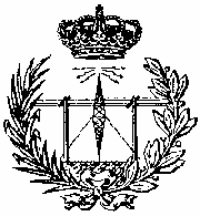

UNIVERSIDAD DE VALLADOLID

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Tesis Doctoral

A pattern-based design process for the creation of CSCL macro-scripts computationally represented with IMS LD

AUTORA

Davinia Hernández Leo

Ingeniera de Telecomunicación

DIRECTORES

Juan I. Asensio Pérez

Dr. Ingeniero de Telecomunicación

Ioannis Dimitriadis Damoulis

Dr. Ingeniero de Telecomunicación

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Advisors:

Dr. Juan I. Asensio Pérez & Dr. Ioannis Dimitriadis, *University of Valladolid, Spain*

Three-month research visit in another European country, advisors:

Dr. Colin Tattersall & Dr. Daniel Burgos, *Open University of the Netherlands, The Netherlands*

Reviewers:

Dr. Hans Hummel, *Open University of the Netherlands, The Netherlands*

Dr. Jan-Willem Strijbos, *Leiden University, The Netherlands*

Committee:

Prof. Dr. Carlos Delgado Kloos, *University Carlos III of Madrid, Spain*

Prof. Dr. Rob Koper, *Open University of the Netherlands, The Netherlands*

Prof. Dr. Josep Blat, *Pompeu Fabra University, Spain*

Dr. Andreas Harrer, *University of Duisburg-Essen, Germany*

Dr. Eduardo Gómez Sánchez, *University of Valladolid, Spain*

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Davinia Hernández-Leo
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To my parents,
the best collaboration practice that I know of

To my brother

To David

Abstract

Information and Communication Technologies (ICT) in Computer-Supported Collaborative Learning (CSCL) are mainly used for mediating social interactions as key activators of learning. One of the major concerns of CSCL is however that free collaboration does not necessarily produce learning and that in several circumstances collaboration should be scaffolded so that the probability of reaching successful outcomes increases. CSCL scripts embedded in ICT systems aim at shaping the way learners interact with each other in order to elicit fruitful interactions. The specific focus of this Ph.D. Thesis is on CSCL macro-scripts which describe pedagogical methods defining flows of coarse-grained activities. This document identifies and faces up to three challenges around the problem of facilitating teachers the design of those ICT-embedded CSCL macro-scripts.

The first challenge refers to the design of the potentially fruitful scripts. This work proposes the use of patterns to capture good practices in structuring CSCL situations for the purpose of reusing them in the design of new scripts. In this sense, we present a conceptual model for CSCL scripting pattern languages and a specific pattern language that is compliant with the model. The model defines the different types of patterns and relationships among them so that it is possible to specify numerous meaningful sequences of patterns that shape the design of specific scripts.

The second challenge deals with the implementation of the scripts in ICT systems. With the aim that the scripts can be automatically interpreted without the need of developing new systems, we propose the use of IMS Learning Design (LD) specification to computationally represent the macro-scripts. This approach fosters interoperability and enables teachers participate in the design of the behaviour and functionality of the systems by providing a script adapted according to their particular situations. This work analyzes the support of this educational modelling language for expressing CSCL scripts considering the possibilities of the LD notation but also the use of related specifications and tooling.

The combination of the previous proposals enables us to propose *a pattern-based design process for the creation of CSCL macro-scripts computationally represented with LD*. The specific patterns considered in the approach are the so-called *Collaborative Learning Flow Patterns* (CLFPs), a particular type of CSCL scripting patterns that suggest generalized structures of macro-scripts. The main goal of the design process is twofold. On the one hand, it aims at enabling the conceptualization of the expected interaction focusing on CSCL critical elements through the refinement of CLFP-based templates. And on the other hand, it intends facilitating the teacher-friendly creation of LD-represented scripts by hiding LD details; thus facing up to the third challenge related to the fact that computational representations are not familiar to the majority of the teachers. The design process is implemented in an authoring tool (named *Collage*) which proves its feasibility and enables its proper evaluation.

Overall, the applied research methodology is characterized by the multidisciplinary problem domain within which the dissertation is framed. Particularly, the evaluation phase is accomplished by means of a multicase study that comprises three case studies, which aim at assessing the same contributions but from different perspectives. The cases involve workshops with the target audience (teachers interested in applying CSCL) and experiences with students in authentic situations; but they also involve experts in the collaborative learning or LD fields and researchers proposing related approaches. The results of the evaluation not only show that the objectives of the dissertation have been achieved but they also offer relevant clues for future research directions.

