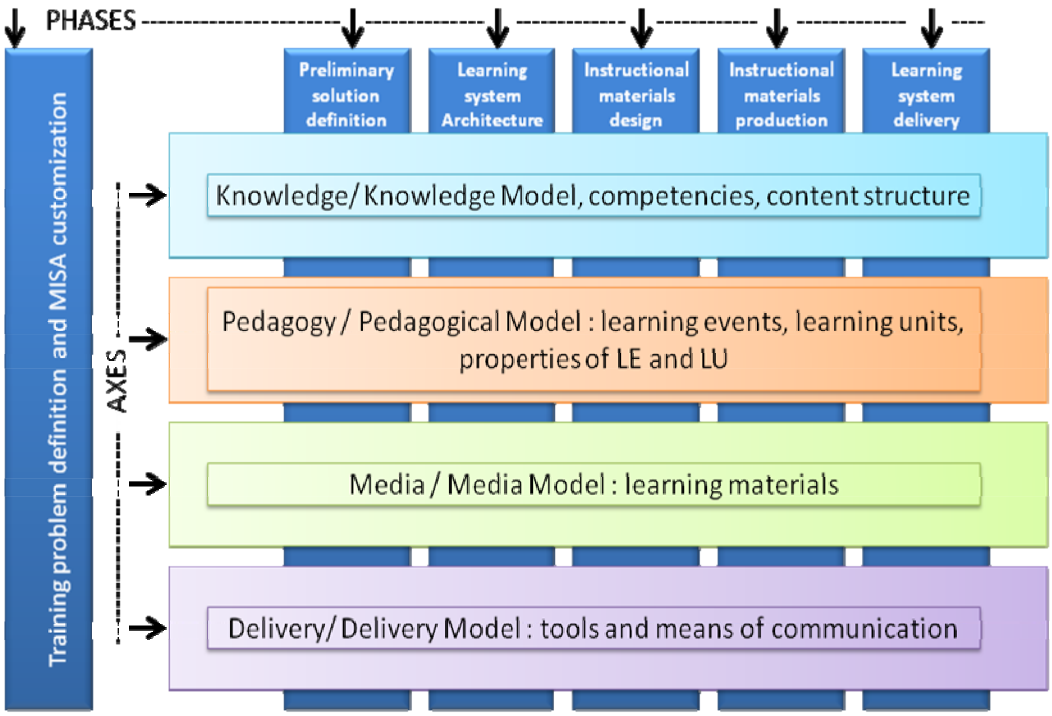


Figure 4-2. MISA matrix of phases and axis (simplified representation).

4.1.3.1 MISA vertical track: the phases

The MISA method entails a progressive, iterative and refining process of designing a learning system throughout six phases of development interlaced with four axes that decompose the design problem into four layers of concern. The phases are not strictly consecutives but they propose a logical incremental and in-depth learning system design process, allowing moving back-and-forth in order to adjust and arrange possible documentation elements mismatches or incoherence. The phases are as follows:

- Phase 1, “Define the Training Problem and Customize MISA”, is intended to produce a first definition of the aimed LS including a portray of the situation of departure in terms of resources, constraints, learners profile, etc. This phase also proposes making explicit the project expectations in terms of the learning content, the instructional approach, the technological means, etc. The project scope also allows the customization of MISA according to the LS specificities by the appropriate selection of the documentation elements. This task of applying customization principles in order to adjust MISA could mean skipping most of the tasks propose into the phase 1. Even though, the method recommends (at least) a draft, as each design project is subject to specific constraints that contribute significantly to shape the solution.
- Phase 2 , “Define a Preliminary Solution”, splits the design process into the four MISA axis, establishing knowledge, instructional, media and delivery orientation principles and refining and completing each axis’ documentation elements through constant crosschecking of the system-in-design coherence. The information generated and gathered makes it possible to analyse costs, benefits and impacts of the new LS. In this sense, the MISA method reveals the need for an early solution subjected to refinement which is coherent with the vision of a layered view of the design process (Gibbons & Rogers, 2009).
- Phase 3, “Build the LS Architecture”, deepens into the models of each axis and their integration, particularly associating knowledge units to specific pedagogical scenarios. In this phase the learning material model is also developed in much more detail, defining each learning material component. The same logic is applied in order to make explicit the specificities of the delivery model.
- Phase 4, “Design the Instructional Materials”, is concerned with the design of each learning material where the designer specifies the knowledge addressed in each one, and verifies their complementarities and their integration into the LS learning units.
- Phase 5, “Produce and Validate the Materials”, is concerned with the development of the learning materials, a process that is undertaken by technologists and developers monitored by the instructional designer or project manager. It includes the validation of the materials and the test of the delivery plan. The development team produces a prototype of a part or of the whole LS. This prototype is also a first delivery put to validation.

- Phase 6, “Prepare the Delivery of the LS”, deals with the implementation of the LS taking into account the inputs from the prototyping phase.

4.1.3.2 MISA horizontal track: the axes

- Within the knowledge axis are defined the knowledge to be acquired and the competences to be developed by learners. The concept of competence is expressed here in terms of knowledge, skills, and learning needs; moreover, a proposed typology of skills allows the integration of the cognitive, emotional, social, and psychomotor learning domains. This axis document information that is the basis for decisions taken later, when working on the other three axis that support the make up the learning system.
- Within the instructional axis is deployed the pedagogical scenario of learning events, the teaching and learning activities, the associated resources as well as the rules guiding the learning flow. Its creation is supported on a pedagogical inclusive technique that allows the expression of theory-informed and/or expertise-based instructional strategies.
- Within the learning materials axis is described the structure of the instructional resources at a macro level: They are outlined independently from the specificities added at the stage of micro-design by the specialists on each media/support. In this approach, reusability or repurposing of the materials is facilitated.
- Within the delivery axis all of the elements composing the learning system are organized according to a specific delivery mode (synchronicity, pace and tutor support). It covers the delivery infrastructure as well as the training management tasks and processes required to operate the learning system.

4.1.4 The phase and axe intersection: the documentation elements

The learning system blueprint is the main output of the MISA method. All along the process of progressing through the phases and/or developing the axis, a series of documents are produced to keep track of the process that shapes the LS. MISA involves the designer in up to 35 “intermediate” and “finalist” documents, which number may vary depending on the scope and specificities of the learning design project. These “documentation elements” (DE), as so called within the method, embody the LS specifications as well as record the on progress decisions of the designer. Each DE is identified with three numbers that refer to (from left to right): The phase, the axis, and the intersection point in an ascendant orderly manner, as more than one DE can be found in the intersections.

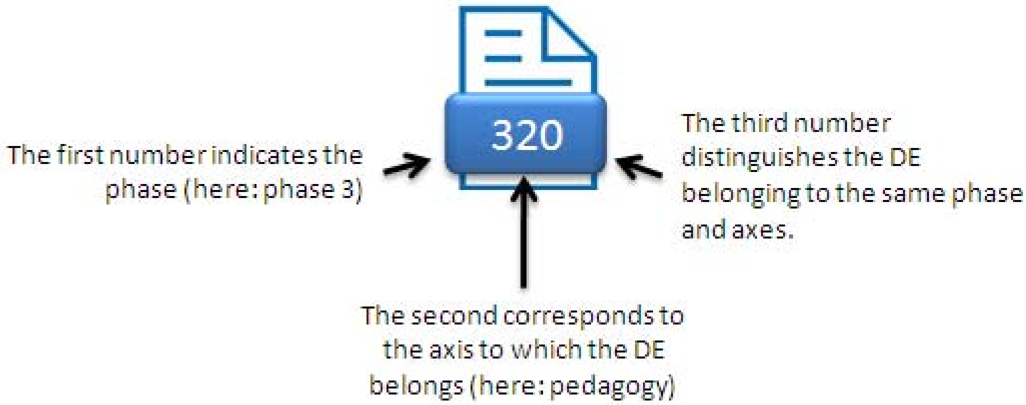


Figure 4-3. MISA documentation elements' identification

ALthough all of the documentation elements are somehow interrelated, some of them are more directly linked since the information gathered in one may propagate to the other unaltered (e.g.: the learning objectives, from the knowledge axis into the instructional one). Also, even though all of them can be modified and adjusted to keep coherence with new decisions taken overtime; some of them are explicitly presented as "expanding", meaning that special attention is required at different moments of the design process. This characteristic of the MISA method clearly states the recursive and refining aspects of the method.

Each documentation element is composed of attributes (or properties) with a specific value. To illustrate this concept: the attribute "title" can be assigned with a "specific title" (tile: The MISA method), or the attribute "mode of evaluation" can be described as "Formative, during activities". The documentation elements can be grouped by phase, resulting in a "record", or by axis, composing the axe "specification".

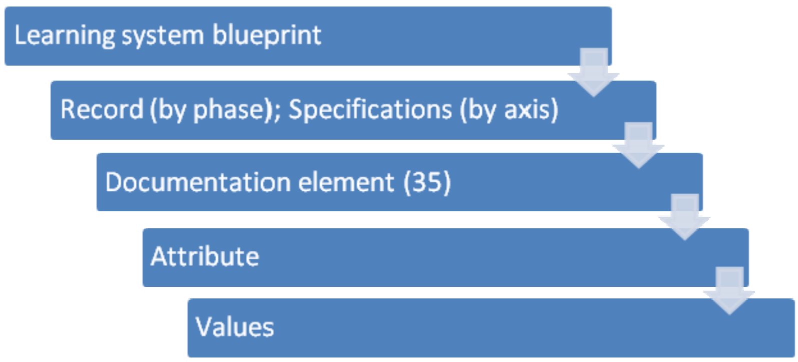


Figure 4-4. Hierarchical organization of information in MISA

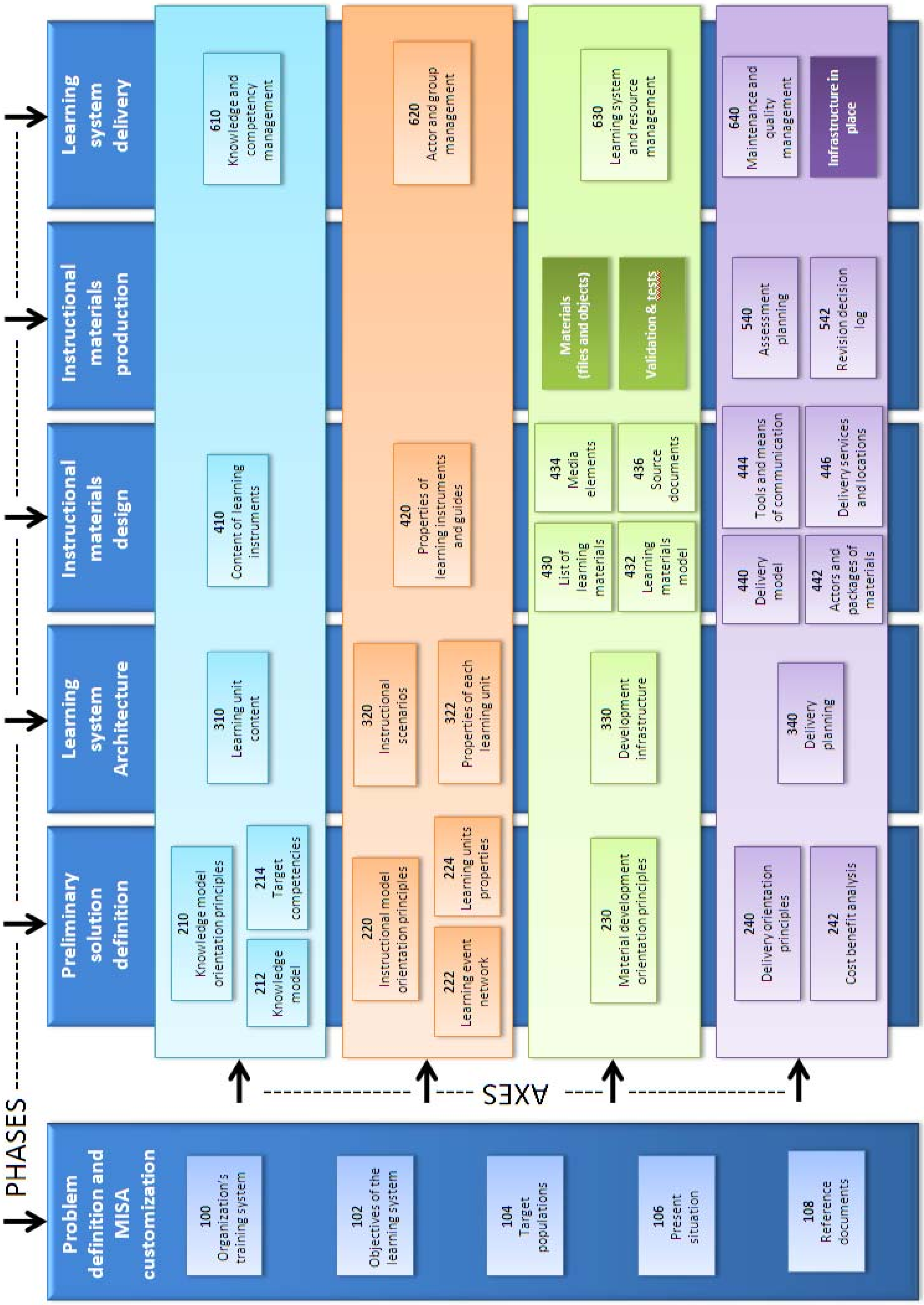
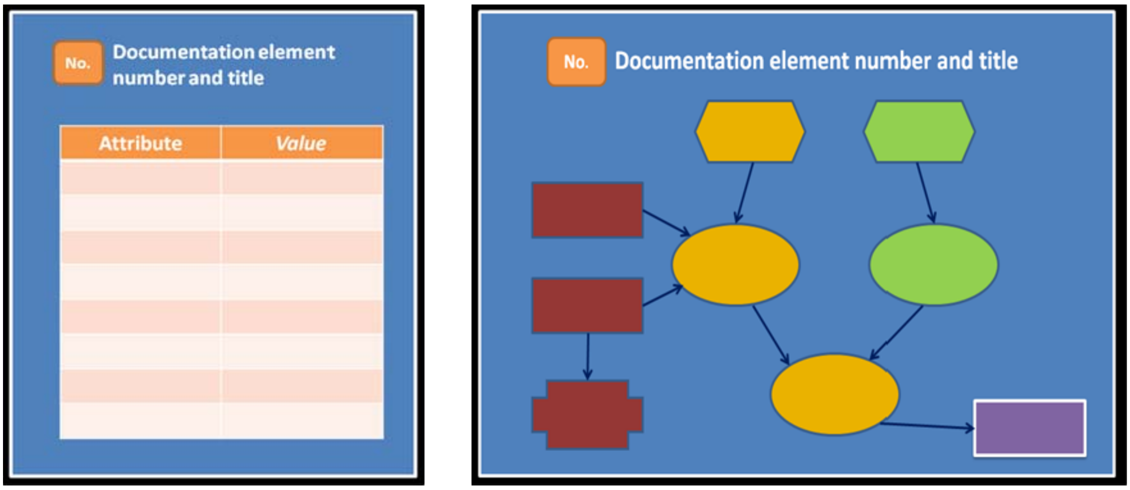


Figure 4-5. MISA documentation elements by axes and phases.

The Documentation Elements adopt two main shapes: forms and models. MISA is made up of 28 generic forms and 7 generic models. The final number of forms and models depend on the learning system itself and its complexity.



Form-based DE Model-based DE

Figure 4-6. MISA documentation elements basic shapes.

Each form is presented with a set of predefined attributes and some additional information that aims at guiding the designer on the kind of information to be declared (the "values of each attribute"). The name and number of attributes can also be customized according to the LS particular requirements and contextual constraints. For example, evaluation marks vary from on institution to the other, or typologies of activities may differ according to distinct authors or views. This form is a "suggested" formal representation that can be adapted to the designer (or design team) habits or routines (e.g.: instead of a form, a table or text, or even visual representations in some cases).

The models' design is supported by a set of interrelated artifacts: a generic visual language for model expression and representation (MOT language, see pages 116-119), a software tool for the models drawing and recording (MOT tool), and a specific technique for scaffolding each model building (knowledge, pedagogy, media, and delivery). A "technique" should be understood as a series of tasks and operations carried out in order to create a new, concrete artifact; this contrasts with mechanical production of identical deliverables. Techniques are likened to heuristic principles that support the execution of different procedures. A heuristic principle is not a deterministic rule that prescribes the proper way to proceed and guarantees success. Rather, it provides advice that will generally allow those who heed it to obtain satisfactory results (Paquette, 2002b).

4.1.5 Running the process of design

There are alternative ways to use MISA in specifics contexts, applied to concrete learning system design projects and according to the designer's preference and comfort. This translates in different design paths, one emphasizing the "phase" dimension, other focusing on the "axes" and a third, a hybrid approach pointing directly to the documentation elements themselves. The number of DEs to develop depends always on the design project itself. The MISA method is akin to a spiral problem-decomposing and pivoting problem-solution design process that benefits from successive iterations.

The chosen process paths are guided by operational principles that distinguish as follows:

- Adaptability principles, the hybrid path: the designer, at the onset of the project or once completed the first MISA phase, select a series of DEs considered relevant in accordance to envisioned learning system. It also customizes each DE deciding on the level of detail of each one of them (by selection, adding, and/or subtracting of attributes). These actions provide an individualized design path. For example:
    - An already existing course syllabus presenting content units and evaluation criteria, but lucking of a sound pedagogical strategy could focus on the Pedagogy axes by completing DEs 222-Learning event network, and 320-Instructional scenarios, as well as associated to these model-based DEs, the form-based DEs: 224-Learning units properties and 322-Properties of each learning unit.
    - A professor lecturing in a face-to-face mode could concentrate of the modeling of the knowledge avoiding most of the work from the rest of the axes.
    - The design of a new program requires a detailed completion of MISA phase 1. As a program usually comprises several courses, an effort in developing a macro knowledge model is also important as well as some general orientation principles covered in phase 2. Phases 1 to 5 will be more relevant in each course design.
- Progression principles, the phases' path: this approach is directly inspired from the software engineering methodology that works from abstract to concrete specifications. The starting point is an abstract definition of the LS at phase 1, more in term of requirements and constraints. During phase 2, the orientation principles and first models advance on temping a preliminary solution, yet incomplete and needing refinements. In the two subsequent phases, 3 and 4, the system adopts a more concrete shape as the definitions of the elements of the models are more precise. Phase 5 consists on the production of the leaning resources and

the actual learning environment, a prototype ready to be tested. Phase 6 plans the actual delivery of the educational piece to the students. A logical basis of required definitions and decisions prior to development of subsequent tasks guides the pass from one phase to the other (e.g.: cost analysis, content development before editing and printing). This project approach supports gradual rather than block building of the LS:

- Deliveries of the design process can be split according to the learning units (e.g. a first delivery of LU1, and a second of all the LUs), or types of materials (a first delivery of text and video based learning materials, a second delivery, the course website architecture, and a third delivery an integration of both). This approach facilitates teamwork.
- Orientation principles for each of the main models of the LS (EDs 210, 220, 230, and 240) ensures the coherence between them, besides their key role in clarifying intentions and facilitating communication between different design and development team project members.

- <u>Coordination principles, the axis' path</u>: these principles govern the interactions between the learning system documentation elements pertaining to the different axis. Even the four axes can be approached independently, it exists interdependency in terms that ensures coherence and quality control of the LS taken as a whole:

  - The Knowledge Model can be decomposed into sub-models, each of which is associated to a specific learning unit (the smallest learning event in an instructional structure: e.g. a lesson, where the biggest learning even is the course, the intermediate the module, and the smallest the lesson). This operation let define the content as well a targeted competences of the learning unit. The learning unit is in turn described as a series of learners and tutor activities that constitute the learning scenario.
  - The content of the each learning material of the Learning Materials Model is defined and described through the association of a Knowledge sub-model.
  - Within the learning scenarios, a sub-model of the Knowledge Model is also associated to each learning material, therefore defining their content.
  - The Instructional Model is coordinated with the Learning Material Model through the learning materials that are associated to activities composing the learning scenarios, thus adding a contextual dimension of their use.
  - The Delivery Model is coordinated with the Instructional and Learning Material Models through the resources identified in the Instructional Scenarios: tools, services, locations,

means of communication, etc. The materials defined in the media axis will be grouped into packages according to intended recipient and support medium. Instructional Scenarios will serve as a basis for defining tools, means of communication, and delivery services and locations. Finally, in order to be used, the various types of learning materials (in whatever support) and communication tools will require an infrastructure and a series of services to run properly. (Paquette, Léonard, De la Teja, & Dessaint, 2000).

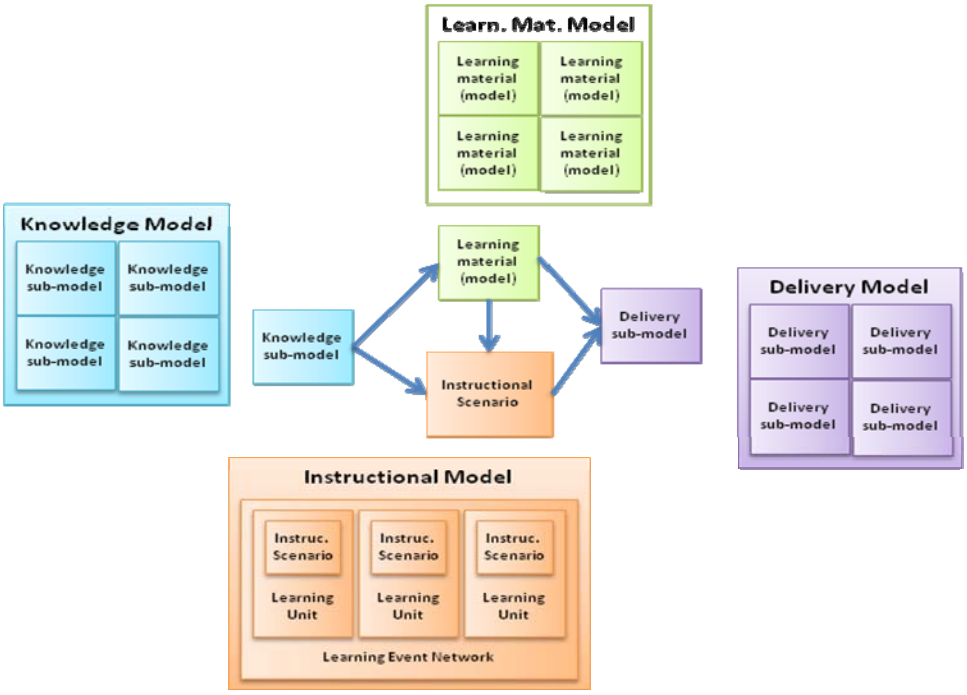


Figure 4-7. Coordination between MISA axes.

4.1.6 Understanding MISA instructional design language (IDL)

MISA is an established instructional engineering design method that since its creation has been subject to several minor improvements and adjustments in order to integrate technological innovations and support up-to-date professional practice. Even though, the MISA method and its instructional design language are previous to the emergence of the educational modeling language propositions and the learning objects paradigm, constituting a groundbreaker method into the instructional design field.

MISA's instructional design language (IDL) is actually a set of various languages that allow designing the 35 documentation elements, which span the design process and help build a learning system blueprint. The documentation elements come in two shapes: "forms" and "models."

Fields in the forms represent attributes or properties. Those attributes correspond to educational and instructional design elements. While some of them allow for open answers, others like the attribute “type” in the unit of learning form offer a closed set of values (example, exercise, simulation, etc.), imposing a strong semantics and allowing for consistency principles validation.

Some forms are directly linked to models, providing detailed information on model components, specificities, and interrelationships (e.g., a pair of consecutive activities, which is declared in the pedagogical “model,” is subject to certain rules detailed in a corresponding “form,” where information about duration, grading or other items is given).

The “models” are built with a common notation system called MOT (Modeling with Typed Objects) (Paquette, 2002, 2004a). Six types of knowledge can be used in the creation of the knowledge, instructional, learning material and delivery models. In the MOT notation system, each knowledge-type is represented by a different symbol: a rectangle for “Concepts”, an oval for “Procedures”, a hexagon for “Principles” and an irregular dodecagon for “Facts”; “Examples”, “Traces” and “Statements” are all instances (sub-types) of “Facts”. Six types of links (relationships between knowledge) can also be employed in the models: instantiation, composition, specialization, precedence, input-product (output), and regulation.

The MISA IDL is thus composed of:

- Terminology based on educational and instructional design literature and practices. The MISA method presents a glossary with 165 terms with their correspondent definitions. Even exhaustive, these terms do not comprehend the whole terminology. Many other terms not included in the glossary yet being part of the other two MISA method documentation, complete the MISA terminology: well developed taxonomies of skills, resources, learning scenarios, delivery modes, etc. as well as series of terms used to describe the properties and pertaining values of the DEs. For example, the skills taxonomy given for the knowledge model is a synthesis and integration of selected theoretical works from Bloom (1956); Krathwohl, Bloom, & Masia (1964) and, Romiszowski (1981); “resources,” used to carry out an activity and classified into “guides”, “instruments”, “tools”, etc., are another example of terminology relating to the pedagogical model, but based on practices, in this case.
- A syntax that regulates the building of each documentation element (forms and models): at a micro-level, regarding its attributes and corresponding values (values either from a predefined scale or more freeform), and at the macro-level, ensuring that the documentation

elements are bound together coherently, according to principles of progression between phases and coordination between axes.

- A semantics that emerges in each documentation element as an independent component of the learning system and as a part of the whole system, when one considers the semantic relationships between documentation elements.

- A common notation system that is used to create the four main models of the learning system, according to the the MOT a knowledge representation technique. This technique features a synthetic, abstract, economical and symbolic language for visual representation and linking of knowledge. The modeling techniques for each of the four main models (knowledge, instructional, media and delivery) prescribe how the language is employed. As MOT allows instantiations of general classes of knowledge for specific uses, all models share the same basic language (Stubbs & Gibbons, 2008).

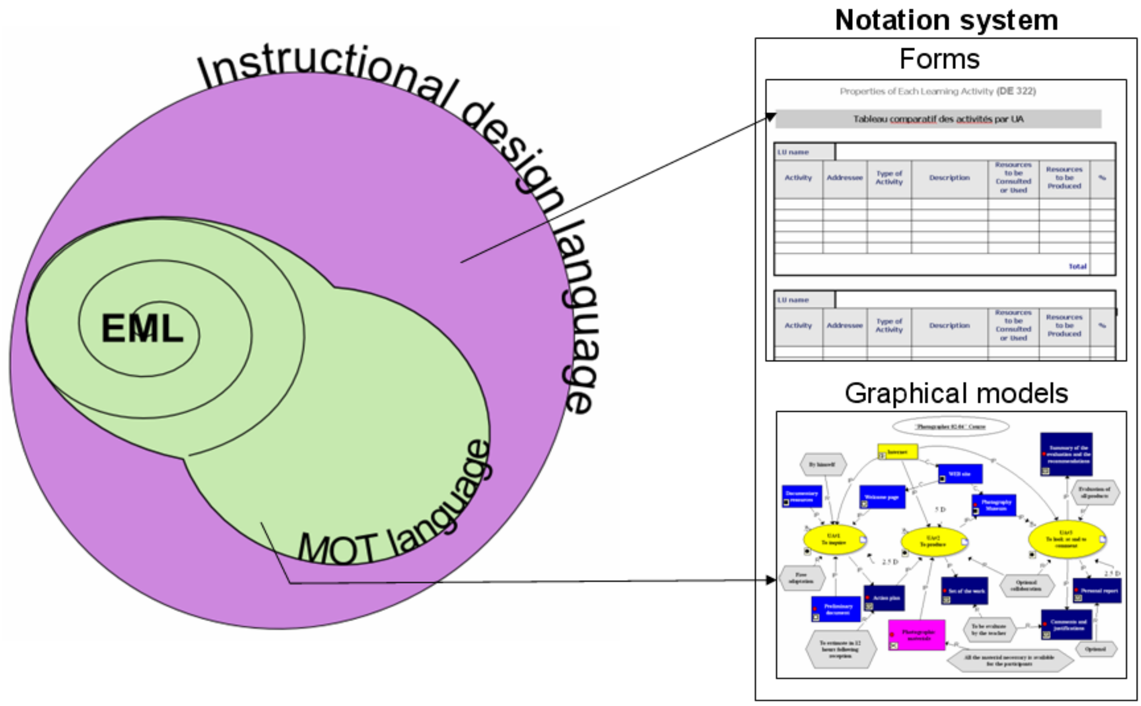


Figure 4-8. MISA instructional design language.

4.1.7 MISA modeling language and technique

The models built in MISA are supported on the knowledge representation technique called MOT, for Modeling with Typed Objects (Paquette, 2004). This technique proposes a synthetic, abstract, economic and symbolic notation system for knowledge representation and linking. For instance, MOT enables the instantiation of specific vocabulary applied in the building of the four main models of the MISA method: knowledge, instructional, media and delivery. MOT models *deal with knowledge broadly defined: not only factual and abstract knowledge, concepts, procedures, and principles but also the cognitive skills that are considered meta-knowledge. Indeed, anything that can be learned by humans, including cognitive, motor, or socioaffective skills, may be called knowledge* (Paquette, 2004. p.74).

4.1.7.1 MOT theoretical basis

MOT was built on the concept of schema as introduced in the cognitive sciences, the knowledge taxonomies from the educational sciences, and the collaboration and cooperation between agents as presented in different disciplines of the artificial intelligence, the software engineering and also the educational sciences (Paquette, 1996).

MOT proposes the creation of a series of graphical models based on the notion of schema and their suitability for graphical representation. In the shift of the psychology paradigm from behaviorism to congitivism, Jean Piaget (Inhelder & Piaget, 1958) is recognized as a pioneer theorist that introduced the terms *schema*, *scheme*, *structure*, *strategy* and *operation* to describe cognitive processes. The growth of the intellect is then based on the development of schemas increasingly logic, complex and growing in number. Gestalt psychologists as Wertheimer (1945) developed on the notion of entities, patterns and structure. Bruner (1973) advanced on the concepts of internal construction and knowledge representation while Newell & Simon (1972) proposed a rule-based representation of a problem solving activity. In the same line, Minski (1975) defined the concept of “frame” as an essential component for the understanding the perception, but also as a way to conciliate the declarative and the procedural views of knowledge. The work of Rumelhart & Ortony (1977) capitalizes on the previous developments classifying the schemas as: 1) a structure of mental data, 2) a representation of knowledge on objects, situations, events and sequences of actions (Anderson, 1985), 3) a scenario and, 4) a theory structuring the knowledge on a subject. Seen all together, these processes describe learning “as a schema transformation enacted by higher order processes, aiming at schema construction and reconstruction through interaction with the physical, personal or social world, instead of a simple transfer of information from one individual to another” (Paquette, 2007).

The declarative schemas structure the knowledge while the conceptual schemas establish the procedures or methods that organize information. A third category, the “conditional” or “strategic” schemas, proposed by Paris (1983), integrate a component that identifies the conditions and context needed for the selection of a sequence of actions or the selection of a concept. The schemas, whether conceptual, procedural or strategic, are well suited to graphical representation. MOT identifies the major schema components known as attributes, as well as the type of "value" that these attributes can take. These values are "concrete" values (a number, a color, a particular shape) or even other schemes.

The advancements into the research of the educational sciences distinguished different knowledge types. They are the building blocks of a schema that represents an instructional strategy which primary goal is to facilitate the acquisition of the knowledge covered by the learning piece. The MOT developers based their knowledge classification on the works of Merrill's Component Display theory (1994) and on Romiszwoski (1981), Tennyson & Rasch (1988) and West et al. (1991) knowledge taxonomies. While presenting some nuances with the taxonomies of Merrill or Romiszowski, those of Tennyson and West regroup the facts and concepts as "declarative knowledge", and the principles represent the "contextual knowledge" or "conditional knowledge". MOT proposes four categories of cores units: facts, concepts, procedures and principles. The schemas are used to describe these four types of knowledge in an integrated manner.

Finally, MOT creators wanted to integrate the collaboration and cooperation dimension to give account of the coordination of different agents when modeling a learning or performance support system. The works on the field on distributed artificial intelligence (Bond et Gasser 1988, Gasser 1991), on multi-agent cognitive or reactive systems (Ferber, 1994) and mainly the information system engineering and knowledge management methodology KADS[15] (Schreider et al, 1993) allowed the integration into the schema of the agent for task distribution and assignation.

4.1.7.2 MOT postulates:

- All knowledge can be represented as schemas able to contain the following knowledge types: facts, concepts, procedures and/or principles
- All the relationships between the different types of knowledge are connected through semantic links: instantiation, specialization, composition, precedence, input-product and regulation.
- All abstract knowledge (concepts, procedures and principles) may be instantiated to produce factual systems.
- All abstract knowledge (concepts, procedures and principles) can be hierarchically organized

[15] KADS : Knowledge Acquisition and Documentation Structuring

- The notion of process may be represented as knowledge of type “procedure” with input and product knowledge types; the main procedure may be decomposed into sub-procedures, linked between them by precedence links and containing principles controlling the passage from one to the other.
- The inputs and products of a procedure may be represented as facts or concepts depending on its degree of generality.
- The procedure control structure may be externalized as regulation principles or integrated into the procedure as a principle component (decision rule).

4.1.7.3 MOT primitives, syntax and grammars

Six types of knowledge and six types of relationships compose the MOT meta-language. The meta-language strength resides in its capacity to instantiate specific terms according to the intended design artifact. This meta-language enables to capture specific vocabulary from different sources and spares the designer the incorporation of new large vocabularies. For instance, this meta-language and coupled notation system supports the creation of pedagogical scenarios (instruccional model in MISA) according to different pedagogies.

The MOT meta-language enables in MISA the design of the knowledge, the instructional, the learning material and the delivery models. MOT notation system establishes a different geometrical figure for each knowledge type: a rectangle for the “Concept” type of knowledge, an oval for the “Procedure” type of knowledge, a hexagon for the “Principle” type of knowledge and an irregular dodecagon for the “Fact” type of knowledge. The “Fact” knowledge instantiates the other three abstract knowledge types and so for it decomposes into “Example”, “Trace” and “Statement” respectively.

Abstract knowledge	Notation system element
Concepts, or conceptual knowledge, describe the nature of the objects of a field (the “what”); they represent an object class through their common properties, each object of the class distinguishing itself from others through the values these properties take.	
Procedures, or procedural knowledge, describe the series of operations used to act on objects (the “how”); they are concerned with the action combinations that can be applied to several cases, each case distinguishing itself from the others through the objects to which the actions can apply and the transformations they undergo.	

Principles, or strategic knowledge, are statements that describe the properties of objects, to establish cause-and-effect links between objects (the "why") or to determine which conditions apply to a procedure (the "when"); principles generally take the form: "if condition X, then condition Y or action Y."	

Figure 4-9. Definitions and symbols of MOT knowledge types. Adapted from Paquette, 2004, pp 74-75.

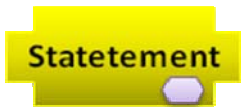
Facts	Notation system element
Examples are obtained by specifying the values of each attribute of a concept, obtaining a series of facts describing a very precise, concrete object.	
Traces are obtained by specifying the variables of each action in a procedure, obtaining a very precise series of particular actions called an execution trace.	
Statements are obtained by specifying the variables of a principle, thus obtaining cause-and-effect links among the particular properties of an object or among the properties of a particular object and a specific action to carry out.	

Figure 4-10. Definitions and symbols of MOT knowledge types. Adapted from Paquette, 2004, pp 74-75.

The model grammars let link these knowledge types through significant relations (Paquette, 1999) as follows:

- The **composition** link (C) connects a knowledge unit to one of its components or parts. Any object's attributes may be specified as a knowledge unit's components.
- The **specialization** (link S) connects one abstract knowledge object to a second one that is more general
- The **precedence** link (P) connects two procedures or principles, where the first must be terminated or evaluated before the second one can begin or be applied.
- The **input-product** link (I/P) connects a concept to a procedure, the concept being the input of the procedure, or a procedure to a concept which is the product of the procedure.
- The **regulation link** (R) is directed from a principle towards a concept, a procedure or another principle. In the first case, the principle defines the concept by specifying definition

or integrity constraints or it establishes a law or relation between two or several concepts. A regulation link, from a principle to a procedure or to another principle means that the principle exerts external control on the execution of a procedure or the selection of other principles.

– The **instantiation** (I) link relates abstract knowledge to a group of facts obtained by giving values to all the attributes (variables) that define a concept, a procedure or a principle, respectively examples, traces or statements.

The syntax of MOT modeling permits to combine knowledge and links types in the following manner:

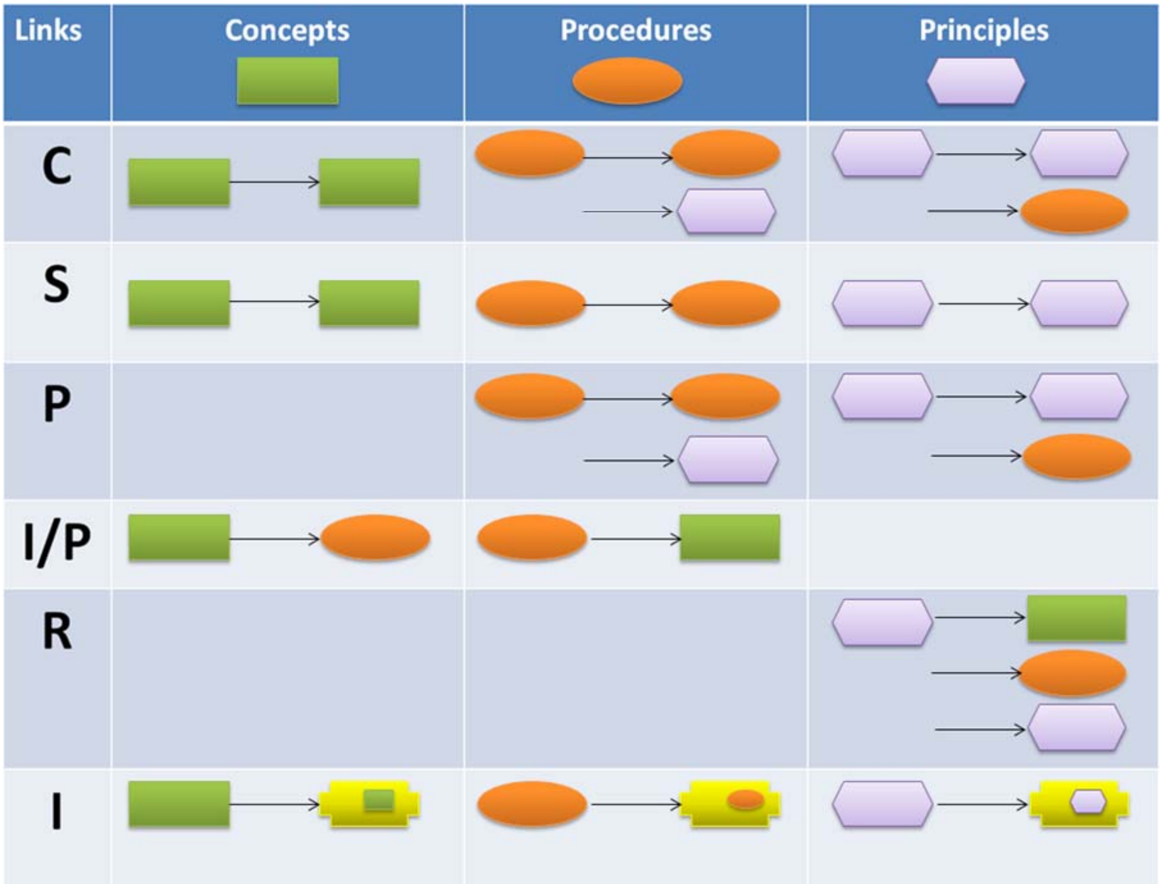


Figure 4-11. MOT syntax

As mentioned before, MOT notation system allows the expression of the four main models of the MISA method. For the purpose of this research, we will concentrate on the instructional axis within which an instructional model is defined. We will show how this axis particularly deals with concerns of the same nature as IMS LD, and we will establish a common ground from where it is possible to link both approaches.

4.2 Educational modeling languages and IMS LD

Gibbons and Rogers (2009a) present a theory of instructional design that decomposes the problem of design into subunits of artifact functionalities or layers of concern. Within layers operate a set of constructs selected on the basis of theoretical principles together with a set of design and development tools, and specialized design processes.

Design languages alongside with layers constitute the two main concepts of the authors' theoretical proposition. In a previous publication, Gibbons and Brewer (2005) mention different dimensions that allow the identification of design languages through the lens of their specificities. This classification includes the design languages standards intended for the reuse and interoperability of design objects. These standards are supported by international organizations like the Aviation Industry Consortium (AICC), the IMS Global learning consortium (IMS), the Advanced Distributed Learning initiative (ADL), and the IEEE Learning Technology Standards Committee (IEEE/LTSC).

Within the framework of our research we will focus on educational modeling languages (EML), and more specifically on IMS LD, an EML adopted as specification by the IMS Global consortium (IMS 2003a,b,c).

4.2.1 Educational modeling languages

The concept and first development of an Educational modeling language was brought up by the Open University of the Netherlands in 1998 with the intention to provide a way to codify units of study (e.g. courses, modules, activities). The EML defines in a formal manner a learning process understood as a set of activities for both learners and teachers, emphasizing the interactions among participants, the content and other resources used and developed, and the conditions under which the process is carried out. The EML has been designed to allow many different pedagogies to be expressed (Koper, 2001) in a unit of learning, allowing integrating learning objects with learning objectives, prerequisites, learning activities, teaching activities and learning services in a workflow.

From a pedagogical perspective, the concept of pedagogical (or learning) scenario corresponds to the EML unit of learning. A pedagogical scenario describes a process of interaction between teachers and learners within a specific social setting and learning situation. Each participant in their role performs a series of activities directed towards learning, using resources and evidencing acquired knowledge and competencies (Klebl, 2006). Formalized pedagogical scenarios are also interpreted as leaning flows, this concept emphasizing the description of the teaching-and-learning process on the basis of concepts of workflow management: actors, roles, goals, activities, resources, rules of progression, and outcomes (Karampiperis & Sampson, 2007; Marino, Casallas, Villalobos, Correal, & Contamines, 2006).

The EML is defined in more technical ways as "a semantic information model and binding, describing the content and process within a 'unit of learning' from a pedagogical perspective in order to support reuse and interoperability" (Rawlings, van Rosmalen, Koper, Rodríguez-Artacho, & Lefrere, 2002, p. 8). EML aims then at standardization and interoperability. This approach focuses attention on the 'computable' side of a design language and its capacity to run in different systems:. EML's modeling is focused on two different issues: (i) the elements involved in a unit of learning (e.g. persons, artifacts, goals) and (ii) the coordination mechanisms required to achieve that such elements interact in certain ways (e.g. sequencing of activities, assignment of persons to goals) Cairo-Rodríguez et al. (2006).

The interest in EML is revealed through several developments that have been documented: OUNL EML (Open University of the Netherlands) (Hermans, Manderveld, & Vogten, 2004), PALO (Rodríguez-Artacho & Verdejo Maíllo, 2004), E2ML (Botturi, 2006), coUML (Derntl & Motschnig-Pitrik, 2008), poEML (Caeiro-Rodriguez, Llamas-Nistal, & Anido-Rifón, 2006), and CPM (Nodenot & Laforcade, 2006).

Since the end of the 90s, many publications and conferences have helped to disseminate the research related to the educational modeling languages. The research focuses on language development, tools supporting the declaration of reusable scripts and environments that can run pedagogical scenarios by making them interoperable. For mentioning the most relevant: specials issues of *Journal of Interactive Media in Education*[16] (2005, vol. 1) and *Journal of Educational Technology & Society*[17] (2006, vol. 9, no 1); some volumes compiling state of the art of the research and development like the *Handbook of Visual Languages for Instructional Design: Theories and Practices* (Botturi & Stubbs, 2008); the *Handbook of research on Learning Design and Learning Objects: Issues, applications, and technologies* (Lockyer Bennet, Agostinho, & Harper, 2008); and also chapters in the *Handbook of Research on Educational Communications and Technology* (Spector, Merrill, van Merrienboer, & Driscoll, 2008) as well as the *Handbook on Information Technologies for Education and Training* (Adelsberger, Kinshuk, Pawlowski, & Sampson, 2008).

16 Journal website: www-jime.open.ac.uk
17 Journal website: www.ifets.info

4.2.2 IMS LD specification

The IMS Learning Consortium, an international organization dedicated to learning standards, officially adopts in 2003 the OUNL EML proposition and publishes it as the IMS LD specification (LD, for learning design) (Koper & Marderveld, 2004). This recognition pursues wide acceptance of the specification in order to assure interoperability of the pedagogical scenarios.

IMS LD becomes then a leading specification (Koper 2005) within the learning object paradigm that breaks with the content chunk dominant Learning Object approach. IMS LD is built upon a theatrical metaphor. According to the specification developers, every learning situation can be seen as a theatrical play where actors (teachers and students) perform their role (activity), use learning resources (learning objects) and follow a script (pedagogical method). This metaphor is used to outline a generic pedagogical meta-model, which enables the expression of many different pedagogies. The meta-model is intended for supporting interoperability of the pedagogical scenarios or Units of Learning, as named within the IMS LD terminology. IMS LD primary purpose is “to be used as an interchange specification that enables the storage and transfer of units of learning between e-learning systems” (Caeiro-Rodríguez, Llamas-Nistal, & Anido-Rifón, 2005, p.1).

IMS LD documentation has been published by the IMS Consortium. The three documents explaining the specification are available through the organization’s website: “IMS Learning Design Best Practice and Implementation Guide” (IMS, 2003a), “IMS Learning Design XML Binding” (IMS, 2003b), “IMS Learning Design Information Model” (IMS, 2003c).

The theatrical metaphor serves to explain how a *play* unfolds, but also how different representations of the *play* may be supported. In the same way that a theatre play can be staged with different actors, in different theatres with alternative props, a UoL can be run with different learners and facilitators, on different systems, with alternative learning resources or tools.

The *method* is the main element of the UoL (or pedagogical scenario) and is designed to meet the *learning objectives* and *prerequisites* (knowledge and/or competence level of entry) that must meet the learners in order to efficiently participate of the activity.

Following the theatrical metaphor, the *method* (see figure 4-15) consists of one or more <u>concurrent</u> *play*(s) which in turn break down in one or more <u>sequential</u> *act*(s). Each act is related to one or more <u>concurrent</u> *role-part*(s), each of which associates exactly one *role* with one *activity* or *activity-structure* (a group of activities nested into one). The *act* is ‘completed’ after all its activities have been completed or by a pre-established time limit. Then, another act may be initiated. The *play* is completed once all the acts have been completed.

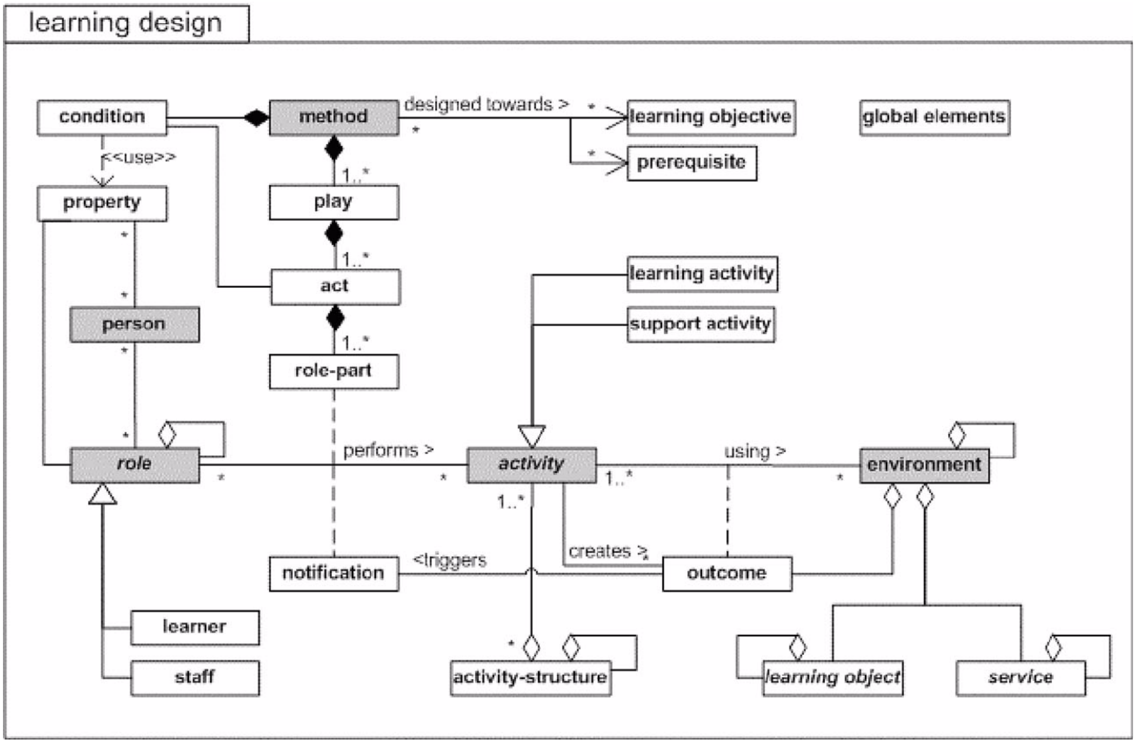


Figure 4-14. Conceptual model of overall Learning Design (gray coloring is only used to increase the readability). From "*IMS Learning Design Information Model* (Version 1.0 Final Specification)" by IMS Global Learning Consortium, Inc., 2003c, p.10.

The *activity* describes a task expected to be done within an *environment* that provides *learning objects* (learning resources) and *services* (e.g. communication tools). The *role-part* associates an activity to the role that should play it (do it). According to the theatrical analogy, "the assigned *activity* is the equivalent of the script for the part that the role plays in the act, although less prescriptive" (IMS 2003c, p.11). *Activities* may include, for example, discussing with classmates around a subject. If there is more than one *role-part* within an *act*, these run in parallel (e.g. a learner may play, within a discussion forum, the role of a 'participant' and that of the 'moderator'). An *Activity-structure* aggregates a set of related activities into a single one, which can be associated to a role in a role-part. *Activity structures* can be assembled as either in a sequence or a selection (e.g. the learner can decide the order in which perform the activities).

The IMS LD conceptual model shows three levels of semantic aggregation.

- Level A contains the bulk of the IMS LD constructs, including the *method*, *play(s), act(s), role(s), activities/activity structure(s), environments* (pointing to *learning objects* and *services*). Since IMS LD clearly separates the approach to learning from the actual *learning objects* (LO) and *services*, reusability opportunities are raised. The structure of a UoL (e.g. deploying the skeleton of activities for solving a case study) may be applied to different domains, and thus, referencing different LO. In the same way, the *services* will be adapted to the specific features of a learning management system where the UoL is run (e.g. a forum in Moodle, in Sakai or in Blackboard).

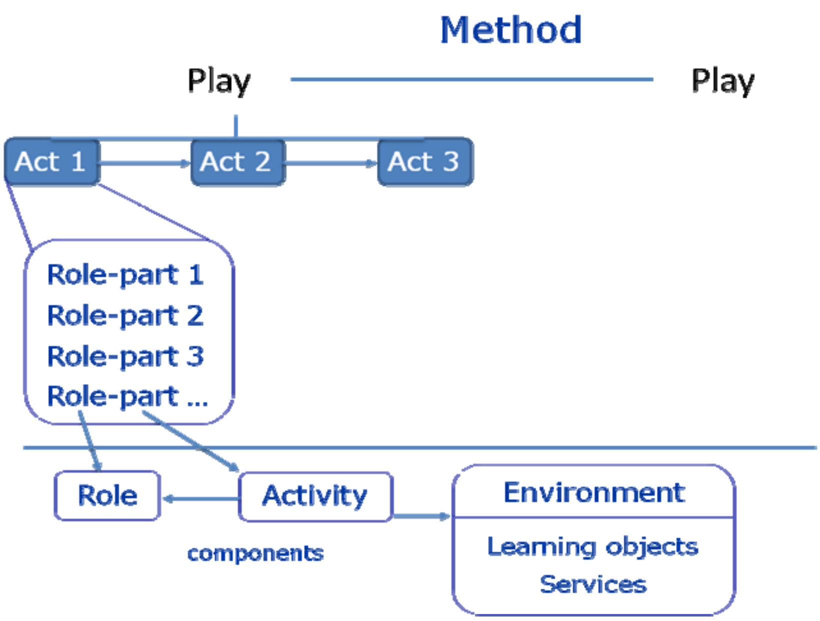


Figure 4-15. Relating the learning flow to its constituent components. Adapted from "Learning Design Specification" by B. Olivier, and C. Tattersall, 2005. In R. Koper & C. Tattersall (Eds.) "Learning Design: A Handbook on Modelling and Delivering Networked Education and Training", Berlin Heidelberg: Springer-Verlag, p.29.

- Level B adds *Properties* and *Conditions* to level A, enabling personalization and more elaborate sequencing and interactions based, for example, on learner portfolios. Properties can be used to direct learning activities as well as record outcomes. "Properties may be internal (local) or external (global). They are used to store information about a person, such as test results or learner preferences; a role, such as whether the role is for a full-time or part-time learner; or a learning design itself. Internal properties persist only during a single run of a learning design, while external properties retain their values beyond the end of a run, and can be accessed from different runs and/or different learning designs. Currently the reuse of external properties is confined to the learning design author or to agreed usage within a community or institution." (Jeffery & Currier, 2003, p.1)

- Level C adds notifications to Level B. A notification (messaging) is triggered automatically in response to a given event in the learning process. It can make a new activity available for a specific role to perform. "For instance, a teacher may be notified by email that an assignment has been submitted and needs marking; once the score has been posted, the learner may be notified to undertake a new activity according to the result." (Jeffery & Currier, 2003, p.1).

4.3 A gateway between MISA and IMS LD

A first study conducted from a software engineering approach concluded that the underlying ontologies of MISA and IMS LD share a common perspective as they both strongly emphasize, "the representation of pedagogical methods [scenarios] enacted as processes" (Paquette, 2004b, p.18). Moreover, an exercise in transposition, by an expert researcher, of a MISA compliant pedagogical scenario into an IMS LD Unit of Learning (De la Teja, Lundgren-Cayrol, & Paquette, 2005) showed that « MISA is an ID method compatible with the IMSLD specification, because they share a lot of common conceptual elements permitting a harmonious binding » (p.13). Based on the previous results, we carry out a complimentary analysis of MISA and IMS LD from an instructional design perspective, comparing them both as design languages according to the notions developed by Gibbons and Brewer (2005).

4.3.1 The MISA pedagogical scenario: an instructional axis concern

Looking at MISA from the horizontal perspective, we can distinguish four axes or layers. Each axis comprises several DEs that make up an *axis specification,* i.e. one or more graphical models together with a few templates that describe the properties of the objects represented in those models (figure 4-5).

As mentioned above, an axis specification comprises all the DE of the axis. The instructional specification (figure 4-16) includes thus the **Instructional Model,** which represents the learning and instructional approach, and identifies the materials and tools required by this approach. The ***Instructional Model*** is composed of the ***Learning Event Network,*** or LEN (DE 222), and of ***Instructional Scenarios*** (DE 320) (see figure 4.5).

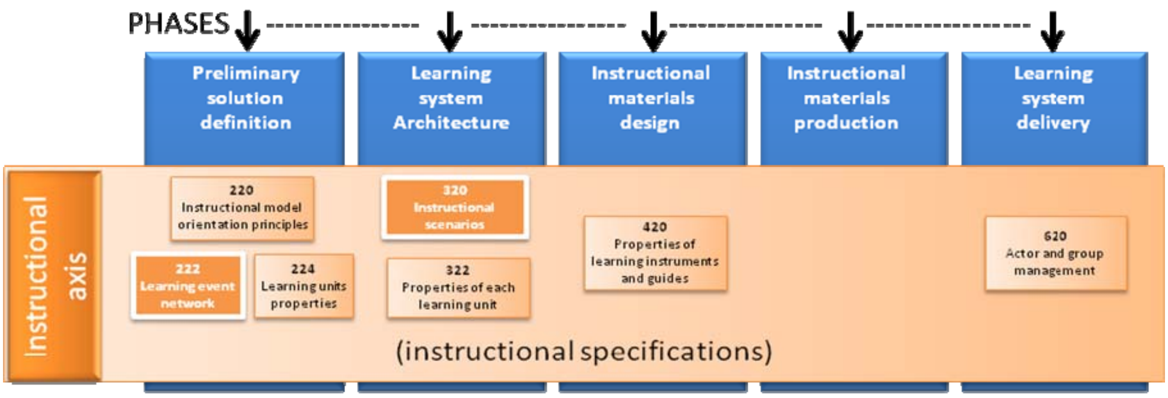


Figure 4-16. Instructional Axis: Documentation Elements making up the axis specifications

Pedagogically speaking, DE222, the Learning Event Network, LEN, deploys an ***instructional structure***, which is a structure of learning events that shapes the curriculum/syllabus-related hierarchy (program, course, module, lessons, chapter, unit, etc.) depending on the degree of granularity of the Learning System being designed. DE320 constitutes the ***instructional scenario*** that articulates the learner/support activity flow together with needed resources.

MISA Learning Event Network (DE222) is the "**instructional structure** of a learning system (LS) consisting of several learning events (LE). The links between them suggest the most efficient way to progress through the LS by specifying rules of advancement" (MISA Glossary, p.26). MISA does not limit the number of LEs, neither horizontally (on the same level) nor vertically (from one level to the next). As mentioned above, the LEN limits itself vertically when the LE (part of a curriculum/syllabus structure) can only be decomposed as a learning scenario describing learner/support activities or, in MISA terms, a learning unit (LU).

In MISA the LEN and the instructional scenarios are connected through the LEN's smallest learning event, also known as "learning unit" (not to be confused with the UoL in IMS LD). The learning units cannot be broken down but through instructional scenarios. The MISA Instructional Scenario (DE320) is a "component of a learning unit (LU) […] that consists of a learning scenario proposed for the learner and a scenario of assistance designed for tutors/teachers/coaches […]. Modeling an educational scenario consists in specifying the activity or activities appropriate for the learner and the assistance, including all the resources required to complete these activities as well as the productions resulting from these activities"(Glos, p. 23). Each instructional scenario (in the form of a model) structures learner/assistance activities together with the required resources and makes explicit the rules guiding the learning flow. Instructional specifications also include the Learning Unit Properties (DE 224), the Properties of Each Learning Activity (DE 322) and the Properties of Learning Instruments and Guides (DE 420) (see Appendix 4-A for the details of documentation elements enunciated here).

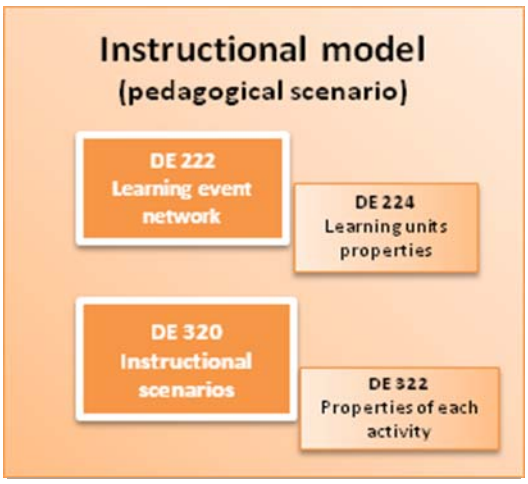


Figure 4-17.MISA Instructional Model (pedagogical scenario) documentation elements

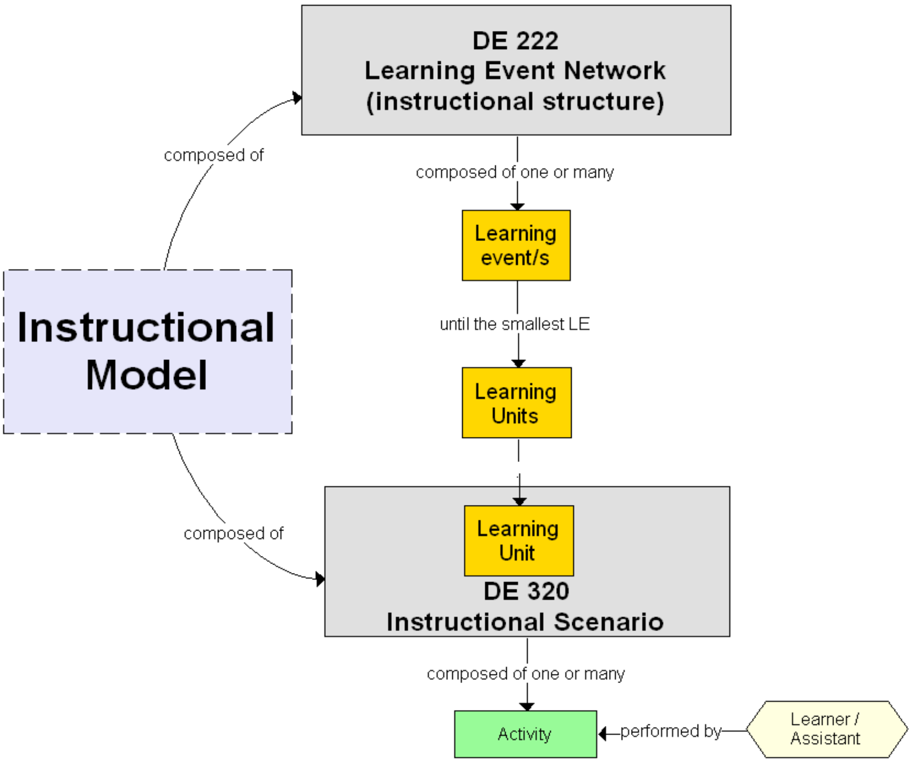


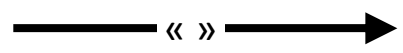
Figure 4-18. The MISA instructional model (pedagogical scenario) granularity

4.3.2 Instructional model and MOT notation system

The Instructional Model meta-language and corresponding visual notation system is instantiated with specific terms that are meaningful to the designer. Some concrete terms are suggested by the MISA language (i.e. a taxonomy of resources: guide, instrument, production, service, location, tool, means of communication, production)

Table 4-1
Basic elements of an instructional model explained

Abstract knowledge	**IM notation system**	**IM meta-language**	**IM suggested terminology**
Procedure		Learning Event Learning Unit Activity	Model granularity: no imposed taxonomy (suggested: Romizwoski ….)
Concept		Resource	Resource taxonomy

Abstract knowledge	**IM notation system**	**IM meta-language**	**IM suggested terminology**
Principle		Rule Actor	Rule taxonomy Actor, no imposed taxonomy. Suggestions based on type of scenario, pedagogical strategy, instructional model, theory of instruction applied
		Link	instantiation composition specialization precedence input-product regulation

With a composite of only four different typified graphical forms it is possible to build concrete instructional models. In the following graphic we present an example of MISA instructional model (LEN and IS) visual representation (for illustration purposes only) composed of: one Learning Event, two Learning Units, two activities assigned to the learner and the tutor respectively and where we have identified a Resource and an Outcome (or Product). We complete the pedagogical model with a Rule governing the first Learning Unit.

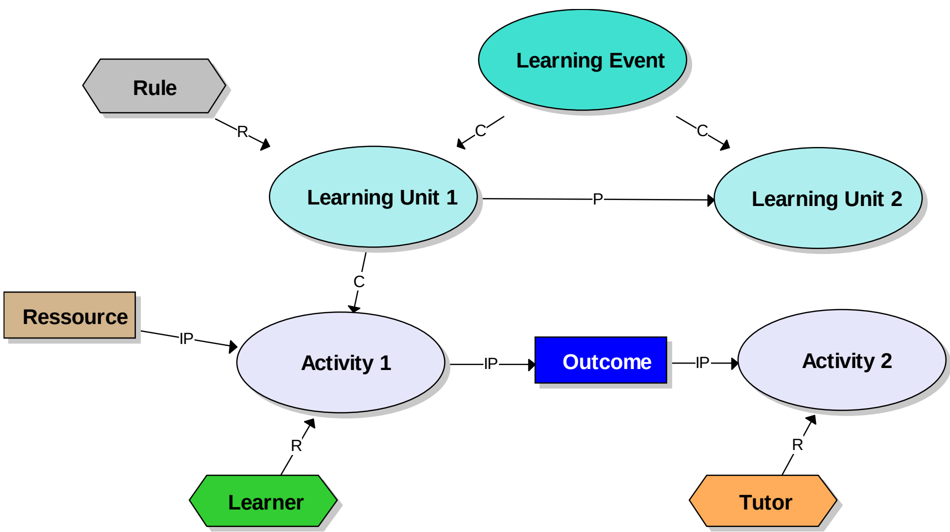


Figure 4-19. Basic elements of an instructional model (modeled in MOT editor)

The figure below illustrates in a layered fashion the relationship between the MOT language primitives and the concrete instantiations into an instructional model.

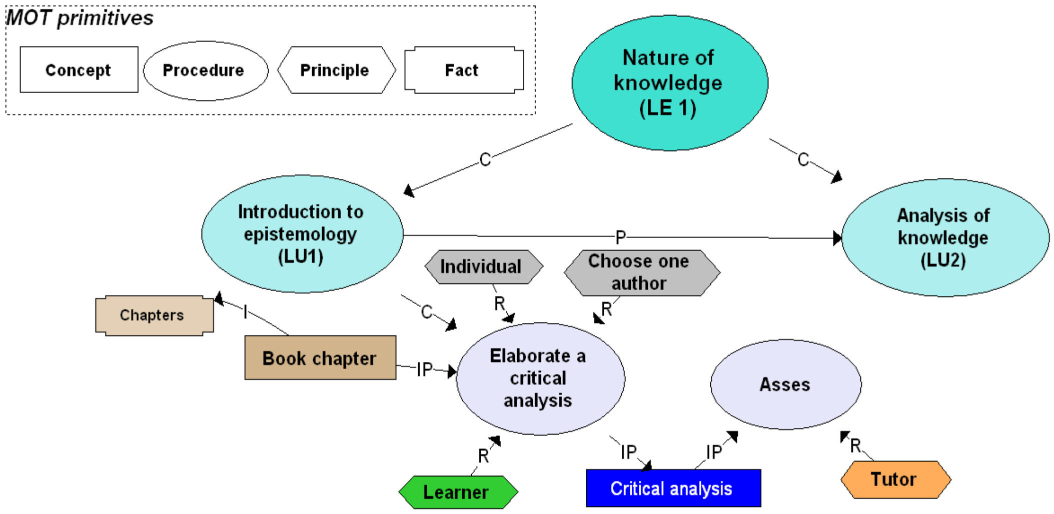


Figure 4-20. MOT notation system applied to the expression of an instructional model

4.3.3 Instructional model and complementary Forms

MISA Forms are those documentation elements composed by a two column table, the first one corresponding to the "Attribute" enunciation and the second one for "Values" attribution. While "Attributes" are by default presented in the Forms, concrete "Values" are established by the designer at the design moment. Following the previous example, complementary to DE222-LEN and DE320-IS (MOT graphic models) MISA proposes DE224-Learing Unit Properties and DE322-Properties of each Activity that allow describing in detail the instructional model characteristics. The Form corresponding to DE224 let add valuable information related to a Learning Unit as (just for mention some of them) "Allotted time" attribute with its correspondent values in period, hours or minutes; "Evaluation" attribute with its correspondent values expressed as a percentage of the qualification or other, "Target populations" attribute specifying in the value field if any specific in case of personalized or collaborative approaches, etc. In DE322 the activities are described in terms of for example "Life span" attribute with values in hours or minutes, "Directions for Study Approach" where the values determine if the activity is optional or must be completed in a mandatory order, etc.

Many of these attributes may also be declared within the graphical models. MISA proposes these alternative and complimentary documentation elements in order to avoid an overcharge if the model's representation. A graphical representation of an instructional model detailed with all the parameters structuring the learning flow risks to become hard to manipulate and to interpret.

4.3.4 MISA EML

Rawlings et al. (2002, p. 8) define an educational modeling language (EML) as a "a semantic information model and binding, describing the content and process within a 'unit of learning' form a pedagogical perspective in order to support reuse and interoperability", MISA language supporting the design of the Instructional Model corresponds to the EML definition. The "Learning Event Network" together with its corresponding instructional scenarios and associated knowledge models represent, in a graphical fashion, a semantic information model that describes both content and process of a unit of learning. Further, the translation of this MISA unit of learning into a set of XML files (allowed by the a MOT editor functionality) corresponds to a semantic information binding. Reusability is then supported in a compliant editor and system. Additionally, MISA EML is coupled with a visual notation system for the pedagogical scenario representation.

4.3.5 Comparative EML 'general requirements' checklist

Other than the formal definition given by Rawlings et al. (2002) that let us first identify the EML within MISA, we have cross check MISA EML and IMS LD according to a set of requirements that these languages must fulfill. The set was proposed by Koper and Manderveld (2004, p. 539-541)) and established with the consultation of a group of educational technologists and experts in ICT (information and communication technology) (We found this framework useful for understanding and better explain MISA and IMS LD on a common basis.

Table 4-2

EML set of requirements: MISA and IMS LD

A. General requirements	**IMS LD**	**MISA**
• EML should describe a model for a unit of learning.	✓	✓
• EML should describe units of learning in a formal way, so that automatic processing is possible. This includes: editing, storage, assembly and delivery.	✓	✓
• EML should use an interoperable notation for units of learning. Through this, investments in educational development will become resistant to technical changes and conversion problems.	✓	✗
• EML should describe the units of learning so that repeated execution is possible. This means that EML should model artefacts that are designed and developed in advance and not the artefacts that are produced in runtime.	✓	✓

A. General requirements	IMS LD	MISA
• EML should model all the content resources and communication services, which are present in the unit of learning.	✓	✓
• EML should not describe the actual 'run' of a unit of learning for actual learners at a given time, but instead it must describe the general case which can be instantiated as many times as necessary for different learners at different times.	✓	✓
• EML should allow the packaging of a unit of learning in one container or file to enable transportation. However, it must also be possible to break the container down to its subcomponents or to edit subcomponents and integrate them into an unit of learning by reference.	✓	✓
• EML should describe metadata for the unit of learning and all of its reusable sub artefacts in order to identify the characteristics and ownership, to support search, reference and assembly.	✓	✓
• EML should be built on available standards and specifications where possible. This includes specifications from IMS (http://www.imsproject.org), IEEE LTSC (http://www.ltsc.ieee.org/), ISO/IEC JTC1/SC36 (http://jtc1sc36.org/), IACC (http://www.aicc.org), and ADL SCORM (http://www.adlnet.org).	✓	✗
• EML should make it possible to produce, mutate, preserve, distribute and archive units of learning and all of its containing learning artefacts.	✓	✓
B. Instructional design requirements for units of learning	**IMS LD**	**MISA**
• EML should be able to fully describe a unit of learning, including all the typed learning objects, the relationship between the objects and the activities and the workflow of all students and staff members with the learning objects, regardless of whether these aspects are represented digitally or non-digitally.	✓	✓
• EML should define the conditions under which different learning artefacts can be aggregated into a valid unit of learning.	✓	✓
• EML should explicitly express the semantic meaning of the different learning artefacts within a unit of learning, using a pedagogical vocabulary from the educational domain.	✓	✓
• EML should allow users to map the pedagogical terminology used in EML to their own terminology.	✓	✓
• EML should allow the modelling of different kinds of pedagogical models, including the more traditional teacher directed and information transmission based models, as well as the more student centred, collaborative and constructivist approaches.	✓	✓
• EML should make a distinction between different roles, especially learner and staff roles. However, it should not be rigid in allowing certain kinds of activities only for certain roles. One must be able to assign all kinds of activities to staff as well as to learner roles in order to be able to shift learning functions from the one to the other (Shuell, 1988; Koper, 1995).	✓	✓

B. Instructional design requirements for units of learning	IMS LD	MISA
• EML should enable the definition of formal criteria for a student to meet in order to complete (parts of) a unit of learning. This means that assessment procedures and tools, along with other completion facilities must be available. In this respect, classical testing such as multiple-choice testing, as well as new assessment models such as performance tests or portfolio assessment should be supported (Hambleton, 1996; Sluijsmans, 2002).	✓	✓
• EML should be able to describe personalisation aspects within units of learning, so that the content and activities within units of learning can be adapted based on the preferences, prior knowledge, educational needs and situational circumstances of users.	✓	✓
• EML should be able to use and define properties in a learner dossier, in order to build portfolios, support monitoring facilities and support student tracking.	✓	✓
• EML should allow units of learning to contain other units of learning. This allows the building of a curriculum (a unit of learning) from underlying courses (a unit of learning) which itself can consist of different units of learning (eg, a lesson).	✓	✓

Most of the EML requirements are covered by MISA except those directly related to interoperability and integration of other existing standards. It bears mentioning that IMS LD was created with that purpose in mind while MISA predates these developments and its main focus in on design.

4.3.6 Comparing EML in MISA and IMS LD

We undertook a comparative analysis of the pedagogical scenarios as expressed in MISA (instructional model) and IMS LD (Unit of Learning) in order to highlight correspondences and differences between both educational modeling languages (see figure 4-1).

To start, we began by representing the pedagogical scenario as in MISA (instructional model) and IMS LD (unit of learning), their composing elements and relationships. The MOT notation system was used to facilitate the analysis and evaluate a visual representational option of IMS LD.

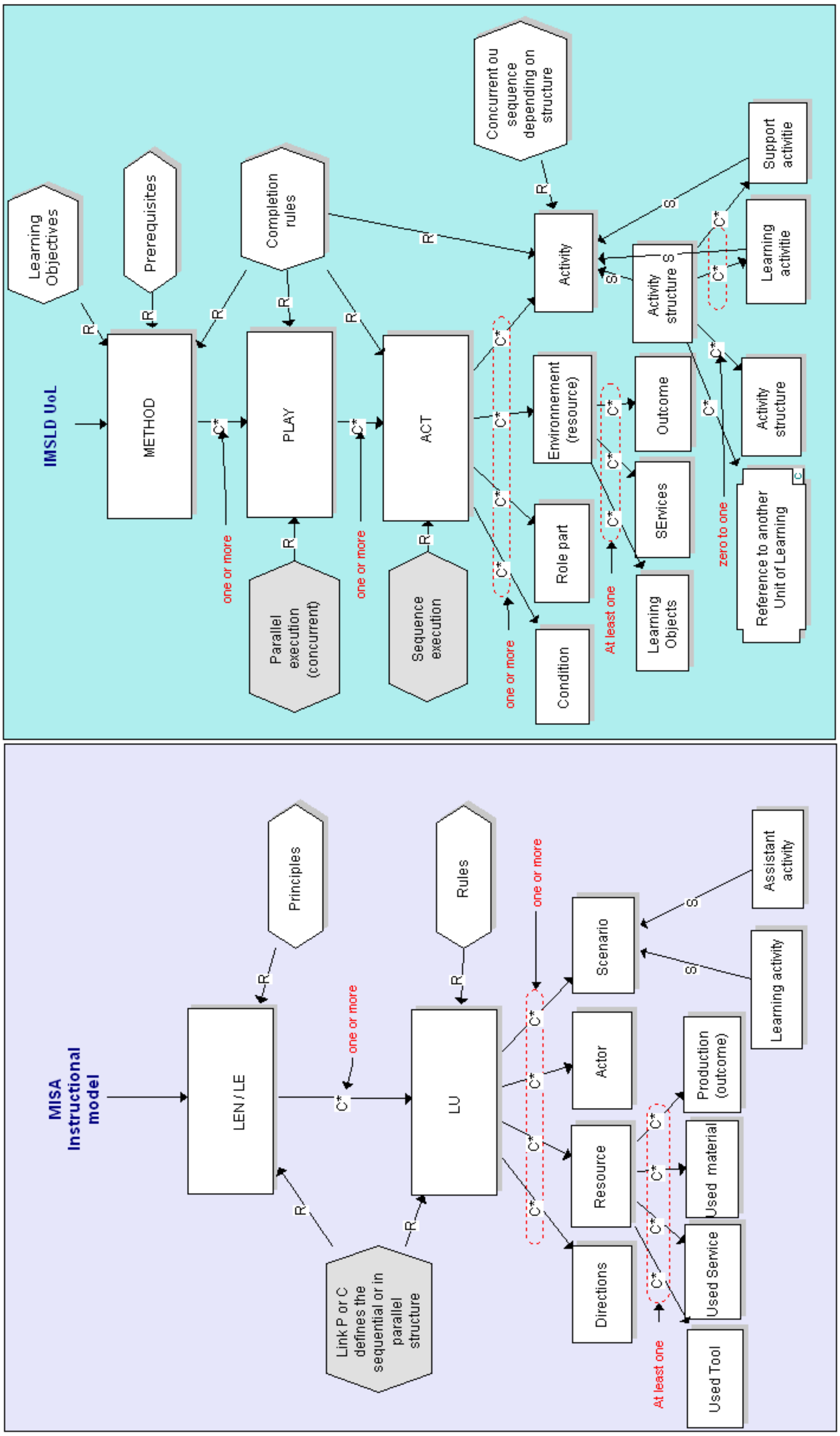
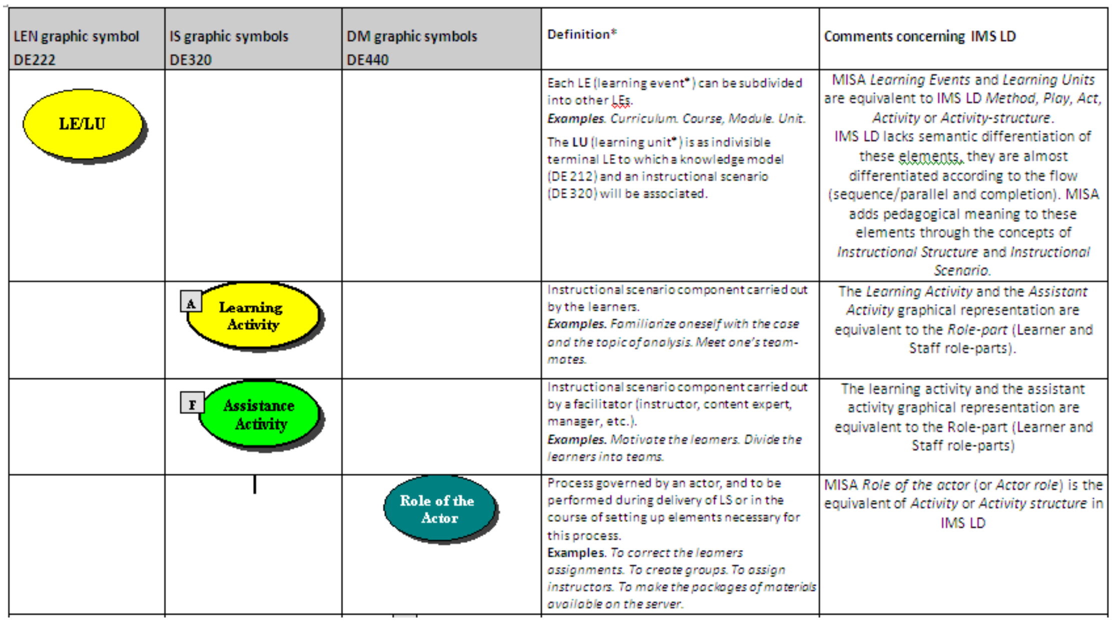


Figure 4-21. Pedagogical scenario correspondances between MISA and IMS LD, a graphic representation.

After the mapping of elements and relationships, we undertook a deeper conceptual analysis of the pedagogical scenarios. The study consisted in a semantic analysis of the definitions of MISA instructional model elements' compared to those of elements composing an IMS LD UoL. Some elements of the MISA delivery model were also considered, as they showed their correspondence to some UoL components. In Appendix 4-B we present a table with our analysis. This table presents a first column with the MISA Learning Event Network elements (DE222), a second column the MISA Instructional Scenario elements (DE320), a third column with the relevant MISA Delivery Model elements (DE440). The fourth column introduces the elements definitions according to MISA (2000a,b,c). The fifth column introduces the possible correspondences of each element to an IMS LD UoL element (IMS 2003c).



LEN graphic symbol DE222	IS graphic symbols DE320	DM graphic symbols DE440	Definition*	Comments concerning IMS LD
LE/LU			Each LE (learning event*) can be subdivided into other LEs. **Examples**. *Curriculum. Course, Module. Unit.* The **LU** (learning unit*) is as indivisible terminal LE to which a knowledge model (DE 212) and an instructional scenario (DE 320) will be associated.	MISA *Learning Events* and *Learning Units* are equivalent to IMS LD *Method, Play, Act, Activity* or *Activity-structure*. IMS LD lacks semantic differentiation of these elements, they are almost differentiated according to the flow (sequence/parallel and completion). MISA adds pedagogical meaning to these elements through the concepts of *Instructional Structure* and *Instructional Scenario*.
	A Learning Activity		Instructional scenario component carried out by the learners. **Examples.** *Familiarize oneself with the case and the topic of analysis. Meet one's team-mates.*	The *Learning Activity* and the *Assistant Activity* graphical representation are equivalent to the *Role-part* (Learner and Staff role-parts).
	F Assistance Activity		Instructional scenario component carried out by a facilitator (instructor, content expert, manager, etc.). **Examples.** *Motivate the learners. Divide the learners into teams.*	The learning activity and the assistant activity graphical representation are equivalent to the Role-part (Learner and Staff role-parts)
		Role of the Actor	Process governed by an actor, and to be performed during delivery of LS or in the course of setting up elements necessary for this process. **Examples**. *To correct the learners assignments. To create groups. To assign instructors. To make the packages of materials available on the server.*	MISA *Role of the actor* (or *Actor role*) is the equivalent of *Activity* or *Activity structure* in IMS LD

Figure 4-22. Section of the table presenting MISA language analysis (see Appendix 4-B)

The table below presents main conclusions on terminology correspondences and mismatches between MISA language and IMS LD drawn from the previous analysis.à

Table 4-3

MISA and IMS LD EML terminology correspondences

IMS-LD	MISA 4.0	Comments
Unit of learning	Instructional model	An IMS-LD Unit of Learning is semantically equivalent to the MISA Instructional Model
Learning Objectives	Target competency	Mainly a terminology difference. IMS-LD does not add structured competencies as mandatory. They can be simple text.
Prerequisites	Entry competency	

IMS-LD	MISA 4.0	Comments
Method	Learning event	First learning event of the MISA instructional structure
Play, Act	Learning event	While in IMS LD are distinguished according to their execution in parallel or in sequence, in MISA the distinction is semantic, according to the instructional structure.
Role-part	Learning or Support Activities	Role-parts as in IMS LD, are represented in MISA instructional scenario with the MOT notation system that links ('regulation' link) an 'actor role' to an 'activity'.
Role	Actor role	A simple terminology difference
Activity	Activity	Similar within the MISA instructional scenarios that break down a learning unit.
Activity Structure	Learning unit, activity	Semantically close to activities within instructional scenarios. A learning unit is the first level of MISA instructional scenario.
Environment	Package of resources	In MISA, the packages of resources are usually organized in the delivery model.
Learning object	Resource	A terminology difference
Service	Communication Services	Included in the resource concept in MISA which doesn't limit the type of services.
Property, Global Elem. Condition, Notification.	Rules governing the Learning Event network and the instructional scenarios	Rules in MISA aren't expressed in a formal way Rules in MISA are organized in 4 categories: execution, collaboration, evaluation, adaptation

This study led us to conclude that indeed, the MISA Instructional Model has the same scope as the IMS-LD Unit of Learning. While the LD theater metaphor provides for parallel and sequential activities, equivalent learning scenarios are built by MISA with elements such as the learning unit, the learning event and the learning event network. MISA resources correspond to LD Learning objects and environments and LD Learning Objectives and Prerequisites can be associated to Entry and Target Competencies in MISA. Less direct is the relationship between IMS LD Level B elements and MISA rules although, in both cases, these elements help enrich the scenarios with information on learners, on groups and on run time data. MISA proposes four categories of rules: collaboration, evaluation, adaptation and execution rules. Only execution rules are directly integrated in the learning scenario graph, the other ones are integrated in the forms used to describe the units of learning. Nevertheless all four types of rules can be described in terms of IMS-LD level B properties and conditions.

4.3.7 EML in MISA and IMS LD as design languages.

Another important classification, this time for design languages, is provided by Gibbons and Brewer (2005, p. 115 a 118), where they mention seven dimensions allowing their interpretation (Complexity, Precision, Formality and standardization, Personal versus shared, Implicit versus explicit , Standardized versus nonetandardized, Computability). In the table below we have also integrated two other dimensions borrow from Botturi (2006, IEEE, p. 1218: generative and finalist). A detailed explanation of each of the dimensions have been already exposed in this work, we suggest the reader to go back to Chapter 3, pages 69-70.

Based on the previous analysis, we have qualified the languages' dimensions in low-medium-high for those of qualitative nature. The other dimensions referring to the presence or not of the attribute, is indicated with a yes or no.

Table 4-4

MISA and IMS LD according to design languages' dimensions

Dimensions	MISA EML	IMS LD
Complexity	medium	high
Precision	medium	high
Formality and standardization	medium	high
Personal versus shared	shared	shared
Implicit versus explicit	explicit	explicit
Standardized	no	yes
Computability	yes	yes
Finalist	yes	yes
Generative	high	low
Meta-language	yes	yes
Notation system	Visual, graphic	Abstract, xml

MISA complexity can be ranked as 'medium' since it can be built with just a few terms that are closer to the designer or teacher experience. IMS LD is also economic in the number of elements but the metaphor behind may result constraining or not easily transferable to all situations. Following this reasoning, precision is higher in IMS LD since it demands a strict organization of the pedagogical scenario that must be interpreted and run within a learning system. The formality and standardization features are present in both, although more formalized in IMS LD; formal aspects are identifiable in MISA EML as generic terms that have the designer must follow and interpret, but the scenario structure is less constraining. Both EML are explicit, since they are documented and well detailed. The next dimension clearly shows IMS LD standardized trait since it is an already recognized specification. Regarding computability, both EML are computable, but if we take into account there computational facture, MISA EML must be nuanced in its 'finalist' trait, since MISA produces a pedagogical scenario blueprint requiring adjustments for its running, while IMS LD focuses special attention on this subject and describes all scenario running requirements. Generative aspects are better associated with MISA EML, since it is supported by a design technique and it is integrated to a general instructional design language and a whole process of design. Generative aspects are reinforced by the MOT notation systems.

All the above characterization of MISA EML and IMS LD does not explicitly and directly endorse one specific trait of these languages as 'meta-languages'. A meta-language is used to in this context, to compose and express statements in another language, known also as object language (we have already included this dimension to table 4-4 for the purpose of integrity). This approach is coherent with what Gibbons and Brewer (2005) highlight, that design languages have specificities and boundaries, but their interrelationships help shape the design; in this sense design languages complement each other (Botturi et al., 2006).

The EML behind IMS LD is the result of an "extensive examination and analysis of a wide range of pedagogical approaches" (IMS LD, 2003c) enabling the expression of this pedagogical diversity. The theatrical metaphor provides a small group of terms (method, play, act, activity, role, outcome, environment, and a few more) and composing syntax for a UoL (pedagogical scenario) that compose this meta-language:

> "… rather than trying to capture the terminology of each approach, which could lead to an indefinitely large vocabulary or set of vocabularies, a single relatively small vocabulary can be used to express what, in concrete terms, each of these approaches asks of the learners and support staff involved. It also allows different pedagogical approaches to be integrated into a single 'learning design' where different approaches may be appropriate for different types of learners." (IMS LD, 2003c)

Similarly, the EML in MISA is also a meta-language for expressing multiple pedagogical approaches and capture professional expertise with a short number of terms that can be assigned with specific vocabulary. The instructional model (pedagogical scenario) in MISA, composed of the instructional structure and instructional scenarios, is based on a finite number of terms (learning event, learning unit, learner or support activity, resources, outcomes and rules).

A design language gains communicability if “coupled with a sharable, public, consistent” (Gibbons, 2005) notation system (already integrated to table 4-4). The authors defines a notation system as a “set of symbolic, graphic, gestural, artifactual, auditory, textual or other conventions for expressing outwardly designs created using a particular design language”. MISA EML expressed with MOT notation system corresponds to a notation system and constitutes a visual design language that “captures abstract ideas to create transferable designs” (Boot, E., Nelson, J., & De Faveri, D., 2008, p. 370). MOT notation system and software editor reflect the view that “visual design languages and tools are envisaged as a solution for the reflective communication and creative generation of designs” (Hernandez-Leo, Villasclaras-Fernandez, Asensio-Perez, & Dimitriadis, 2008, p. 394-395). The MOT notation system is “transitional” since “is used as an intermediate step between other notations systems” (Waters & Gibbons, 2004, p. 65): graphical representations are translatable into an XML structure and code within the MOT software editor.

4.3.8 Concluding

A detailed comparative analysis of the EML of the MISA method and the IMS LD specification in their terminology showed similar but not one-to-one correspondence. In terms of the EML syntax ruling the arrangement of the pedagogical scenario, MISA EML combinatorics and deployment of activities is dependent on the designer’s envisioned leaning solution and vocabulary. Regarding the syntax, IMS LD imposes the theatrical metaphor and underlying logic to all pedagogical structure, thus resulting constraining and complex. Concerning semantics, even if both EML allow the expression of pedagogical scenarios, the syntax constraints in each one lead to different formal representations, where MISA gains in expressiveness and clarity. While IMS LD presupposes a strict way of structuring learner and support activities together with environments composed of learning resources and tools, focusing the learning flow on delivery (or run), the MISA instructional model is more flexible with regard to the way in which the learner and support scenarios are built, and focuses, rather, on instruction. When designing the pedagogical scenario, MISA focuses on the organization of learning events and activities that meet the curriculum requirements and the guidelines of a chosen pedagogical approach. MISA’s EML and design technique enable the creation of theoretically informed pedagogical scenarios, but also allow capturing designers’ tacit knowledge. In this sense, the technique is knowledge-eliciting and captures expertise on pedagogical know-how in a semi-formal manner. In MISA, the constraints of delivery and execution are addressed later, when focusing on the delivery layer.

MISA has what IMS LD lacks and vice versa. MISA's EML is supported by a rigorous, layered instructional design process, which is pedagogically inclusive and addresses the preoccupations of designers, whereas IMS LD offers an interoperability solution shared by the international research and software development communities. Additionally, MISA EML is coupled with a visual and graphical notation system that facilitates the pedagogical scenario representation and easies the process of design by providing the designer a powerful tool for handling and modifying the scenario in a friendly way.