Resumen

Las Tecnologías de la Información y las Comunicaciones (TIC) se utilizan principalmente en el campo del Aprendizaje Colaborativo Apoyado por Ordenador (*Computer-Supported Collaborative Learning*, CSCL) para mediar interacciones sociales como activadores significativos del aprendizaje. Sin embargo, un problema importante en el CSCL es que la colaboración libre no produce necesariamente aprendizajes. En determinadas circunstancias la colaboración debe ser guiada de manera que aumente la probabilidad de alcanzar beneficios educativos. Precisamente, los guiones de CSCL integrados en sistemas TIC tienen como objetivo indicar cómo los alumnos deben interactuar entre ellos para que tengan lugar interacciones fructíferas. El ámbito de investigación específico de esta Tesis Doctoral recae sobre los denominados macro-guiones de CSCL, que describen métodos pedagógicos formulados como flujos de actividades. Este documento identifica y hace frente a tres retos relacionados con el problema de facilitar a los profesores el diseño de estos macro-guiones integrados en las TIC.

El primer reto hace referencia al diseño de los guiones de manera que éstos sean potencialmente productivos. Este trabajo propone utilizar patrones para capturar buenas prácticas en cuanto a la estructuración de situaciones de CSCL. El objetivo es que los patrones puedan ser reutilizados en la creación de nuevos guiones. Para ello, presentamos un modelo conceptual de lenguajes de patrones para guiones de CSCL, así como un lenguaje de patrones concreto que es conforme con el modelo. Dicho modelo define los diferentes tipos de patrones y relaciones entre patrones de manera que es posible definir numerosas posibilidades de secuencias de patrones que dan forma al diseño de guiones específicos.

El segundo reto tiene que ver con la implementación de los guiones en sistemas TIC. Con el propósito de que los guiones puedan ser interpretados automáticamente sin necesidad de desarrollar nuevos sistemas, proponemos representarlos computacionalmente utilizando la especificación IMS *Learning Design* (LD). Esta aproximación fomenta la interoperabilidad a la vez que hace posible la participación de los profesores en el diseño del comportamiento y la funcionalidad de los sistemas. Para ello, basta con que los profesores creen los guiones de acuerdo con las condiciones particulares de su situación de enseñanza-aprendizaje. Este trabajo analiza las posibilidades del lenguaje de modelado educativo LD para expresar los guiones considerando la propia notación pero también el uso de otras especificaciones y herramientas relacionas.

La combinación de las propuestas anteriores nos permite proponer *un proceso de diseño basado en patrones para la creación de macro-guiones de CSCL representados computacionalmente con LD*. Los patrones concretos que se han considerado son los llamados Patrones de Flujo de Aprendizaje Colaborativo (*Collaborative Learning Flow Patterns*, CLFPs). El objetivo principal del proceso de diseño es doble. Por una parte, pretende posibilitar la conceptualización de las interacciones esperadas de manera que los elementos críticos del CSCL son considerados al refinar plantillas LD basadas en los patrones. Por otra parte, persigue facilitar la creación amigable de guiones LD escondiendo los detalles de la especificación. De este modo, proponemos una solución para el tercer reto que se refiere al hecho de que las representaciones computacionales no les son familiares para la mayoría de los profesores. El proceso de diseño ha sido implementado en una herramienta de autoría (denominada *Collage*) que demuestra la viabilidad de la propuesta y permite su conveniente evaluación.

En conjunto, la metodología de investigación aplicada se caracteriza por el ámbito multidisciplinar en el que se enmarca la tesis. Particularmente, la fase de evaluación se ha llevado a cabo mediante un estudio múltiple de (tres) casos. Los tres pretenden evaluar las mismas contribuciones pero desde diferentes perspectivas. Incluyen talleres destinados a la audiencia potencial de nuestra propuesta principal (profesores con interés en aplicar CSCL) y experiencias con alumnos en situaciones reales. Los casos también involucran a expertos tanto en aprendizaje colaborativo como en LD e investigadores que proponen aproximaciones relacionadas. Los resultados de la evaluación no sólo muestran que los objetivos de la tesis se han conseguido sino que también ofrecen indicaciones relevantes de trabajo futuro.

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CHAPTER ONE

INTRODUCTION

This chapter introduces the main problems in the Computer-Supported Collaborative Learning field of research that motivate the dissertation. The chapter formulates the objectives, the expected contributions and the applied research methodology as well as the structure of the dissertation.