Towards DDR phase 3

In the first phase of our research we wanted to establish a coherent framework relating the actual instructional design practice to a theory of instruccional design. We searched also to reflect on a set of artifacts or tools enabling the design activity.

Having in mind the ultimate goal of developing an instructional design method for the creation of pedagogically-inclusive scenarios for reuse and interoperability, we acknowledge the need of an instructional design method sufficiently structured as to propose formal or semiformal languages for expressing pedagogical scenarios. This condition should lead us to a possible solution through a deeper analysis of the meta language compared to the IMS LD specification, already identified as the educational modeling language officially adopted by the IMS Learning Consurtium.

The identification in MISA of a proprietary EML argues in favor of our DDR aim since it proved being part of the already existing set of tools assisting the instructional design activity. A detailed comparative analysis of the EML in MISA and in IMS LD identifying specificities and commonalities helped foresee a possible adaptation of the method for the creation of compliant to IMS LD pedagogical scenarios. In the next chapter we present a first developmental solution o an adapted version of MISA, followed by a case study aiming at its validation.

Chapter 5

Development and testing

MISA new technique and Case study

(DDR Phase 3)

Chapter 5

Development and testing of a solution (DDR 3)

Overview of this chapter

Phase 2, presented in the preceding chapter, was crucial to establish a possible gateway from the MISA method to the IMS LD specification. The fact that MISA and IMS LD understand pedagogical scenarios in terms of learning flows (actors, resources, activities and coordination and progression rules) and that MISA possesses its own educational modeling language coupled with a graphical notation system and a software editing tool capable of exporting the pedagogical scenario into an XML format, opened the door for the development of a possible solution. Based also on the lack of a robust method for the design of IMS LD units of learning (UoL), and supported by evidence that the MISA method encompasses a rigorous process of design of a pedagogical scenario semantically equivalent to a UoL, the first alternative solution explored pointed to the development and validation of a new MISA technique for the design of an IMS LD compatible pedagogical scenario. This developmental step was carried out within the LORNET[18] group at Téléuniversité.

In order to test the technique, a case study was conducted with an instructional designer with expertise in MISA, MOT and knowledge-modeling but little background in IMS LD and related technical knowledge. This study focused on a transposition of a MISA collaborative pedagogical scenario designed for a graduate course in information technology and cognitive development (Basque, Dao, & Contamines, 2005). Our research followed Yin's (2003) four-stage case study recommendations of designing, conducting, analyzing and developing conclusions.

5.1 Developmental step: a new MISA technique

This first solution explored focuses on the extension of the MOT notation system to convey with IMS LD language and the creation of a technique to encompass the process of designing a Unit of Learning. This first attempt emphasizes the Specification and tries to accommodate both, notation system and technique to IMS LD. The creation of the MISA LD technique included:

- The development of a notation system to represent IMS LD elements according to the MISA visual design language, specifically based on MOT primitives (see Appendix 5-A).

[18] LORNET (Learning Object Repository NETwork) project: http://www.lornet.ca

- The elaboration of a detailed procedure supporting the visual representation of a UoL level A, the MOT+ LD Modeling Technique (see Appendix 5-A).
- The upgrading of the MOT editing tool for the support of a new notation system for the representation of a UoL as well as the adding of XML export capabilities.

5.1.1 The notation system

The notation system kept previous representational traits of common MISA and IMS LD elements, and added coherent new graphics to cope with IMS LD specific requirements. The representational system gained expressiveness throughout the integration of a series of built-in icons embedded within the MOT primitives.

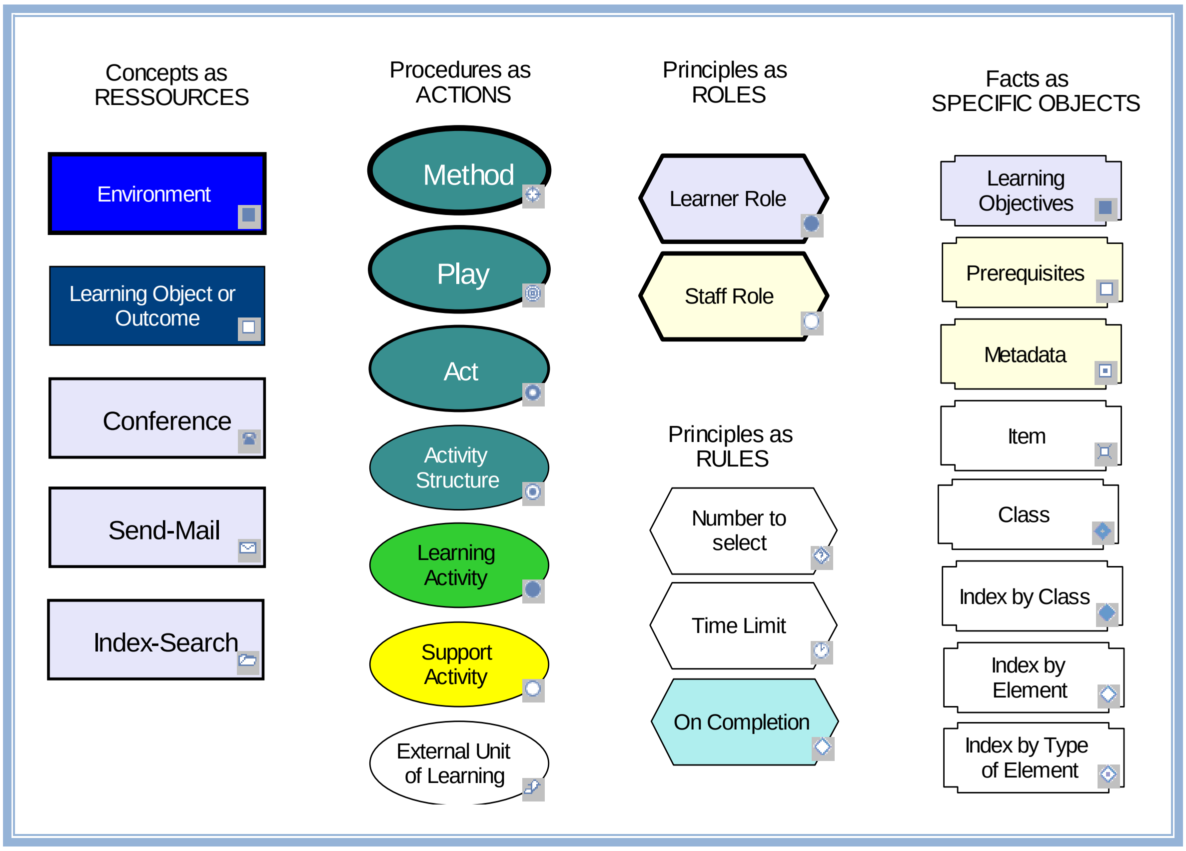


Figure 5-1. IMS LD visual notation system

A set of links used to express relationships between the UoL elements complete the notation system:

C – links to express what an object is composed of

P – links to express order of process objects, i.e., Act 1 is preceding or has to be performed before Act 2;

I/P – links to express inputs to or products of a Learning or Support Activity or an Activity Structure;

I – links to express instantiation of an object, i.e., from the Method to a Learning Objective object containing its URL to a resource

R – links to express a rule or role governs another object, i.e., a time limit regulates an act;

A – links to express that something applies something to an object, i.e., from the metadata object to any main object.

5.1.2 The procedure background

The new developed technique for MISA-IMS LD compliant UoL representation is a detailed procedure inspired on the "IMS Learning Design Best Practice and Implementation Guide" (IMS GLC, 2003a). This official IMS document includes a simplified procedure for structuring a UoL based on software engineering tasks.

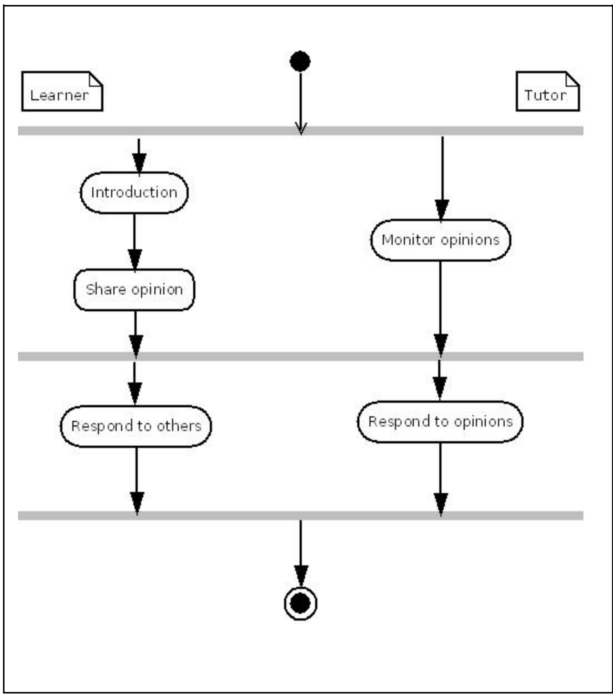
It consists on the definition of a use case and the drawing of an activity diagram using UML (unified modeling language).

A use case template is suggested in order to capture a concrete educational problem expressed as a pedagogical scenario in the form of a "narrative". Use cases are commonly employed in software engineering as a scenario-based procedure for requirements elicitation. It describes a systems behavior as it responds to a request originated from outside; in other words, it identifies actors, roles, actions, etc. in envisioned situations. The use case template is justified in IMS GLC (2003a) as appropriate to explore the design problem and draw a draft of a solution organized on the basis of a checklist.

Use case usual items

1.	**Use Case Identification**
1.1.	Use Case ID
1.2.	Use Case Name
1.3.	Use Case History
1.3.1	Created By
1.3.2	Date Created
1.3.3	Last Updated By
1.3.4	Date Last Updated
2.	**Use Case Definition**
2.1.	Actors
2.2.	Trigger event
2.3.	Description
2.4.	Preconditions
2.5.	Post-conditions
2.6.	Normal Flow
2.7.	Alternative Flows
2.8.	Exceptions (errors)
2.9.	Includes (other cases)
2.10.	Priority
2.11.	Frequency of use
2.12.	Special Requirements
2.13.	Assumptions
2.14.	Notes and Issues

The resulting narrative is then cast in the form of a UML activity diagram. UML is a standardized general-purpose modeling language used in the field of software engineering. An activity diagram is a graphical workflow representation detailing activities and actions with support for choice, interaction and concurrency. This is, according to the IMS GLC (2003a) document, the first step of the design process that adds rigor to the analysis and makes explicit the learning solution. The second step in this process of design is based on the UML activity diagram which is easily transformed into an XML (Extensible Markup Language) document instance.



UML activity diagram of a learner-led tutor-monitored discussion.

```
<?xml version="1.0" encoding="UTF-8"?>
-------
<learning-design identifier="Domain1"
            uri="URI" level="A" >
 <title>Activating prior knowledge</title>
   <components>
        <roles>
            <learner identifier="Domain1Node7">
                 <title>Learner </title>
            </learner>
-----
            <activities>
                        <learning-activity
identifier="Domain1Node5" isvisible="true">
                        <title>Share your opinion</title>
------
```

XML structure (partial)

Figure 5-2. UML learner and tutor activity diagram and correspondent XML structure (partial).

5.1.3 The MISA LD technique

The MISA LD technique is made up of a template for composing a structured “narrative” of the pedagogical scenario and the MOT+LD Editor and Modeling Technique for the scenario visual representation. The technique replaces the previously explained activity diagram approach and UML language solution. The technique focuses on IMS LD level A and suggests the use of RELOAD for the completion of levels B and C (see pages 115-115 for the levels description).

The template includes the items orienting the design of a concrete UoL, as follows: the UoL title, the UoL author, the pedagogical approach, a short context description, the prerequisites and learning objectives, the actors’ roles, the services, the scenario pathways, the acts and the activity structures. The template is presented as a double column table where the left one presents the items and the right one is left empty for the designer free writing. This document is intended for gathering the information about the pedagogical scenario organized according to the IMS LD UoL requirements. It is a first approach that predefines a UoL as a narrative, a more informal manner , closer to the usual way to express an envisioned learning situation (see Appendix 5-B).

Éléments d'une narrative pour faciliter la construction d'une Unité d'apprentissage (UdA)

Avant de commencer un modèle IMSLD il convient d'avoir en tête certains éléments qui vont être intégrés dans le modèle IMSLD. L'information portant sur ces éléments peut provenir de différents ÉD de la méthode MISA. Pour faciliter la modélisation, il convient de préparer un répertoire de fichiers pour certains éléments de l'UdA (**)

Dans ce tableau les objets (symbole graphique) IMSLD du logiciel MOT+ sont en italiques.

*** optionnel**

ELEMENTS	DESCRIPTION
Titre de l'UdA	
***Auteur**	
***Type de pédagogie**	
Description/contexte	
*****Préalables/*** **Compétences seuil**	
****Objectifs d'apprentissage/ Compétences visées**	
Rôles	

Figure 5-3. Screen-capture region of the IMS LD narrative template.

The MOT+ LD Modeling Technique (MMT) (see Appendix 5-A) supports the representation of a UoL within an IMS LD framework, using the MOT+ LD editor. This guide was elaborated with regard to IMS LD Level A and the editor interface.

The MMT is structured in four main consecutive tasks: 1) Start the modeling process, 2) Build a role definition sub-model, 3) Complete the main model, and 4) Develop the act's learning scenario. This UoL top down design approach is a progressive, detailing, and refining process intended for non IMS LD specialists, but with sufficient background as to understand the Specifications main concepts and aims. This step-by-step procedure provided along with detailed explanations and illustrations supports the designer's tasks and subtasks for representing a UoL.

The first main task, "Start the modeling process", explains how to create a new UoL project within the MOT+ LD editor. The selection of the IMS LD type of model automatically creates a first structure (main model) of "method-play-act", and a sub-model of an "Act" composed of an "activity structure" made up of a "learner role part", a "staff role part" together with "environments". This preset structure is intended for modification according to the envisioned UoL.

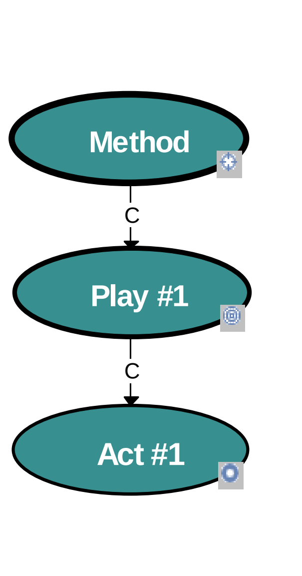
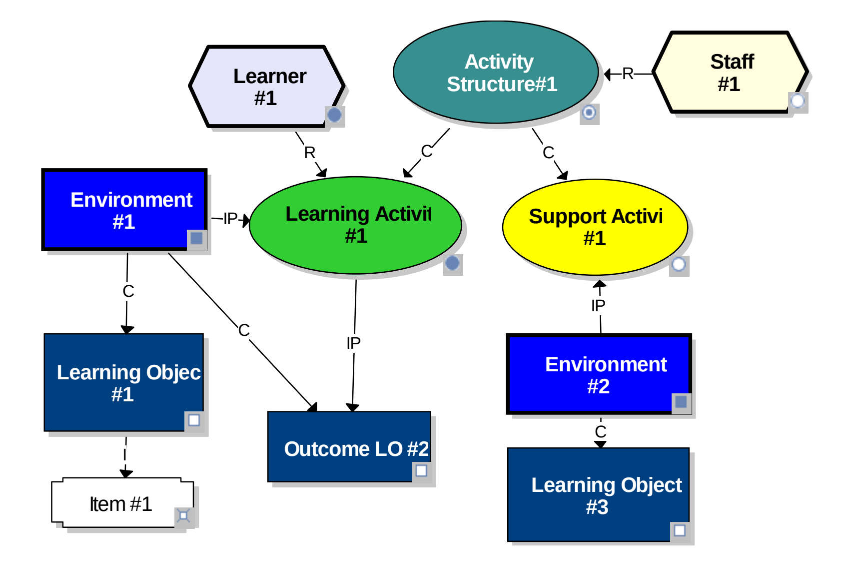
Preset main model	Preset sub-model of an Act
	

Figure 5-4. Preset MOT+LD main model and sub-model of an Act.

The second main task, “Build a role definition sub-model”, establishes the completion of a role sub-model where all the roles of the UoL must be declared. If the designer is aware of all of them it is recommended to include them from the very beginning. If the designer needs to add more roles later, it can return to this sub-model and add then during the design of the UoL.

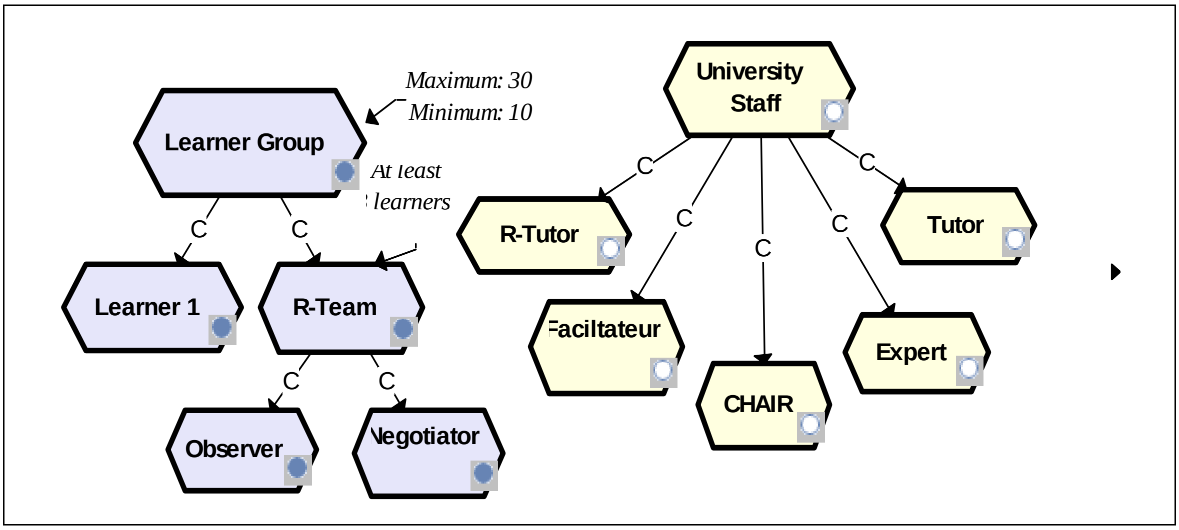


Figure 5-5. Role definition sub-model (example)

The third task, “Complete the main model”, explains how to deploy the main model into “Plays” and “Acts”, highlighting main considerations of progression and completion rules, and mechanisms of visibility of the components of the model.

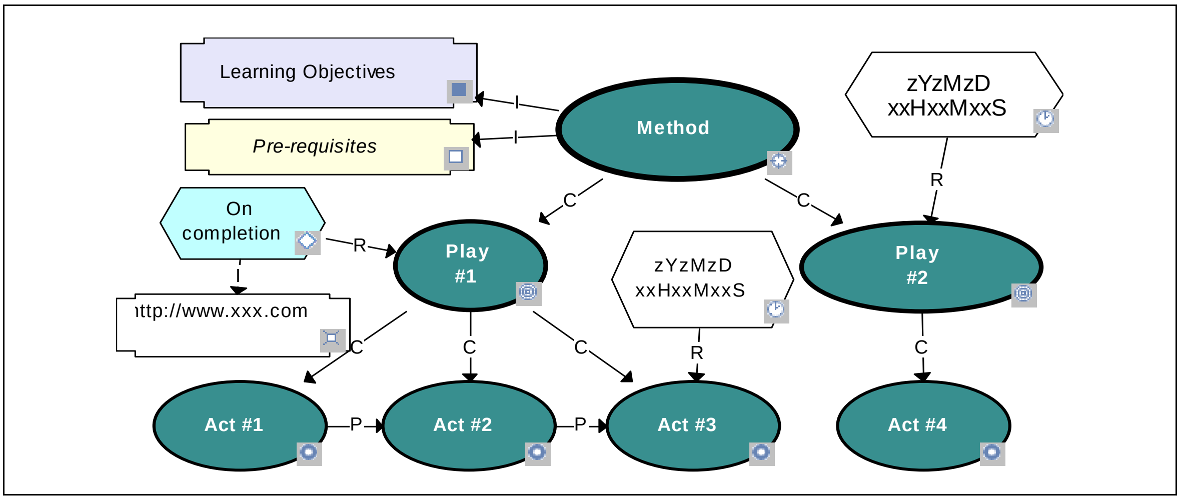


Figure 5-6. Main model on completion (example)

The forth task, “Develop the Act’s learning scenario”, explains how to break down the “Acts” into “Activity structures” and/or “Activities”, as well as, how to create Role-parts and assign “Environments”. This procedure adds fine granularity to the sub-models.

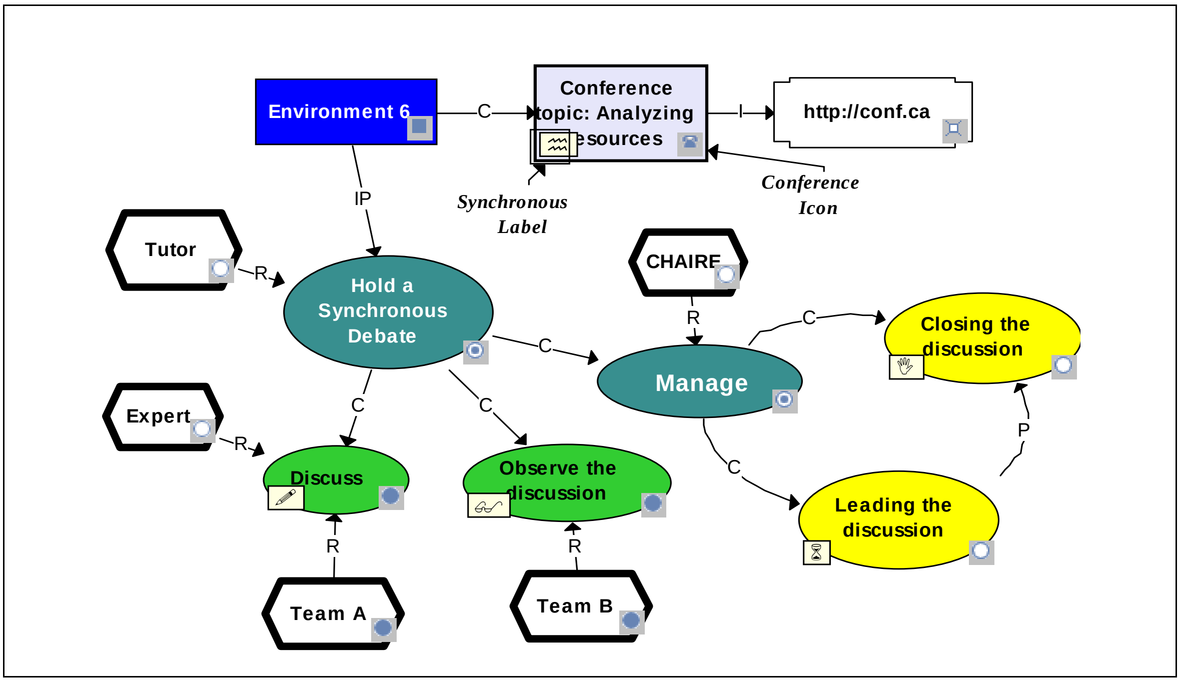


Figure 5-7. Partial Act breaking down (example)

This completes a Level A UoL that can be exported into XML code, and imported in Reload or any other compliant editor. Reload supports the completion of levels B and C of the Learning Design.

The software development group within the LORNET project added a new module into the MOT editing tool. The upgraded version was called the MOT+ LD editor. It supports a graphical way of representing a UoL. As IMS LD is an educational modeling language that must be interpreted by a computer, the design of a UoL must be done in an editor application allowing the creation of an XML manifest within which the UoL structure is embedded.

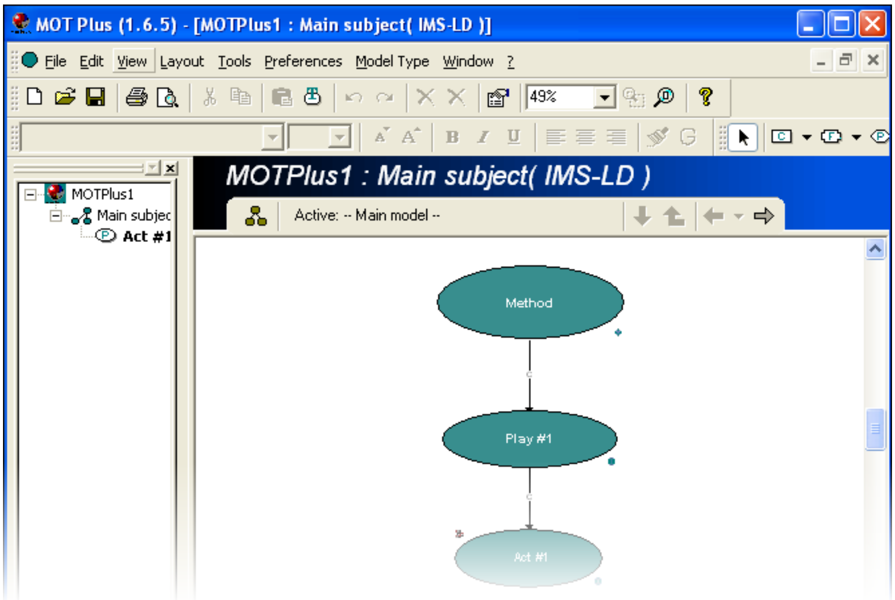


Figure 5-8. Screen-capture region of the MOT+ LD editor.

5. 2 Test: The Case Study

Design and development research approach is iterative and calls for a rich methodology for data collection and analysis. For this phase step of the research, we use a concrete developmental research method called "formative research," (Reigeluth and Frick, 1999) that is "intended to improve design theory (or models) for designing instructional practices or processes" (p. 633). The authors just quoted explain, based on overwhelming evidence, how formative research methodology is useful and appropriate to improve theories and models in almost all fields of education. This method follows Yin's (200319) four-stage case study recommendations:

1. Design the case study,
2. Conduct the case study,
3. Analyze the case study evidence, and
4. Develop the conclusions, recommendations and implications.

5.2.1 Design the case study

5.2.1.1 The case study

As explored initially by Paquette (Paquette, Marino, De la Teja, and Léonard., 2004) and in the second phase of our research, the MISA method and the IMS LD specification have significant conceptual similarities that enable adapting this Method to the Specifications requirements. Moreover, one of the researchers' previous experience (De la Teja, Lundgren-Cayrol, & Paquette, 2005) in transposing a MISA learning scenario to an IMS LD compliant UoL added further information and evidence to support interest in adapting the MISA method. As De la Teja et al. state in this study (op. cit.), a "transposition from a source to a target model implies that there exists some type of equivalences [sic] at least at the conceptual level between the two frameworks".

In our case study we wanted to go a step further into the analysis of concrete components and elements of the Method that need to be adapted. We therefore focused on two main aspects: the clear identification of MISA processes and documentation elements to be modified and the verification of the appropriateness of the principles guiding the MISA ID process in order to design an IMS LD compliant UoL.

The case is defined as the transposition of a MISA pedagogical scenario to an IMS LD compliant UoL through a representation technique from an instructional designer's perspective. In one sense, the technique is a procedure for manually translating a MISA pedagogical model into an IMS LD UoL syntax. Based on the evidence of similar but not identical EMLs of the MISA method and the IMS LD specification, the technique supposes an ad hoc solution for the scenario recomposing.

The case study involves a previously designed MISA compliant course that is intended to be represented according to an IMS LD structure. The main objective is to verify the need for a MISA adaptation and, consequently, to identify the MISA elements to be adapted. If our assumptions are correct, the representation technique is not enough to succeed in the building of a UoL. Changes to the MISA method itself are necessary.

The departure course was a collaborative and authentic e-learning scenario designed for graduate students in information technology and cognitive development. The course scenario invites the learners to participate in an asynchronous virtual scientific conference, metaphor used to present the four main course activities: Preparing for the conference; Participating in a poster session; Attending a symposium; and Participating in the plenary session as illustrated in the figure below (Basque, J., Dao, K. & Julien, C., 2005a, 2005b).

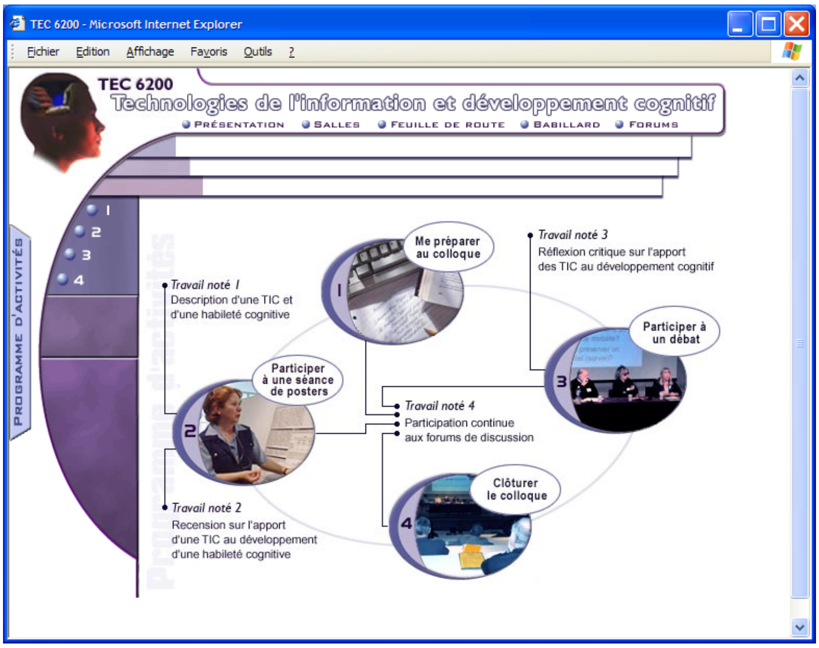


Figure 5-9. TEC6200 course learning events (from Basque et al., 2005a)

5.2.1.2 Case research protocol

The following protocol (see Appendix 5-C for more detail) was used for the case study, which took place at LORIT/Téluq[20] laboratory for a 4 projected sessions in a period of one week and a half, depending on the instructional designer's availability.

- Goal

To collect empirical evidence about the need for an adaptation of MISA in order to produce Learning Designs.

- Objectives

Objective 1: to identify the MISA documentation elements and attributes needed to describe an IMS LD UoL.

Objective 2: to identify MISA instructional design procedure that better satisfies the designing of an IMS LD UoL. .

- Participant profile

The participant needed to be an expert in the use of MISA, with very little or no prior knowledge of IMS LD. This let us focus on the viability to adapt MISA for the support of the IMS LD language, and thus, the design of pedagogical scenarios compliant to the Specification.

- Participant requirements

[20] Laboratoire-Observatoire de Recherche en Ingénierie du Téléapprentissage

The participant was also required to have designed an online MISA compliant course containing at least one collaborative activity. He or she was asked to provide the documentation elements (DE) for the researchers prior to the case study development. This allowed researchers to identify possible transposable instructional scenarios, eventually suggested to the participant.

- Artifacts

During the exercise the participant was allowed to use:

- The template: an IMS LD Structured Narrative. It allows collecting the required information for an IMS LD Level A to be represented in the editor.
- The MOT+ LD Modeling Technique: a representation technique that allows one to represent a UoL within an IMS LD (Level A) framework, using the MOT+ LD editor.
- MISA documentation elements: documentation elements from a MISA compliant course (previously designed by the participant), which were reused for the representation of the UoL.
- The Course Web site: the course itself.
- IMS LD Reference Documentation: documents with information about concepts related to the specification, to help the participant understand the task to accomplish. These documents are discussed later.
- The MOT+ LD editor: the editor software application that offers a graphical way of representing a UoL.

- Techniques for data collection

To accomplish our goal and objectives, our case study method involved several data collection techniques

- Observation and note taking: to gather the perspectives of three different observers
- Screen recording: to capture the participant's actions as he uses the editor
- Work environment recording: to capture participant's use of artifacts
- Think-Aloud Protocol: to allow participant to verbalize his intentions explicitly
- Appreciation questionnaire: Before-and-After Design
- Debriefing: to gather participant's reflections on the session
- Interview: to collect participant's reflections on the process and on the artifacts used

- Participant productions: to keep a trace of the narrative and evolving UoL representation

- Instruments for data collection

- Think-aloud protocol guide: to capture the designer's spontaneous explanation of the ongoing activity (see Appendix 5-D)
- Observation grid: to take notes about the ongoing process of design (see Appendix 5-E)
- Debriefing questionnaire: to capture the designers' reflective explanation of the sessions as well as additional relevant information (see Appendix 5-F)
- Appreciation questionnaire : to capture a predefined set of items relevant to the research (see Appendix 5-G)

- Case scenario and task assignment

The following table presents task assignments for each session. Session facilitation and data collection involved members of the Lornet Team 6.3. I refer to myself as R1. Other researchers are identified as "R2", "R3", etc.

Table 5-1

Session tasks' assignment

Session	Duration	Task	Responsible
Session 0	30'	MOT+ LD editor introduction	Editor developer (R4) and participant
Session 1	15'	Fill in the appreciation questionnaire	Participant
	25'	Introduction to IMS LD conceptual framework	R2
	2h	Tasks issued from the narrative and the MOT+ LD Modeling Technique	Participant
		Observation and note taking Think-aloud protocol guidance	R1
		Observation and note taking	R4, R5
		Assistance	R2, R3, R4
	15'	Debriefing	Participant, R1, R2, R3
Session 2	15'	Return to previous session tasks and future session tasks if needed.	Participant, R1, R2, R3
	2h	Tasks issued from the narrative and the MOT+ LD Modeling Technique	Participant
		Observation and note taking Think-aloud protocol guidance	R1
		Observation and note taking	R4, R5

Session	Duration	Task	Responsible
		Assistance	R2, R3, R4
	15’	Debriefing	Participant, R1, R2, R3
Next sessions (3 and 4)		As in session 2	
Last session (3 or 4)	15’	Return to previous session tasks and future session tasks if needed.	Participant, R1, R2, R3
	2h	Tasks issued from the narrative and the MOT+ LD Modeling Technique	Participant
		Observation and note taking Think-aloud protocol guidance	R1
		Observation and note taking	R4, R5
		Assistance	R2, R3, R4
	15’	Debriefing	Participant, R1, R2, R3
	30’ to 45’	Interview	Participant, R1, R2, R3

5.2.2 Conduct the case study

The case study sessions consisted of a half-hour introductory session and two subsequent three-hour work sessions. It took place at the LORIT where three cameras recorded the working environment and sound, and special software captured the computer screen. Below, we present the progression of the two sessions in detail.

Participant’s profile

- Instructional designer and cognitive modeling expert (12 years experience)
- 7 years experience using the MISA method (teaching and implementing the method)
- 10 years using various versions of MOT software
- 4 full online courses designed applying MISA and MOT
- Online course facilitation and tutoring.
- Very little prior knowledge of IMS LD
- MISA compliant documentation elements created from an online course ready to reuse in the present study.

This profile is appropriate for the case study given the participant’s knowledge and experience using the MISA method and the MOT editor, a knowledge modeling tool for course design.

Session description

Session 0: Training - half an hour

On the first meeting the participant met with a MOT+ LD software editor specialist who introduced the tool and explained the main concepts related to the application.

Session 1: 3 hours

1) Researcher 1 (R1) explained to the participant the main steps of the session's work.
2) The participant filled in the appreciation questionnaire.
3) Researcher 2 (R2) explained the main concepts of IMS LD with:
    a. five slides presenting IMS LD basics, and
    b. a template for a UoL narrative (adapted from Coksburn's Use Case template).
4) R1 explained the think-aloud technique, the exercise objectives, the documents and software to be used during the session.
    a. Documents
        i. Previously designed by the participant:
            1. EDs from previous course design based on MISA, and
            2. course Web site.
        ii. Given by researchers:
            1. Use case template for the description of the UoL (narrative).
            2. The MOT+ LD Modeling Technique.
            3. *Lexique anglais / français des termes IMSLD utilisés dans l'interface MOT+.* LICEF internal document.
            4. Jeffery, A. & Currier, S. (2003). *What Is...IMS Learning Design?* Cetis standards briefings series, JISC's Centre for educational technology interoperability standards.
            5. Tattersall, C., Manderveld, J., Hummel, H., Sloep, P., Koper, R., & De Vries, F. (2003). *IMS Learning Design Frequently Asked Questions Version 1.0*. Netherlands: Educational Technology Expertise Centre, OUN.
            6. Griffiths, D. (2004). *UNFOLD Discussion Document: the first steps in creating a Unit of Learning*. Spain: Universitat Pompeu Fabra,.
    b. Software editing tool: MOT+ LD v. 1.4.2
5) The participant executed the exercise, verbalized his thoughts and, when needed, asked for assistance from the researchers at critical stages. R2 facilitated the think-aloud technique (2 hour-long exercise).

    Guidelines given to the participant:

   a. To choose between two sections of his MISA instructional scenario suggested by the researchers. These two sections included collaborative activities.
   b. To begin filling in a template for the narrative of the chosen UoL.
   c. To design the UoL, using the MOT+ LD editor following the Guide.
6) Once the exercise was finished, the researchers and participant shared ideas during a fifteen minutes debriefing period.
7) All data were recorded and published on a secure server.

Main steps taken by the participant

The participant chose a learning activity from his course (Learning Event 2.3.2 from his Learning Event Network)

He completed the narrative (filling in the template)

He used MOT+ LD following the guide: from 1.0 (Opening a new IMS LD UoL Model) to 3.2.3 (Add a feedback message reference address in the Item object).

Session 2: 3 hours

1) Researchers talked to the participant about the progression of the task.
2) R1 gave a reminder of the think-aloud technique, explained the exercise objectives, the documents and software to be used during the experience (the same as in session 1)
3) The participant executed the exercise, verbalized his thoughts and asked for the researchers' assistance, when needed, at critical stages. R2 facilitated the think-aloud technique (2 hour-long exercise).
4) Once the exercise was finished, the researchers and participant took part in a debriefing and interview period (35 minutes-long).
5) All data were recorded and published on a secure server.
6) The case was declared finished. Near the end of the sessions, the participant needed more and more help to be able to continue. The exercise became more like a training session, which was not suitable to the research objectives.

Main steps taken by the participant

The participant decided to begin his UoL from an upper level. He chose activity 2.3 from his course (Learning event 2.3 from his Learning Event Network).

He used MOT+ LD following the guide: from 3.2.3 (Add a feedback message reference address in the Item object) to 4.8.3 (Adding Send-Mail Services).

- Summary of the sessions:

Before the beginning of the design sessions, the participant attended a brief presentation of the MOT+ LD editor and an introduction to the main concepts related to the Specification (30 minutes).

At the beginning of the first session, the participant completed an appreciation questionnaire regarding the MISA method, the IMS LD specification and the MOT+ LD editor (10 minutes).

Subsequently, a researcher presented the conceptual IMS LD framework (30 minutes).

Finally, the participant designed a UoL (2 hours approximately) by:

- first, completing a narrative based on a template provided by researchers, and
- second, representing a UoL based on a chosen MISA instructional scenario from his previously designed course,
    - following the editor MOT+ LD Modeling Technique, and
    - using the MOT+ LD editor.

The participant's first step was to collect all the information required to represent a UoL. This was done by completing a template that organizes the information as a narrative. As is detailed in point 3 of the IMS Learning Design Best Practice and Implementation Guide, this template is an adaptation of a Use Case Template, originally developed by Alexis Cockburn for the software engineering process. The next step explained in this document referred to the building of a UML activity diagram that represents the learning flow. It is obvious that this modus operandi is appropriate to a software developer but not to an instructional designer. In our case the UML diagram was discarded.

Instead of representing the learning scenario as a UML diagram, the participant was invited to build a UoL graphical representation using the MOT+ LD editor. To do this, he was asked to follow the MOT+ LD Modeling Technique.

For the transposition to a UoL researchers anticipated that three to four sessions would be needed.

During these work sessions, the participant verbalized his intentions during the elaboration of the UoL. An observer remained near the participant in order to facilitate the think-aloud protocol. Two other observers took notes from the Lorit control room.

At the end of each session the participant saved the resulting documents and the files were identified, backed-up and printed by a researcher.

If needed, before each session, the participant and the researchers discussed previous and future work.

At the end of each session, the researchers and the participant could discuss the exercises that had just completed during a 15-minute debriefing period.

At the end of the last session, the participant was asked to complete an appreciation questionnaire identical to that filled out at the beginning of the first session. Also, the researchers interviewed the participant.

5.2.3 Analyze the case study evidence

This section presents the data analysis related to the first and second objectives of identifying reused MISA documentation elements in the designing of the UoL as well as the procedure followed to do so. We briefly describe the data analyzed and explain the information needed to understand the possible links between MISA and IMS LD. We have divided the analysis of data into two subsections:

- the comparative analysis of the participant course MISA DE and the participant case study outcomes (related to objective 1), and

- the analysis of the UoL representation procedure (related to objective 2)

5.2.3.1 Comparative analysis of subject productions

The purpose here is to identify within the MISA documentation elements and the course itself which information and attributes are reused to represent the UoL. To do this we followed the following steps:

1. As MISA is an adaptive and flexible pedagogical engineering method we begun analyzing the documents provided by the participant in order to establish their correspondence to MISA's DE, hence, we also identified their attributes. These documents were those previously created by the participant, through the MISA pedagogical engineering process, for an online master's degree course. Here is the list of the analyzed documents including the online course itself.
    - DE222-Learning Event Network (LEN) of the course (see Appendix 5-H): a MOT+ model : this LEN expresses the course instructional structure:
        - course title,

- activity (LE first level),
- task (LE second level), and
- assignment (LE third level).

Assignments have associated instructional resources (guides, instruments, outcomes) and delivery resources (tools, means of communication).

Task and assignments have associated learner outcomes with assessment estimation expressed as percentage quotations. In MISA, this is an attribute of DE224-Learning Unit Properties Form (attribute *Evaluation* - Section A) and it is not represented into the LEN graph. It is also present at the Learner Activity level in DE322-Properties of each activity Form at the *% of the Mark* attribute that indicates the weight given to the evaluation of the activity compared to the LU's overall evaluation.

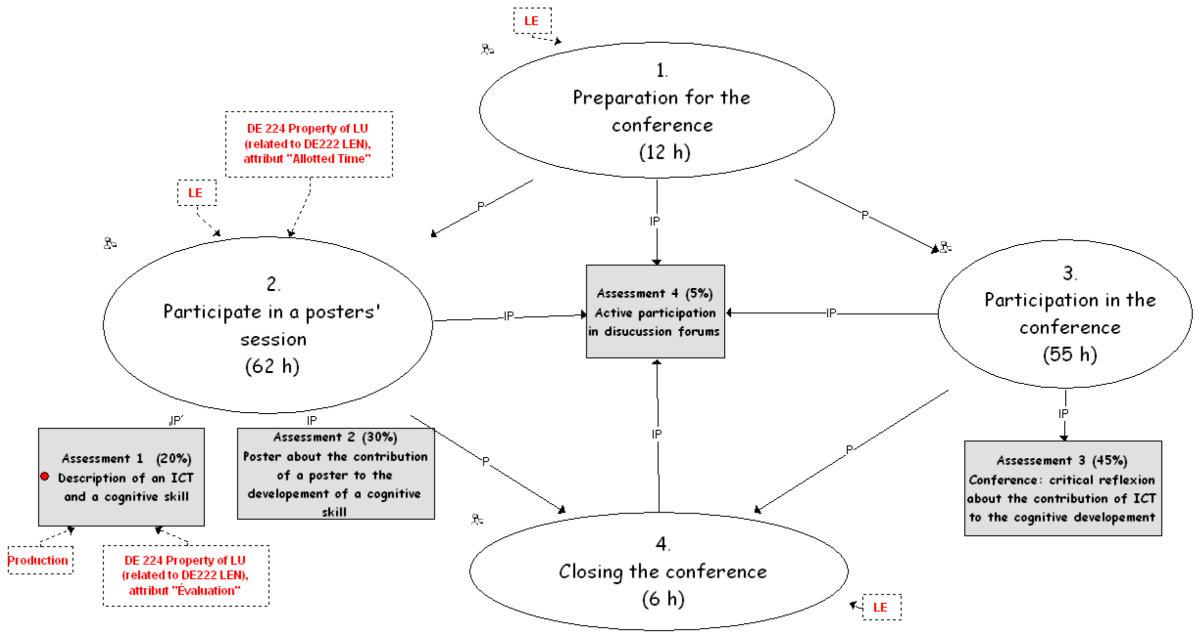


Figure 5-10. Course MISA LEN at the task level of description (translated to English from original in French)

We also analyzed task 2.3 (LE 2.3) (see Appendix 5-H) since it is reused by the participant during the experience.

- DE320-Instructional scenario from the course Web site (in the form of html pages). As before, based on the participant's reutilization of this DE, we analyzed Assignment 2.3.2 (see Appendices 5-Ia,b). The Assignment level is the deepest level of the LEN that corresponds to the MISA Learning Unit (LU). It is a learning event that cannot be subdivided but is described by an instructional scenario (see MISA glossary, p.28). This IS represents the LU 2.3.2 (third level of the LE) as learner and assistance activities (fourth level or “step” level).

- DE430-List of Learning Materials: this documentation element is an organized list of all the instructional resources within the learning system. It is a DE that assigns to each learning material a title, an actor responsible for its realization, a description of the realization state, a copyright, a file production format and a final delivery format. As the participant does not directly reuse this DE, but instead reuses DE222 and DE320 (where these materials are attached to learning events and to learning/assistance activities respectively), we considered that deeper analyses were unnecessary.
- The “Revision file” approved by the Teluq Committee. This is an instructional design course template standardized by Teluq for expert peer approval. It contains information that can be reused in different MISA phases. As it was not used during the sessions we decided to forego adding the description of this document.
- The Course Web site: the instructional model and scenarios expressed in a hierarchic structure of learning and support activities linked to learning materials and communication services.

This first contact with the participant’s course documentation elements prior to the sessions better prepared us to identify reuse during the case study.

2. The next step was to analyze the outcomes produced by the participant during the case study, seeking attributes that were reused to build the UoL, and then to identify their correspondence to MISA’s DE. To this end, we begun selecting the DE based on the instructional scenario for transposition chosen by the participant.

   Here is the list of outcomes produced by the participant during the case study:

   - Narrative from the first session (see Appendix 5- J)
   - UoL (in progress) from the first session (see Appendix 5-K)
   - UoL (in progress) from the second and final session (see Appendix 5-L)

Based on this analysis we identified the following correspondences between the participant session’s outcomes and the MISA documentations elements he provided.

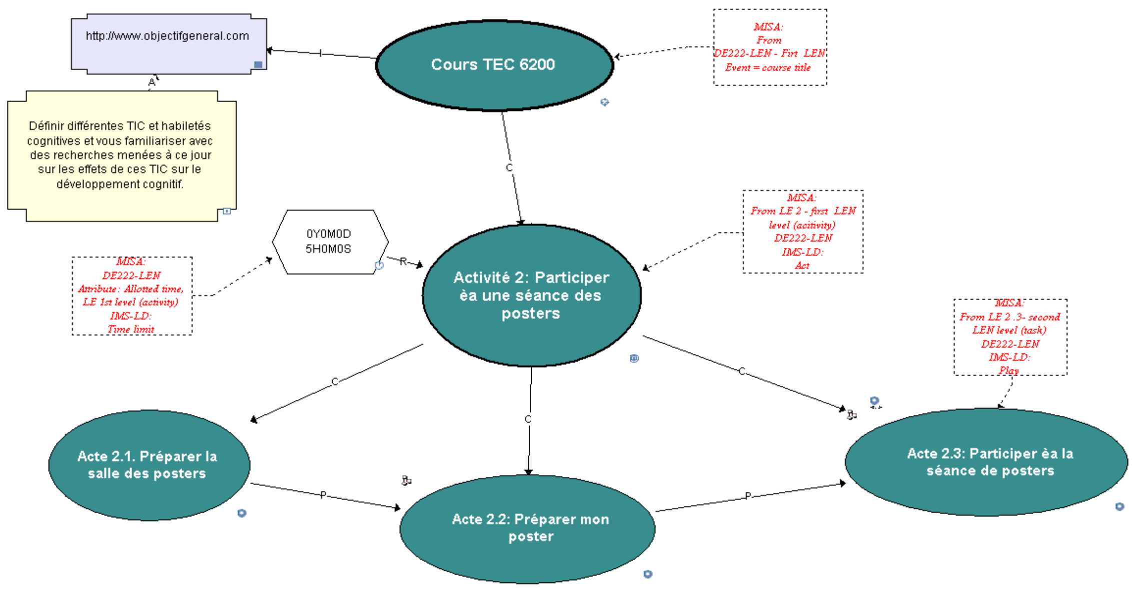


Figure 5-11. Partial UoL (Method, Play and Acts) from second session built in MOT+ LD (see Appendix 5-L for a detailed presentation)

Session 1: UoL modeling (in progress)

The table below results from the analysis of the UoL as represented at the end of session 1. The first column presents the UoL elements as the participant named them and it is divided in two parts: the first contains the main element and the second holds other elements associated to the main element. The second column identifies the IMS LD elements named as in the Specification metamodel. The third column establishes the equivalences with MISA Documentation Elements and their attributes, as reused by the participant. The last column clarifies the type of link between the elements and also contains comments regarding limitations of these equivalences.

The participant chose assignment 2.3.2 from his course (Learning event 2.3.2 –third level- from his Learning Event Network also identifiable as a learning unit from the instructional scenario)

For the representation of the UoL he used MOT+ LD editor and followed the MOT+ LD Modeling Technique from 1.0 (Opening a new IMS LD UoL Model) till 3.2.3 (Add a feedback message reference address in the Item object).

Table 5-2

Participant's partial UoL after session 1: identification of correspondences between IMS LD elements and MISA DE attributes

Element name in the on progress UoL		Corresponding IMS LD element	Corresponding MISA DE and attribute
Main element	**Associated element/s**		
Course TEC 6200		Method	DE222-Learning Event Network Attribute: *LE*, course title.
	Learning objective explained.	Learning objective	Learning objective from his online course. Learning objectives in MISA: DE214-Target Competencies attribute *Expected skill* expressed as a value and, attribute *Target Competency* articulated as a paragraph linking knowledge and skill scale. "*The learning objectives specific to the LU are the target competencies associated with the LU's principal knowledge. These are described in DE 214*" (MISA DE, p. 85) Comment: Linked to Learning objective as an instantiation. This is not a valid procedure in IMS LD. Participant should have defined a URL pointing to the learning objective.
Assignment 2.3.2		Play	DE222-Learning Event Network Attribute: *name*, *LU*, 3rd level (assignment) = DE320-Instructional Scenario Attribute: *name*, *LU*, 3rd level (assignment) Comment: Play is linked to Method by a "Composition link"
	5 hours	Time limit	DE222-Learning Event Network Attribute: *Allotted time, LU*, 3rd level (assignment) = DE320-Instructional Scenario Attribute: *Allotted time, LU name* (assignment) Comment: Linked as a rule on activity 2.
Act 1: personal question elaboration		Act	DE320-Instructional Scenario Attribute: *LA name* (learning activity) Comment: Acts are linked to Play by a "composition link". Acts are linked by "Preceding links" (A sequence in IMS LD)
	If finished	Condition (level C)	Rule Comment: Participant adds the rule about the automatic message that the system should send to the learner.
	Confirmation of question placement		Comment: The message itself. This is not a valid procedure in IMS LD. Participant should have defined an URL pointing to the message.
Act 2: personal question placement		Act	DE320-Instructional Scenario Attribute: *LA name* (learning activity)
Act 3: answering to pair question		Act	DE320-Instructional Scenario Attribute: *AA name* (assistance activity)
Act 4: forum		Act	DE320-Instructional Scenario

Element name in the on progress UoL		Corresponding IMS LD element	Corresponding MISA DE and attribute
Main element	Associated element/s		
discussion participation			Attribute: *LA name* (learning activity)
Act 5: assessment of students outcomes		Act	DE320-Instructional Scenario Attribute: *AA name* (assistance activity)

Role definition sub-model

Element name in the participant's on progress UoL		Correspondent IMS LD element	Correspondent MISA DE and attribute
Main element	Associated element/s		
Student collection		Role	Actor / Comment: In MOT+ LD Roles are defined in a separate model and integrated into the UoL at the activity structure or activity level. These roles are generic and they become role-parts when associated to an activity or activity structure.
	Student group	Role	Actor
	Individual student	Role	Actor
Facilitator		Role	Actor

Participant day 2: UoL (in progress) production

At the beginning of session 2, the participant decided to change the UoL and build it from an upper level. He chose activity 2.3 from his course (Learning Event 2.3 from his Learning Event Network). Once again, he used the editor application and the MOT+ LD Modeling Technique from 3.2.3 (Add a feedback message reference address in the Item Object) to 4.8.3 (Adding Send-Mail Services). The table follows the same structure as previously.

Table 5-3

Participant's in progress UoL after session 2: identification of correspondences between IMS LD elements and MISA DE attributes

Element name in the participant's in progress UoL		Corresponding IMS LD element	Corresponding MISA DE and attribute
Main element	Associated element/s		
Course TEC 6200		Method	DE222-Learning Event Network Attribute: *LE*, course title
	URL to learning objective	Learning objective	Not defined Comment: Linked to Method. Participant finds awkward having to create a link to a pre-written learning objective. He asks himself when the designing process begins.

Element name in the participant's in progress UoL		Corresponding IMS LD element	Corresponding MISA DE and attribute
Main element	**Associated element/s**		
	Learning objective explained.	Learning objective	Learning objective from his online course. Comment: Linked to Learning objective as an instantiation.
Activity 2: participate in a poster session		Play	DE222-Learning Event Network Attribute: *LE name*, 1st level (activity) Comment: Play is linked to Method by a "Composition link"
	5 hours	Time limit	DE222-Learning Event Network Attribute: *Allotted time*, LE 1st level (activity) Comment: Linked as a rule on activity 2.
Act 2.1: arrange the poster room		Act	DE222-Learning Event Network Attribute: *LE name*, 2nd level (task) Comment: Acts are linked to Play by a "composition link". Acts are linked by "Preceding links" (A sequence in IMS LD)
Act 2.2: prepare the own poster		Act	DE222-Learning Event Network Attribute: *LE name*, 2nd level (task)
Act 2.3: participate in the poster session		Act	DE222-Learning Event Network Attribute: *LE name*, 2nd level (task)
Activity structure # 1		Activity structure	DE222-Learning Event Network Attribute: *LU*, 3rd level = DE320-Instructional Scenario Attribute: *LU name* Comment: No specific name is assigned by participant, only a generic one.
	Reread assignment guidelines	Learner activity	DE320-Instructional Scenario Attribute: *LA name*, 4th level (step)
	Choose two researches	Learner activity	DE320-Instructional Scenario Attribute: *LA name*, 4th level (step)
	Inform your facilitator about the chosen research	Learner activity	DE320-Instructional Scenario Attribute: *LA name*, 4th level (step)
	Individual student	Role-part	DE320-Instructional Scenario Attribute: *Actor* Comment: In MISA, DE322-Property of each activity, Attribute: *Addressee*
Activity structure # 2		Activity structure	DE222-Learning Event Network Attribute: *LU*, 3rd level = DE320-Instructional Scenario Attribute: *LU name*
	Approve student's choices	Staff activity	DE320-Instructional Scenario Attribute: *AA name*, 4th level (step)
	Facilitator	Role-part	DE320-Instructional Scenario Attribute: *Actor* In MISA,

Element name in the participant's in progress UoL		Corresponding IMS LD element	Corresponding MISA DE and attribute
Main element	**Associated element/s**		
			DE322-Property of each activity Attribute: *Addressee*
Activity structure # 3		Activity structure	DE222-Learning Event Network Attribute: *LU*, 3rd level = DE320-Instructional Scenario Attribute: *LU name*
	Read the two research documents	Learner activity	DE320-Instructional Scenario Attribute: *LA name*, 4th level (step)
	Inform yourself on the research methodologies	Learner activity	DE320-Instructional Scenario Attribute: *LA name*, 4th level (step)
	Elaborate a poster	Learner activity	DE320-Instructional Scenario Attribute: *LA name*, 4th level (step)
	Send your poster to the facilitator	Learner activity	DE320-Instructional Scenario Attribute: *LA name*, 4th level (step)
	Individual student	Role-part	DE320-Instructional Scenario Attribute: *Actor* Acts are linked to Play by a "composition link". Acts are linked by "Preceding links" (A sequence in IMS LD)Attribute: *Addressee*
Activity structure # 4		Activity structure	DE222-Learning Event Network Attribute: *LU*, 3rd level = DE320-Instructional Scenario Attribute: *LU name*
	Approve student's poster placement	Staff activity	DE320-Instructional Scenario Attribute: *AA name*, 4th level (step)
	Facilitator	Role-part	DE320-Instructional Scenario Attribute: *Actor* In MISA, DE322-Property of each activity Attribute: *Addressee*
Activity structure # 5		Activity structure	DE222-Learning Event Network Attribute: *LU*, 3rd level = DE320-Instructional Scenario Attribute: *LU name*
	Place the poster in the poster room	Learner activity	DE320-Instructional Scenario Attribute: *LA name*, 4th level (step)
	Individual student	Role-part	DE320-Instructional Scenario Attribute: *Actor* In MISA, DE322-Property of each activity Attribute: *Addressee*
Explor@		LO	Location Comment: The participant misunderstands the meaning of Environment in IMS LD associating this with a specific LCMS (Explor@). IMS LD is platform independent. In this sense a specific platform is not referenced, only the services and the

Element name in the participant's in progress UoL		Corresponding IMS LD element	Corresponding MISA DE and attribute
Main element	Associated element/s		
			Learning Objects.
	Work guidelines	LO	DE320-Instructional Scenario, Attribute: *Actor*
	Poster room thematic document	LO	DE320-Instructional Scenario Attribute: *Guide*
	Webography	LO	DE320-Instructional Scenario Attribute: *Guide*
	Virtual library	Service?	DE320-Instructional Scenario Attribute: *Tool*
	Two chosen researches	LO	DE320-Instructional Scenario Attribute: *Instrument*
	InfoSphere	LO	DE320-Instructional Scenario Attribute: *Guide*
	E-mail service	Service	DE320-Instructional Scenario Attribute: *Means of communication* Comment: First, the participant wants to represent "the message" to be sent and not the service itself.

To better understand the reuse of elements in the final UoL, we have put together the following table that presents the elements of a generic UoL and, in its second column, we identified the DE attributes reused from the participant's preexistent course DEs. In those cases where the attribute was not directly reused from a DE, we have added a third column to explain where these attributes can be found in the MISA method.

Table 5-4

IMS LD elements and MISA DE attributes correspondence in the participant's UoL.

Generic UoL elements(Level A)	MISA DE and attributes used by the participant	MISA DE and attributes
Method	DE222 Attribute: *LE* (LEN head name)	In DE222 the LEN represents LE in a hierarchic manner. Each LE has a name and it is represented as an oval shape.
Method – objective reference (URL)	Not defined in MISA	---
Method – objective instance	From his course Web site.	DE214-Target competencies – Attribute: *Target competency* of the LE corresponds to the learning objective in IMS LD. In DE212-Knowledge Model, generic skills are assigned to main knowledge units. The DE214-Target competencies card establishes, for each Target Population (DE124), a *Present* and *Expected generic* and *level of skill* to be translated into a *Target competency* as a text and associated to each main knowledge unit. In MISA, target competencies are defined on the knowledge axis and are classified and quantified within a structure involving skills. It is a knowledge modeling approach that is subsequently associated with the

Generic UoL elements(Level A)	**MISA DE and attributes used by the participant**	**MISA DE and attributes**
		instructional scenario.
Play	DE222-Learning Event Network Attribute: *LE name*, 1st level (activity)	
Play – Time limit	DE222-Learning Event Network Attribute: *Allotted time*, LE 1st level (activity)	
Act	DE222-Learning Event Network Attribute: *LE name*, 2nd level (task)	
Activity structure	DE222-Learning Event Network Attribute: *LU*, 3rd level = DE320-Instructional Scenario Attribute: *LU name*	
Environment – LO	DE320-Instructional Scenario Attribute: *Guide, Tool, Instrument,*	
Environment – Service	DE320-Instructional Scenario Attribute: *Means of communication*	
Learner activity	DE320-Instructional Scenario Attribute: *Learner Activity name*, 4th level (step)	
Staff activity	DE320-Instructional Scenario Attribute: *Assistance Activity name*, 4th level (step)	
Role part	Participant uses his DE320-Instructional Scenario to assign role-parts to activities.	In MISA, DE322-Property of each activity Attribute: *Addressee*

Role sub-model

UoL elements (Level A)	**MISA DE and attributes**
Role part: all learners	Implicitly defined in the participant's DE222 and DE320 (through his Web course)
Role-part: Learner	
Role-part: Group	
Role part: facilitator	

5.2.3.2 Analysis of the representation procedure (objective 2)

The purpose of this section is to identify critical elements that can provide guidelines about the MISA method design process leading to the modeling of IMS LD UoL, that is, a learning flow that respects the Specification patterns.

The identification of DE attributes and values is not sufficient in itself to isolate all the elements that are common to the Method and Specification. How they are organized and structured and how decisions are taken must also be examined. We will explore these questions through a process analysis, a dynamic view, complementary to the rather static analysis of outcomes produced by the participant, which was presented in the last section.

In order to reconstruct the participant's activity, we have created two tables. The first one presents the prescribed tasks for the completion of an instructional scenario narrative. This narrative should be used to represent a UoL in a graphic mode using the MOT+ LD editor. The LD graphical representation is then exported as a machine readable specification compliant document called "Manifest" (an XML document). To accomplish this, the editor's MOT+ LD Modeling Technique (representational technique) prescribed an ordered list of tasks that gave shape to the second of the two tables further below.

We understand the terms 'task' and 'activity' as explained by Leplat (1991). He defines the task as a goal, which is assigned to an individual or group, and which is to be reached under a determinate (although not necessarily explicit or well defined) condition. An activity, according to the same author, is the response to the prescribed task, the mechanisms used to perform the task including cognitive strategies, and anticipation mechanisms.

The first column presents a numbered task list following the template and the guide. The second column describes the participant's activities. To reconstruct this process we used the observations notes, the outcomes produced by the participant, as well as the screen and work environment recordings, which includes a soundtrack of the participant's voice (thus capturing verbalization yielded by the think-aloud technique). The third column establishes the relationship between the activities and the MISA method. In this sense we identify the DEs -- and the DE attributes -- that are reused during design. We have also written down possible relationships with the MISA process and we noted instances of terminological conflict between the method and the specification (i.e., use of the same words, but with different meanings).

The second table, based on the guide, also has an additional column. The forth column identifies difficulties experienced by the participant while using the editor and user guide-related problems.

Table 5-5

Participant narrative analysis

	Narrative		
	Prescribed tasks	**Participant activities**	**MISA implications**
	UoL information		
0.1	Define UoL title	He chooses activity 2.3.2 from his LEN	Reuse of activity 2.3.2 from DE222-LEN, attribute *Title*
0.2	Name the Author	Himself	
0.3	Describe the instructional approach	He defines the learner curriculum degree, the UoL content as well as facilitator and pair support (the guide isn't clear enough).	**The learner curriculum degree** may be retrieved from DE100-Organisation Training System, attribute: *Training Client* (more specifically from the LU, DE224-Learning Unit Properties, attribute: *Section A Target Populations*). The **UoL content** may be understood as a knowledge sub-model associated to the learning scenario. However, it can be associated to DE212-Knowledge Model, specifically to *Section B Sub-models*, and to DE310-Learning Unit Content. **Learner support** is analogous, in the first instance, to DE100-Organisation's Training System, attribute: *Learner Support*. This support is indirectly associated to the *Collaboration Rules* attribute in DE222-Learning Event Network and DE320-Instructional Scenario, as well as to DE440-Delivery Model, at attribute: *Actor*.
0.4	Describe context	He consults his course Web site to describe the delivery environment (the guide isn't clear enough).	For the forum: The *Means of Communication* attribute in DE222-Learning Event Network and DE320-Instructional Scenarios (as well as DE440-Delivery Models, which had not been used by the participant). For **Explor@** including LCMS **Poster room**: Attribute *Package of Materials* in DE440-Delivery Models
0.5	Define Preconditions: present skills	He establishes no precondition	DE214-Target Competencies, attribute: *Present skills*
0.6	Define Objectives: targeted skills	He copies and pastes the learning objective of an upper level (2.3) from his online course. He does so, because he realizes he is into a relatively deep level of the course where it does not make much sense to define further, more precise objectives (i.e., activity 2.3.2 is part of activity 2.3, and ipso facto, the objective is valid).	DE214-Target Competencies, attributes: *Expected Skill* (expressed as a value) and *Target Competency* (articulated as a paragraph linking knowledge and skill scales). "*The learning objectives specific to the LU are the target competencies associated with the LU's core knowledge. These are described in DE 214.*" (p 85 MISA DE)

	Narrative		
	Prescribed tasks	**Participant activities**	**MISA implications**
0.7	Define Roles	He defines facilitators (facilitator and pairs) and learner role.	"*The choice of types of learning scenarios has a determining effect on the overall instructional strategy adopted and on the role attributed to learners and instructors. Each type of learning scenario determines the role in general of learners (from spectator/listener to more active roles). In each case, the instructor's role will be different and will be specified during the construction of the delivery model.*" (p 54 MISA DE) DE222-LEN and DE320-Instructional scenarios orient the role definition. DE440-Delivery model, attribute Actor has the property to better describe and represent Roles (in MISA are Actors). Participant hasn't got DE440; instead he uses his course Web site.
0.8	Define Services	He identifies the forum tool for the conference and the e-mail tool.	Attribute *Means of communication* in DE222-Learning Event Network, DE320-Instructional Scenarios (and DE440-Delivery Models, DE not elaborated by the participant)
0.9	Define Plays	He doubts about what this means and how to establish this hierarchy. She ends by copying and pasting the learning scenario of activity 2.3.2 from his course Web site.	DE222-Learning Event Network, attribute LE (Learning Event) DE320-Instructional scenario – attribute LU (Learning Unit), a the name of the LU
0.1 0	Define Acts	He has doubts about what this means and how to establish this hierarchy. He first thinks it's the same as 0.9 but she will finish by breaking down the Instructional scenario in a deeper granularity	DE320-Instructional scenario - LU (Learning Unit) attributes *Learning activities* and *Assistance activities*
0.1 1	Define Activity Structure	Not define as he founds it identical to the previous definitions of steps0. 9 and 0.10. The participant demands some objective criteria to be able to differentiate this hierarchy.	From a MISA perspective we could say that the user has in mind his LEN and LSs and he tries to establish the equivalences between the MISA hierarchic way to decompose the course and the way that the specification understands this. This commentary is valid for steps 0.9 to 0.11

Table 5-6

Participant process design analysis based of the modeling technique

	GUIDE			
	Prescribed tasks	**Participant activities**	**MISA implications**	**MOT+ LD and GUIDE**
1.0	**Opening a new IMS LD UoL Model**	**Finding correspondences between LEN and IS and IMS LD UoL hierarchy.**		
1.1	Choose the option 'Educational' in the Model Type Menu.	OK		
1.2	Modify the objects names to suite your purposes.	He assigns his Course title to the Method, his Assignment 2.3.2 to the Play and the steps of her instructional scenario to the Acts.	He tries to establish equivalences between his LEN DE222 and his Instructional scenario DE320. In this sense, the Method corresponds to his first level LEN, the Play to the smallest level of the LEN (the Learning Unit – in MISA).	MOT+ LD: He asks why the tree representation on the right of the screen isn't the same as his model. He expects to find the same graphical hierarchic representation as a thread. GUIDE: it doesn't provide the necessary explanation. Terminology is "too close" to the specification.
1.3	Renaming Main Subject Title	He does not understand what a "subject" is in this context		GUIDE: it isn't clear. Terminology is "too close" to the specification.
1.4	Save your model using a representative name.	OK. He names the file as the assignment 2.3.2 and as an "instructional scenario"		
2.0	**Build a Role Definition Sub-model**	**Creating a sub-model of roles.**		
2.1	If the Roles hierarchy is known, they can be described in a Definition Sub-model, otherwise Roles are defined in the Act's sub-model.			MOT+ LD: Problems identifying the access to create role sub-model.
2.2	Create a Role hierarchy using the two IMSLD types: **Staff** or **Learner**	He first thinks it is a simple solution, only learner and staff roles. After, he thinks better and he founds a problem of how to differentiate an individual learner role and a learners' team or group role. He is thinking about the students that will be involved in a discussion, as they act individually in a team activity. He defines then Learner and Group of Learners, and Facilitator roles. He doesn't know where to create the sub-model. His first intention is to add the roles model into the main model he is working on (somewhere in the Method, Play, Act model). In fact, after expert help, he	He thinks about the assignment 2.3.2, the instructional scenario DE320. He doesn't quite well understand why she has to build this "role sub-model". He thinks in terms of activities and in MISA roles are attached directly to activities.	MOT+ LD: Problems of how to rename the model and where to edit it. It is confusing to create a sub-model away from the main model he is working on. GUIDE: it isn't very clear about the **need** to create a role sub-model and **where** to do it.

GUIDE				
	Prescribed tasks	**Participant activities**	**MISA implications**	**MOT+ LD and GUIDE**
		creates this sub-model where the editor awaits it. He asks for help.		
3.0	**Complete the Main Model**	**Finding correspondences between LEN and IS and IMS LD UoL hierarchy.**		
3.1	According to your needs, complete the Main Model Structure by adding: • Parallel **Plays** with a using a composition link (C) from the Method object. • Sequential Acts are C-linked from the Play and have P-links between them.	He reviews his structure. Tries to resolve the problem of criteria for separating Plays and Acts. He hypothesizes about thinking in terms of C or P links as a way to guide the learning scenario breaking down.	He tries to reinterpret equivalences between his LEN DE222 and his Instructional scenario DE320. In this sense he keeps the Method and Play as established before (Method corresponds to course title and Play corresponds to LE 2.3.2 from his LEN). He adds Acts based on his Instructional scenario (IS) for the 2.3.2 assignment steps. He uses her broken down IS from the narrative (template) to deploy the acts. He finds the need for description too exhaustive. He asks himself if it wouldn't have been better to begin the UoL at a higher level of his LEN. He asks once again criteria for establishing these levels.	
3.2	According to your needs, add the following objects			
3.2.1	• Pre-requisite or a Learning Objective.	He would prefer to add objectives to the Play level. He copies and pastes the course objective from his online course and assigns it to the Method. He doesn't understand that he is not suppose to do that directly; he should first associate a reference (an URL) pointing to the objective as a text paragraph.	In his LEN he has assigned learning objectives to the LE identified as Plays in the IMS LD UoL He says he has began this UoL at a too deeper level. The idea of referencing objectives means the previous elaboration and saving somewhere. It supposes a prior development. In this sense the model "integrates" elements of instructional design previously though and created and placed somewhere in order to be accessible by the referencing. The participant finds that awkward.	GUIDE: it isn't clear enough.
3.2.2	• A Time-Limit object as a rule on	He wants to assign a time but in terms of	He reuses his LEN and IS. Once again	GUIDE: it isn't clear enough.

GUIDE				
	Prescribed tasks	**Participant activities**	**MISA implications**	**MOT+ LD and GUIDE**
	the Play or Act.	duration and not in terms of a specific day and hour.	he has the problem of hierarchic level chose to describe the UoL.	
3.2.3	• Add the **On Completion** symbol R-linked to a Play or Act.	He assigns the Completion rule to a Play. He writes the message object. There's a help intervention to explain that he has to write a reference to the message, in the same way of the objectives. The participant finds this way of proceeding awkward, having to refer, during the design process to an element so simple like a message situated somewhere else.	DE320	GUIDE: it isn't clear enough.
3.2.4	• Labels and other IMSLD objects.	The participant doesn't complete this task.		GUIDE: it isn't clear enough. Terminology is too close to the specification, an informatics' language.
3.3	Save your work as usual to create the MOT+ graphical file and then click on the **Export to IMSLD** option in the **Tools** Menu.			MOT+ LD: Editor problems.
	During session 2 of the experience, the participant decides to redesign the Unit of Learning beginning it in an upper level of his LEN.	The participant redesigns his UoL going to un upper level.	DE222 and DE320. As repeatedly mentioned during session 1, the participant finds he has begun the development of his UoL in a too deeper level. He is conscious that if he keeps the UoL unchanged, next in-depth steps will fall into the operational level like describing the way to use an application, a non sense. He will then establish a new correspondence with his LEN and IS. Method will remain unchanged as the course title but Play will correspond to its IS Activity 2.3 and Acts will correspond to the Learning Units in MISA.	
4.0	**Develop the Act's Learning Scenario (flow)**			
4.1	Open the sub-model of an **Act**	From the new beginning (the modified		

GUIDE				
	Prescribed tasks	Participant activities	MISA implications	MOT+ LD and GUIDE
		upper level UoL) he deploys some acts.		
4.2	Add **Roles** according to their type : **Learner** or **Staff**			
4.3	Add **Activities**, choose **either: Activity Structures, Learning** or **Support Activities**.	He deploys acts into activity structure and activities. He first thinks that he could separate activity structures by roles, but soon he realizes this is not a criterion for that. Help is given.	Using IS steps (DE320) from his course Web site and the narrative.	
4.4	Identify **Activity Structure**'s Type: **Selection** or **Sequence**	He adds links between activities. Once again he doubts about the hierarchic elements of his UoL. She believes that the type of activity structure, either Selection or Sequence is a criterion to determine the breaking down of Plays. Help is given.		
4.5	Create **Role-parts** by link **Roles** to **Activities**	He links roles to activities. Once again, Learner role and Learner Team role are not clear to differentiate.		
4.6	Identify whether Support Activities must be performed separately with each person in a **Role** or once with all persons in a **Role**.			GUIDE: it isn't clear enough.
		Understanding where to add environments whether to activity structure or to activity		
4.7	Add an **Environment** by using the IP link to one or several Activities.	The participant adds un Environment in the MISA sense, which differs from the specification conceptualization. He tries several times to add environments to activities but it is only permitted to activity structure. He finds that not pertinent because the activities may use different environments (in the MISA sense). Should environment be another criterion to separate activities or activity structure?	This terminology similarity (of Environment) but different meaning results confusing.	
4.8	Add the **Environment's** components	**Adding/associating learning objects to environments**		

	GUIDE			
	Prescribed tasks	**Participant activities**	**MISA implications**	**MOT+ LD and GUIDE**
4.8.1	Adding **Learning Objects** and **Outcomes**	He adds then LO to the environment.	From his LEN and IS that incorporate the LO identified in DE430-List of Learning Materials	
4.8.2	Adding **Conference Services**			
	• Identify the **Type** by adding an appropriate label	The participant says he has no conference service to add.		
	• Identify conference rights for each Role by adding one or several appropriate labels.			
4.8.3	Adding **Send-Mail** Services	**Understanding where to add whether e-mail service or e-mail message**		
	• Identify the Type by adding the adequate label	He receives help.		MOT+ LD: Problems identifying the Type of label menu.
	• Identify the destination Roles of emails	He has problems differentiating the addition of an e-mail tool or an e-mail message. He tries to represent a message to be sent so he tries to link the message to the activity and not to the environment.	On designing the UoL the designer has to pass from a learning flow description to the addition of services and LO. This process is subdivides in MISA in DE440-Delivery Model.	
Not completed from 4.8.2 till 4.9.7 (although prescribed in the MOT+ LD Modeling Technique, they were not carried out given the participant's much greater need for assistance)				
4.10	Save your work as usual to create the MOT+ graphical file and then click on the **Export to IMSLD** option in the **Tools** Menu.	OK		MOT+ LD: Manifest incomplete.
Researchers decided to end the experiment as the participant needed more and more help to continue. The experience became a training session. Researchers realized the need for a more pedagogical guide and the need for a method.				

Data interpretation: synthesis

As previously mentioned, the MOT+ LD Modeling Technique is a way to help in the representation of a UoL, but is not a method in and of itself. For the purpose of the study, UoLs had been primarily understood as a different way of representing a MISA instructional model, leaving open the possibility of UoLs being able to capture any other element of MISA that can take part in such a representation. In this spirit, we tried to identify possible means of, and difficulties in, doing so, in order to introduce the necessary changes to MISA.

The analysis of the sessions' data let us conclude that beyond the prescribed tasks, we could identify, from the participant's perspective, five main activities:

1. Creating a sub-model of roles.
2. Finding correspondences between MISA Learning Event Network and Instructional Scenario with IMS LD UoL hierarchy.
3. Understanding where to add "environments" whether to "activity structure" or to "activity"
4. Adding/associating learning objects to environments
5. Understanding to add either "e-mail service" or "e-mail message"

Creating a sub-model of roles

The participant begins session 1 by creating a sub-model of roles. To accomplish this, he analyses the MISA learning unit (DE320) to be represented, identifying pre-established roles included into the learning and assistance scenarios. Depending on activities described in the scenario he builds a role sub-model composed of the course facilitator and student roles. As the learning activity to be represented is collective, he decomposes the latter into "individual student" and "student group" roles.

As we can see, building a role sub-model presupposes a clear understanding of the learner/support activities to be represented. Although MISA does require a role description during its first phase (DE104-Target populations), this is a preliminary and general definition of roles that must be refined during the design process. The detailed role description of a UoL may seem inadequate to the instructional design process. It would end up being easier to build during scenario creation, as a way to collect and organize all the identified roles. This is what actually happened during the session, since the participant was indeed counting on his prior design of a MISA learning unit.

Finding correspondences between LEN and IS and IMS LD UoL hierarchy

As stated before, the UoL built during the sessions was partial and did not strictly comply with the IMS LD specification. As a result of this, we will mention the DEs directly used as a source of information for the UoL representation.

The search for correspondences between the MISA DE and the LD was the most central and time consuming element of the sessions.

From the analysis of the materials produced by the participant during the first session (template and LU graphical representation), it emerges that the main problem was finding correspondences between the LEN (DE222) and the pedagogical scenario (DE320) that was to be expressed in an IMS LD format. The participant found very difficult to establish equivalences between the hierarchic structure of the Method and the Specification. During the second session, as the problem persisted, the participant explored an upper level of his MISA hierarchy in order to establish a better correspondence with the IMS LD pedagogical meta-model. This decision resulted consequences that satisfied him, as he was able to continue to add other elements to the UoL.

Reuse of DEs and DE attributes.

MISA DE222-Learning Event Network, together with DE-320-Instructional Scenario, is the documentation element most utilized as an information source for the representation of the UoL.

DE222-Learning Event Network

The MISA Learning Event Network expresses the **instructional structure** of a learning system consisting of several learning events organized in hierarchic (vertical) and progressive (horizontal) modes. There are no pre-established limits about the number of LEs or LEN depth. The links between them suggest the most efficient way to progress through the learning system by specifying rules for progression. The smallest LE is called a Learning Unit (LU) and it can only be decomposed into a learning and/or an assistant scenario.

A LEN consists of a graph where the nodes represent the learning events (procedures). To these LEs are associated resources required to accomplish the procedures and principles guiding them (study approach, collaboration, evaluation and customization rules).

From LEN222 we could identify the reuse of “Learning Events Name” attribute associated to IMS LD UoL hierarchy elements (viz. method, play, act, activity structure, and learner/staff activity). The LEN “resources” are not appropriate for a UoL representation as there is semantic difference between the method and the specification in respect to ‘resources'. The “links” shape the UoL hierarchy, which breaks down into plays, acts and activities. Although it is possible to declare explicit rules (viz. study approach, collaboration, evaluation and customization rules), formally in a LEN, the participant’s own network was not rich, in this regard. We suppose that explicit rules together with better criteria (see next section) for the scenario break-down could help with scenario creation/transposition.

DE-320-Instructional Scenario

Directly linked to the LEN via the Learning Units, an instructional scenario consists of:

> a learning scenario proposed to the learner and a scenario of assistance designed for tutors/teachers/coaches. Modeling an educational scenario consists in specifying the activity or activities appropriate for the learner, in addition to any elements of assistance, including all of the resources required to complete the activities, as well as the expected products of these activities (MISA glossary, p. 25).

From DE320, the participant reused the “learning unit name”, the “learner activities”, the “assistance activities”, and the “resources” associated to the activities. Once again, the “links” helped to establish the activity acts, the activity structure and the activity divisions. Rules were implicitly narrated within the scenario evolution, thus aiding the scenario division, but the lack of clear criteria for building a hierarchic LU led to failure to represent a totally compliant LU.

From a pedagogical perspective, the UoL hierarchic decomposition is not yet clearly established by the Specification. This problem of UoL granularity is partially addressed in a “role-part” or “sequential versus alternate executing activity” perspective. Once again, a detailed description of MISA instructional model rules (DE222 and DE320) could be the solution to these hierarchic criteria for the UoL break-down.

Further crucial information, related to the degree of description and detail required by the UoL, emerges from this case study. The participant (an advanced instructional designer) declared having the impression of “not designing”, and expressed the sensation of having to deploy the “Delivery model”. (Data origin: from debriefing). In fact, the MISA “*Delivery Models (DE 440) highlight the relationships between* ***Actors*** *and* ***Packages of Materials*** *(DE 442),* ***Tools*** *and* ***Means of Communication*** *(DE 444),* ***Delivery Services*** *and* ***Locations*** *(DE 446) that will be used or made available.*”

From the analysis of the resulting UoL and DE222 and DE320, it is possible to envision a way of building the pedagogical scenarios in an LD-compliant partial state (plays, acts and activity structures) and to complete the LD (environments) during the building of the UoL delivery model. The additional information required to "rebuild" the pedagogical scenario during development of the UoL delivery model would have to be found in DE224 Learning Unit Properties and DE322 Properties of Each Learning Activity. Explicit declaration of rules is crucial to guide the UoL design process.

Understanding where to add environments to activity structures and to activities

Following the MOT+ LD Modeling Technique, the participant is asked to add environments to the UoL. Terminological similarities combined to significant semantic differences between MISA and IMS LD led to misinterpretations of the guide regarding the association of environments to activities. (Data origin: from observation and notes) In MISA, "environments" refer specifically to the LMS or LCMS, whereas in IMS LD, the "environment" is composed of services and learning objects. Likewise, other terminology with multiple meanings amounted to further confusion during the session.

More than just terminological similarity or disparity, but also the way in which the UoL elements are grouped together must be taken into account. It is possible to think of a way to add LD environments during the building of the Delivery Models as a means to configure the MISA packages in an LD manner. As MISA Delivery Models may be built in different ways -- organized by actors, locations, etc -- LD-compliant Delivery Models would have to be built for each UoL. This could simplify the task by aggregation of UoL Delivery Models.

Adding/associating learning objects to environments

Even though a "LO" was associated to an "environment" by the participant, this procedure was quite partial, as the terminological confusion persisted. DE430-List of Learning Materials and DE432-Learning Material Model constitute two possible ways of populating environments with LO and Services.

Understanding where to add an e-mail service and e-mail messages

The participant hesitated many times about whether the guide was requesting the addition of the e-mail tool or an e-mail message. The participant wasn't sure if he had to declare the activity flow (the message to be sent to the facilitator) or add a component to the "environment" (e-mail service adding).

5.2.4 Conclusions, recommendations and implications

5.2.4.1 General conclusions

The participant represented an incomplete and only partially compliant UoL, which included a method with “plays”, “acts”, “activity-structures” and “learner-and-staff-activities”. He associated a “learning-objective” to the “method”. Following the MOT+ LD Modeling Technique, the participant established a role hierarchy as a sub-model, which was reused when declaring “role-parts” associated to “activity-structures” or “learner-and/or-staff-activities”. He also associated “environments” (“learning-objects” and “services”) to “activity-structures” and “learner-and/or-staff-activities”. Some “outcomes” were declared within “activity structures”.

At a glance, we could believe that a UoL was actually built during the sessions. A deeper analysis of the work and materials produced by the participant allowed us to realize that this result was not an IMS LD-compliant UoL, even if we identified most of its components.

On the other hand, the sessions reveal many strategic key problems that point towards possible adaptations of MISA.

Criteria for breaking down the UoL

It has been evidenced that the concepts and structure of the Method and Specification share common ground but that this is not enough to produce a coherent UoL. Correspondences between the MISA instructional scenario and the UoL are not one to one. We must explore ways to establish criteria for breaking down instructional scenarios. These elements have to relate the UoL hierarchic elements to the learning flow; in other words, we have to examine the close relationship between the MISA instructional and delivery models. We also have to make more explicit the interdependence between the hierarchical LD structure (method, play, act, activity structure and activities) and the other elements (viz. role-parts, activity sequence, and environment). In this sense must also look at the possible impact of Levels B and C in both MISA DE222-LEN and DE-320-IS.

MISA proposes an instructional model based on two main DE elements: DE222-LEN and DE320-IS. DE222-LEN is composed of Learning Events (LE), and the smallest LE (also known as Learning Unit-LU[21]) is the one that can only be decomposed by an instructional scenario (IS). The LUs are the transition points between the two DEs. The IS is composed of learning and assistance activities and can be drawn up as a complementary learner and assistance scenario.

[21] One should not misinterpret the concept of Learning Unit (LU) in MISA for that of UoL in the IMS LD standard.

IMS LD, based on a theatrical metaphor, proposes that the UoL has to deploys a three in-depth levels before introducing the activity-structure.

In order to understand possible relationships between the structures of the MISA mentioned DEs and the IMS LD UoL we could assume that a UoL integrates the LEN and the pedagogical scenarios (DE222 and DE320). It would also require limiting the LEN to three in-depth levels and expanding the pedagogical scenarios into learner/support activities or activity structures. But this interpretation is not sufficient, in and of itself, to establish the links between the Method and the Specification. As presented before disposing of a criterion for breaking down the scenario could complete the gap. Rules seem to be one first answer to this lack of criterion; they can help to distinguish and establish levels in the UoL. A complementary way to give a solution to this would also be adapting the properties of DE224- Learning Units and of DE322-Learning Activities may be the answer to this question. The learning flow and the role-parts have to be integrated into MISA DEs in an explicit way.

Design process

An LD requires organizing information in a certain way but it does not provide a method to do it. Representing a UoL supposes a previous process of instructional design where many decisions have been taken in advance. In this sense, the UoL can be understood as “a result” of the instructional design (ID) process (or pedagogical engineering process as proposed by MISA). Decisions about knowledge to be treated, learning objectives, target learning profiles, learning events, learner and staff activities, pedagogical material and services, etc., must be previously clarified in order to be expressed in the UoL.

As emerged from sessions analysis, the UoL builds on previous decisions, the outcomes of which are later integrated in the Learning Design; just mention some used by the participant from his previous design: the present and targeted skills, the identification of LO (in MISA, mainly a product on the knowledge axis), the assignation of services (in MISA mainly a product of the instructional and delivery axes). In this transposition study, DE222 and DE320 were the most reused by the participant, confirming the importance and need of a previous decision process. For example, the roles are described in MISA at the very beginning, in DE104-Target Populations. This DE describes a general, more or less complete profile of the groups of learners, at a high level. Each specific learner group profile card contains several attributes, and among them: *name, definition, number*, etc. DE212-Knowledge Model, DE214-Target Competencies, DE214-Learning Units’ properties, DE240-Delivery Orientation Principles, DE322-Properties of Each Activity (addressee), DE420-Properties of the Learning Units and Guides (addressee), as well as

DE430-List of Learning Materials (addressee) all take into account the target populations in order to define and associate specific knowledge, skills, competencies, activities and resources. If we do not modify the progressive design in MISA and retain DE320-IS as the DE to alter, we only have to consider the previous DE associated to DE320.

A UoL links together activities, roles, environments and so on, and this scenario snapshot is difficult to create all at once. A process of instructional design must support this progressive problem solving process.

Terminology

The MOT+ LD Modeling Technique was attached to the specification's terminology which, it turns out, diverges from the instructional design vocabulary.

Identical terms used with different meanings by MISA and IMS LD caused misinterpretations and induced errors.

We suppose that it is possible to keep the MISA definition of resources and propose the building of environments as packages at the delivery model stage.

MISA Documentation Elements and attributes reused by the designer

During the sessions it has been evidenced the reuse of Documentation Elements and attributes in order to produce a UoL. Learner/support activities and resources together with some of their attributes are reused during the scenario transposition, but here is what the analysis highlights:

- The attributes from the Documentation Elements, specifically DE222 and DE320, are reused but they are organized differently. While IMS LD supposes a strict way of structuring learner and support activities together with association of environments and establishment of the learning flow focuses on the delivery (or run), MISA pedagogical model is more flexible in the way the learner and support scenarios are built and focuses on instruction.
- MISA proposes declaring instructional rules (viz. study approach, collaboration, evaluation and customization) that are "*statements guiding the completion of the learning events, the learning units or the learning activities in the instructional scenario*". We suppose that the explicit declaration of rules will enable the operation of reorganizing the instructional scenarios, during the building of the delivery model according to IMS LD restrictions (boundaries). These poorly specified attributes, in the preexistent DE, seemed of great importance at the moment of building a UoL. Special attention must also be given to DE224 - Learning Unit Properties and DE322 - Properties of Each Learning Activity.

- The classification of MISA resources into LO and Services will facilitate the creation of IMS LD environments associated to specification-compliant learner/support activity and/or activity structures. In this sense we should explore adding of attributes to DE430 - List of Learning Materials.
- Designing a learning/teaching experience and shaping it to suit the machine running requirements revealed itself a complex task. MISA clearly separates the pedagogical and delivery models. Complementary processes of pedagogical and delivery scenario building could lead to better support for an instructional designer and better understanding for the creation of a UoL. MISA pedagogical scenario seems to be appropriate enough for the purposes of building a learning flow that respects the IMS LD structure. MISA Delivery Model could be appropriate for the addition of IMS LD "environments" organized as MISA "packages".

Reflection on the method and instruments applied.

The methodology proved to be appropriate for the research objectives. We find appropriate a short review about the applied method and supporting instruments that can reveal useful for later application in similar situations.

Table 5-7

Reflection on the method ant instruments applied in the case study

Instruments	Conclusions
Session protocol	It revealed satisfactory and supportive of both the participant's and the researchers' tasks.
LORIT booking form	Data collected (audio, computer screen and work space recording) was correctly captured and archived for later browsing and consultation.
Video recording	It helps understand the participant activity involving artifacts other than the application.
Screen recording	It helps understand the participant use of the software tool (in this case: building of a UoL with the MOT+ LD editor)
MOT+ LD Modeling Technique	Useful both as a procedural guidance and as a complement to the case study scenario.
Observation grid	It revealed useful helping focusing of relevant to the study events to pay special attention. The "Time" marking helped the video reviewing.
MISA, IMSLD and MOT+ LD appreciation questionnaire	Provide an before and after participant's perception fn the used tools.
Debriefing questions	Helped clarify some aspects and served as a participant evaluation of the sessions.

Think-aloud protocol guide	Very useful to capture the participant's intention when performing an activity.
Interview questionnaire (final debriefing)	Helped clarify some aspects and served as a participant evaluation of the case study as a whole.

Some lessons learned from the case data gathering:

- A longer period of participant training may be important for success of the field test.
- Having the participant filling in an appreciation questionnaire before the beginning of the first session and at the end of the final session allows comparing the perception before-and-after the use of artifacts, thus providing the range between expectations and actual appraise.
- Additional observer/s other than the session's coordinator appears to be very useful. The notes taken by other research collaborators enable capturing a more realistic portrait of the situation. The researcher leading the think-aloud protocol has to rest very attentive to the participant's actions, and it is difficult for him to take rigorous and sufficient notes at the same time.
- The debriefings adds critical information about the participant's work. As it takes place just before and after the exercise, it provides valuable information that could otherwise be forgotten afterwards. Open questions let the subject explain the activities and problems encountered.

5.2.4.2 Recommendations and implications

From the above analysis and interpretation we obtained a wealth of information that may be used in order to maintain essential MISA principles while proceeding to a deeper study and modification proposal of identified MISA Documentation Elements.

MISA DE106 – Current Situation requires identifying and describing *"the boundaries of the LS as well as the available human resources, material resources and services, and the constraints that may have an impact on the implementation of the LS*" (MISA DE descriptions, p.31).

In this sense, if the pedagogical engineering objective is to produce an IMS LD UoL, we have to determine the specific implications, in this DE, of such a decision within the MISA process.

Phase 2 of our research project has allowed us to discover some of the implications of an IMS LD impact on MISA. We will continue working on adapting the following DEs so that they can be explicitly referenced in DE106 as those mandatory to develop.

Other than DE106, we present the DEs that will be given particular attention in their modification. They will be validated by experts, as stated for phase 3 of our research.

- **DE 222 - Learning Event Network**
  - We will study the possibility of limiting the LEN to three levels of Learning Events: method (course name), play (course version name) and act (modules or chapters)
- **DE 224 - Learning Unit Properties**
  - This DE has to provide enough information for UoL building at the Delivery Model stage: the assignment of role-parts, the establishment of the (sequential or parallel) activity flow, the association of resources (LO and Services)
- **DE 320 - Instructional Scenarios**
  - Supported in DE222 and DE224, this DE should contain the activity structures and/or the leaner/support activities together with the needed resources or external UoL.
- **DE 322 - Properties of Each Learning Activity**
  - Same as DE224.
- **DE 430 - List of Learning Materials**
  - Through a semantic clarification between Method and Specification, this DE should include a new attribute to enable categorization of the resources into LOs and Services and help their aggregation into environments during the building of the Delivery Model.
- **DE 440 - Delivery model**
  - This DE should be the final operation leading to the UoL. DEs 222, 224, 320, 322 and 430 should provide information for the Delivery Model, to reorganize activity-structures and assign environments in an IMS LD-compliant way.

A UoL, from the MISA perspective, is the result of a pedagogical engineering process. In other words, it is the outcome of a problem solving and decision making process of learning design.

[22] Leplat, J. (1991). Organization of activity in collective tasks. In J. Rasmussen, B. Brehmer and J. Leplat (1991). Distributed decision making : cognitive models for cooperative work. John Wiley and Sons Ltd.
[23] Leontiev, A. (1974). The problem of activity in psychology. *Soviet Psychology*, 13, 2, 4-33.

This case study mostly showed the importance of maintaining the MISA process and structure unchanged. We can also conclude about the need to maintain and modify some documentation elements fundamental to keep track of the whole design process. We have also identified the need to expand MISA rule declaration to facilitate UoL break-down and the need to add attributes in appropriate documentation elements, to describe IMS LD activities, resources and sequencing. Special attention must be given to the adjustment of the Specification terminology to the method vocabulary, particularly, in order to facilitate the creation of IMS LD environments as MISA packages.

3. Towards phase 4 of the DDR

We can draw some conclusions from the solution explored before regarding the boundaries of the technique. Positive outcomes of this phase are the development of a visual instructional design language together with a software editor tool for the representation of IMS LD compliant pedagogical scenarios. However, the new pedagogical technique that is based on an MISA EML notation system and that adapts to IMS LD requirements was found to be more suitable for the technical profiles of teachers or designers comfortable with software engineering approaches, which is quite a narrow target group.

Even though, the case study let us identify most of the MISA Documentation Elements and attributes required to describe an IMS LD UoL, as well as instructional design principles for an adaptation of MISA to the design of a reusable pedagogical scenario. It also allowed us to collect empirical evidence that motivates the development of solutions focused on a MISA perspective, and on the designer's activity. The solution should also take into account the specification's underlying logic regarding three complementary issues: (1) dealing with MISA and IMS LD EML mismatches through minor accommodations that keep the overall MISA pedagogical scenario semantics unaltered, (2) introducing, in identified documentation elements, adaptations to enable a progressive UoL design process, and (3) identifying software requirements for further development of the pedagogical scenario editing tool that supports the declaration of all the required information at design time in a friendly way. The next phase focuses primarily on issues one and two. The next phase focuses primarily on issues one and two.

[24] Kuutti, K. (1996). Activity theory as a potential framework for human-computer interaction. In B. A. Nardi (Ed.), *Context and consciousness: activity theory and human-computer interaction*, Cambridge and London, MIT Press, 69-103.

Chapter 6

Development and validation

A two round Delphi consultation:
MISA for the design of interoperable scenarios

(DDR Phase 4)

Chapter 6

Further development and validation (DDR 4)

Overview of this chapter

This is the fourth and last phase of the developmental research approach for the adaptation of the MISA method.

Phase 2 was crucial to establish possible venues between the MISA method and the IMS LD specification. The MISA instructional model and the IMS LD UoL, share a common background of pedagogical scenarios definition in term of learning flows (actors, resources, activities and coordination and progression rules), which opens the door for the search of a way to adapt MISA to support the design of IMS-LD compatible units of learning.

Phase 3 was a first attempt of solution focused on the development of the MOT notation system enabling the expression of an IMS LD UoL. ALthough the notation system was extended satisfactorily, accounting for all the required IMS LD specificities, the technique for the representation of the UoL proved to be overly complex for the designer.

In phase 4 of this research, we decided to focus on the MISA method mainly as a process, trying to minimize MISA modifications, while, at the same time exploring complementary aspects of the design endeavor, specifically considered into the constraints of producing interoperable pedagogical scenarios.

This phase 4 presents a two round Delphi as follows: a general introduction to the applied Delphi method; the first Delphi round of six-opened questions addressed to the experts; the second round of the Delphi comprising the analysis and report of the experts first round answers together with the new questionnaire; and finally, the analysis and report of the second round with the adapted version of MISA. For detailed information about the justification of the Delphi method as well as information about the experts profile and number of rounds carried out we refer the reader to the second chapter of this dissertation (sections 2.2.4.1 to 2.2.4.3).

6.1 Delphi round one

This first round consisted of two steps: in the first step, based on a careful validation and analysis of the previous phase's results, we indentified the main orientations and required adjustments to MISA. In a second step, we presented to the experts the rationale of the research together with a set of propositions for validation.

The panel of experts consisted of four highly qualified professionals with deep knowledge of the MISA method and the IMS LD specification (see Appendix 2-A for details). The four experts had known MISA between 7 to 13 years, having 3 of them participated in its development and upgrading. The four had taught the method in undergraduate and graduate studies and designed learning solutions with it. In terms of IMS LD, all the experts had participated in teaching and research related activities, including academic communications in seminars and publications in scientific journals. Even all the experts fulfilled a complete background as researchers, developers and teachers, the collected data about their expertise allowed us to identify two of the profiles with an emphasis on research, one on development and one on teaching. These complementary profiles were considered valuable as they provided different perspectives in the search for a solution.

The experts received a set of documents with the intentions of the research, including the point reached throughout the three previous phases, and opinion set of questions regarding some overall issues about the adaptation of the MISA method (mainly in terms of principles applying to the method, the way of decomposing the problem), the documentations elements supporting the instructional model building, and terminological concerns.

The information presented was organized in a set of documents sent by e-mail. The set included: 1) an introductory letter with the schedule and directions for the Delphi study together with the six open-ended questions to be answered (see Appendix 6-A), 2) the overall research problem statement, research general methodology and up-to-the-moment research findings, and 3) the results of the first and second phase of the research.

In the following section, we present the main elements of information given to the experts, both from the previous research steps and from our analysis. We only present here the main issues provided to the experts. Experts were given a more detailed information, that we omit here to facilitate the reading of this document.

6.1.1 Synthesis of main aspects resulting from previous research phases and their analysis

The following text summarizes the information given to the experts:

The up-to-the moment findings and further reflection in search of a solution to the adaptation of the MISA method according to IMS LD requirements was organized according to four main issues. The first subject discusses the instructional design as a process, emphasizing the role of MISA over IMS LD in this matter. The second analyzes the need of criteria for breaking down a leaning flow, and points to the constraints of the IMS LD theatrical metaphor. The third subject explains the different way in which resources and tools (or learning objects and services) are integrated into the pedagogical scenarios in MISA and IMS LD. Finally, the question of a terminology to privilege is also discussed.

a. Design process

Previous studies have underscored the fact that building UoLs from scratch is an arduous enterprise. In our approach, building a UoL is regarded as a design activity, as opposed to a modeling problem. Designing and modeling are different in nature. While modeling (such as in IMS LD) focuses on the 'shape' and 'compliant arrangement of elements' of an educational piece, designing (such as in MISA) encompasses a progressive and iterative process of reasoning, pondering, generating, creating, and adjusting learning solutions. In other words, while MISA supports a multi-layered problem solving approach to the design of a learning solution, IMS LD is focused on achieving the right arrangement of learning scenario elements, apt for (machine) execution. In this sense, an IMS LD UoL is like a snapshot of a very detailed instructional scenario set up for delivery.

Based on a theatrical metaphor, a UoL describes a detailed learning sequence organized as a simple hierarchical structure. The said structure is modeled in a meta-language allowing a generic description and describing a series of events and activities associated to different roles that are played out in a coordinated manner; digital and non-digital resources, together with services (such as communication or search tools), are assigned to these activities.

Representing a UoL presupposes a prior process of instructional design where certain important decisions have already been taken. In this sense, the UoL can be understood as 'a result' of the instructional design process (or pedagogical engineering process, as proposed by MISA). When the instructional designer is not an IMS LD expert, decisions concerning knowledge to be assimilated, learning objectives, target learning profiles, learning events, learner and staff activities, pedagogical materials and services, etc., should be taken beforehand in order to facilitate creation of the UoL.

By coupling the two approaches, we can conclude that MISA is suitable for the purpose of designing a UoL. Our first proposition, then, is to keep the MISA process and structure unchanged. Further support for this proposition is presented just below.

b. Criteria for breaking down the learning flow

While IMS LD presupposes a rigid and accurate way of structuring learner and support activities together with 'environments' (composed of learning objects and services), focusing the learning flow on delivery (or run), the MISA pedagogical model is more flexible with regard to the way that the learner and support scenarios are built, and focuses, rather, on instruction.

b.1 The breaking down in MISA

The instructional specifications (see figure 6-1) comprise the **Instructional Model,** which represents the learning and instructional approach, and identifies the materials and tools required by this approach.

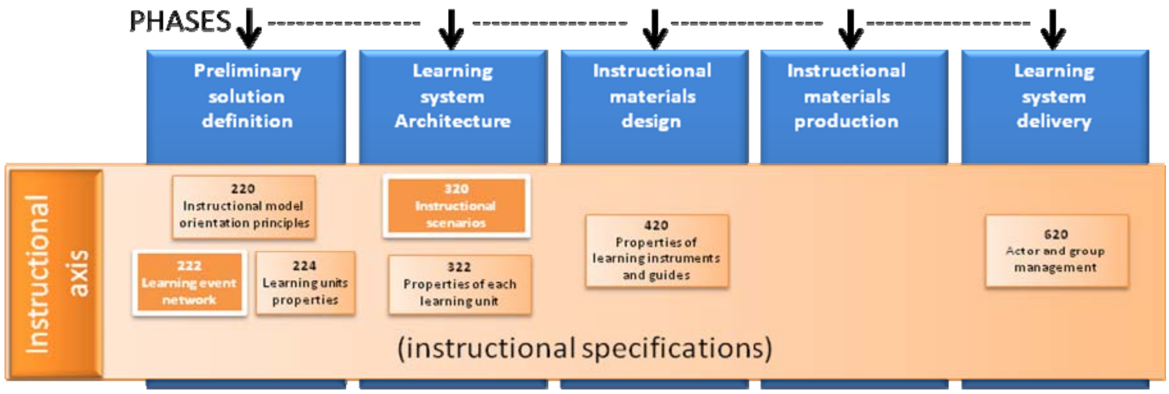


Figure 6-1. Instructional Axis: Documentation Elements making up the axis specifications (this figure corresponds to figure 4-16)

The ***Instructional Model*** (see figure 6-2) is composed of the ***Learning Event Network,*** or LEN (DE 222), and ***Instructional Scenarios*** (DE 320) (figure 3). It also includes the Learning Unit Properties (DE 224) and the Properties of Each Learning Activity (DE 322). (for a detailed presentation of each documentation element see Appendix 4-A).

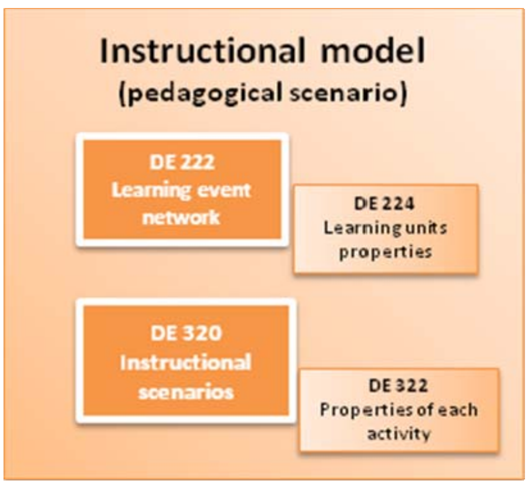


Figure 6-2.MISA Instructional Model (pedagogical scenario) (this figure corresponds to figure 4-17)Pedagogically speaking, DE222 deploys an ***instructional structure***, which is a structure of learning events that shapes the curriculum/syllabus-related hierarchy (program, course, module, lessons, chapter, unit, etc.) depending on the degree of granularity of the Learning System being

designed. MISA Learning Event Network (DE222) is the "**instructional structure** of a learning system (LS) consisting of several learning events (LE). The links between them suggest the most efficient way to progress through the LS by specifying rules of advancement" (MISA Glossary, p.26). MISA does not limit the number of LEs, neither horizontally (on the same level) nor vertically (from one level to the next). As mentioned above, the LEN limits itself vertically when the LE (part of a curriculum/syllabus structure) can only be decomposed as a learning scenario describing learner/support activities or, in MISA terms, a learning unit (LU).

The MISA Instructional Scenario (DE320) is a "component of a learning unit (LU) […] that consists of a learning scenario proposed for the learner and a scenario of assistance designed for tutors/teachers/coaches […]. Modeling an educational scenario consists in specifying the activity or activities appropriate for the learner and the assistance, including all the resources required to complete these activities as well as the productions resulting from these activities"(Glos, p. 23).

b.1 The rules in MISA

In MISA, the learning flow is progressively developed and expanded through a series of stages comprising the identified documentation elements, mainly: DE222, DE224, DE320, DE322, and DE440 (see Appendix 4-A). These are graphical models wherein the main components are linked together, representing the progression from one to the other. The information declared in these links is not sufficient to give a comprehensive understanding of all the conditions governing the flow. Additional valuable information can be given in DE224 and DE322 where it is possible to explain the rules structuring advancement within a scenario. These rules were studied in detail in a previous work (Paquette et al., 2003), which concluded that MISA rules (study approach, collaboration, evaluation, and customization) may be translated into IMS-LD conditions. We therefore consider appropriate to propose an explicit declaration of rules governing the learning flow in order to provide more accurate information to the system, which in turn will allow automatic execution. Additional modifications are necessary– for example, extending rules declaration (which is only possible in the Learning Units component in the actual version of MISA) to all Learning Events in DE322.

b.2 MISA Delivery Model

The level of refinement of a detailed IMS-LD UoL run-time description usually exceeds that of a MISA learning scenario. However, in MISA the run-time or delivery aspects of a learning system are addressed when constructing the Delivery Model. The MISA Delivery Model describes the roles of the actors during the delivery of a learning system (LS), as well as their interactions with the course structure, materials, tools, means of communication, services, and locations, which they either use or supply to other actors. In this sense, it is complementary to the learning scenario, focusing on delivery matters.

b.3 The breaking down in IMS LD

From a pedagogical perspective, IMS LD specifications do not clearly establish criteria for breaking down the UoL. The concepts structuring a UoL are based on the theatrical metaphor that shapes EML encoding according to the requirements of the machine used for execution. No additional information is provided about the granularity of the learning design.

In IMS LD the teaching-learning process is modeled in the Method element (not to be confused with MISA terminology), which is the first hierarchic component that "releases" the learning design. Inner decomposition is followed by Plays and Acts. A Play has Acts, and each Act has one or more Role-parts. These role-parts are the conjunction of activities assigned to a role into a specific environment. Plays must be declared concurrently, while Acts run in sequence. This description constitutes Level A of the specification. Level B (which stipulates additional conditions for progression within the learning scenario) and Level C (which triggers notifications as a form of event-driven messaging sent both to elements of the design and to human participants) add details and complete the learning flow. The power of a generic pedagogical/delivery scenario concept is that it simplifies machine interpretation; however, it reveals itself to be a "straitjacket" for the designer, requiring him to express the entire learning situation through this rigid syntax and semantic interpretation. We must enrich this metaphor with more learning specific terminology in order to reduce the level of abstraction of the meta-model.

Based on a MISA LEN and IS unrestricted structure, we have looked for a way to make MISA compatible with IMS LD learnflows). As an exercise, we attempted to conceptually adapt the LEN and the Instructional Scenarios to an IMS LD structure (see Appendix 6-B). But we encountered a limit that constrains the solution to learning flows, specifically those where the MISA Learning Units follow one progressive and exclusive path. Learn flows with optional paths are difficult to represent with MISA notation system. We found this solution incomplete and only partially satisfactory. Forcing the LEN and instructional scenarios to conform to IMS LD's rigid structure makes for a contrived process. It can be confusing for the instructional designer since, in some cases, it compels him to mix instructional structures with instructional scenarios. Semantic contradictions may arise, such as having learning events of the same nature (e.g., modules) at different levels of the learning scenario, due to IMS LD execution restrictions (where Plays run in parallel and Acts in sequence - see Appendix 1). This also addresses another important problem with IMS LD, that is, UoL granularity.

Exploring ways to establish criteria for breaking down instructional scenarios we proposed, as in MISA, to gradually build a UoL using two of the main MISA models – the instructional and delivery models (fourth axis of the MISA method) – instead of forcing design through a single operation. We previously mentioned that the UoL is a ready-to-run learning scenario, which is to say that it constitutes a very detailed scenario structuring the learning flow, where macro and micro design decision outcomes have to be declared explicitly. Such decisions might concern interaction (i.e., choosing between interaction with a human or with the system), resources required for the accomplishment of proposed activities, or even interface transitions (i.e., choosing which LD elements should be made visible and when to do so).

c. Association of environments

Another key issue from our previous case study was to understand the notion of “environment” in IMS LD and the way environments are assigned to activities within the UoL. The UoL not only describes a learning flow, but also defines the environments where activities take place. These environments are composed of learning objects and services. MISA pedagogical and delivery scenarios use a similar but not identical way of describing this flow. MISA has a more detailed taxonomy of resources derived from the instructional field. They are understood as components (or elements) of “an instructional scenario or a delivery model that either serves to carry out one or more activities or is the product of an activity. Resources can be used or produced by either (sic) a learner, an instructor or other actors such as managers, administrators or designers” (MISA, 2000c, p. 41). As we can see, resources are present both in the instructional model and in the delivery model. They are gradually declared and organized into packages throughout the delivery planning phase. Moreover, the MISA media axis focuses (among other things) on the human and material resources that will be required to design and produce the LS. These resources are listed so as to classify and organize them into packages during the creation of the delivery model. These packages gather resources needed for the accomplishment of activities.

To enhance the adapted MISA version, we propose using these MISA concepts and processes to express and bind IMS LD environment creation. This problem is treated below as an inadequacy of terminology.

d. Terminology

One must acknowledge the interdependency between problems noticed in the breaking down of UoLs as well as in the association of environments, and interference due to the use of similar terminology with varying meanings. Even though it is possible to establish a few equivalences or correspondences between given elements of MISA and IMS LD, certain terms that appear to be identical have different meanings. During the case study (phase 2 of this doctoral research), identical terms used with different meanings in MISA and IMS LD caused misinterpretations and led the designer to commit errors.

We understand the MISA language as more appropriate in the context of the designer's profession, and we only envision minor modifications or additions to make solutions to some specific problems possible. For example, IMS LD environments assemble specific learning objects and services required for the accomplishment of a given activity. This is similar to the concept of "packages" in MISA delivery models. The concept of learning objects and services in IMS LD is similar to the concept of resources in MISA. We can help the designer by asking him to classify (in DE430-List of learning materials) resources declared in DE222 and DE320 as LOs and services. Then, when modeling the delivery model (DE440), the designer can assemble them into packages as is required in IMS LD environments. Further, we need an additional modification: changing DE430 from a "list of learning materials" to a "list of resources" so that the services, too, can be gathered together, as required by IMS LD.

6.1.2 A proposal for first adaptations of MISA

Our approach for these adaptations is to try to modify the MISA method as little as possible and to support the instructional design activity as best we can. That said, currently, our main interest is to ensure the gathering (through MISA's process and Documentation Elements) of all the **information required** to build a UoL. Software application and usability issues are not addressed on this research.

MISA is an adaptive method. One can choose between three independent or complementary ways of progressing through the method: DE-based progression, Axis-based progression or Phase-based progression. The scope of this "Learning System (LS) engineering process covers all the LS's design activities, from identifying the learning and training needs to implementing the final product that will enable learners to acquire the knowledge sought. The instructional design approach makes it possible for the various people involved in producing an LS to work effectively together (sic.) and make the right decisions throughout the development process" (MISA Presentation, p. 4).

MISA enables the production of 35 Documentation elements that can be grouped by axis (axis specifications) or by phase (phase records). In this sense, all the LS actors (learners, instructors, content experts, managers, technical developers) can "rely on structured activities, […] define milestones for tracking the project's progress and […] create more and more concrete representations of the LS"(MISA, 2000a, p.4).

There would be two ways to address the problem posed by our approach to the design of a UoL (and these solutions are not mutually exclusive):

- 1) create a minimal approach to the design of UoLs based only on DEs, which we identify as being absolutely necessary and directly related to this purpose;

- 2) allow for the possibility of using the full approach based on the modified DEs if one wishes to do so, that is, make it possible to apply all 35 MISA DEs if required by a given situation. This processual goal includes, but it is not limited to, the UoL design.

Based on results from previous iterations in our research, we propose to keep the MISA phases and axis structure unchanged. Considering the complexity of designing learning solutions as a decision making and problem solving process, we found that the principles of progression between phases and of coordination among axes are adequate as a framework for the design of UoLs.

We will now focus on the DEs directly involved in the building of a UoL and we shall keep the rest of the DEs untouched. In our view, roughly, UoL design can be thought of as the combination of two complementary procedures: that of designing the pedagogical model and subsequently the delivery model. Going even further, we also propose the completion of other DEs found in the media axis.

As a minimal approach to accurately representing UoLs based on MISA Documentation Elements:

1 – Allow the declaration of the UoL design intention by adding an attribute to DE106.

(Optionally) Define a competence table (DE214) in order to extract learning prerequisites and learning objectives, as in IMS LD.

2 – Begin designing the UoL according to DE222, DE224, DE320, and DE322.

3 – Classify MISA resources in DE430 as Learning objects and Services, as is required by the IMS LD specification.

4 – Complete the design of the UoL by applying attributes from DE440 (restructuring DE322 if necessary, creating and associating environments to activity-structures or activities).

The process of designing Units of Learning supported by the chosen MISA documentation elements should be as follows:

Step 1: Establish the boundaries of the learning system design (DE106)

- Establish the UoL design intention.
- Proceed with DE222, DE320, DE430, and DE440.

(Optional) Define a competence table with current and expected competences. These can be captured in the IML LD UoL as requirements and objectives, respectively. Since a UoL establishes these elements as being optional, we do not propose them as mandatory items. However, we do recommend them because we consider them to be important for the quality of any given learning design.

Step 2: The instructional model

2.1 DE222 - The Learning Event Network or instructional structure

- o Proceed with the building of a LEN, as in MISA

2.2 DE224 - Learning *Event* Properties (we extend the properties declaration to the LEs)

- o Declare explicit rules for the flow of LEN learning events.

2.3 DE320 - The instructional scenario

- o Proceed with the building of the instructional scenario, as in MISA

2.4 DE322 - Properties of Each Learning Activity

- o Declare explicit rules for the flow of IS learner and facilitator activities.

Step 3: DE430 - List of learning *resources* (we extend the notion of resources to listing services too, as in IMS LD)

- List the resources declared in DE222 and DE320.
- Classify resources as LOs and Services

Step 4: DE440 - The delivery model

IMS LD jointly addresses instructional and delivery matters. This approach is appropriate for machine execution, but it appears to be too complex from the designer's perspective. The MISA method can be seen as a solution to this problem; it is a powerful tool encompassing the instructional designer's work. Recent conceptual and empirical studies are at the basis of this proposition. The experts' opinions should provide founded insights in order to undertake deeper modifications and support or reorient the proposed approach.

- Integrate and reorganize DE222 and DE320, decomposing the learning flow as per IMS LD requirements (sequenced or paralleled). Use DE224 and DE322 for more detailed structure decomposition.
- In the list of the learning resources, identify those that should be assigned to each activity-structure or activity and gather them within a package (understood as an IMS LD environment).

The delivery model will be the object of a deeper and detailed study if this first MISA modification proposal is validated.

We presented this first proposition to the experts' consideration through the six open-ended questions as follows:

Q1. Do you agree with the idea of keeping MISA's main structure and principles intact to produce a UoL?

Q2. What is your opinion of the MISA "minimal approach"?

Q3. Do you think that the selected DEs are sufficient to gather all of the required information to build a UoL?

Q4. Do you agree with the modifications proposed to the DEs?

Q5. Do you agree with the approach of maintaining MISA terminology and of finding alternative ways of binding it to IMS LD terminology?

Q6. Which recommendations would you suggest to improve the adaptation of MISA for the design of a UoL?

6.2 From Delphi round one to round two

Following the Delphi protocol, we have collected and analyzed the expert's answers to the first round.

As Delphi stands on an asynchronous dialogue, we have adopted an analogous structure to present this section: a) a first item with a synthesis of each conclusion of the first round, b) a second item with a discussion around each conclusion that triggers further development of the MISA method according to IMS LD requirements, and c) a third item with the elaboration of new propositions around MISA adaptations put forward for expert consideration throughout a set of closed questions (questions are referred to the corresponding appendix).

The conclusions based on the experts' first round answers are presented according to the following subjects:

1- The MISA main structure, and respect, in the proposed adaptation of MISA, of the principles of progression between the phases, coordination between the axis, and of adaptation according to specific constraints of the project of design (Q1);

2- The MISA minimal approach to the design of IMS LD compliant pedagogical scenarios based on the selection of a few number of MISA documentation elements (Q2, Q3);

3- The modifications suggested for the selected set of MISA documentation elements at the level of their attributes (Q4); and

4- Terminological aspects of both MISA method and IMS LD specification (Q5).

Experts' additional comments corresponding to Q6 were integrated into the analysis of the other questions, as explicitly suggested by the respondents.

Each of these four main subjects serves as introduction and guidance for a deeper reflection that is presented accordingly under a subsection named 'discussion'. Each subject related discussion ground a rationale for the development of new modifications to the MISA method. The new modifications are put into consideration as a series of propositions clustered into four groups. Experts' are asked to answer a set of likert-scale questions organized according to each group of propositions (see Appendix 6-C).

We have adopted this strategy for reporting the second round because the questionnaire reproduces most of the propositions, organized as individual items and structured in such a way that the reader can easily retrace the original text.

6.2.1 MISA structure: progression, coordination and adaptation principles

6.2.1.1 Round 1 synthesis

There is agreement among the experts who participated in Delphi round 1, that the first round proposition respects the general operational principles of MISA. *Progression* principles between phases and *coordination* principles between axes are evident since the suggested DEs correspond to different phases and axes, showing the interrelationship between MISA layers, both horizontally and vertically. The selection of certain DEs with a specific goal, that of building an IMS LD compliant UoL, also respects another MISA general operational principle: *customization*. "The customization principles enable the LS designer to follow an itinerary that is custom-built for each project, i.e. tailored to its scope, the type of training problem, the objectives, the instructional approach, and the media and mode of delivery" (MISA Presentation, p. 61).

Nevertheless, a deeper analysis of the principles is suggested to review IMS LD and its implications for the *customization* principles. One respondent suggested revising the proposition for reorganizing/regrouping the elements declared in previously suggested DEs when building the Delivery Model instance, i.e. reorganize the *LE*/*LU*/*Activities* following the IMS LD syntax, and also classify and regroup the MISA *Resources* into IMS LD *Environments*. In other words, given that IMS LD can be interpreted as merging the instructional and delivery models, this fact can have a strong impact on the way the instructional model is thought up and built.

6.2.1.2 Round 2 discussion

IMS LD and the MISA Instructional and Delivery Models

The previous suggestion can lead to expand the design of the Instructional Model, introducing some of the notions and concrete elements of the Delivery Model. This approach does not render the delivery axis irrelevant; it has more global and general purposes within the MISA method as a whole. The DE 440 Delivery model's objective is to "*build one or more graphical models highlighting the relations that will exist among the actors, the users or the suppliers of services, at the time of the delivery of the LS. Also, [it aims to] include the packages of materials, the tools and means of communications, as well as the services and the locations that will be used or made available.*" (MISA4.0 Glossary). We will concentrate, for the purpose of our research, on the actors appearing (implicitly) in the Instructional Model, i.e. the learner and teacher in all their possible roles, as individuals or in groups (generic learner/s: learner, moderator, participant, peer, team member, team, group, etc.; generic teacher: professor, teaching assistant, facilitator, tutor, member of a teaching team, etc.)

One pertinent question, derived from the experts' opinions, is what impact the learner/teacher actors' Delivery Model (a specific DE440 model) has on the Instructional Model: alteration of the organization of the learning flow, addition or loss of information, or other significant changes?

For better analysis and comprehension, we presented the table containing the graphic symbols that make up the LEN (DE222), the IS (DE320) and the Delivery Model (DE440) borrowed from our first phase analysis and integrating some visual representations from the MOT notation system extended for IMS LD (for those new elements to incorporate within the MISA instructional model) (see Appendix 6-D). This table helped compare the MISA models, discuss the concepts, and see the implications, for the MISA method, of adjusting the Instructional Model to better suit the IMS LD requirements through the integration of some elements of the Delivery Model.

The main items found in DE440 that differ from the instructional model are:

- Explicit declaration of an *Actor* and *Role of the Actor*
- Reorganization of the instructional model *Resources* into packages:
    - *Packages of Materials*: the grouping of *Materials* (*Guides* and *Instruments*) and *Tools* according to how they are used and coordinated by a group of actors
    - *Delivery*: the grouping of resources (*Packages of Materials*, *Tools*, *Means of Communication*, *Services,* or *Locations*) intended for one or several types of *Actors*.
- Addition of a new rule:
    - *Delivery rule*: statement that specifies the conditions of actor roles (instructor, learner, manager, etc.) for when and how to use resources during the distribution of the LS.

- On the notion of MOT *Activity* and *Role*

Even though conceptually, MISA and IMS LD share the notions of activity and role, there is a significant difference in how they are declared and represented with the MOT and IMS LD notation systems. In the MOT language, the Role within the instructional scenario is embedded into the *Activity* and, so merged, they are represented by a label and a different color oval shape. In IMS LD the role is assigned separately to an *Activity* or *Activity-structure*.

MISA DE320 doesn't explicitly proscribe the Actor (Role) declaration in the model. The MOT language assigns the hexagon shape (principle) to represent the Actor. It is then possible to add explicit representation of a Role in DE320. This helps bind MISA IS to IMS LD terminology: *Role*, *Activity*, *Activity-structure* and *Role-part*.

As the IMS LD UoL has to be interpreted by a compliant Learning Management System, it is indispensable to be coherent when declaring the roles. The designer has to avoid either using a role with different meanings or a different named role but with the same meaning. Neither the system nor an IMS LD validation expert will be able to correctly interpret the designers' intention. It is important then to keep track or the Role declaration. The DE320 should remember this as a way to keep the designer aware of this requirement or the system should have to dynamically capture and list the Roles as they are created and used.

- On the notion of Package of Resources

In the previous proposition, we argued in favour of proposing DE430 List of Learning Material as a way to classify the declared *Resources* of DE222 and DE320 into new *LO* and *Services* MISA attributes, as a way to facilitate building IMS LD compliant *Environments*. This last operation should take place in the building of the DE440 Delivery model.

Results from Delphi round 1 helped reorient the MISA adaptation proposition. We previously discussed the tight relationship between the MISA instructional and delivery models, and the IMS LD UoL. We have proposed minimal changes to the instructional model together with a complementary solution that can be modified in accordance with future software evolution. We suppose that the declarations of Resources in DE222 and DE320 are sufficient for a system to reorganize them into IMS LD *Environments*. The idea of keeping the concept and notation system for *Packages of Resources* can be useful to unfold the models' visual presentation and facilitate the designer's task.

- On the notion of IMS LD Service

The notion of *Service* in IMS LD is introduced in the IMS Learning Design Information Model online document as follows:

> Besides resources which can be defined at design time, there are numerous so-called 'service facilities' used during the teaching and learning, for instance, a discussion forum or some other communication facility. **Service facilities are resources that cannot be given a URL at design time**. They have to be instantiated by a local runtime service. This is because, if a service facility is bound at design time, then that specific service would have to be used by all users of all instances of the learning design. When what is needed is an instance of the service that is unique to the runtime instance of the learning design and its assigned users, (e.g., if a chat forum is to be dedicated to the use of a specific group of learners and support staff associated with an particular instance of a learning design), then this has to be created and the local URL assigned after the instance of the design has been set up and the group of learners and staff associated with it. For this to work, it requires a well defined set of service types, which are known to the runtime service, such as chat, discussion forum, announcement channel etc. These are now commonly found in learning management systems. In a learning design, the use and setup of such a service is declared at an abstract level, so that a runtime facility (or a human) can setup the necessary facility according to the requirements. In the learning design specification, the abstract declaration of a service facility is called a 'service'. The instantiation of a service is called a 'service facility'.

> Current service types are: send-mail, conference, monitor (level B), and index search. The selection of services to be included needs to be driven by the community. We therefore decided to start with the most widely implemented and used services in online learning environments.

From the MISA instructional engineering perspective, services are types of *Resources* required for the execution of activities.

The *Send-mail service* can be interpreted as an e-mail software tool (MISA *Resource Means of Communication*) to be declared as associated to an activity making use of it.

The *Conference service*, since it is typified in *asynchronous*, *synchronous* and *announcement*, can be expressed through MISA as a *Resource* (MISA *Resource Means of Communication*), whose inner characteristics may be defined as Rules.

The *Index-search service* is another *Resource* (MISA *Resource Tool*): a research tool for information search and retrieval.

The *Monitor service* is more of a parameter that allows, for example, a learner to consult his notes or other relevant information about his progression within a course and be able to compare with the rest of the group. This is more of a Delivery option that could be declared in MISA as a comment or, more formally, as a Rule.

As the official IMS LD (2003) document itself explains, the IMS LD list of Services is just an initial enumeration to be proposed by the community interested in this subject. For example, MISA proposes *Videoconference* as another *Means of Communication*.

6.2.1.3 Round 2: Proposition A

Based on the previous analysis of elements composing MISA DE222, DE320, and DE440, we propose the integration of some key elements of DE440 into DE222 and DE320. In terms of the MISA instructional design approach, this means making effective the addition or some delivery matters within the instructional axis.

The following main propositions result:

For DE222 - LEN

- Integrate and formalize a notation for *Means of communication* to represent the IMS LD *Send-mail* and *Conference* services.
- Integrate and formalize a notation for *Tool* to express IMS LD *Index-search*
- Introduce the new *Package of resources* term to bind MISA to the IMS LD *Environment* term.

- Integrate and formalize a notation for *Entry Level Competency* (IMS LD *Prerequisite*) and *Target Level Competency* (IMS LD *Learning Objective*)
- Add the "I" link to instantiate *Resources* and link *Entry Level Competency* and *Target Level Competency*
- Formalize Instructional rules to match IMS LD rules:
  - Differentiate Rule declaration from Rule explanation: on LEN Rules, apply rule declaration (Rule explanation is part of subsidiary DE224).
  - Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance.
  - Extend the rules to express Conditions for *Resources* and *Roles.*
  - Extend the notion of instructional rules to take into account delivery matters, such as establishing Conditions for Visibility of *LEs*, *LUs*, and *Resources*.

For DE320 - IS

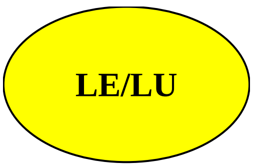
- Change the term *Actor* for *Role.*
- Add the Learner and Teacher (generic) *Roles* to the notation system for IS modeling.
- Integrate and formalize a notation for *Entry Level Competency* (IMS LD *Prerequisite*) and *Target Level Competency* (IMS LD *Learning Objective*).
- Add the "I" link to instantiate *Resources* and link *Entry Level Competency* and *Target Level Competency.*
- Integrate and formalize a notation for *Means of communication* to express the IMS LD *Send-mail* and *Conference* services.
- Integrate and formalize a notation for *Tool* to express IMS LD *Index-search.*
- Introduce the new *Package of resources* term to bind MISA to the IMS LD *Environment* term*.*
- Formalize Instructional rules to match IMS LD rules:
  - Differentiate Rule declaration from Rule explanation: on IS Rules, apply rule declaration (Rule explanation is part of subsidiary DE322).
  - Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance.

  - o Extend the rules to express Conditions for *Resources* and *Roles.*
  - o Extend the notion of instructional rules to take into account delivery matters, such as establishing Conditions for Visibility of *LEs*, *LUs*, *Activities*, *Resources* and *Roles*.
- Formalize Instructional rules to include IMS LD rules
  - o Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance. Explain the notion of Rule computability to introduce Rule formal expression. Formal expression should be suggested but not mandatory. A technician or a user-friendly and efficient software tool should help in this task (see the discussion on Rules further below).
  - o Extend the rules to express Conditions for *Resources* and *Roles*
  - o Extend the notion of instructional rules to take into account delivery matters such as establishing Conditions for Visibility of *LEs*, *LUs*, *Activities*, *Resources,* and *Roles*.
- Change the denomination of DE224-Learning Unit Properties and DE322-Properties of Each Activity to 'DE224 Attributes of the LEN elements' and 'DE322 Attributes of the IS elements'. We consider changing the name of the DEs from "Properties" to "Attributes" so as to distinguish them from IMS LD properties, which are related to rule declaration, and to stay consistent with MISA, since Form DEs are composed of "Attributes" and "Values". We reserve, then, the term "Attribute" to describe DEs and "Properties" in order to introduce the IMS LD notion in the formalization of rule declaration.

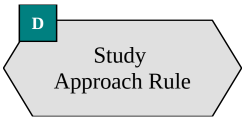
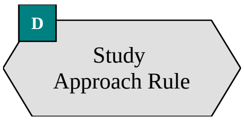
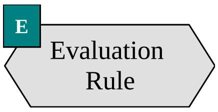
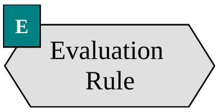
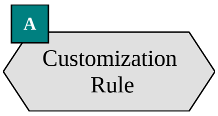
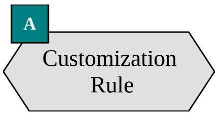
The table below presents the graphic symbols that should be part of the LEN and IS so that they can be built according to IMS LD requirements.

Table 6-1

MISA LEN and IS models adjusted to convey with the IMS LD Specification.

DE222 - LEN Graphic Symbol	DE320 – Instructional Scenario Graphic Symbols	IMS LD Level	MISA DE additional information	IMS LD element
		A		Method, Play, Act, Activity-structure, Activity

DE222 - LEN Graphic Symbol	DE320 – Instructional Scenario Graphic Symbols	IMS LD Level	MISA DE additional information	IMS LD element
	Activity	A		Method, Play, Act, Activity-structure, Activity
	Role	A		Role: learner / staff
G Guide	G Guide	A		LO
I Instrument	I Instrument	A		LO
Production	Production	A		Outcome
O Tool	O Tool	A		LO
E Package of Ressources	E Package of Ressources	A		Environment
S Service	S Service	A		LO
C Means of communication	C Means of communication	A		Service
URL	URL	A		URL
Entry level competency	Entry level competency	A		Prerequisite
Target level competency	Target level competency	A		Learning objective
M Location	M Location	A		LO

DE222 - LEN Graphic Symbol	DE320 – Instructional Scenario Graphic Symbols	IMS LD Level	MISA DE additional information	IMS LD element
		**B, C**	**Also DE224, DE232**	Condition, property, notification
		**B**	**Also DE224, DE232**	Condition, property, notification
		**B**	**Also DE224, DE232**	Condition, property, notification
		**B**	**Also DE224, DE232**	Condition, property, notification
Links (C, P, I/P, R, I)	**Links (C, P, I/P, R, I)**	**A, B, C**		(help determine Method/Play/Act/Activity-structure/Activity)

Links and LEN/IS decomposition into an IMS LD syntax

The MOT language proposes a set of links between four knowledge units. This basic terminology and syntax is at the origin of all that the model proposes through the MISA method.

In DE222 and DE320 (before our previous modification propositions), three kinds of knowledge (concepts, procedures and principles) and four main links (composition, precedence, regulation, and input/product) are the primitives that allow building these models.

The *Composition* and *Precedence* links between learning events and activities govern the main aspects of the model sequence. In Rule declaration, the *Regulation* link adds more specific detail to the conditions applying to the learning events and activities flow. This subject is analysed in more detail further below (see Rules).

The *Composition* and *Precedence* links are the first elements to be considered, as they provide clues on how to reorganize the MISA pedagogical model to fit the IMS LD syntax.

The MISA *Leaning Event* and *Learning Unit* LEN components are the notions that are the most akin to the *Method*, *Play* and, *Act* concepts in IMS LD. While MISA establishes no limits for LEN depth and no restrictions to component organization and sequencing, IMS LD, on the contrary, establishes a strict way of organizing them: a *Method* may contain one or more **concurrent** *Plays,* which decompose into **sequenced** *Acts*.

MISA instructional scenarios (resulting from the decomposition of Learning Units) describe sequencing similar to IMS LD **concurrent** *Role-parts.*

Our first analysis based on this evidence tended to associate the MISA LEN to a first section of the IML LD UoL comprising *Method/Plays/Acts,* and the MISA IS to a second section of the UoL where the Role-parts are deployed (see figure below).

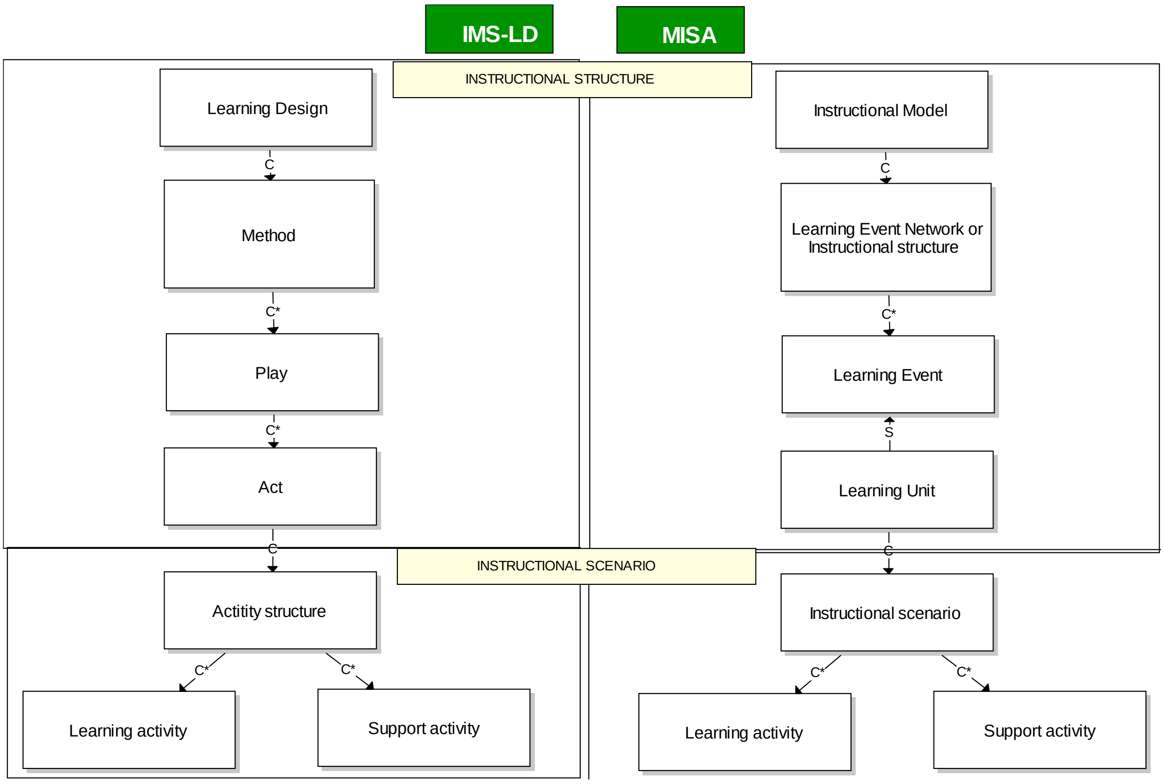


Figure 6-3. MISA instructional model and IMS LD structures

Our first conclusion was to write principles in order to accommodate the LEN and IS to the IMS LD syntax. But a deeper analysis and certain examples, such as the one presented in Appendix 6-B or the Delphi round 1 document, showed that this solution was too constraining: it imposes either semantic problems (like being forced to rename LEN components or to add new, fictitious ones artificially and only for purposes of machine interpretation) or a significant workload to the designer (multiplying the LENs to express the different options). The case study (in the previous phase of this doctoral research) gave evidence of the difficulties encountered by an expert instructional designer when trying to reorganize MISA DEs according to IMS LD requirements.

The example below illustrates how a simple situation of a scenario with a low degree of hierarchy and a linear flow may become complex when represented following the IMS LD syntax. Let's suppose we write guidelines for the set up of a LEN to fit IMS LD UoL requirements.

Case 1:

A two-level LEN with all of the second level learning events in sequence.

Reorganize LEN elements:

- first LEN learning event = IMS LD method
- second LEN learning event, interpose a "Play" element, between first level learning event and second level of learning events

Case 2:

A three level LEN with all of the second and third LEs level in sequence.

Reorganize LEN elements:

- first LEN learning event = IMS LD method
- second LEN learning event, interpose a "Play" element, between the first and second learning event level
- rename the learning events of the third LEN level as Activity-structures

Problem: Loss in MISA's semantic coherence, given that new "Activity-structures" are now found in the LEN instructional structure, and not in the instructional scenario as MISA prescribes.

This semantic problem worsens, as the scenario gets more complex when the LEs are not sequenced.

As we see, we would need to establish an indefinite number of principles applying to a typology of models whose interpretation and execution are both arduous. More generic principles, e.g. "if the LEs are concurrent then create new Play", become semantically complex and pedagogically meaningless.

[See "Proposition A" questions in Appendix 6-C]

6.2.1.4 Round 2: Proposition B

A complete and wholly satisfying, answer doesn't seem to emerge from the analysis. We create solutions on one side, but risk multiplying problems on the other.

With the previous, simple example we tried to illustrate and explain why we have abandoned the idea of establishing principles for pedagogical scenario reorganization. Compelling the instructional designer to interpret and translate an instructional model into the IMS LD syntax is not a realistic solution. Instead, we tend to favour a software solution for “interpretation” and “reorganization” of LENs and ISs. A third intermediate solution would be the intervention of a “technician” with knowledge of IMS LD, educational modeling language, and formal declaration expressions, as well as a basic education in computer science. We are aware that finding a definitive solution may exceed our competence in terms of being able to fully evaluate computability matters.

The *Composition* and *Precedence* links give clues on how to recompose this model into an IMS LD syntax. This re-composition may appear very hazardous for the designer but it can be handled with a software application that interprets the links and reorganizes the scenario components based on some rules of adequacy between them (e.g. analysing the LEN’s and the IS’s “C” and “P” links and reorganizing them according to IMS LD requirements[25]). To start with, the results of this research have an impact on the MISA method at the level of its software tool, providing relevant information for the definition of a “requirements’ document” for the MOT editor tool. These conclusions also reaffirm the robustness of the MISA method as a mental tool for the “instructional designer” conceiving Learning Systems. It also provides evidence on how to conceptualize “pedagogical scenarios” for human learning and differentiate them from “meta-delivery-scenarios” for machine interoperability and machine reusability. We deliberately add the adjective “machine” to “reusability”, as the pedagogical reusability will only be facilitated if a semantically significant metadata for UoL granularity is developed.

MISA has the power to provide semantic expression to the UoL, since it builds on the concept of *instructional structure* (DE222), which is a structure of learning events that shapes the curriculum/syllabus-related hierarchy (program, course, module, lessons, chapter, unit, etc.) and the notion of *instructional scenario* that articulates the learner/support activity flow. This helps bind pedagogical terminology to the theatrical metaphor and the machine-code requirements. IMS LD terms (*Method*, *Play*, *Act* and others) are not appropriate, pedagogically speaking. In this sense we do not endorse the use of IMS LD specification terminology, and instead favour instructional design vocabulary. This is an important issue because the MISA method can supply the IMS LD specification with concrete pedagogical terminology allowing the creation of a UoL granularity typology, while making gains in reusability.

[25] The MOT+ software is being developed with this in mind.

For the purposes of design process (reflect, solve problems and take decisions concerning instructional structure matters [DE222] and instructional scenario matters [DE320]) and facilitation of the designer's task, the aforementioned DEs can be optionally developed separately (models can become difficult to manipulate as the design process unfolds). Once finished, the models should be integrated in order to export them in an IMS LD manifest. This integration of models is easily accomplished with one operation in the MOT editor.

Keeping DE222 and DE320 as separate but complementary models has an additional advantage: if the UoL being designed is only a stand-alone learning activity, that is to say, not formally attached to an instructional structure (course, module, etc.), the designer could just decide to complete DE320 and avoid dealing with DE222. This additional adaptation helps establish another criterion for UoL granularity. Otherwise, if the UoL is of bigger granularity, DE222 and DE320 should be separate, at first, and only later integrated into one model, corresponding to the UoL.

In this sense, a principle should be stated:

- If the UoL contains an instructional structure, DE222 is required.

- If the UoL is an activity, begin the pedagogical scenario at DE320

[See "Proposition B" related questions in Appendix 6-C]

6.2.2 The MISA minimal approach

6.2.2.1 Round 1 synthesis

The MISA minimal approach is well perceived by all participants. Main recommendations imply additional DEs to be considered, revised, and possibly integrated:

- DE102 Objectives of the Learning System: the "priority" attribute could be important to declare the intention of the design of an IMS LD UoL. It may also be important to take into account other attributes of this DE.
- DE104 Target Populations: to better define the "learners".
- DE 212 Knowledge Model: even if not "mandatory", its importance resides in a strength that the MISA method possesses and the IMS LD specification lacks, that of being able to connect knowledge and competencies to pedagogical scenarios. The strength of MISA is also that it guides certain decisions concerning the learning scenario in order to carry out design oriented by the knowledge/competency model.

- DE 214 Target Competencies: as in the case of DE 212, even if optional, this DE helps thinking and taking decisions about the pedagogical model to be developed.

Another relevant point to consider is the balance between a minimal approach and an instructional engineering method of quality. As explained by one of the participants, the MISA method is a solid instructional engineering method and loosing some of its components (DEs) may have an impact on the quality of the design. This is subject to discussion with respect to two main aspects:

- According to the MISA *customization* principle, the selection of a series of DEs is allowed based on the context of the Learning System under design.
- Instructional design does deal with probabilities: even when completing the whole process, there's still space for uncertainty. We should add that this margin for unintended events is seen favourably by the community of teachers who propose active pedagogies.

6.2.2.2 Round 2 discussion

The above position is also valid and deserves to be discussed from other angles. As we pointed out, the MISA minimal approach does not invalidate or call into question the MISA method as a whole. The process of planning the learning materials to be developed, or of building delivery models for actors other than the learner and teacher, does remain relevant. We circumscribe our problem as the process of "designing an IMS LD UoL" in order to establish the MISA method as a valuable approach for the design of IMS LD UoLs: an appropriate and suitable instructional engineering method that integrates a detailed prescriptive design process based on an instructional language (that includes an EML) and an editor created for the purpose of modeling a Learning System Design.

The suggestion of integrating other relevant DEs to a new adapted version of MISA is similar to the discussion about certain DEs (212 Knowledge Model and 214 Target Competencies), which were proposed in the Delphi round 1, being left as either optional or mandatory.

The dilemma can be resolved by proposing a single version of the MISA method that includes DEs "recommended" for quality insurance and supported progressive design, together with "mandatory" DEs, where all the required information for a UoL is gathered in order to be translated into an IMS LD compliant syntax.

Following the experts' recommendations we have analyzed the DEs they indicated, as well as the rest, to account for those that have an impact on the quality of the process of building an IMS LD UoL with the MISA approach.

The table below presents the "recommended" DEs, with their main objectives, and a discussion of their importance for thinking out the design and making decisions.

Table 6-2

Recommended documentation elements

DE	Objective	Pertinence for the UoL design
100 - Organisation's Training System	Link the learning system to be developed with the client organisation's training plan. Create an overview of the client organisation's (or one of its divisions') present and prospective situation. This would be a review of the training content, instructional approach, media, and techniques for designing and managing the proposed learning system.	In the DE100s series, Phase 1 helps define the training problem and customize MISA. It allows the definition of the "LS to be designed in enough detail to lay the foundation for choosing a training solution and the resulting developmental orientations. The DEs produced during this Phase are grouped in the "Learning System Project Definition" record. The first to be produced, this record enables the designer to decide whether design of the LS will proceed, or not, and on which Method tasks the emphasis will be placed. Accordingly, the designer will refer to the customization principles indicated in Part VI and the documents dealing with the MISA 4.0 Method's techniques". This initial systematization and synthesis helps contextualize the Learning System (LS) to be designed.
102 - Objectives of the Learning System	Identify the general learning objectives that the proposed or revised LS must achieve. Identify the learning priorities and the type of learning actions to be taken, and determine the scope of the LS, its life span, date of delivery, etc.	Section A helps establish priorities (*Priority* attribute) where the intention and reason to build a UoL for reusability can be stated. Section D can be also helpful as the first ideas about the *Scope of the LS* are written down. Other details are also drafted: the *Type of Training intervention*, the *Type of Knowledge Models*, the *Targeted Skill Domain*, the kind of evaluation (*Certification with a Final Exam*, *Certification with Cumulative exams*), the need for *Face-to-Face Collaboration* and/or *Computer-Assisted Collaboration*, the need for *Instructor Assistance* and/or *Computer Assistance*, the type of *Delivery Modes*, the *Means of Communication* and *Material* requirements. These attributes will guide decisions about the UoL structure. They also let one preliminarily identify, in an informal way (text in a Form), certain main elements that will be formally declared in the UoL. As we can corroborate, MISA is a progressive and iterative way of proceeding with reflection, decision, and design.

104 - Target Populations	Define a general profile of the groups of learners for which the training is proposed.	In this DE, it is possible to determine the learners' general characteristics in a global manner. Its purpose is to draw a developed portrait of the learner to guide the knowledge and instructional model building. This should not be confused with the specific roles that learners will assume within the UoL, meaning those related to the learning activity they will be involved in (e.g. moderator in a discussion forum). It is not yet possible to define these at this stage of the design process.
106 - Present Situation	Identify and describe the boundaries of the LS (e.g. related projects) as well as the available human resources, material resources and services, and the constraints that may have an impact on the implementation of the LS. Make recommendations on the focus to be given to the proposed LS, the conditions for its success, and the principal risk factors that must be taken into account.	Particular attributes of this DE as *Related Projects*, *Management Systems* and *Program, Courses and Activities* (already developed in similar or related subjects to the LS to be designed), help determine implementation issues that are intimately linked to the decision of design an IMS LD UoL.
108 - Reference Documents	Identify all the documents (reference documents) that may prove useful during the LS's engineering phase and catalogue them on index cards.	The *Type of Access* attribute of this DE is suitable for the purpose of declaring the URL of a resource that will be later declared in the UoL. It will be helpful when building the UoL *Environments*.
210 - Knowledge Model Orientation Principles	State the orientations for the knowledge model. These orientations make it possible to develop a structured knowledge model and to incorporate the targeted competencies expected by the LS.	The Knowledge and Competency Model defines and structures the knowledge to be learned. Even though this model changes according to the competencies to be acquired by the learner, in no way does it depend on the Instructional Scenarios and materials supporting the learning or the infrastructure and services ensuring the delivery of the LS. Although independent, the models in MISA are coordinated to produce an efficient LS. In the Knowledge and Competency Model, a sub-model is associated to each *Learning Unit*, thus defining the content of the learning scenario. Within the learning scenarios, a sub-model is also associated to each learning instrument, therefore defining the content to be made available in the instructional materials (encompassing the instruments). These DEs provide what IMS LD has identified as (optional) *Prerequisites* and *Learning Objectives*.

<table>
<tr><td>212 - Knowledge Model</td><td colspan="2">In phase 2: Develop a graphical representation, structured according to the content of the learning system, built in parallel with the evaluation of the gap between the present and target competencies of the target population (DE 214).

In phase 3: Add all new knowledge units to the main knowledge model according to the content of the associated sub-models (DE 310). This iterative action allows you to complete the main knowledge model.</td></tr>
<tr><td>214 - Target Competencies</td><td colspan="2">For each of the main knowledge units in the model (DE 212), determine the present competencies and the competencies expected by the learning system for each target population.

In phase 3, if necessary, revise the competency descriptions after building the knowledge model associated with the learning units (DE 310). This revision sometimes makes is possible to define new principal knowledge units.</td></tr>
<tr><td>220 - Instructional Model Orientation Principles</td><td colspan="2">State the instructional orientations that make it possible to develop a structured model of learning events, units and activities, as well as the resources and instruments that go into their creation and result from them. Also, state principles guiding the instructional approach, learner evaluation, collaboration and customization of the instructional scenarios</td></tr>
<tr><td>230 - Material Development Orientation Principles</td><td>In phase 2: State the principles that guide the choice of delivery modes. These statements particularly concern the human resources, the means of communication, the tools, the services and training locations needed during delivery. These elements will be used to analyse costs (DE 242).

In phase 3: Taking into account the instructional scenarios and the properties of the learning activities, specify principles in order to establish a development infrastructure (DE 330), a delivery plan (DE 340), and the various elements of the delivery model (DE 440, DE 442, DE 444 and DE 446).</td><td>In this DE the Delivery Mode, Means of Communication, Tools, Delivery Periods, Delivery schedules, and Delivery locations are preliminary established. In this DE, the following are determined for the identified LE, LU, or learner activity: the start dates (Organisation and Start-up of Groups), requirements in terms of assistance (Instructor and or other Facilitator), and relevance for evaluation (Content Evaluation Goal and Evaluators). These decisions will guide the declaration of rules later on.</td></tr>
</table>

240 - Delivery Orientation Principles	Link the learning system to be developed with the client organisation's training plan. Create an overview of the client organisation's (or one of its divisions') present and prospective situation. This would be a review of the training content, instructional approach, media, and techniques for designing and managing the proposed learning system.	In the DE100s series, Phase 1 helps define the training problem and customize MISA. It allows the definition of the "LS to be designed in enough detail to lay the foundation for choosing a training solution and the resulting developmental orientations. The DEs produced during this Phase are grouped in the "Learning System Project Definition" record. The first to be produced, this record enables the designer to decide whether design of the LS will proceed, or not, and on which Method tasks the emphasis will be placed. Accordingly, the designer will refer to the customization principles indicated in Part VI and the documents dealing with the MISA 4.0 Method's techniques". This initial systematization and synthesis helps contextualize the Learning System (LS) to be designed.

6.2.2.3 Round 2: Proposition C

The previously enumerated DEs encompass a context grounded, and rigorously guided creative process of instructional design. The completion of these recommended MISA DEs orient the designer with respect to the kind of Learning Design (pedagogical scenario) under development. It is a process where certain well-founded decisions are taken before designing the UoL more concretely, i.e. decisions concerning the insertion of the LD within the constraints of a given organization, the determination of what knowledge is to be covered and what competencies are to be developed, the kind of pedagogical approach that will be used, the modes of delivery, and a preliminary identification of pertinent resources. All together, this constitutes a solid base for UoL design and representation. We therefore propose a version of the MISA method for the design, or a UoL integrating the following DEs

Table 6-3

The MISA adapted version for expert consultation

MISA DEs for the designing of a UoL	
Recommended	100 - Organisation's Training System
	102 - Objectives of the Learning System
	104 - Target Populations
	106 - Present Situation
	108 - Reference Documents
	210 - Knowledge Model Orientation Principles
	212 - Knowledge Model

	214 - Target Competencies
	220 - Instructional Model Orientation Principles
	230 - Material Development Orientation Principles
	240 - Delivery Orientation Principles
Mandatory	222 - Learning Event Network
	226 - List of Properties (see next discussion and proposition)
	224 - Attributes of each LEN element (see next discussion and proposition)
	320 - Instructional Scenarios
	322 – Attributes of each Instructional Scenario element (see next discussion and proposition)

[See “Proposition C” related questions in in Appendix 6-C]

6.2.3 Modifications to the DE

6.2.3.1 Round 1 synthesis

Since they were accurately identified as crucial for the design of a UoL, the modifications proposed up to this point, for the DEs that were singled out, have been accepted. Nevertheless, refinements and deeper analyses are required. This is consistent with the greater level of detail involved in the second round of the Delphi approach.

6.2.3.2 Round 2 discussion

The discussion around the specific modifications to be introduced into the DEs integrates previous reflection from points 1 and 2. We will concentrate here on the subject of rules – both in MISA and IMS LD – that have an impact on DE222 and DE320, and especially on DE224 and DE322.

Rules in MISA

“Rules in MISA help instructional designers specify relevant pedagogical issues. In the first phases of MISA, instructional designers define general execution, evaluation, collaboration and adaptation principles for their learning system, which they then translate into concrete rules associated to a Learning Event or a Learning Unit. Those concrete rules in turn can either guide designers further in the description of the activities and the Learning Events structure (static model), or help in the description of the actions to be triggered during the delivery process (dynamic model).”(Paquette et al., 2005, p.7)

MISA rules are "statements guiding the completion of the learning events, the learning units or the learning activities in the instructional scenario" (MISA Glossary). There are three types of rules: instructional rules, media rules guiding the layout and design of the LS delivery model (which are not part of this study), and delivery rules.

Instructional and delivery rules are subject to our attention. Instructional rules are composed of four sub-types described in the following table

Table 6-4

MISA instructional rules

Instructional Rule sub-type	**LEN (DE222 and DE224)**	**IS (DE320 and DE322)**
Study Approach Rule*	Statement defining the approach taken by the learners to the LEN, most notably in terms of the choice and order of LEs/LUs carried out.	Statement governing the study approach to be taken by learners in one or more scenario activities, especially with regard to sequencing of activities.
Instructional Rule sub-type	**LEN (DE222 and DE224)**	**IS (DE320 and DE322)**
Collaboration Rule*	Statement defining the organization, the type of commitment, and the sharing of information during the course of teamwork in one or more LEs/LUs.	Statement governing the set-up of information sharing among actors in order to carry out activities in the scenario.
Evaluation Rule*	Statement defining the object, the data, the type of analysis and decisions, as well as the timing and the function of learner evaluations related to LEs/LUs.	Statement on the object, on gathering and analysis of data, as well as on the timing and function of learner evaluations during one or more activities in the scenario.
Customization Rule*	Statement defining how the LEs/LUs may be customized by the users during delivery, with regard to study approach, collaboration, and evaluation.	Statement defining how the scenario activities may be customized by the users during delivery, especially with regard to study approach, collaboration, and evaluation.

* Definitions are taken from MISA (2000c).

In MISA, these rules are not well formalized but the method offers the designer a significant list of examples for each one. MISA rules are declared in the DE222 and DE320 models as "Principles" (the hexagon shape in the MOT notation system) connected to *LEs*, *LUs,* and *Activities* through a *Regulation* (R) link. Due to concerns of model expansion and visual comprehensiveness, *Rules* are explained in detail as text paragraphs in subsidiary DE Forms DE224 and DE322.

- Rules and *Resources*

Rules that govern the learn flow, and that directly apply to *Resources* in the LEN or IS, are not explicitly presented in MISA. Nevertheless, the DE440 Delivery model includes an exclusive delivery rule, defined as "*a statement that specifies the conditions of actor roles (instructor, learner, manager, etc.) on when and how to use resources during the distribution of the LS*". That is to say that rules operating on *Resources* are considered when the delivery model is built.

As we argue in favour of integrating into the MISA Instructional Model, certain elements of the MISA Delivery model for Learner/Teacher generic roles (to better meet IMS LD requirements) we consider borrowing the notion of this Delivery rule, but integrate it as an extension of the Instructional Rule sub-types. This lets one define rules applied to *Resources* in the instructional model.

- Rules and *Roles*

As we previously explained, the current version of MISA, in DE320, has an "embedded role" (into the activities). The identification of a learner or assistance activity is taken care of by a label and a specific color. In the new adapted version, we have justified the need for a split between Activity and Role to meet IMS LD requirements. This proposition is also coherent with the need for applying rules to Roles, here again trying in with IMS LD logic. In this sense, we therefore also propose an extension of the scope of rule application in MISA, so that they apply to Roles. In fact we do not find this to be conflicting with MISA, as the method itself allows the declaration of rules affecting roles but in a less graphical and less formal way. While the current version of MISA is more "Activity-driven", the modifications imposed by the IMS LD Specification call for a more "Role-driven" scenario. In doing this, MISA not only gains expressiveness, but also a capacity and ease for designing multi-role scenarios.

MISA instructional rules should thus be redefined as "more or less formalized statements guiding the conditions regarding progress and completion of learning events, learning units, and learning activities applying to one or more of their constituent elements (*Roles* and *Resources*)". In fact, this extension may even be understood as already entailed by the original definition, depending on the interpretation given to the *Rule* definition. We believe that explicitly stating our own definition clarifies this extension of the scope of rule application.

It is important to assert that the approach of integrating certain "delivery issues" into the Instructional model does not entail that the building of a UoL is confined to a single step; it is crucial to maintain a separation of concerns that are distinct. DE222 and DE320 better correspond to IMS LD Level A, whereas DE224 and DE322 match up with Levels B and C of the Specification.

IMS LD Level B and C: Conditions, Properties, Notifications and Rules

MISA instructional *rules* have much in common with IMS LD Level B (*Conditions* and *Properties*) *and* Level C (*Notifications*). At Level B, the learning design (or UoL) can be more explicitly regulated through the establishment of *Conditions*. "Conditions provide the capability for learning designers to define rules as to what should happen when certain events take place" (Olivier & Tatterstall, 2005, p.37). *Conditions* are expressions that conform to: "IF {expression} THEN {show, hide, change something, or notify someone}", or more simply "IF {X} THEN {Y}," where {X} and {Y} may contain a *Property* that can be expressed by a *Value* (Boolean expression[26]). Some of these values may be set in a manner that the system is able to interpret, while others can only be interpreted and applied by humans.

To illustrate this, consider a more detailed, formal way of expressing rules:

"IF {Condition: Property/Value (=, ≥, >, <, ≤) } AND/OR { } THEN {statement}" ELSE { }", where the Property-numeric[27]-or-string[28] expression and the AND/OR-and-ELSE operators are present depending on the complexity of the rule to be expressed.

At Level C, "notifications provide a greater level of interactivity and control over a live learning design, as a form of event-driven messaging system within an LD player. Notifications can be sent both to elements of the design, as well as to human participants. At Level C, a notification can be triggered by an activity completing or by a rule" (Olivier & Tatterstall, op. cit.).

We illustrate our previous presentation with two examples.

Example 1

Suppose the instructional designer establishes that, to begin a second activity, the score for an assignment from the first activity (A1) must be equal or greater than 70 points (on a scale of 1 to 100). Hence, a reinforcement activity (A1b) is proposed to learners who scored less than 70 points. We can express this scenario in the following formal manner:

---

[26] Boolean expression: an expression that results in a value of either TRUE or FALSE. For example, the expression: **2 < 5** (2 is less than 5) is a Boolean expression because the result is TRUE. All expressions that contain *relational operators*, such as the *less than* sign (<), are Boolean. The operators -- AND, OR, XOR, NOR, and NOT -- are Boolean operators. Boolean expressions are also called *comparison expressions, conditional expressions,* and *relational expressions.* From: **http://www.webopedia.com/TERM/B/Boolean_expression.html**

[27] Numeric: any expression that can be evaluated as a number. Elements of the expression can include any combination of keywords, variables, constants, and operators that result in a number. From: http://www.csidata.com/custserv/onlinehelp/VBSdocs/vbs587.htm

[28] String: any expression that evaluates to a sequence of contiguous characters. Elements of a string expression can include a function that returns a string, a string literal, a string constant, or a string variable. From: http://www.csidata.com/custserv/onlinehelp/VBSdocs/vbs587.htm

Rule: evaluation

Condition: IF { assignment score A1 ≥ 70 } THEN { go to A2 } (where *Property*: score, *Value*: 1 – 100)

Notification:

- message to the system: make A2 visible to learner with exam score A1 ≥ 70

IF { assignment score A1 < 70 } THEN { go to A1b } (where *Property*: score, *Value*: 1 – 100)

Notification:

- message to the system: make A1b visible to learner with exam score A1 < 70

- send e-mail to learner (IMS LD *Service*: send-mail) notifying score and additional activity (A1b)

Implications for design:

The example below declares a Rule in two different ways: first, as a text paragraph, which is clear but informal and, second, in a formal expression that is system programmable. This second way of declaring the rule depends both on the designer's knowledge of the subject but also on the ergonomics of software tools that may support this kind of formal declaration.

Example 2:

Suppose the instructional designer decides to establish rules that must be followed in a discussion forum. He could decide that all participants should post at least 1 message. He could also decide that any learner who hasn't posted a first message within 7 days of the start of the discussion should automatically be contacted to be reminded of this obligation. He could also establish that the course tutor only intervenes if he encounters conceptual misunderstandings or poor arguments in the discussions.

First, we can deduce that this designer wishes to implement two distinct types of rules:

- one that can be configured in such a way that the system can automatically execute it: *check after 7 days if each learner has sent at least one message, otherwise, notify them*
- one that can only be executed by a human: in this case, hinging on the moderator's capacity to evaluate the participants' arguments or conceptual misunderstandings.

The automatable rule can be configured in the system, according to system capacities and functionalities.

Rule: collaboration

Condition:

IF { discussion number of days > 7 } AND { learner number of messages = 0 } THEN { send-mail to learner } (where *Property*: number of days, *Value*: 1 – 31; *Property*: number of messages, *Value*: 1 – 100)

Implications for design:

Similarly to the first example, this second one presents the rule in both an informal and a formal way. This example calls attention to the computability limits of formal declaration of rules (for system programming) from those that can only be stipulated as guidelines or advice for a learner or teacher. There is thus a first differentiation between those Rules and Conditions that can be set up to be automatically executed by the system and those that require human intervention.

A more elevated degree of formality in the declaration of Rules, Conditions, Properties and Values can become annoying for an instructional designer or a teacher. We can suppose that professionals who deal with logical expressions on a normal basis (e.g., physicists, mathematicians, computer programmers, or software engineers) could be more predisposed to formalizing rules. But this is an ideal situation. Instead, rule declaration in MISA DEs could take the form of statements that include all the elements necessary for *subsequent* logical formalization. This formalization could be the task of a competent professional or would otherwise rest on the user-friendliness of a software tool supporting this task.

- Rules and time conditions

In MISA the notion of time is handled in DE224 (*Allotted Time* attribute) and in DE322 (*Life span* attribute). Both attributes require an estimate of the time (in hours/minutes) necessary for the accomplishment of the LU and the Activity, respectively. In IMS LD, time is a Rule. “The time can simply be checked against the current date and time, or it can be the time since the UOL or since a particular Activity started” (Olivier & Tatterstall, 2005, p.37). IMS LD time is formalized as YYYY/MM/DD and/or H/M/S. This notation can be easily incorporated in the above mentioned MISA DEs.

- On Properties

Properties can be used for many different purposes. In a previous section, we explained how properties “can be used to determine, dynamically, when an action should be triggered (e.g. on the completion of an Act, or indeed to trigger other events)” (Olivier & Tatterstall, op. cit., p.36). Another “common use is to use Person Properties to provide more detailed information about learners to adapt a learning design to individual needs and preferences. This can be either before a run of a UoL starts or during the run, using tests that are integrated in the LD (Olivier & Tatterstall, op. cit.). In this sense, “properties are also associated with a further addition to the level A specification: ‘Global elements’. In essence, global elements enable properties and groups of properties to be both viewed and set by participants at runtime” (Olivier & Tatterstall, op. cit., p.37). This is a very important aspect as it allows, for example, a teacher to personalize or change the learning scenario “on the fly,” providing enough flexibility for scenario adaptation to unpredictable events.

A previous analysis (Paquette et al., 2005) showed that the MISA instructional rules can be translated into IMS LD conditions. Moreover, “MISA rules are stated in a textual informal way and they all describe actions to be taken depending on the state of one or more variables. Those variables correspond to the five types of properties of IMS-LD: local, local-personal, local-role, global-personal, and global” (ibid). They are defined as follow (IMS LD Information Model, V.1)

- Local properties […] are stored with a scope local to the run of a unit of learning. They are defined and used in the unit-of-learning. The value of this property is the same for every user in the run of the unit-of-learning, but can differ in different runs. Local personal property indicates values that can be different for every user in all the roles for a run of the unit-of-learning.
- Personal properties […] are owned by a person (local or global). These properties are used for personalization. For example, a portfolio that works across units of learning can be modeled with […] (global personal) properties. The personal properties can be stored in a personal, portable 'dossier'. Global-personal property specifies the value for every user, regardless of the different runs of units-of-learning. It has persistent values from one run to the other
- Role properties […] are owned by a role and are always local. Every user in a specific role can access this property and has the same value in the same run of the unit of learning.
- Global properties […] are accessible outside the context of a unit of learning (e.g., by more than one unit of learning). They can be defined in one unit of learning and used in another one. In IMSLD global properties can be defined. Runtimes are expected to control whether a defined global property URI already exists or not. Global properties - once defined - may never change definition. So when the property already exists the definition is ignored.

This explanation of the properties appears complex but it can be made easier to understand by designers with some representative examples, in the same way that MISA does for its rules. The designer can thus declare properties, without having to cope with IMS LD typology terminology, by dealing with (examples below are based on MISA execution rule)[29]:

- Property values that apply to all the **users** (e.g., Course starting-date: 21 September 2007 - MISA execution rule) in the actual run (date will change for another run). [IMS LD **Local** property]
- Property values that apply to every **person** (e.g., Number of activities completed by **the** student) and can be different for every user in all the roles for a run of a UoL [IMS LD **Local-personal** property]

[29] The examples mentioned to illustrate the Properties are taken from Paquette et al. (2005)

- Property values that apply to all users in a **role** (e.g., N = num of activities assigned) for a run [IMS LD **Local-role** property]
- Property values that apply to all **users,** regardless of the different runs of the UoL (e.g., Num. of courses taken). [IMS LD **Global-personal** property]
- Property values that are stored and are **independent** of users, UoLs, and roles (e.g., N = Minimal number of students to start a course) [IMS LD **Global** property]

As a property may apply to similar situations within the same UoL, it is extremely important to be consistent with property names in order to inform either the system or the IMS LD expert that a given property used at some point is exactly the same as that which was previously declared.

In example 1 above, we deal with the “assignment score” Property that was hypothetically first defined when the designer was declaring a rule applying to a specific Activity outcome. Let’s suppose that this case is valid for another sequence, in the same UoL, where the designer decides to apply the same rule and property (regardless of whether its value is the same). The Property was declared once and is then applied to this new situation. In this case we have to ensure that the designer will use this property without having to redefine it again. We also have to guarantee that the system is able to identify the Property as the same which was previously declared and we need to remind the designer of its definition; it is thus necessary to keep track of declared properties.

6.2.3.3 Round 2: Proposition D

The previous discussion lets us conclude that the declaration of Rules in DE224 and DE320 should be of two types:

- informal: as statements, and
- formal: as conditional expressions

The way in which a rule is declared will depend on certain interrelated factors:

- the designer’s skills,
- the supporting software’s user-friendliness and effectiveness for formal rule declaration,
- the availability of support provided by competent human experts.

DE224 and DE322 will therefore have to:

- Extend Rule declaration beyond *LE/LU* and *Activities* to *Resources* and *Roles,*
- Allow/support the declaration of rules in informal *and* formal ways,
- Allow/support IMS LD *Property type* declaration,
- Add Visibility and Accessibility notions,

- Add the IMS LD *Notification* notion,
- Formalize IMS LD *Time* declaration.

DE224 (Attributes of the LEN elements) and DE320 (Attributes of the IS elements) should provide support for declaring Rules and Properties in their attributes, together with an explanation (like the one presented in the above discussion), to help designers and, eventually, experts whose task it is to formalize declarations of rules and properties.

Both the DE224 and DE320 Element Attributes should include the following items.

Element is

☐ Visible
☐ Accessible
☐ Visible/Accessible based on Rule ____

Time	YYYY/MM/DD and/or H/M/S ☐ checked against the current system date and time ☐ since ____ (a particular activity) started

Rule

Study Approach (execution)	☐ Statement: ☐ Formal declaration (IF... THEN) Notification: ☐ To specific role ☐ To all roles ☐ To the system Property name: O From the list (DE226): ____________________ O New: __________________________________ ☐ The property value applies to all the users in the current run of the UoL ☐ The property value applies to every person and can be different for every user in all the roles for a run of a UoL ☐ The property value applies to all users in a role, in the current run of the UoL ☐ The property value applies to all users regardless of the different runs of the UoL ☐ The property value is stored and it is independent of users, UoLs, and roles
Collaboration	Same Study Approach rule as above
Evaluation	Same Study Approach rule as above
Customization	Same Study Approach rule as above

Figure 6-4. DE224 and DE320 Element Attributes

As explained before, *Properties* can be seen from two different angles: 1) from the design angle, properties are declared progressively while deploying DE222 and DE320; 2) from a machine-system angle, the same properties applying to different places in the UoL may only be correctly "interpreted" if they are named and referenced in exactly the same way. Through the MISA method, we must support both these requirements, which are of different nature. Thus, there is a need to keep Property declaration consistent. We suppose, here, that a new DE is necessary. We propose adding "DE226 List of Properties" to gather all the properties declared during design of the UoL. This DE must be completed progressively and in parallel with the design of DE222 and DE320.

It is difficult to imagine a "Form paper solution" for DE224 and DE322, as they have to dynamically prompt for declaration of given information in order to capture certain programmable system behavior. We suppose that these proposed DEs would be more like "drafts" or "mock-ups" of electronic Forms to be integrated into a new version of MOT. These forms for DE224 and DE322 should let one parameterize, or at least declare, rules in a free text format, for later use by a programming expert. The form for DE226 should automatically add the Properties and then dynamically display them when declaring new rules. We are also aware of the fact that the programming of such a software editor tool is a challenge, as it will have to integrate a verification function to prevent overlapping or incongruence of the UoL under design. It also challenges the designer that now has to deal with delivery matters, such as the dynamic interface (visibility and accessibility of elements of the UoL) proposed to the learner and the teacher during the different stages of the execution of the educational piece.

We suppose that an integration of Model design, together with Properties, in the MOT modeling tool could eventually simplify the designer's task, making it easier. A similar decision has been taken in what can be considered an evolution of the MOT software, known as Scenario Editor (under development). Below, a screen capture (modified to suit our purposes) illustrates this idea.

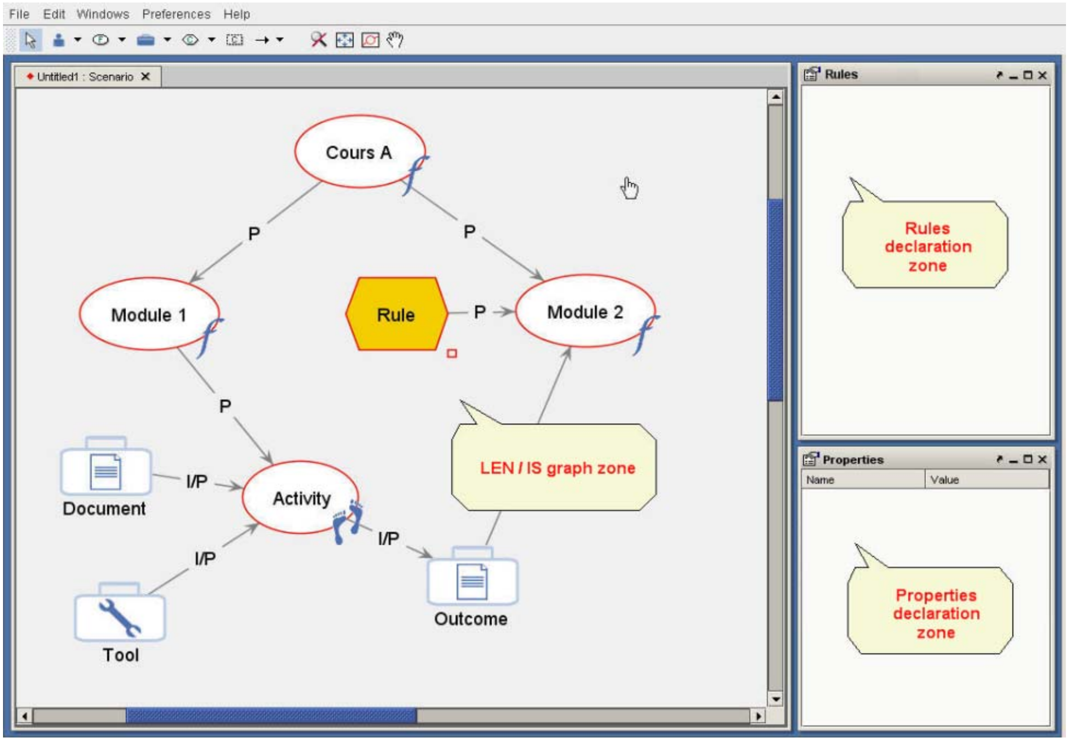


Figure 6-5. Mock-up screen for the integration of Model design and declaration of Properties

As a result of the discussion just above and a synthesis of sections 1 and 2, here is a list of the DEs that were singled out, along with the proposed modifications.

Table 6-5

MISA recommended and mandatory documentation elements.

	DE	Modifications
Recommended	100 - Organisation's Training System	idem
	102 - Objectives of the Learning System	idem
	104 - Target Populations	idem
	106 - Present Situation	Section A *Related Projects* attribute: declare the reason and intention for producing an IMS LD UoL Section B *Human resources* attribute*:* indicate an IMS LD expert for rule formalisation.
	108 - Reference Documents	idem
	210 - Knowledge Model Orientation Principles	idem
	212 - Knowledge Model	idem
	214 - Target Competencies	idem

	220 - Instructional Model Orientation Principles	idem
	230 - Material Development Orientation Principles	idem
	240 - Delivery Orientation Principles	idem
Mandatory	222 - Learning Event Network	- Integrate and formalize a notation for *Means of communication* to express the IMS LD *Send-mail* and *Conference* services. - Integrate and formalize a notation for *Tool* to express IMS LD *Index-search* - Introduce the new *Package of resources* term to bind MISA to the IMS LD *Environment* term - Integrate and formalize a notation for *Entry Level Competency* (IMS LD *Prerequisite*) and *Target Level Competency* (IMS LD *Learning Objective*) - Add the "I" link to instantiate *Resources* and link *Entry Level Competency* and *Target Level Competency* - Formalize Instructional rules to match IMS LD rules: o Differentiate Rule declaration from Rule explanation: on LEN Rules, apply rule declaration (Rule explanation is part of subsidiary DE224)
Mandatory	222 - Learning Event Network (continous)	o Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance. o Extend the rules to express Conditions for *Resources* and *Roles* o Extend the notion of instructional rules to take into account delivery matters such as establishing Conditions for Visibility of *LEs*, *LUs*, and *Resources*.
	226 – List of Properties	Include *Property name* and *Property type* attributes
	224 - Attributes of each LEN element	- Formalize Instructional rules to include IMS LD rules o o Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance. Explain the notion of Rule computability to introduce Rule formal expression. Formal expression should be suggested but not mandatory. A technician or a user-friendly and efficient software tool should help in this task o Extend the rules to express Conditions for *Resources* and *Roles* o Extend the notion of instructional rules to take into account delivery matters such as establishing Conditions for Visibility of *LEs*, *LUs*, and *Resources,* and *Notification* messages.
	320 – Instructional Scenarios	- Change the term Actor for Role - Add the Learner and Teacher (generic) Roles to the notation system for IS modeling. - Integrate and formalize a notation for *Entry Level Competency* (IMS LD *Prerequisite*) and *Target Level Competency* (IMS LD *Learning Objective*) - Add the "I" link to instantiate *Resources* and link *Entry Level Competency* and *Target Level Competency* - Integrate and formalize a notation for *Means of communication* to express the IMS LD *Send-mail* and *Conference* services. - Integrate and formalize a notation for *Tool* to express IMS LD *Index-search* - Introduce the new *Package of resources* term to bind MISA to the IMS LD *Environment* term

	320 – Instructional Scenarios	- Formalize Instructional rules to match IMS LD rules: o Differentiate Rule declaration from Rule explanation: on IS Rules, apply rule declaration (Rule explanation is part of subsidiary DE322) o Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance. o Extend the rules to express Conditions for *Resources* and *Roles* o Extend the notion of instructional rules to take into account delivery matters such as establishing Conditions for Visibility of *LEs*, *LUs*, *Activities*, *Resources* and *Roles*.
	322 – Attributes of each Instructional Scenario element	- Formalize Instruccional rules to include IMS LD rules o o Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance. Explain the notion of Rule computability to introduce Rule formal expression. Formal expression should be suggested but not mandatory. A technician or a user-friendly and efficient software tool should help in this task o Extend the rules to express Conditions for *Resources* and *Roles* o Extend the notion of instructional rules to take into account delivery matters such as establishing Conditions for Visibility of *LEs*, *LUs*, *Activities*, *Resources* and *Roles*, and *Notification* messages.

[See “Proposition D” related questions in in Appendix 6-C]

6.2.4 Terminology

6.2.4.1 Round 1 synthesis

The issue around terminology – in particular on whether to respect MISA terminology or to introduce the IMS LD terminology into the instructional method – is where opinions somewhat differ.

It has been pointed out that even if it is possible to find similarities in the terminologies, and even certain correspondences, there is no one-to-one equivalence between the MISA and IMS LD terms.

It has also been said that if the intention is to build IMS LD UoLs, it could be interesting to introduce this Specification’s terminology into MISA. An example was provided where the notion of the MISA Learning Event is matched up with the IMS LD notions of Play, Act and/or Activity Structure. As they are not equivalent, a series or rules should be added to better differentiate them.

Lastly, it has been suggested that yet another version of MISA be developed: one that would flexible enough to support designers who are familiar with IMS LD, but also designers who aren’t.

Our position with respect to the MISA adaptation is to emphasize the strength of the MISA method as a pedagogical engineering method with its own design language, notation system, and software editing tool. The challenge of our research is to identify, in the MISA method, modifications that are necessary to facilitate the design of reusable and interoperable IMS LD UoLs. We intend to remain within said approach, where the instructional designer doesn't have to deal with extradisciplinary terminology and ways of conceptualizing, but can instead focus on learning situation design from an intradisciplinary angle. We found it appropriate to keep as close as possible to the MISA language and avoid computer science development terminology. Nevertheless, throughout this document we have proposed adjustments to MISA that borrow from IMS LD at both the procedural and terminological levels, thus facilitating the building of a UoL. Still, an instructional designer who is familiar with IMS LD could go further towards a final (executable) version of a UoL than an instructional designer who is not.

Some issues about terminology adjustments have been singled out and included as propositions within the three main subjects discussed previously based on their interrelated nature.

6.3 Delphi round two analysis and conclusions

This phase features a version of the MISA method revised for the design of IMS LD compliant UoLs and for additional considerations concerning software development and design task distribution and assignment within teams.

As we described in a previous section, we asked the experts to indicate (on a 5-point Likert scale) the degree to which they agree to given statements. The experts were also encouraged to make freeform comments for each of the statements.

For the analysis and interpretation of expert opinions in the second round of the Delphi technique, we used quantitative and qualitative data processing. The analysis is based on a discussion and synthesis of the experts' ratings and corresponding comments. Based on interpretation of the data and the evaluation of the degree of acceptance of the questionnaire propositions, we have come up with general conclusions for a new version of MISA adapted to the design of IMS LD compliant UoLs.

6.3.1 Questionnaire coding and processing

We begin by explaining the rationale for coding and interpretation of collected data. We have developed a system for scoring the experts' answers in order to measure two different aspects of the validation questionnaire.

First, we wanted to establish the extent to which the experts agreed with one another when asked to give their opinion on given propositions. To organize this data, we grouped "agree" and "strongly agree" answers into a *positive* (or +) category. Similarly, we grouped "disagree" and "strongly disagree" into a *negative* (–) category. A "neither agree nor disagree" answer was qualified as *impartial* (or ±). In the case where there was no specific answer for a given statement, this was coded as "n/a" and was not taken into account in the data processing.

We have then established the following criteria:

- When there were more positive answers than negative and neutral answers put together, we labeled the overall level of agreement to a given statement as POSITIVE CONVERGENCE (PC).
- When there were more negative answers, the overall level of agreement was labeled: NEGATIVE CONVERGENCE (NegC).
- When there were more neutral answers, of the overall level of agreement was labeled: NEUTRAL CONVERGENCE (NeuC).
- When there was an equal number of negative and positive answers, the overall level of agreement was labeled: DIVERGENCE (D).
- When the number of negative or positive answers was equal to the number of neutral answers, the overall level of agreement was labeled: RELATIVE DIVERGENCE (RD), i.e. this topic would be subject to deeper analysis based on qualitative information.

Table 6-6

Convergence / divergence computation

Convergence / divergence computation (CDC)		
Number of positive, negative, and neutral answers	**Overall level of agreement among the experts**	**Code**
$> +$	Positive Convergence	PC
$> -$	Negative Convergence	NegC
$> \pm$	Neutral Convergence	NeuC
$+ = -$	Divergence	D
$+ \vee - = \pm$	Relative divergence	RD

>: majority of

Next, we wanted to establish the degree of approval or disapproval of given propositions. These results will guide decisions relative to the adaptation of MISA. We assigned a score of 1 to 5 to each expert's answer, coherent with the Likert scale used in the questionnaire:

- 5 is assigned to STRONGLY AGREE, i.e. the expert is in complete agreement with the given proposition;
- 4 is assigned to AGREE, i.e. the expert agrees but has reservations;
- 3 is assigned to NEITHER AGREE NOR DISAGREE, i.e. when the expert's opinion is neutral or conditioned upon other related arguments;
- 2 is assigned to DISAGREE, i.e. the expert disagrees with the proposition but has reservations;
- 1 is assigned to STRONGLY DESAGREE, i.e. the expert is in complete disagreement with the given proposition.

The overall approval/disapproval score for each questionnaire item is computed by calculating the average of all the individual expert score for that item. In the case where an expert omitted to answer, the average will simply be calculated with a lesser number of answers.

Table 6-7

Approval/disapproval computation

Approval/disapproval computation (ADC)		
Average score	**Meaning**	**Code**
> 3	Approval	A
= 3	Conditional Approval	CA
< 3	Disapproval	D

We built a summary table where the first column contains the id. number of each questionnaire item, the second presents a synthesized version of the item, the third contains the id. number of the expert, the fourth presents the score given by each expert for each statement, the fifth provides the CDC (convergence / divergence computation) result, the sixth contains the ADC (approval / disapproval computation) result, and the seventh presents a summary of the expert's comments.

To help us understand and interpret the Likert scale responses for the individual items, we made sure to keep track of any comments made in addition to those responses (a space for free-form comments was left after each item and the experts were encouraged to express their ideas in a detailed manner). These comments turned out to be quite useful at the data interpretation stage, since they provided details and helped resolve ambiguities or apparent contradictions. We then proceeded to write summary interpretations of the opinions, including accounts of coincidences, discrepancies and nuances.

Lastly, based on our analysis of the data we established a list of modifications leading to an adapted version of the MISA method. Our research helped us understand specificities of the MISA method that relate to the design of IMS LD UoLs and the extent of the impact of adapting MISA , not only on MISA itself, but also on software tool improvement efforts and on the new competencies that a designer or other such actor would need to acquire.

Proposition A – Integration of MISA delivery matters into the pedagogical model

Validation statement	Evaluation subject	Expert	Score	convergence / divergence calculation (CDC)	approval / disapproval calculation (ADC)	Comments integration and analysis
A1.1	Adjust the MISA Pedagogical Model to integrate a relevant MISA Delivery Model elements in order to gather the information required by an IMS LD UoL	1	+ ⇒ 4	>+	3.75	IMS LD can be interpreted as a merge of MISA pedagog is the result of a sequenced process and a combination synthesize the whole: 1) the adequacy of the MISA peda MISA delivery model elements, 2) the adaptation of some progressive approach to the design of the UoL and 3) recomposing (reorganizing) in order to meet IMS LD "technologist" together with a series of software automata As one of the respondents clearly recalls, the first vers delivery axis. Some issues now addressed in the deliver some planning operations. The lack of specific and m
		2	+ ⇒ 4	PC	A	
		3	+ ⇒ 4			
		4	± ⇒ 3			

Figure 6-6. Part of the table used for the analysis of expert opinions (see Appendix 6-E for the full table)

6.3.2 Data analysis and interpretation

For presentation of the Delphi 2 results, we grouped the experts' opinions under three main (interrelated) topics. The first one relates to MISA as an instructional engineering approach to the design of IMS LD UoLs. The second is characterized by a deeper analysis of the MISA instructional model in relation to the delivery model and to scenario rule declaration for learning flow control. The last topic relates to a three-fold complimentary approach to the design of UoLs comprising the MISA method itself, the software modeling tool, and the definition of an adequate instructional designer skill set.

For each topic, we reference (between brackets) the corresponding questionnaire statements that can be found in Appendix 1 of this document. As the text below progresses, the discussion for each questionnaire item is also referenced and identified between parentheses, together with an indication of the corresponding level of convergence among experts as well as the degree to which they approve of the proposed modifications.

6.3.2.1 MISA, a holistic approach to IMS LD UoL design

[Ref: statements C1 - C2.1.4; B1, see Appendix 6-E]

In a recent paper, Sodhi et al. (2007, p.2) differentiate bottom-up from top-down IMS LD authoring (design) approaches:

> The authors [designers] can start either from defining the lower process level details and refining the details up, till a learning design emerges (bottom-up), or commencing from selecting the type of education to be modeled and working down to the process level details, aided and guided in the application of learning design rules to capture their knowledge into effective, pedagogically sound UoLs (top-down). Traditionally, strategies for processing information and knowledge ordering, these approaches can also be used to characterize educational process modeling techniques.

In this, we find support for our position that creation of reusable and interoperable IMS LD compliant UoLs is a significant instructional design issue. The proposition of the MISA pedagogical engineering method as a solution for the design of IMS LD UoLs fits well with the top-down approach. The top-down approach is defined as *holistic* and made concrete through explicit a design process (based on design rules, learning theories, tools and templates, best practices, etc.) that provides sufficient and detailed guidance to the designer.

The MISA 4.0 Presentation Document (p.18) explicitly stipulates that the MISA method “can be customized to suit the needs of the LS designer, whatever the size of the organization, the type or scope of the LS to be designed or the available human, material, and financial resources. The designers do not have to produce all the DEs, go through all the steps, develop all the axes or perform all the Method's tasks. The flexibility and consistency of the design approach offered by MISA 4.0 is largely based on four groups of principles.”

In the previous Delphi round, we had chosen, based on the MISA customization principles, a series of Documentation Elements encompassing a robust and a quality ensuring process of design, which we named “minimal approach.”

Based on these Delphi first round results, we had proposed a single version of the MISA method that includes “recommended” DEs for quality insurance and progressive design, together with “mandatory” DEs, wherein all the information required for a UoL is gathered in order to be translated into an IMS LD compliant syntax.

The “recommended” and “mandatory” DEs in this new version of MISA constitute a customized version of the method with respect to the creation of IMS LD UoLs in accordance with the MISA principle of customization (the selection of those DEs appropriate to a concrete project, from the 35 included in the MISA method as a whole). We acknowledge progression and coordination principles, since there is a suggested order for design and recursive interdependence between the DEs. All of the MISA phase 1 DEs are recommended, together with other DEs pertaining to each of the four MISA axes. The major impacts of the changes we proposed are mostly in the fusion of the MISA pedagogical model with the teacher/learner delivery model.

Mandatory DEs

In the questionnaire the recommended DEs are proposed as *relevant* and the “mandatory” DEs are characterized as *crucial*. This difference between relevant and crucial DEs rests on previous research evidence showing that while the former encompass the process of initiating the learning design, the latter (which mainly pertain to the MISA instructional axis) correspond to those DEs which, once completed, result in a pedagogical sequence equivalent (but not strictly identical) to an IMS LD UoL structure; in this sense, these are the DEs that support the design of a quasi-compliant UoL, and they are therefore indispensable.

All the experts agreed with the proposed mandatory DEs, i.e. 222, 224, 226, 320, and 322 (see C.2.1: PC/A). Certain specific comments deserve to be addressed. One expert suggested that DE212 and DE214 should also be declared mandatory. We suppose this proposition stems from an interest in ensuring the quality of the UoL by gains associated to integration with the knowledge model. Even though we consider his position valid on this matter, we believe that the intermediate solution of putting these DEs in the “strongly recommended” category (as stated previously) informs the designer about the importance of these DEs for the building of a coherent UoL, from an instructional design perspective.

DE 222 – Learning Event Network and DE 320 – Instructional Scenarios

The experts were unanimous with regard to the importance of DE 320 (see C.2.1.3: PC/A). DE 320 (Instructional Scenarios) describes and articulates the learner/support activity flow together with required resources and expected outcomes. DE 222 (Learning Event Network) is the instructional structure that deploys an organized set of learning events, which shape the curriculum/syllabus-related hierarchy (program, course, module, lesson, chapter, unit, etc.). Previous research had already shown that DE 222 and DE 320 are the main DEs enabling the creation of a pedagogical sequence expressed with a syntax similar to that of an IMS LD UoL. DE 320 – independently, or attached to DE 222 – can be interpreted as an EML proprietary to the

MISA method according to the EML definition given by Rawlings et al. (2002, p. 8): “an EML is a semantic information model and binding, describing the content and process within a ‘unit of learning’ from a pedagogical perspective in order to support reuse and interoperability.” DE 222 and DE 320 constitute an instructional structure of learning events, together with one or more instructional scenarios deploying learner and tutor activities (learning intended process) with associated resources (content). Both models are conceived with the MOT tool, which allows them to be exported in XML form (binding). They can be reused and potentially played with a compatible LMS like Concept@.

Based on his experience, one expert pointed out that certain instructional designers do not complete DE 222 in given projects. Keeping DE 222 and DE320 as separate but complementary models has an additional advantage: if the UoL being designed is only a stand-alone learning activity, that is to say, not formally attached to an instructional structure (course, module, etc.), the designer could just decide to complete DE 320 and avoid dealing with DE 222. This additional adaptation helps establish another criterion for UoL granularity. Otherwise, if the UoL is of coarser granularity, DE 222 and DE 320, at the outset, should be developed separately, and later integrated into one model aggregating them into a UoL ready for XML exporting.

We have stated that if the UoL in design is not attached to a LEN structure, DE 222 could be skipped. All the experts agreed with the statement that was proposed on this issue: “If the UoL is not attached to an Instructional Structure, then proceed with the design of DE320 IS” (see B.1.1: PC/A).

For the purposes of the design process (reflect, solve problems, and take decisions concerning an instructional structure [DE 222] and instructional scenario issues [DE 320]) and the facilitation of the designer’s task, the aforementioned DEs can optionally be developed separately (models can become difficult to manipulate as the design process unfolds). Once finished, the models should be integrated in order to export them in an IMS LD manifest. This integration of models is easily accomplished with a single operation in the MOT editor.

MISA has the power to provide semantic expression to the UoL and supply the IMS LD specification with concrete pedagogical terminology, allowing the creation of a UoL typology, while making gains in reusability. This helps link pedagogical terminology to the IMS LD theatrical metaphor and the machine-code requirements. The instructional model’s granularity rests on the designer’s criteria and contextual constraints. This “model” break down addresses a semantically and educationally grounded way of decomposing the learning flow. Although this argument is supported by the experts (see B.1.3: RC/A), two of them pointed out that even if

MISA differentiates instructional structures from instructional scenarios as the first way of establishing the granularity of the pedagogical model, it doesn't propose a typology of references. More formalization is also required of the MISA method in order to have a strong impact on IMS LD reusability. It is then possible to think of developing a taxonomy, e.g. based on the "four design levels" proposed by Romiszowoski (1981): course system, lesson, instructional event, and learning step levels.

Hence, MISA yields additional gains with respect to UoL definition and design, since the UoL can build on knowledge/competence decisions. The "Prerequisite" and "Learning Objective" UoL elements rigorously established when designing within the MISA knowledge axis (MISA notions of Entry ant Target competency levels) link the MISA knowledge/competency model to the pedagogical model (see B.1.4: PC/A).

DE 224 – Learning Unit Properties, DE 322 – Properties of Each Learning Activity and DE 226 – List of Properties

DE 224 and DE 322 associated to DE 222 and DE 320, respectively, were also considered crucial by the experts (see C2.1.2; C2.1.3: PC/A). These DEs provide more information on the properties applying to the elements of DEs 222 and 320: the LEN and the instructional scenarios. A deeper analysis on the subject is undertaken in the next section, as these DEs (224 and 322) are directly related to the declaration of rules and conditions, which corresponds to IMS LD levels "B" and "C". As discussed further below, we propose that rule declaration be extended and applied to Roles and Resources, which in turn have an impact on DE denominations: the experts agreed upon the proposition for DE224 *Attributes of each LEN element* and DE322 *Attributes of each IS element* (see A4.2: PC/A).

Lastly, with regard to the introduction of the new (mandatory) DE226 - List of Properties, two experts were clearly in favor of this proposition while the other two remained neutral (see D.1.8: RD/A). One expert saw advantages if this list is created and updated by the designer, while automatically maintained by a software application. This list would work as a reference and should guarantee coherence of the declared properties by avoiding overlap and redundancy. Another expert was in favor but only if the Delivery model were removed from this MISA version. Yet another expert perceived this solution as being more technical than pedagogical.

One of the experts added that some elements of DEs 440 to 446, 620 and 630 may be of interest. We recall here that we have taken into account DEs 440, 442, and 446 by extending the notion of Attributes to all of the MISA Resources. We have also addressed DE 620 through the

Rules and Properties declaration. We thought DE 630 relevant to a Learning System design approach but not crucial for the designing of a UoL.

Recommended DEs

As in MISA's original version, the decision of choosing all or some of the recommended DEs will depend on project scope and actual requirements. We have listed all the DEs that are needed in the (hypothetical) case where all the information must be collected and the feasibility analysis must be carried out. In this sense, our selection of these "recommended" DEs is based on what is required for the design of a new UoL as opposed to the transposition of a learning scenario that has already been built.

The "recommended" DEs include those comprising MISA Phase 1: Define the Training Problem and Customize[30] MISA. This phase encompasses series 100 DEs (100, 102, 104, 106, and 108). As explained in the MISA documentation, "Phase 1 defines the LS to be designed in enough detail to lay the foundation for choosing a training solution and the resulting developmental orientations. The DEs produced during this Phase are grouped in the 'Learning System Project Definition' record" (MISA 4.0 Presentation, p. 42). This record enables the designer to decide whether or not to begin the design of the LS (learning system), and in the affirmative case, to determine the MISA tasks on which the emphasis will be placed. Accordingly, the designer will refer to the customization principles and the documents dealing with MISA techniques.

We have also selected a series of DEs (210, 212, 214, 220, 230, and 240) that pertain to MISA Phase 2: Define a Preliminary Solution. This second phase "consists in defining the LS's Instructional, Material Development and Delivery Orientation Principles and includes the development of the Knowledge Model and the Learning Event Network (LEN). The information gathered makes it possible to analyze costs, benefits and impacts of the new LS. The DEs produced during this Phase are grouped in the "Preliminary Solution" record" (MISA 4.0 Presentation, p. 44).

The previously enumerated DEs encompass a context grounded, and rigorously guided creative process of instructional design. The completion of these recommended DEs orient the designer with respect to the kind of Learning Design (pedagogical scenario) under development. It is a process where certain well-founded decisions are taken before designing the UoL more concretely, i.e. decisions concerning the insertion of the LD within the constraints of a given organization, the determination of what knowledge is to be covered and what competencies

[30] The "customization" in MISA is a principle that let the instructional designer, at the very beginning of the design process, to select, between the 35 DEs that compose MISA, those considered pertinent according to the specific learning design project.

are to be developed, the kind of pedagogical approach that will be used, the modes of delivery, and a preliminary identification of pertinent resources. All together, this constitutes a solid base for UoL design and representation.

There was agreement among the experts that the above mentioned “recommended” DEs are relevant to the design of a UoL (see C.1.1: PC/A). This convergence of opinions reinforces the proposition that the creation of a UoL is a design issue. It allows us to bring the building of learning solutions back into the instructional design field. The modified version of MISA that is currently being developed adheres to the same principles as the original version. That version, adapted for the design of UoLs, includes the entire set of DEs considered *relevant* for the quality assurance of the design process and its outcome.

There are issues, related to specific DEs, to be considered. Although there was general agreement on the importance of “108 - Reference Documents” (see C.1.1.5: NeuC/CA), two of the experts suggested that this DE should be updated in order to integrate the notion of “Learning object” and conform to LOM metadata. We also received interesting remarks on DE 214 - Target Competencies (see C.1.1.7: PC/A): one expert proposed that it should be “strongly recommended,” while another saw it as “mandatory”. A third expert thought it was “very useful.” Yet another expert recalled that the competency approach is not necessarily used in all design projects and proposed to keep it optional. In accordance with our analysis of the relationships between the Knowledge and Instructional models in MISA and their implications in the design of a UoL (and in the interests of meeting the IMS LD requirements), we believe that it should be ‘strongly recommended’ but not mandatory, yet.

We thus conclude that the version of MISA adapted for the design of UoLs should include the following “recommended” DEs: 100, 102, 104, 106, 108, 210, 212, 214, 220, 230, and 240. DE 108 should be modified to include LOM metadata and DE 214 is strongly recommended based on the need for a UoL that is tightly linked to the knowledge/competency axis.

The resulting customized version of MISA should then be composed by the following DEs:

Table 6-8

Customized version of MISA agreed by the experts

MISA DEs used for the design of a UoL	
Recommended	100 - Organization's Training System
	102 - Objectives of the Learning System
	104 - Target Populations
	106 - Present Situation
	108 - Reference Documents
	210 - Knowledge Model Orientation Principles
	212 - Knowledge Model
	214 - Target Competencies
	220 - Instructional Model Orientation Principles
	230 - Material Development Orientation Principles
	240 - Delivery Orientation Principles
Mandatory	222 - Learning Event Network (LEN)
	226 - List of Properties (see next discussion and proposition)
	224 - Attributes of each LEN element (see next discussion and proposition)
	320 - Instructional Scenarios
	322 – Attributes of each Instructional Scenario element (see next discussion and proposition)

6.3.2.2. The instructional model revised

[Ref: statements A1, A2, A3, D1.3-D1.8, see Appendix 6-E]

Instructional model and delivery issues

The previous section presented the selected MISA DEs used for the design of an IMS LD UoL. From a MISA point of view, we have applied "customization" principles in order to adapt MISA to the LS constraints that we stated for the design of an IMS LD compliant UoL.

The customized version of MISA resulted in a list of DEs classified as “recommended” and “mandatory.” The next step was a detailed study of the DEs identified as mandatory for the creation of a UoL and equivalent in meaning (pedagogical model) and structure (model elements) to the IMS LD specification. Based on the fact that previous analysis had already described the IMS LD UoL as a merging of the MISA instructional and delivery models, we have undertaken to carry out a comparative analysis of the elements comprising MISA DEs 222 (Learning Event Network), 320 (Instructional Scenario) and 440 (Delivery Model). This careful analysis also included subsidiary DEs 224 (Learning Event Properties) and 322 (Properties of Each Learning Activity). The underlying aim of this analysis was to verify to what extent it was possible to integrate delivery model elements and address delivery concerns within the instructional model in order to meet IMS LD requirements without altering MISA’s main principles. The first phase of this doctoral research studied the MISA instructional language and terminology so as to compare it with the IMS LD EML (educational modeling language). The MISA pedagogical model and the IMS LD UoL are built upon different types of EML. We have also explained that these EMLs have different strengths: the MISA EML is part of a more general instructional design language, while the IMS LD EML supports interoperability and has received attention from the international research community. This study was a first attempt to fill in the gap between the two languages and look for possible “interpretations” and “translations” of specific terms. The main modifications proposed, resulting from the above comparative analysis, were: the integration of delivery model elements into the instructional model, a deeper description of the instructional model through formal and informal rule declaration, and the extension of the declaration of rules other than those for activities to other model elements. The first phase also helped establish the pertinence of the MISA method as a valid design approach among a vast number of ISD models and approaches, as it relies on a rich instructional computable language and shares IMS LD’s approach: that of describing instructional scenarios as processes organizing learner and facilitator activities together with resources and expected outcomes.

Cumulative and corroborative evidence showing the need for a closer binding of the pedagogical and delivery models was collected during the second phase of this study (the case study) and the first Delphi round of expert consultation.

The second Delphi round included explicit expert validation of the binding of both models and of the specific elements and concerns to be included in the pedagogical model. The experts generally agreed with the following statement, since the proposed changes were considered minor: “Adjust the MISA Pedagogical Model to integrate relevant MISA Delivery Model elements in order to gather the information required by an IMS LD UoL" (see A1.1: PC/A). However they felt that a "complete" merging of the Pedagogical and the Delivery models is not warranted since each model has its specific purpose. The separation of these models in MISA better supports the instructional designer's activity by helping him or her focus on different "layers" of concern: pedagogical strategy and implementation topics. This partial merging is progressive and distributed among five DEs (222, 224, 226, 320 and 322), throughout the entire design process explained further below. One of the experts recalled that the first versions of the MISA method didn't include the delivery axis. Some issues now addressed in the delivery model were solved by and reduced to certain planning operations. The lack of specific and more explicit documentation elements for the production of the instructional material and the implementation of the Learning system into a platform were the driving forces for the emergence of the delivery axis, which granted attention of these issues. The delivery axis was developed to respond mainly to the needs of producers and integrators. It also provided more detailed information about the pedagogical model flow conditions, including resource availability and facilitator interventions at the implementation stage.

The activity of designing a UoL from a MISA perspective rests upon a sequenced and iterative process. It relies mainly on: (1) complementary role attribution and task distribution between the instructional designer (or teacher) and the technologist, depending on the former's competencies, and (2) a computerized set of operations translating the pedagogical model design into a compliant IMS LD UoL. We will look for arguments that support this approach within the experts' answers to the questionnaire.

Resources, Learning Objects **and** ***Services***

Once a consensus was established about the introduction of minor modifications to the pedagogical model in order to better satisfy the IMS LD syntax, we also proposed changes to the DE222 and DE320 elements. The statements that the experts considered regarded the choice between keeping the MISA terminology and adjusting it to the IMS LD specification. The terms proposed for expert validation were the result of our first research phase, a deep analysis of MISA and IMS LD EMLs, where the main terms that could be binded were identified. The second phase of our research, the case-study, corroborated most of the findings of the previous phase.

The notion of *Resource* in MISA is quite broad and covers both of the IMS LD terms *Learning Object* and *Service*. The MISA *Resource* concept is split out into a taxonomy that classifies terms enabling specification; examples are given but the list remains open: *Means of communication* (e-mail, conference, videoconference, chat, telephone, etc.), *Tool* (computer, peripherals, operating systems, application software, etc.), *Location* (laboratory, learner's residence, workstation, etc.), *Production* (exercise, project plan, assignment, etc.), *Package of materials* (a group of materials organized to support an actor in the execution of an activity), and *Services* (lab supervisor, tutor, field expert, technical support, etc.). As our interest is at the "design" stage of the UoL, some runtime concerns addressed by IMS LD are seen differently from the design perspective: e.g. from the MISA perspective, a *Conference* is a (Resource of type) *Means of communication*, whereas from the IMS LD perspective, as a runtime concern, a *Conference* is a *Service*.

To resolve these differences, we proposed to "Integrate and formalize a notation for *Means of communication* to express IMS LD's *Send-mail* and *Conference* services" (see A2.1; A3.5), "Integrate and formalize a notation for *Tool* to express IMS LD's *Index-search*" (see A2.2; A3.6) and "Introduce the new *Package of resources* term to bind MISA to the IMS LD *Environment* term" (see A2.3; A3.7).

On this point, the experts' opinions were somewhat dissimilar: for *Means of communication,* the general opinion was more positive (see A2.1; A3.5: PC/A) than for *Package of resources* (see A2.3; A3.6: PC/A), while for *Tools* (see A2.2; A3.6: NegC/A), the negative opinion had more weight.

One argument against keeping the MISA denominations considers that the terms *Means of communication*, *Tools*, *Services* are "old fashioned" compared to the newly coined term "Learning Object". The expert who was in partial disagreement on keeping MISA terminology added that MISA would benefit from updating it to better bind it to the LO paradigm. Nevertheless, he proposed to keep the MISA Resources typology.

Other experts argued in favor of keeping the MISA terms, seeing them as being adequate and meaningful for the teacher or instructional designer. They added that IMS LD would gain from incorporating this terminology, which is used in the field of education. The generic term LO is not helpful at the design stage. MISA terminology helps specify more concrete instances of this generic concept. We can argue in favor of keeping the term *Means of communication* as a generic denomination that can be specified as e-mail or discussion forum (already included into the IMS LD specification), but it can also cover items resulting from development in communication technology, such as chats, wikis, blogs, podcasts, vodcasts, videoconferences, webmeetings, etc.

As the experts' responses on this subject tend to be slightly positive, we consider keeping the MISA classification, which can be interpreted by a computer system as an *LO* or *Service,* depending on the *Resource*'s nature and purpose.

The MISA knowledge model and the UoL

Among the minor modifications to the MISA pedagogical model, we included the integration and formalization of a notation for *Entry Level Competency* (IMS LD *Prerequisite*) and *Target Level Competency* (IMS LD *Learning Objective*). In general, the experts agreed with this (see A2.4: PC/A). Nevertheless, we there was some hesitation from one of the experts about the possible merging of the knowledge and pedagogical models. The introduction of these new elements into the pedagogical model must not be perceived as a merging of the aforementioned models. Instead, it must be seen as a formal and explicit aggregation of both through common, linking elements. In fact, MISA does proceed in this manner, as the Entry and Target competency elements guide the design of the Learning Units (not to be confused with the IMS LD UoL). Our proposition is to simply establish the creation of a notation symbol for the Entry and Target competency elements and to explicitly declare them into the model, in order to meet IMS LD syntax requirements. The knowledge and pedagogical models remain separate but interrelated, thus conforming to MISA principles.

We must also remember that the IMS LD *Learning objective* and *Requirements* are "optional" elements. We think that, from a design perspective, it is crucial to establish a closer relationship between these, since the educator designs for a concrete learning situation. With IMS LD, this optional character might be more understandable since the UoL can have a generic purpose (like a template), e.g., the case study approach expressed as a UoL for reuse in several different disciplines.

The knowledge model is developed partially in advance and is reviewed as the design progresses, following the MISA logic. The proposition allows for the autonomy of the axes and focuses on the coordination principles.

- On *Roles*

Even if MISA and IMS LD share the notions of activity and role, there is a significant difference in how they are declared and represented with the MOT and the IMS LD notation systems. In the MOT language, the IS Role is embedded into the *Activity* and, so merged, the role and activity are represented by a label and an oval shape with a different color. In IMS LD the role is assigned separately to an *Activity* or *Activity-structure*.

MISA DE320 does not prevent one from declaring the Actor (Role) in the instructional scenario. The MOT language assigns the hexagon shape (principle) to represent the Actor. It is then possible to add an explicit representation of a Role in DE320. This helps bind MISA IS to IMS LD terminology: *Role*, *Activity*, *Activity-structure,* and *Role-part*.

As the IMS LD UoL has to be interpreted by a compliant Learning Management System, it is indispensable to be coherent when declaring the roles. The designer must avoid using the same name for roles that have different meanings or roles with different names, but which have the same meaning. Neither the system nor an IMS LD validation expert will be able to correctly interpret the designer's intention. It is important, then, to keep track of Role declaration. DE320 should track this in order to keep the designer aware of this requirement or the system should dynamically capture and list Roles as they are created and used.

These considerations were exposed to the experts in the form of a statement proposing to replace "Actor" by "Role" (see A3.1: PC/A). Two experts were favorable to the proposition, since the Actor concept is usually understood as referring to a single person, while the Role concept is more flexible, the implicit idea being that a single person may play different roles at different times. In this sense the adoption of the term Role helps bind the MISA and IMS LD terminologies. One expert proposed adding the notion of Roles so as to express the Learner and Teacher IMS LS generic roles, a suggestion with which all the experts agreed (see A3.2: PC/A). Another expert remained neutral and proposed that both terms be suggested to the designer who could choose between the two.

- Rules declaration

DE 224 and DE 322 are accessory to the LEN and IS, respectively. They contribute to a detailed description of rules and properties applying to the DE 222 and DE 320 elements and, in so doing, make the conditions governing the learning flow explicit.

"Rules in MISA help instructional designers specify relevant pedagogical issues. In the first phases of MISA, instructional designers define general execution, evaluation, collaboration and adaptation principles for their learning system, which they then translate into concrete rules associated to a Learning Event or a Learning Unit. Those concrete rules in turn can either guide designers further in the description of the activities and the Learning Events structure (static model), or help in the description of the actions to be triggered during the delivery process (dynamic model)."(Paquette et al., 2005, p.7)

MISA rules are "statements guiding the completion of the learning events, the learning units or the learning activities in the instructional scenario" (MISA Glossary). There are three types of rules: instructional rules, media rules guiding the layout and design of the LS delivery model (which are not part of this study), and delivery rules.

We have made propositions regarding rules and these propositions touch upon four main aspects: (1) the extension of rules to express conditions applying to *Resources* and *Roles*; (2) the extension of the notion of instructional rules to take into account delivery concerns such as establishing conditions for Visibility of *LEs*, *LUs*, and *Resources*; (3) the differentiation of Rule declaration from Rule explanation; and (4) the clear distinction between rules for automation and rules for human implementation at the UoL delivery stage.

1) Rules that govern the learning flow, and that directly apply to *Resources* in the LEN or IS, are not explicitly presented in MISA. Nevertheless, the DE440 Delivery model includes an exclusive delivery rule, defined as "*a statement that specifies the conditions of actor roles (instructor, learner, manager, etc.) on when and how to use resources during the distribution of the LS.*" That is to say that rules operating on *Resources* are considered when the delivery model is built.

Because we argue in favor of integrating certain elements of the MISA Delivery model for Learner/Teacher generic roles into the MISA Instructional Model (to better meet IMS LD requirements), we consider borrowing the notion of this Delivery rule, but integrate it as an extension of the Instructional Rule sub-types. This lets one define rules applied to *Resources* in the instructional model.

Three of the experts agreed with the proposition of extending the rules to express conditions for *Resources* and *Roles* (see A2.6.c; A3.8.c; A4.1.b: PC/A). This operation, which is inexistent in the MISA pedagogical model, was perceived as lacking and its introduction was seen as positive as it can help the designer add detail to the learning flow. Only one of the experts hesitated, stating that it might be confusing for the designer. Unfortunately, we did not have the opportunity to follow up with this expert in order to better understand his reasons for saying this.

2) Going one step further with this reasoning and proposal, we also probed the experts on the extension of the notion of instructional rules to take into account delivery concerns such as establishing Conditions for Visibility of *LEs*, *LUs*, and *Resources*. Conditions on Visibility of *LEs*, *LUs*, *Activities,* and *Resource*s are not considered in the MISA instructional model. They are indirectly or tacitly included in the delivery model as one kind of delivery rule (we should not forget that rules in MISA are not declared formally, but rather in natural language). From the MISA perspective, extending the notion of rules to account for visibility concerns means bringing a delivery issue into the pedagogical stage of design. Two experts were in favor, while one didn't have a clear position, and another was more cautious, taking this matter to be one for

“technologists” (see A2.6.d; A3.8.d; A4.1.c: PC/A). The analysis (presented further below) of the proposition of a new role within the design and implementation process of a UoL helps complete this idea, where some delivery-specific concerns could be addressed by a more technically proficient member of the design team.

3) There is agreement among the experts (see A2.6; A3.8.a: PC/A) that rule declaration and corresponding explanations be made at two complementary stages: first, the enunciation of a short rule (based on MISA rule typology: collaboration, customization, study approach and evaluation) when building the LEN and IS; second, a detailed description when completing complementary DEs 224, 226, and 322. Rule declaration in the LEN, as a short statement, attends to model intelligibility and simplicity, whereas the rule description provides detailed information on conditions, properties, and values.

4) On a matter closely related to the preceding point, the need for a distinction between computable and non computable rules was recognized by all the experts (see A2.6.b; A3.8.b; A4.1.a: PC/A). One expert also noted that there is a need to better think about the ways in which this formalization should be done.

6.3.2.3 A three complimentary approach for UoL designing

[Ref: statements B2, D1.1-D1.2, D2, see Appendix 6-E]

Together with DE selection and modification, the need for new modifications to the model editor software[31] has been emphasized. New requirements are proposed, such as automating the reorganization of the instructional structure in conjunction with instructional scenarios and automating the grouping of Resources to satisfy the IMS LD syntax. Moreover, the new software tool should also let one declare rules and properties in a formal and user-friendly way.

We have also reflected upon a possible intermediate solution for the above functions, which could be assumed by a new role that can be interpreted either as an additional specialist member of a team designing a UoL or as the addition of new competencies to the instructional designer’s profile. This new role should be assumed by someone competent in modeling techniques, EMLs, and *formal condition* declaration. This role definition will depend on software functionalities and usability improvements.

[31] On this subject, we should mention the MOT+ LD editor, which is an IMS LD Level A software editor tool, suitable for a designer with knowledge of IMS LD. However, we remain very cautious with respect to this tool, as it was not designed with our approach in mind.

Our research aims to support an instructional design approach so as to facilitate design (Recommended DEs) and the gathering of information (Mandatory DEs) required to build an IMS LD UoL.

Level A of IMS LD integrates the main elements describing the scenario– those of the MISA instructional structure and instructional scenarios: viz., events, activities, resources, and productions organized in a logical sequence that fits the chosen pedagogical approach.

Level B of IMS LD adds more detail to the scenario by way of conditions and properties that not only extend the scenario description, but also enable personalization and more elaborate sequencing and interaction. Most of these elements are to be established both in the MISA LEN and instructional scenario models, and in the Attribute Forms (DE224 and DE322). Level C of IMS LD adds notifications to level B, a series of system events that can also be interpreted as being part of rule declarations in MISA.

We first explored the possibility of providing additional design principles to guide the instructional designer's task of adjusting the pedagogical model to the IMS LD syntax. Certain examples let us conclude that including said principles would result in an extensive list, which would add enormous complexity to the design process. Indeed, the experts agreed with the following statement: "forcing the designer to make his pedagogical model fit the IMS LD syntax is too complex" (see B2.1: PC/A). It was agreed that for an instructional designer, the design of a pedagogical model using a representational language and technique is already a complex task. The strong degree of formalization of pedagogical scenarios, such as is proposed by the IMS LD syntax, is not usual in the educational field. The use of the theatrical metaphor as a reference (outside the educational collective imaginary), and its focus on delivery and runtime issues, make the task of the instructional designer more difficult.

To resolve this problem, we first suggested a software solution for the interpretation and reorganization of the pedagogical scenario according to IMS LD syntax constraints. The experts' opinions converged positively with respect to this proposition (proposition itself: D2.1.a: PC/A; *Precedence* and *Composition* link reorganization: see B2.2: PC/A; rules and conditions affecting learning flow: see D2.2.a: PC/A). IMS LD syntax is recognized as "not being instructional-designer oriented, but instead falling into the realm of technical teams." Although one expert warned that the software solution might also be a "complex problem to be solved" by the programmer community, another expert, which was involved in MOT+ software development, indicated that such a solution is soon to be released.

IMS LD level “A” syntax could be reached through software interpretation of mainly “P” and “C” links present in the LEN (DE22) and IS (DE320). A more complex automated operation is needed when IMS LD levels “B” and “C” (captured in DEs 224, 226, and 322) are added.

By reflecting on the way that the formal declaration of rules should be carried out and who might be responsible for it, the second complementary solution emerged: we proposed the creation of a new professional profile (new role or new team member) to the experts; this professional profile would address more “technical” tasks dealing with implementation and delivery issues.

While the instructional designer is naturally responsible for explaining the kind of pedagogical model he envisions, he is not required to express the rules governing the learning flow by making use of logical (formal) expressions (see D1.1: PC/A: For DE224 and DE322, allow the designer to declare rules in an informal way –statements). The instructional design method has to support the designer’s task by establishing a distinction between computable and non computable rules (e.g., the difference between a formal expression enabling computability and the declaration of guidelines or advice). The differentiation between computable and non computable rules supports the (later) task of translating computable rules into conditional expressions, either accomplished by the designer himself, or by a technologist or specialist (see D1.2: PC/A). In the same trend of thought, the experts agreed that it is up to the designer to establish the rules governing the learning flow, but that the designer should have the choice of doing so in an informal or a formal way (see D1.1: PC/A).

Nevertheless, formalization is required to be able to program the computer system. Even if the “choice” is given to the designer, the need for formal declaration of rules was confirmed by the experts when giving their opinion on the creation of a new specialist role assuming this responsibility. The experts did not support the idea of assigning new responsibilities to the designer (see D2.1.b: NegC/D; D2.2.b: D/A), in other words, they disagreed with adding new competencies to the already long list of competencies in the ideal instructional designer’s profile. As one of the experts’ comments, an intermediate solution would be an instructional designer profile specifically slanted towards technological competencies. The tasks associated with formal declaration of rules and properties are more appropriately assigned to a new individual – a technologist – who is part of the design team (see D2.1.c: PC/A; D2.2.c: PC/A).

6.3.3 Delphi round 2 conclusions

6.3.3.1 Convergence and approval

Taking all of the Delphi round 2 questionnaire results together, we can conclude that satisfactory degrees of convergence of opinions among the experts and acceptance of the propositions brought forward for validation have been achieved.

We have distinguished the measure of "convergence" from that of "approval" in order to meet Delphi requirements. While approval allows us to choose which modification proposals to implement, convergence refers to the establishment of a reliable consensus for ending the iterative expert consultation.

First, the degree of convergence (both positive and negative) is 85%. If we consider the "neutral convergence" (9%) that was resolved positively (see A2.5; A3.4; C1.1.5; D1.5; D1.6) and the "relative divergence" (5%) revealing a positive tendency (see C2.1.4; D1.8), we face a high degree of convergence of opinions.

Second, there was a 92% level of approval of the propositions, of which 7% was "conditional approval" that was resolved positively after further interpretation (see A2.2; A2.5; A3.6; C1.1.5) and 1% was "disapproval" (see D2.1.b), which must be interpreted positively, as it refers to rejection the addition of new mandatory technical skills to the instructional designer profile; this is coherent with the proposed solutions (a software tool improvement and/or the inclusion of a technically proficient design team member (see D2.1.a; D2.1.c).

Table 6-9

Propositions for an adapted version of MISA: rate of general convergence by the experts

Tally of the experts' rating	**Type of agreement**	**Total answers**
$> +$	Positive Convergence (PC)	48
$> -$	Negative Convergence (NegC)	3
$> \pm$	Neutral Convergence (NeuC)	5
$+ = -$	Divergence (D)	1
$+ \vee - = \pm$	Relative divergence (RD)	3

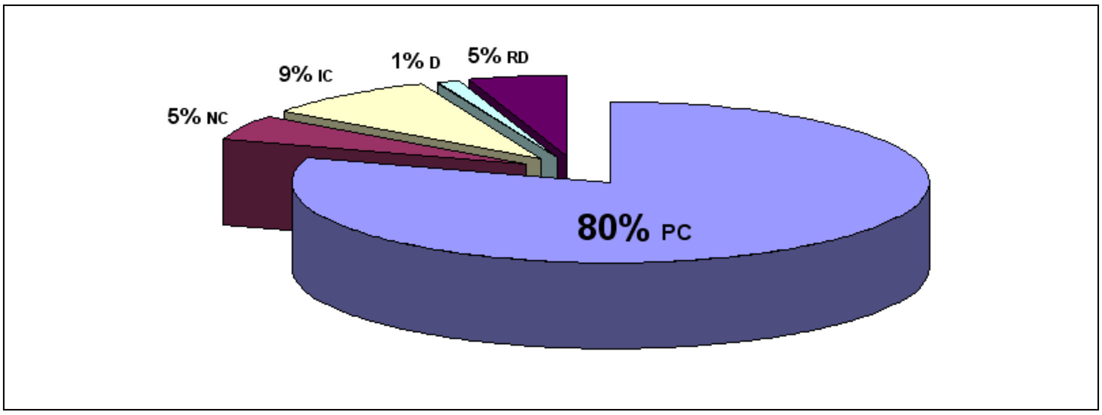
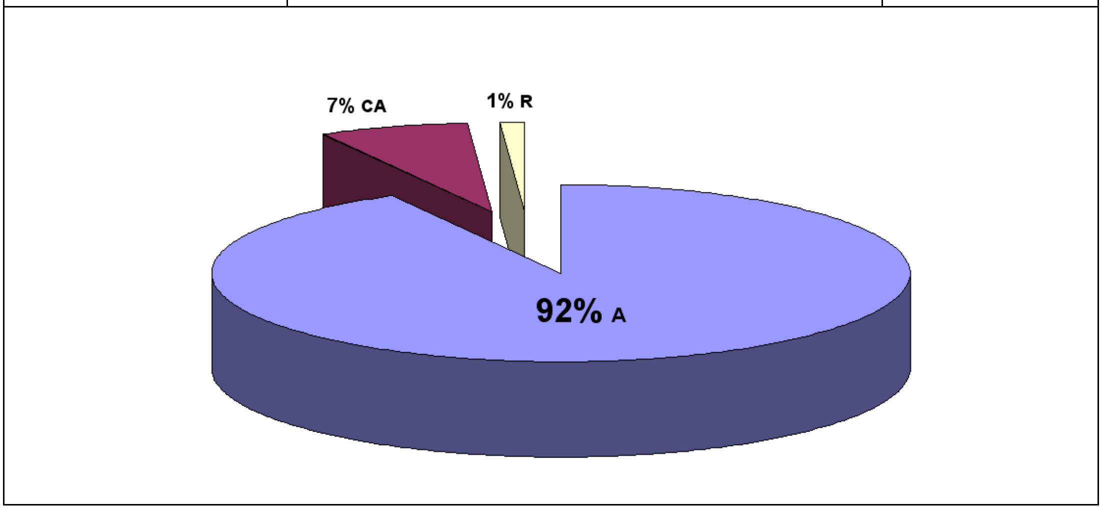


Table 6-10

Propositions for an adapted version of MISA: rate of general approval by the experts

Tally of the experts' rating	Action	Total answers
> 3	Approval (A)	55
= 3	Conditional Approval (CA)	4
< 3	Disapproval (D)	1



6.3.3.2 Adapted version of MISA

The MISA 4.0 Presentation Document (p.18) explicitly stipulates that the MISA method "can be customized to suit the needs of the LS designer whatever the size of the organisation, the type or scope of the LS to be designed or the available human, material and financial resources. The designers do not have to produce all the DEs, go through all the steps, develop all the axes or perform all the Method's tasks. The flexibility and consistency of the design approach offered by MISA 4.0 is largely based on four groups of principles".

The "recommended" and "mandatory" DEs in this new version of MISA constitute a "customization" of the method in regards to the creation of IMS LD UoLs. We verify customization with a selection of DEs from the 35 included in the MISA method as a whole. We acknowledge progression and coordination principles, since there is a suggested order for design and recursive interdependence between the DEs. All of the MISA phase 1 DEs are recommended, together with other DEs pertaining to each of the four MISA axes. The major impacts of the changes we proposed are mostly noted in the fusion of the MISA pedagogical model with the teacher/learner delivery model.

The selection of DEs ensuring a high quality design process and the gathering of required information can only be carried out in conjunction with a second operation of transformation of the MISA method: a look inside, at the level of attributes and values of the DEs. A list of detailed propositions has been drawn up in order to meet IMS LD requirements.

We introduce right above a summary of recommended and mandatory DEs modifications based on the experts opinions.

Recommended DEs

- **DEs: 100, 102, 104, 210, 212, 214, 220, 230, and 240: unaltered**
- **DE 106**

  Section A

  Related Projects attribute: declare the reason and intention for producing an IMS LD UoL

  Section B

  Human resources attribute*:* indicate a technologist for rule formalisation.

- **DE 108**

  Update properties as to meet LOM requirements

Mandatory DEs

- **222 - Learning Event Network**
  - Integrate and formalize a notation for *Means of communication* to express the IMS LD *Send-mail* and *Conference* services.
  - Integrate and formalize a notation for *Tool* to express IMS LD *Index-search*
  - Introduce the new *Package of resources* term to bind MISA to the IMS LD *Environment* term
  - Integrate and formalize a notation for *Entry Level Competency* (IMS LD *Prerequisite*) and *Target Level Competency* (IMS LD *Learning Objective*)

  - Add the "I" link to instantiate *Resources* and link *Entry Level Competency* and *Target Level Competency*
  - Formalize Instructional rules to match IMS LD rules:
    - Differentiate Rule declaration from Rule explanation: on LEN Rules, apply rule declaration (Rule explanation is part of subsidiary DE224)
    - Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance.
    - Extend the rules to express Conditions for *Resources* and *Roles*
  - Extend the notion of instructional rules to take into account delivery matters such as establishing Conditions for Visibility of *LEs*, *LUs*, and *Resources*.

- **226 – List of Properties : add this documentation element**

  Include *Property name* and *Property type* attributes

- **224 - Attributes of each LEN element**
  - Formalize Instruccional rules to include IMS LD rules
    - Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance. Explain the notion of Rule computability to introduce Rule formal expression. Formal expression should be suggested but not mandatory. A technician or a user-friendly and efficient software tool should help in this task
    - Extend the rules to express Conditions for *Resources* and *Roles*
    - Extend the notion of instructional rules to take into account delivery matters such as establishing Conditions for Visibility of *LEs*, *LUs*, and *Resources,* and *Notification* messages*.*

- **320 – Instructional Scenarios**
  - Change the term Actor for Role
  - Add the Learner and Teacher (generic) Roles to the notation system for IS modeling.
  - Integrate and formalize a notation for *Entry Level Competency* (IMS LD *Prerequisite*) and *Target Level Competency* (IMS LD *Learning Objective*)
  - Add the "I" link to instantiate *Resources* and link *Entry Level Competency* and *Target Level Competency*
  - Integrate and formalize a notation for *Means of communication* to express the IMS LD *Send-mail* and *Conference* services.
  - Integrate and formalize a notation for *Tool* to express IMS LD *Index-search*
  - Introduce the new *Package of resources* term to bind MISA to the IMS LD *Environment* term
  - Formalize Instructional rules to match IMS LD rules:
    - Differentiate Rule declaration from Rule explanation: on IS Rules, apply rule declaration (Rule explanation is part of subsidiary DE322)
    - Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance.
    - Extend the rules to express Conditions for *Resources* and *Roles*
  - Extend the notion of instructional rules to take into account delivery matters such as establishing Conditions for Visibility of *LEs*, *LUs*, *Activities*, *Resources* and *Roles*.

- **322 – Attributes of each Instructional Scenario element**
    - Formalize Instruccional rules to include IMS LD rules
        - Clearly distinguish rules for automation from rules for human implementation at the UoL delivery instance. Explain the notion of Rule computability to introduce Rule formal expression. Formal expression should be suggested but not mandatory. A technician or a user-friendly and efficient software tool should help in this task
        - Extend the rules to express Conditions for *Resources* and *Roles*
        - Extend the notion of instructional rules to take into account delivery matters such as establishing Conditions for Visibility of *LEs*, *LUs*, *Activities*, *Resources* and *Roles*, and *Notification* messages*.*

6.3.3.3 MISA variants according the envisioned UoL

The version of MISA customized and modified to assist the design of IMS LD UoL may be decomposed into four possible variants that relate to the UoL granularity and project scope. The most complete version, i.e., the one combining all of the accepted (and certain modified) DEs, is the one we stand for and advocate as it is coherent with the research approach. As previously discussed, our vision and position is fully informed by the field of instructional design as generally understood within the field of educational technology. The proposed variations arise due to two main concerns: whether the UoL to be designed is attached to an instructional structure and whether the project leader or designer has already taken the decisions and collected the required information so as to start directly with the UoL modeling.

What follows is the description of the resulting version of MISA adapted for the design of IMS LD UoL.

The first and second MISA variants are coherent with the holistic approach (Sodhi et al., 2007) to designing UoLs and they integrate both recommended and mandatory DEs.

The third and fourth MISA variants are coherent with the bottom-up approach (Sodhi et al.) and they only include mandatory DEs. We named this the “Straight forward” approach.

Note that the holistic variant, which includes the instructional structure, is the most complete. The second variant refers to a UoL design of smaller granularity. The third and fourth are of a different nature, as they refer to a direct manner of representing the UoL, following MISA precepts.

The table below presents the adapted version of MISA with possible variants and includes the description of the retained documentation elements.

Table 6-11

MISA variants to the design of IMS LD UoL

Approach		Documentation Elements	MH St	MH Sc	MS FSt	MS FSc
Holistic	Recommended	**100 - Organization's Training System** For the establishment of a profile of the organization where the LS will be implemented differentiating the present situation from the expected one in terms of learning content, instructional approach, technological means, training management, etc.	✓	✓	✗	✗
		102 - Objectives of the Learning System For the identification of the general objectives of the expected learning system, the learning priorities and the type of learning actions to be taken, etc., together with the definition of the scope of the LS, its life span, date of delivery, etc.	✓	✓	✗	✗
		104 - Target Populations For the specification of the learners' profile in terms of language(s) used, availability, average level of schooling, learning style, principal weaknesses to overcome, etc.	✓	✓	✗	✗
		106 - Present Situation For the identification of the boundaries of the proposed LS, the available human, material, financial, and organizational resources, and services and the constraints that may have an impact on the implementation of the LS.	✓	✓	✗	✗
		108 - Reference Documents For the building of a List all the documents that may help to design the LS and all the materials that could be used or recycled in the LS.	✓	✓	✗	✗
		210 - Knowledge Model Orientation Principles For the definition of the principles (types of knowledge) to develop a structured model of the Learning Systems' target knowledge and competencies.	✓	✓	✗	✗
		212 - Knowledge Model For the building of a structured graphic representation of the Learning System's content, while evaluating the present and target competencies of the target populations DE 214-Target Competencies: the enumeration of the target competencies aimed by the training solution through a calculation (for each of the main knowledge units in the model DE212) of the gap between the present and the target competencies.	✓	✓	✗	✗
		214 - Target Competencies For each of the main knowledge units in the model, the establishing of the gap between present competencies and the target competencies; indicating the entry and target competencies aimed by the training solution.	✓	✓	✗	✗
		220 - Instructional Model Orientation Principles For the statement of the instructional orientation principles that: 1) will make possible to develop a structured model of learning events and learning units, as well as the resources and instruments that go into their creation or which will be produced by users during delivery and 2) will guide the instructional approach, the knowledge evaluation, the collaboration among participants and the (if pertinent) the customization of the instructional scenarios.	✓	✓	✗	✗
		230 - Material Development Orientation Principles For the statement of the principles guiding the media selection: the type of media, the kind of interactive materials, and the type of support medium.	✓	✓	✗	✗

		240 - Delivery Orientation Principles For the statement of the principles guiding the choice of delivery mode. These principles deal mainly with the human resources, means of communication and tools required for delivery, as well as the delivery services and locations.	✓	✓	✗	✗
	Mandatory	**222 - Learning Event Network** For the structuring of the learning events (LE) in such a way as to identify the links and resources required to perform them as well as the rules governing the progression from one to the other.	✓	✗	✓	✗
		226 – List of Properties For the establishing of the properties names and values as to gather them into a same DE aiming coherence and avoiding overlapping or redundancy.	✓	✓	✓	✓
		224 - Attributes of each LEN element For the description of the properties of the LEN elements with regard to target populations, the duration, evaluation weighting, use of collaborative activities, type of learning scenario and mode of delivery.	✓	✗	✓	✗
		320 – Instructional Scenarios For each learning unit, the building of a structured graphical representation of the activities, resources and directions intended for learners or facilitators (instructors, informational sources, managers, etc.), in keeping with the Delivery Orientation Principles	✓	✓	✓	✓
		322 – Attributes of each Instructional Scenario element the description of the properties of the instructional scenario elements with regard to target populations, the duration, evaluation weighting, use of collaborative activities, type of learning scenario and mode of delivery	✓	✓	✓	✓
MHSt: MISA holistic version with instructional structure **MHSc: MISA holistic version without** instructional structure **MSFSt: MISA straight forward version with** instructional structure **MSFSc: MISA straight forward version** without instructional structure ✗ not required ✓required						

6.3.3.4 Combination of solutions

The developmental research approach has revealed itself to be a relevant and insightful methodology for our research object. A complex problem, such as ours, dealing with an innovative pedagogical engineering approach and new developments in educational technology standardization, had to be grounded in a rigorous research methodology allowing proposition validation and progressive adjustments.

The last Delphi round helped select MISA documentation elements that are appropriate for the design of an IMS LD UoL, study and refine the properties of the DEs to better satisfy IMS LD requirements, resolve terminological differences, specify the nature of problems and corresponding solution domains (instructional method, software development, and enhancement of human actor competencies), and verify MISA principles.

Together with DE selection and modification, the need for new adaptations to the model editor software[32] has been emphasized. New requirements are proposed, such as automating the reorganization of the instructional structure in conjunction with instructional scenarios and automating the grouping of Resources to satisfy the IMS LD syntax. Moreover, the new software tool should also let one declare rules and properties in a formal and user-friendly way.

We have also reflected upon a possible intermediate solution for the above functions, which could be assumed by a new role that can be interpreted either as an additional specialist member of a team designing a UoL or as the addition of new competencies to the instructional designer's profile. This new role should be assumed by someone competent in modeling techniques, EMLs, and *formal condition* declaration. This role definition will depend on software functionalities and usability improvements.

Our research aims to support an instructional design approach so as to facilitate design (Recommended DEs) and the gathering of information (Mandatory DEs) required to build an IMS LD UoL.

Level A of IMS LD integrates the main elements describing the scenario, those of the MISA instructional structure and instructional scenarios: viz., events, activities, resources, and productions organized in a logical sequence that fits the chosen pedagogical approach.

Level B of IMS LD adds more detail to the scenario by way of conditions and properties that not only extend the scenario description, but also enable personalization and more elaborate sequencing and interaction. Most of these elements are to be established both in the MISA LEN and instructional scenario models, and in the Attribute Forms (DE224 and DE322). Level C of IMS LD adds notifications to level B, a series of system events that can also be interpreted as being part of rule declarations in MISA.

Closing words

The Delphi enabled agreement on an adapted version of the MISA method that fulfills the design purpose. The final outcome of the design process is a pedagogical scenario with all the information required to run a UoL organized in a semi-formal manner and capable of translation into an XML structure. In this sense, the pedagogical scenario results in a document that can be understood as an intermediate state between a blueprint and an executable UoL. A fully

[32] In this sense we should mention the MOT+ LD editor that is an IMS LD Level A software editor tool suitable for a designer with knowledge of IMS LD. However, we remain very cautious with respect to this tool, as it was not conceived with our approach in mind.

compliant to IML LD pedagogical scenario may require further development of the software tools supporting the representation and declaration of the required information and, possible, the support of a specialized role. Future developments will balance the solution to one or both sides.

Chapter 7

Conclusion, recommendations and further research

Chapter 7

Conclusion, recommendations and further research

Overview of this chapter

In this chapter we reflect on the findings of the study and on the exploratory journey of the researcher. We explain the relationship between the research questions and objectives that guides the whole enterprise. We also highlight the research contributions and trace some guidelines for further research.

7.1 On the research questions

A first research question of this study was directed towards the exploration of theoretical underpinnings that provide for the development of an instructional design method incorporating educational modeling languages in the design of pedagogical scenarios. The theoretical foundations were intended to explain the nature of the design activity which situates at the midway of a creative-and-rational process pivoting between problem and solution definition. Theoretical inquiry guided the identification of corresponding formalized methods intended to assist the instructional design endeavor. A formal representation of the instructional design problem and process is embedded into a method that outlines main phases and addresses main design concerns. The second research question introduced the notion of educational modeling languages at the heart of the study, orienting the search to ID methods which include formal or semi-formal languages for expressing pedagogical scenarios. Courseware engineering was found to have elaborated in this sense. The third research question was established to go a step further searching for specific methods that support the design of pedagogical scenarios formally declared by using educational modeling languages, EML. EML per se call for pedagogical inclusiveness and combinations coming from theories, models as well as teaching expertise. Both ID method and EML should be coherently integrated as part of a set of tools assisting the designer. Based on available ID methods and EMLs, particularly, on IMS-LD, a recognized specification for expressing reusable and interoperable pedagogical scenarios, we proceeded to develop and evaluate possible solutions, with the ultimate goal of providing a "set of tools" to support the instructional design of reusable scenarios. We then focused on the design and development research phases searching for the adaptation of the ID method found to be suitable to such enterprise, the MISA method, thus, tempting an answer to the fourth research question.

The questions were progressively answered throughout the research process and are developed in the following summary of the study.

7.2 Summary, findings and phases conclusions

The purpose of this study was to construct and validate an instructional design method incorporating educational modeling languages for expressing pedagogical scenarios intended for use, reuse, sharing and interoperation. This study was developmental in nature and involved four separate research phases. The research methods and results for each phase are found in each phase's corresponding chapter. We introduce hereafter a summary of the study with main findings and lessons learned.

The first research objective was to identify a consistent theoretical framework providing intelligibility and grounding to the design of reusable and interoperable pedagogical scenarios. The second objective was to develop a design method flexible enough to include all instances of the design process, and specific enough to enable designers to integrate available design theories and tools into their practice. The third objective examined the application and testing of a methodological framework that provides a rigorous process for the development and validation of such artifacts.

Our doctoral research adopted the Design and Development Research approach for the development and validation of a theoretically-grounded and pedagogically-inclusive instructional design method aimed at the creation of reusable and interoperable pedagogical scenarios.

DDR focuses attention on the model, method or procedure itself, and over iterative cycles of development and validation produces outcomes of a generalizable nature. We have combined method development and validation and divided our research into four main phases. The first phase of theoretical grounding aimed at positioning and establishing an explanatory framework for the research. The second phase of development grounding sought to deploy a rationale for the integration of an EML into a concrete instructional design method. The third phase presented a first developmental solution that was tested in a case study. The fourth and final phase of the research outlined the development of a solution and validation by way of a two-round Delphi method.

Phase 1: Theoretical grounding

Our first commitment with the research was to formulate a theoretical position with respect to our field of study. The research framing is an attempt to situate the instructional design activity in a broader context of design-related fields.

Instructional design is mainly presented in the specialized literature as an organized process (Gustafson & Branch, 2007; Smith & Ragan, 2005) that is both theoretically informed and flexible enough to give place to the 'creative' aspects of a design activity. This process is generally referred to as the generic ADDIE[33] model (Molenda, 2003), which gives a required set of main activities involved in the instructional design endeavor.

Theories of instructional design will either inform the process or explain the process. ID theories are traditionally explained as being supported or informed by "theories of learning, cognition, and motivation" (Reigeluth, 2004, p. 54) as well as by theories of system design and project management (Reiser, 2007). Richey (2007) acknowledges the need for complementing the field with a 'design and development theory'. This claim is in line with authors like Bichelmeyer (2003), Clarck (1989), Edmonds, Branch, and Murkherjee (1994) that posit the need of a more generic and more design-focused theory of instructional design.

Gibbons & Rogers (2009) elaborate a definition of a more general theory of instructional design, one which is close to broader developments in other related design disciplines that share a common background with the instructional design field, e.g. architecture. Instructional design theory, also referred to as 'functional design', is an attempt to change direction from the dominant view of design as pure process. It also articulates two different bodies of theories in a coherent and complementary manner: a design theory detached from a specific knowledge, learning or instructional theory. The expression 'instructional-design-theory' is then reserved to name a design-focused theory of broader scope. In this view, instructional theories, mostly related to theories of teaching, are framed into a more general theory of design; while the former deal with the structure of pedagogical scenarios, the latter deal with the manner in which the elements of those pedagogical scenarios are selected, given dimension, and integrated into a design.

This alternative to the dominant generic design process (ADDIE) de-composition scheme enables the identification of different layers of artifact functionalities that de-compose the design problem and are supported by design languages. While layers enable the breaking down of complex design problems, design languages, residing inside and across layers, constitute

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operational tools by which design solutions can be imagined, represented, shared, and sometimes even implemented. From this perspective, an educational modeling language can be seen as contend a tool for expressing pedagogical scenarios.

This layered or functional view of design theory is adopted as a coherent conceptual framework which provides intelligibility and explanation to this research

Models and methods

Having anchored our research in the context of design theory for instructional design, we have analyzed the relationships and direct impact of the notions of models and methods in design and in instruccional design in order to complete the foundations of our research.

There is a strong link between theories and models in instructional design. According to Richey (2005) models can be distinguished between conceptual and procedural, where the former are of a more abstract nature dealing with taxonomies, and the latter are more prescriptive and present visual representations of a process. These procedural models can be sub-classified as representing either specific aspects of design or prescribing a more general process, usually variants of the generic ADDIE model. In general, models are ill-equipped to follow closely the process of design or represent high-order descriptors of best practices, theoretical elaborations or processes. The author makes clear that "the use of an ID model calls for considerable interpretation and amplification to provide the detail required for specific applications" (p.172). Bichelmeyer et al. (2006) explain how the ADDIE generic model is in fact a 'conceptual framework'.

The design activity entails dealing with ill-defined problems subjected to evolving constraints. More specific guidance would benefit designers; particularly novice designers. Cross (2008) introduces the notion of 'methods' as more prescriptive and detailed descriptions of procedures (also present in literature as activities, tasks, techniques, etc.). The methods have two main features in common: "they *formalize* certain procedures of design, and (…) they *externalize* design thinking" (Cross, p.47) enabling the representation of solutions into concrete artifacts (drawings, charts, diagrams, etc.) of communicative and conversational power.

The differentiation and correlation between models of instructional design and methods of design instruction has been tackled by researchers from the field of instructional design acquainted with software engineering developments, and also by computer science specialists with an interest in the instructional design and the learning sciences fields **(**De Diana and Landhani, 1998; Douglas, 2006; Bostock, 1998; Goodyear, 1995; Spector and Ohrazda, 2004)**.** **C**ourseware engineering is explained both as practice and also as a research endeavor, thus giving birth to an interrelated agenda of professional activity and scientific reflection on the design of technology-based learning solutions Courseware engineering is a strong attempt at 'tooling' the design and development activity.

Instructional design methods

Cebollero, Lamas and Dodero (2006) note that research and development focusing on 'design methods' that take into account software engineering as a reference are not widespread. In the literature we have found two documented and tested methods that interlace both approaches: the CEM (Courseware Engineering Methodology, Uden, 2002) and MISA (French acronym for Learning Systems Engineering Method) methods (Paquette, 2004a).

Instructional design methods present two main intersected dimensions that compose a matrix of horizontal problem-decomposition and vertical learning-system development. This double-entry matrix allows the representation of an intertwined approach that mixes a model-driven and an architecture-centric process for composing with the artifact (i.e. learning system, course, module, etc.). It bears mentioning here that software engineering models are abstractions of a solution to a problem, or an output. They represent components' blueprints of the artifact to be built. This model-driven approach introduces a different decomposition criterion of the design process into design artifact functions, in accordance with the layered view of design as expressed by Gibbons & Rogers (2009).

Software-engineering-infused instructional design provides a 'set of artifacts' that supports the designing of learning solution alternatives. It supports a layered problem de-composition, specific techniques, process iterations, computer and visual languages, computability of design documents, and even ready-to-run learning systems. This approach also advocates a more 'scientific' emphasis on the design of instruction, integrating different local theories that inform each of the layers in which the design artifact is de-composed. It is also inclusive of the designers' expertise as elicits the tacit knowledge and its representation through the provision of formal languages coupled with a notations system.

According to this definition, instructional design methods are coherent with the theoretical view of instructional design as functional design, or layered decomposition of the design problem. Based on this evidence, we have been able to justify our choice of the MISA method and its validity to our research aim.

MISA method

MISA is a consistent instructional design method guiding the design of learning solutions developed at LICEF, Télé-université's research center (Paquette, 2004a). The MISA method is composed of six phases of architectural development that intersect with four layers of model building; they entail a layered decomposition of the design problem into knowledge, instruction, media and delivery issues. MISA provides a toolkit for 'handling' the design process, which includes a rich composite design language, together with well described design techniques. It also contains detailed descriptions of a series of interrelated design documents that specify the decision making process for building a complete blueprint of the learning solution. The MISA method consists of up to 35 macro and micro design documents (Documentation Elements or DE) that keep track of the design process. MISA customization principles makes possible the selection and adaptation of DE according to the contextual constraints and specificities of the design.

The knowledge layer defines the knowledge to be acquired and skills to be developed by the learners. The instructional layer deploys the pedagogical scenario of learning events and teaching and learning activities, the associated resources and the rules guiding the learning flow. The learning materials layer describes the structure of pedagogical resources. The delivery layer presents an organization of all of the elements composing the learning system according to a specific delivery mode (synchronicity, pace and tutor support).

This pedagogical scenario design (core element of the instructional layer) is supported by a technique and a specific design language. A 'technique' is understood as a series of tasks and operations carried out in order to create a new, concrete artifact. Techniques, in contrast with mechanical production of identical deliverables, are likened to heuristic principles that provide advice (Paquette, 2002).

MISA bridges the gap between the theoretical underpinnings and the operational level of design. While complying with the general framework of design layers and design languages, it supports a semi-formal and guided process of design that acknowledges the complexity and multidisciplinarily of the design endeavor.

Phase 1 conclusions

The literature review and inquiry into design theories allowed us to situate the instructional design activity in line with other related design disciplines. The theoretical proposition of functional design aligns it with developments in instructional design methods nurtured in the software engineering field. Methods, even those of a prescriptive nature, can be seen as an attempt in providing tools to assist the designer in design practice, support the complex problem of design education, and (regarding our specific concern) to provide conventional languages for externalizing, representing and sharing pedagogical know-how.

This first phase triggered the research in two ways: as a theoretical prerogative, finding explanatory frameworks to state the research validity; and as a technological pursuit, exploring instructional design formalized processes endowed with computable languages for expressing pedagogical scenarios.

<u>Phase 2: development grounding</u>

The following step in our research was to establish a rationale for a comparison of both MISA and IMS LD, and to highlight what we found as a common ground for comparison. From a software development perspective, an ontological comparison (Paquette, 2004b) concluded that the underlying ontologies of both MISA and IMS LD shared a common perspective as they “put a strong emphasis on the representation of pedagogical methods [scenarios] enacted as processes” (p.18). Moreover, an exercise in transposition, by an expert researcher, of a MISA compliant instructional scenario into an IMS LD Unit of Learning (De la Teja, Lundgren-Cayrol, & Paquette, 2005) showed that “MISA is an ID method compatible with the IMSLD specification, because they share a lot of common conceptual elements permitting a harmonious binding” (p.13). Based on the previous results, we carried out a complimentary analysis of MISA and IMS LD from an instructional design perspective, comparing them both as design languages (Rheinfrank & Evenson, 1996; Seo & Gibbons, 2003; Gibbons & Brewer, 2005).

MISA pedagogical scenario and EML

MISA is composed of a set 35 documentation elements, which span the design process and help build a learning system blueprint. The documentation elements come in two shapes: ‘forms’ and ‘models’. The model in the instructional layer is the equivalent to the pedagogical scenario. Some forms are directly linked to the pedagogical scenario, providing additional information on the scenario elements (e.g., a pair of consecutive activities in the pedagogical scenario, is subject to certain rules declared in a corresponding “form,” where information about duration, grading or other items is given).

The MISA pedagogical scenario deploys a structure of learning events that shapes the curriculum/syllabus-related hierarchy (program, course, module, lessons, chapter, unit, etc.) depending on the degree of granularity of the scenario. Each smallest learning event unfolds into a series of learner and (facultative) facilitator’s activities with the correspondent needed resources, foreseen outcomes, as well as, the rules guiding the learning flow.

The pedagogical scenario is built following a specific technique based on an EML coupled with a notation system (or representation system) (Waters & Gibbons, 2004). This design and representation technique is called MOT (Modeling with Typed Objects) (Paquette, 2004a) and features a synthetic, abstract, economical and symbolic language for the visual representation and linking of knowledge. Six types of knowledge can be used in the creation of the pedagogical scenario. In the MOT notation system, each knowledge-type is represented by a different symbol. Within the pedagogical scenario an 'oval' represents the learning events and activities, a 'rectangle' all kinds of resources, a 'hexagon' rules and actors, and so on. Six types of links establish semantic relationships between the pedagogical scenarios elements: composition, specialization, precedence, input-product (output), regulation, and instantiation.

The pedagogical scenario is created with a software editing tool that integrates the MOT language and notation system. This editor also supports saving the scenario in multiple formats (a proprietary file extension, a bitmap, and an interactive html) and exporting it into an XML document.

IMS LD pedagogical scenario

The IMS LD learning design specification is based on an educational modeling language that enables the expression of pedagogical scenarios (or Units of Learning [UoLs] following IMS LD terminology). The IMS LD specification (Koper & Bennet, 2008) focuses on modeling activities according to a generic meta-model based on a theatrical metaphor. The intention of describing any type of pedagogy accounts for the qualification of this model as 'meta' and refers to a high level of abstraction. The scenario is driven by facultative learning objectives, and deploys the learning events and/or learners and facilitators' activities according to the theatrical metaphor structure composed of 'plays' 'acts', 'activity-structures' and 'activities' respectively. Resources and outcomes complete 'level A' of the scenario. Rules and conditions governing the learning flow complete levels B and C according to IMS LD specification nomenclature. The EML behind the specification can be characterized as "finalist," (Botturi, Derntl, Boot, & Figl, 2006) given that it is used to formalize and freeze a final design solution expressed through a notation system that is interpretable by a machine. In this sense, an IMS LD UoL can be understood as "a result or outcome" of an instructional design process: a snapshot of a very detailed pedagogical scenario set up for delivery via a compliant learning management system (LMS). The IMS LD UoL is packaged into an XML document called 'manifest'.

EML, the gateway between the Method and the specification:

A detailed comparative analysis of the EML of the MISA method and the IMS LD specification in their terminology showed similar but not one-to-one correspondence. In terms of the EML syntax ruling the arrangement of the pedagogical scenario, MISA EML elements' combinations and deployment of activities is dependent on the designer's envisioned leaning solution and vocabulary. Regarding the syntax, IMS LD imposes the theatrical metaphor and underlying logic to all pedagogical structure, with the result that it becomes constraining and complex. Concerning semantics, even if both EMLs allow the expression of pedagogical scenarios, the syntax constraints in each lead to different formal representations, where MISA gains in expressiveness and clarity. While IMS LD presupposes a strict way of structuring learner and support activities together with environments composed of learning resources and tools, when we focus on the learning flow on delivery (or run) we find that the MISA pedagogical scenario is more flexible with regard to the way in which the learner and support scenarios are built, and focuses, rather, on instruction. When designing the pedagogical scenario, MISA focuses on the organization of learning events and activities that meet the curriculum requirements and the guidelines of a chosen pedagogical approach. MISA's EML and design technique enable the creation of theoretically informed pedagogical scenarios, but also allow capturing designers' tacit knowledge. In this sense, the technique is knowledge-eliciting and captures expertise on pedagogical know-how in a semi-formal manner. In MISA, the constraints of delivery and execution are addressed later, when focusing on the delivery layer.

MISA has what IMS LD lacks and vice versa. MISA's EML is supported by a rigorous, layered instructional design process, which is pedagogically inclusive and addresses the preoccupations of designers, whereas IMS LD offers an interoperability solution shared by the international research and software development communities.

Phase 2 conclusions

The foundations for the development of an instructional design method aimed at the creation of reusable pedagogical scenarios should not only have theoretical foundations, but also more technical and specific features that show coherence, pertinence and feasibility of the whole enterprise. The identification in MISA of a proprietary EML favors our DDR aim of tooling the designer with an instructional design method which provides guidance on how to operate with educational modeling languages. It also showed that EMLs are not strange or completely new issue to the instructional design field; they are actually part of the already existing set of tools assisting the instructional design activity. A detailed comparative analysis of the EML in MISA and in IMS LD, aimed at identifying specificities and commonalities, helped foresee a possible adaptation of the method for the creation of pedagogical scenarios compliant to IMS LD.

Phase 3: development and testing of a solution

Phase 2 was crucial to establish a possible gateway from the MISA method to the IMS LD specification. The fact that MISA and IMS LD understand pedagogical scenarios in terms of learning flows (actors, resources, activities and coordination and progression rules) opened the door for the development of a possible solution. Based on previous analysis that showed the lack of a robust method for the design of UoL within the IMS LD documentation, and supported by evidence that the MISA method encompasses a rigorous process of design of a pedagogical scenario semantically equivalent to a UoL, the first alternative solution explored pointed to the development and validation of a new MISA technique for the design of an IMS LD compatible pedagogical scenario. This enterprise was carried out within the LORNET[34] group at Téléuniversité. For this study it was necessary 1) to develop a new technique in MISA for the purpose of supporting the creation of IMS LD conforming pedagogical scenario at IMS LD level A, and 2) to extend the MOT editor tool capabilities to include new graphical symbols enabling the computerized representation of IMS LD language specificities. The technique incorporates the IMS LD terminology as language primitives that follow the visual representation of the MISA notation system. Thus, the technique represents a special case of the MISA EML preserving common terminology between languages and incorporating those borrowed from the Specification.

In order to test the technique, a case study was conducted with an instructional designer with expertise in MISA, MOT and knowledge-modeling but little background in IMS LD and related technical knowledge. This study focused on a transposition of a MISA collaborative pedagogical scenario designed for a graduate course in information technology and cognitive development (Basque, Dao, & Contamines, 2005). The pedagogical scenario is based on the metaphor of a virtual scientific conference where learners are encouraged to participate through the elaboration and presentation of a poster summarizing their research project. Our research (Maina, 2009) followed Yin's (2003) four-stage case study recommendations of designing, conducting, analyzing and developing conclusions.

Design sessions were recorded and observation notes were taken. The in-progress design documents of each session were saved and the sessions were followed by debriefings. Both the design process and the design outcomes where closely studied. A comparison of the MISA documentation elements previously produced by the designer, with those documents created within the case sessions enabled the identification, at a design process level, of those

[34] LORNET (Learning Object Repository NETwork) project: http://www.lornet.ca

documentation elements directly used for the scenario transposition, and, at a micro level, of the MISA pedagogical scenario elements reused for the building of the UoL. The case also revealed the limitations and difficulties related to the implementation of the technique as a "shortcut" (ad-hoc) solution for the adaptation of MISA to IMS LD. The technique, created to cope with IMS LD requirements, increased the level of abstraction of MISA's EML, which led to a loss of semantic coherence in the pedagogical scenario. The pedagogical meta-model behind the new MISA technique, which conformed to the IMS LD theatrical metaphor, revealed the lack of objective pedagogical criteria to break down the scenario, thus leaving unclear the level of scenario granularity that the designer should reach, and risking over scripting of a scenario. The technique was perceived as limiting as well as overemphasizing technical aspects.

The DDR iterative nature and support for progressive improvement of solutions, together with the collected evidence up to this research step, called for a reorientation of the research. Evidence from this study motivates the development of solutions focused on a MISA perspective, and on the designer's activity. The solution should also take into account the specification's underlying logic regarding three complementary issues: (1) dealing with MISA and IMS LD EML mismatches through minor accommodations that keep the overall MISA pedagogical scenario semantics unaltered, (2) introducing, in identified documentation elements, adaptations to enable a progressive UoL design process, and (3) identifying software requirements for the pedagogical scenario editing tool that supports the declaration of the required information in a friendly way.

Phase 3 conclusions

We can draw some conclusions from the solution explored above regarding the boundaries of the technique at the same time that supply enough information for decisions on the research continuity. Positive outcomes of this phase are the development of a visual instructional design language together with a software editor tool for the representation of IMS LD compliant pedagogical scenarios. However, the new pedagogical technique that is based on an MISA EML notation system and that adapts to IMS LD requirements was found to be more suitable for the technical profiles of teachers or designers comfortable with software engineering approaches, which is quite a narrow target group.

<u>Phase 4: reorienting development for a suitable solution</u>

Phase 2 of our study showed MISA's and IMS LD's conceptual common understanding of pedagogical scenarios in terms of learning flows expressed through the languages developed for these purposes. Phase 3 was a first attempt at a solution focused on the extension of the MOT notation system to fit in with IMS LD requirements and the development of a MISA ad-hoc technique. Even though the notation system was adapted satisfactorily, the technique for the representation of the UoL proved to be overly complex to the designer. This first attempt privileged IMS LD and focused on its integration into the MISA method.

In Phase 4 we decided to turn our attention to the MISA method as an entire process, trying to minimize MISA modifications while at the same time explore complementary aspects of the design endeavor. In order to do this, we implemented a two-round Delphi method in line with other DDR studies applied to the development and validation of models and processes of instructional design (Adamski, 1998; Tracey, 2002). Linstone & Turoff (1975, p.3) explain that Delphi is "a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem". The number of rounds is disputed in the literature, but according to Delbecq, Van de Ven and Gustafson (1975) a two or three iteration Delphi is sufficient for most research. We have limited the Delphi to 2 rounds as our research was well advanced based on previous findings.

We requested the participation of four experts that were highly skilled and had broad experience in this area. We established the following criteria for their selection: by knowledge of the MISA method in terms of years (between 7 to 13 years); their involvement in the creation and upgrading of the method (3 of the 4 experts); research undertaken and published both in journals and through seminars; and their experience as teachers of the method itself or its employment in the design of educational solutions. Similarly, we established their knowledge of the IMS LD according to the same parameters.

This developmental step included a selection of a set of MISA documentation elements (from the 35 DE that make up MISA) identified as crucial or mandatory for the design of IMS LD compliant pedagogical scenarios. It also involved some minor modifications to be applied to the retained DE, mainly with respect to some elements that needed to be added, and also to keeping particular MISA terminology or change it to fit in with IMS LD vocabulary (i.e. changing 'resource' to 'learning object').

In round-one, questions were directed toward the validation of the adapted version of MISA. We then followed the recommendations of Hsu and Sandford (2007): "After receiving subjects' responses, investigators need to convert the collected information into a well-structured questionnaire. This questionnaire is used as the survey instrument for the second round of data collection" (p.2). We proceeded with round two, which consisted of a questionnaire of sixty closed questions based on a five-point Likert-scale, this time addressing detailed changes to MISA to support the design of IMS LD compliant pedagogical scenarios.

We have distinguished the measure of 'convergence' from that of 'approval' in order to meet Delphi requirements. While approval allows us to choose which modification proposals to implement, convergence refers to the establishment of a reliable consensus for ending the iterative expert consultation. While the degree of convergence (both positive and negative) was 85%, the level of approval rose to 92%.

The 'mandatory' DEs in the new version of MISA constitute a 'customization' of the method with regard to the creation of an IMS LD pedagogical scenario. They all pertain to the instructional layer of MISA and are distributed into four DE that assist in the design of the pedagogical scenario. Changes relate to the inclusion into the pedagogical scenario of some elements from within the MISA knowledge layer (learning objectives and learners' prerequisites) and the delivery layer (a detailed establishing of rules guiding the learning flow at runtime). This results in a partial merge into the pedagogical scenario of punctual elements found in other DE in MISA.

In terms of a UoL ready for implementation, a twofold strategy is outlined for adjusting the blueprint to the execution requirements of an IMS LD compliant learning management system: 1) the development of a set of semi-automatable operations in the software for recomposing the pedagogical scenario, and 2) the intervention of a human agent (teacher, designer) aware of certain system parameters that ensure the control and monitoring of the learning flow before and at runtime. It is also desirable, from an educational perspective, to leave the pedagogical scenario open to modifications.

Phase 4 conclusions

The MISA method can be customized to suit the needs of the designer and the organisation. The 'recommended' and 'mandatory' DEs in this new version of MISA constitute a 'customization' of the method in regards to the creation of IMS LD UoLs. The 'progression' and 'coordination' principles are also respected since there is a suggested order for design and recursive interdependence between the DEs.

The selection of DEs ensuring a high quality design process and the gathering of required information can only be carried out in conjunction with a second operation of transformation of the MISA method: a look inside, at the level of attributes and values of the DEs. A list of detailed propositions has been drawn up in order to meet IMS LD requirements.

Together with DE selection and modification, the need for new adaptations to the model editor software has been emphasized. New requirements are proposed, such as automating the reorganization of the instructional structure in conjunction with instructional scenarios to satisfy the IMS LD syntax. Moreover, the new software tool should also let one declare rules and properties in a formal and user-friendly way.

We have also reflected upon a possible intermediate solution for the above functions, which could be assumed by a new role that can be interpreted either as an additional specialist member of a team designing a UoL or as the addition of new competencies to the instructional designer's profile. This new role should be assumed by someone competent in modeling techniques, EMLs, and formal rules' declaration. This role definition will depend on software functionalities and usability improvements.

Here we reach the limits of our research, as deeper analysis will require the involvement of enhanced software to corroborate and/or improve the MISA method.

7.3 Contributions

According to the traced objectives and the undertaken design and development research process we can summarize our contributions as follows.

7.3.1 Augmenting the instructional design knowledge base

Richey (2007) posits that DDR should give the instructional design and technology field "a fourth theory base, supplementing the understandings we have already acquired from psychological and learning theory, instructional and teaching learning theory, and communication and message-design theory "(p.6): its own body of theory anchored in design and development. We have, through our work, contributed to nourish the knowledge base in this latter sense providing evidence in support of a theory of instructional design of artifact functional decomposition. We have based our entire rationale in this theoretical view that decomposes the design artifact into layers of concern. We have contributed to actual and current issues in the field, as are witnessed in the last volume of "Instructional-design theories and models" which main concerns are directed to the building of a common knowledge base (Reigeluth & Carr-Chellman, 2009) and the search for agreement among design languages.

7.3.2 Coupling the ID theory with a coherent method for design

According to the theoretical view adopted, we have gone one step further in providing what Vincenti (1990) calls design instrumentalities: "instrumentalities of the process-the procedures, ways of thinking, and judgmental skills [that provide] the power, not only to effect designs where the form of the solution is clear at the outset, but also to seek solutions where some element of novelty is required (p.219). The MISA method (or other courseware engineering approach) adds a coherent operational level to the functional theory of design, allowing performing the design activity according to this view of design layers and design languages.

7.3.3 Advancing on design languages

We have contributed to the study of design languages as suggest by Gibbons and Brewer (2005), particularly in the use of design languages within the 'strategy layer' for "expressing the various aspects of [the] instructional strategy" (p.127).

We have worked on the meta-languages for expressing multiple pedagogies as used in MISA and IMS LD. In one attempted solution we have, together with the LORNET team, coupled the IMS LD specification with a visual notation system (and editor). We have tested a technique which resulted to be complex to the instructional designer, and more suitable for professionals experienced in the Specification. We have then returned to the MISA meta-language and added minor changes to incorporate main IMS LD terms (and notation system). More developments in both meta-languages matching are required in order to translate the pedagogical scenario expressed in MISA to the requirements of IMS LD interoperability.

7.3.4 Providing a method for designing reusable pedagogical scenarios

We have explored and developed an adaptation of the MISA method for designing pedagogical scenarios that capture most of the information required for transforming the pedagogical scenario into an IMS LD unit of learning. The adapted version of MISA enable expressing formally and in a visual manner the IMS LD level A information as well that it captures structured but less formally information about IMS LD levels B and C. In this sense, more developments in the editing software could provide an enhanced solution to this matter. This proposed adaptation of the MISA method, focused on the pedagogical layer, rests congruent with the MISA other layers of design that decompose the design artifact into the four main layers comprising also knowledge, media and delivery the design.

7.3.5 Supporting a DDR approach for the creation and validation of ID methods

Throughout the documented process of DDR we have tried to respond to the usual and also recognized weaknesses in design procedures, models or methods. To the critics of a flawless theory behind instructional procedures or models (Willis, 1998), we have made an explicit effort to theoretically and historically align the design of instruction and the issues raised in terms of nature, process and practice to other design related disciplines. We have purposely and (at first) intuitively looked for eventually common backgrounds of instructional design and other design related disciplines. This search for interdisciplinary explanation of the activity shed light on common interests and developments, as well as it provided new concepts that helped build a rationale for the research. The quest for a metatheory of design, distancing from specific pedagogical approaches or instructional theories, was guided by the objectives in mind, of a meta-language capable of expressing multiple pedagogies.

To the critics of lack of documented processes of development and validation of a structured procedure for instructional design (Gustafson & Branch, 2002; Richey, 2005), we have put the efforts in supporting the research decisions on previous studies as well as keep a detail track of the research procedure.

7.4 Final conclusions and further research

A complex problem of dealing with an instructional design method and new developments in educational technology standardization had to be grounded in a rigorous research methodology allowing development, validation as well as progressive adjustments. The design and development research approach has revealed itself to be a relevant and insightful methodology for our research object. It provided guidance for carrying out the research and development process, enabling the documentation of the process for communication, reflection, replication and improvement.

DDR is a 'process' in which we engage: The research plan is not completely traced at the beginning but unfolds throughout iterative phases guide by theory and based on evidence. The development and testing of plausible solutions involves examining, refining and/or adjusting to emerging issues revealed only during the carrying out of the DDR. The number of phases is based on the degree of satisfaction, which is measured both by accomplishment of the DDR main aim as well as the collected evidence providing support for the achieved state.

From the time when our research began, we have collected evidence to support the proposition of an instructional method aimed at the design of IMS LD compliant pedagogical scenarios. The first promising results were obtained through a semantic comparison of MISA and IMS LD (phase 2) which led to the establishing of a common ground shared by MISA and IMS LD, thus enabling research continuity.

We then undertook the third phase where we studied the introduction, into the MISA method, of a new technique supporting the design of a MISA pedagogical scenario according to IMS LD constraints. The aim was to test an 'economic' solution that would not require further modifications to the MISA method. We therefore conducted a case study where a technique for the representation of a UoL was applied to the transposition of a MISA pedagogical scenario by an expert instructional designer. The results revealed that such a solution is insufficient, but gave us in-depth information about how to revise MISA principles, MISA DEs, and the MISA language. It also provided knowledge about the main steps of a UoL design process using the MISA approach, and more detailed information on terminology similarities, equivalences, and overlapping. Phase 3 allowed us to explore a solution that was suitable to a rather narrow group of teachers.

DDR attributes allowed us to adjust the development of solutions from phase 3 to 4. Phase 4 then enabled us to modify the solution so that, building on previous results, it would target the teaching community at large that is willing to share their pedagogical know-how and benefit from that of others. Results from phase 3 guided how to conceive the Delphi for the fourth developmental research phase, where MISA development and adaptation was put to internal validation by four experts. The Delphi helped select MISA documentation elements that are appropriate for the design of a pedagogical scenario according to IMS LD, study and refine the properties of the DEs to better satisfy IMS LD requirements, resolve terminological differences, specify the nature of problems and corresponding solution domains (instructional method, software development, and extension of the teacher/designer competencies or introduction of a new actor), and verify MISA principles.

This phase 4, of exploring an alternative solution, showed how each phase in itself deserves unique attention in terms of defining the kind of solution to develop as well as the most appropriate way to study it.

The Delphi enabled agreement on an adapted version of the MISA method that fulfills the design purpose. The final outcome of the design process is a pedagogical scenario with all the information required to run a UoL organized in a semi-formal manner and capable of translation into an XML structure. In this sense, the pedagogical scenario results in a document that can be understood as an intermediate state between a blueprint and an executable UoL. The Delphi applied in the last phase not only helped us validate an instructional design method with specific purposes from strictly technical aspects, but also shed light on complementary dimensions arising from social (division of labor) and professional (need for competence development and knowledge background increasing) issues.

Further research should point first to the development of the pedagogical scenario editor software tool, focusing on translational aspects of both MISA and IMS LD educational modeling languages. It should also examine the external validation, by teachers and instructional designers, of the MISA method adapted to IMS LD.

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Appendixes

2-A	Delphi Experts' Profile
4-A	MISA Main Documentation Elements
4-B	MISA EML Meta-language and Notation System Analysis According to IMS LD Requirements
5-A	MOT+LD Editor Modeling Technique
5-B	UoL Narrative
5-C	Case Study Research Protocol
5-D	Think-aloud Protocol Guide
5-E	Observation Grid
5-F	Debriefing Questionnaire
5-G	Appreciation Questionnaire
5-H	Learning Event Network from Course
5-Ia	Assignment 2.3.2 Analysis
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5-J	Designer Narrative
5-K	UoL (in progress) from First Session
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6-A	Letter to the Experts
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6-D	MISA EML Notation System Adds-on
6-E	Delphi Round 2 Data Processing and Interpretation

This dissertation supports the choice of a Design and Development Research approach for the creation and validation of ID methods, thus providing a theoretically-grounded and pedagogically-inclusive method for designing reusable pedagogical scenarios. It also presents a framework for articulating a generic instructional design theory with a coherent instructional design method, and hence, it contributes to augmenting the instructional design knowledge base.

This study presents a research divided into four main phases of development and validation.

The first phase grounds the research in a theory of instructional design that aligns it with other related design disciplines, and decomposes the design problem into layers of artifact functionalities. This theory corresponds to software-engineering-infused instructional design methods also known as courseware engineering.

The second phase explores ways to integrate an educational modeling language within an instructional design method for enabling the representation of pedagogical scenarios of computational facture. To reflect and experiment on this issue, we have chosen to study the MISA instructional design method developed at the LICEF research center and the IMS LD specification.

The third phase presents an initial developmental solution, which is tested in a case study. We studied the introduction, into the MISA method, of a new technique supporting the design of a MISA pedagogical scenario according to IMS LD constraints. The aim was to test an 'economic' solution that would not require further modifications to the MISA method. We therefore conducted a case study where a technique for the representation of a conformed to IMS LD pedagogical scenario was applied to the transposition of a MISA pedagogical scenario.

The fourth and final phase extends the development and validation of a solution by way of a two-round Delphi method. This developmental step included a selection and introduction of minor modifications of a set of MISA design documents for the design of IMS LD compliant pedagogical scenarios. The Delphi enabled agreement on an adapted version of the MISA method that fulfills the design purpose. The final outcome of the design process is a pedagogical scenario with all the information required to run an IMS LD-like pedagogical scenario organized in a semi-formal manner and capable of translation into a structured markup language for running in a compliant learning management system. In this sense, the pedagogical scenario results in a document that can be understood as an intermediate state between a blueprint and an executable pedagogical scenario.

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