1.1 Introduction

Computer-Supported Collaborative Learning (CSCL) represents a rather new multidisciplinary paradigm within the field of Technology-Enhanced Learning (TEL), in which Information and Communication Technologies (ICT) are employed in order to improve various educational aspects (Koschmann, 1996; Stahl, Koschmann, & Suthers, 2006). The main characteristics of CSCL include highlighting the importance of social interactions as an essential element of learning (Dillenbourg, 1999a), as well as the need of participatory modes of designing new technological environments (Häkkinen, 2002). CSCL solutions (developed by technologists) should offer the functionality desired by the set of potential actors that participate in collaborative learning situations (mainly teachers and students).

One of the main concerns in CSCL is that the expected interactions that would lead to learning outcomes do not necessarily occur when the students are asked to collaborate freely (Dillenbourg, 2002). Among many different approaches that share the goal of enhancing effective collaboration we can mention two important ones. The first approach is to monitor the collaboration and intervene as necessary in order to redirect the group work in a more productive direction (Soller, Martínez-Monés, Jermann, & Muehlenbrock, 2005). The other solution refers to an increase of the probability of reaching successful CSCL situations by providing students with a set of instructions that guide potentially fruitful collaboration (Dillenbourg, 1999b). When the instructions are technology-mediated, they form what is called a *computer-supported collaboration script* (*CSCL script* or simply *script*).

The goal of the guidance provided by the scripts refers to cognitive or educational objectives. This difference is characteristically related to the granularity of the scripts (Fischer, Kollar, Haake, & Mandl, 2007). *Micro-scripts* are intended for facilitating that students internalize them from a cognitive psychologist perspective (e.g. learning how to argument by following a script that scaffolds argumentation). They typically provide support for specific activities by describing the fine-grained actions (e.g. sentence starters) that each participant should accomplish (Weinberger, Fischer, & Stegmann, 2005). On the contrary, *macro-scripts* denote pedagogical methods defining flows of coarse-grained activities (Dillenbourg & Jermann, 2007). They aim at organizing situations that elicit desired interactions potentially leading to learning outcomes from the educational point of view (e.g. understanding the key ideas of a topic by following a script that distributes the knowledge and promotes mutual explanation).

Unfortunately, up to now the scripts are "hardwired" in specifically devoted learning environments (Jermann, Soller, & Lesgold, 2004; Häkkinen & Mäkitalo-Siegl, 2007). This fact limits their reusability in a different situation and imposes significant time and cost efforts when a new script needs to be implemented. Moreover, developing a new scripting environment is not trivial. This is mainly due to the inherent characteristic of multidisciplinarity in CSCL, which implies a need for mutual understanding among the involved stakeholders (mainly experts in education and in ICT) (Stahl et al., 2006). This need demands active participation of all these stakeholders during the whole development cycle of CSCL solutions. Participatory Design (PD) approaches (Muller & Kuhn, 1993) propose a diversity of practices with the goal of working directly with users and other stakeholders in the design of social software systems.

In CSCL, it has been shown that there is a significant efficiency problem in performing identification and analysis of requirements for the development of CSCL solutions that support effective ways of learning (Dimitriadis, Asensio-Pérez, Martínez-Monés, & Osuna-Gómez, 2003). Collaborative learning practitioners also become active players in the process of customizing technological solutions to their particular needs in every teaching-learning situation. PD poses a new requirement that CSCL technologists should tackle: how to obtain technological solutions for collaborative learning capable of being particularized/customized by teachers that usually do not have technological skills. The domain problem undertaken in this dissertation is related to facilitating teachers play the role of designers of those technological solutions. Specifically, the problem to be solved consists in how PD can be enabled by providing authoring tools for creating macro-scripts which can be automatically interpreted and executed by learning environments such as Learning Management Systems (LMSs). This type of systems makes possible the delivery of learning activities and digital content to students (E-LANE, 2004; Bote-Lorenzo, 2005; Burgos, Tattersall, Dougiamas, Vogten, & Koper, 2006).

One of the problems associated to this research focus refers to the fact that scripts need to be computationally represented (formalized) in order to enable their automatic interpretation. Educational Modelling Languages (EMLs), in contrast to metadata specifications (e.g. Learning Object Metadata, LOM) for describing reusable chunks of learning content (so-called Learning Objects or LO) (Hodgings, 2000; Duval, 2001), are focused on specifying teaching-learning processes (Rawlings, van Rosmalen, Koper, Rodríguez-Artacho, & Lefrere, 2002). *IMS Learning Design* specification (*IMS LD* or simply *LD*) is currently accepted as the *de facto* standard EML and the amount of developments around LD is significant (IMS, 2003b; Koper & Tattersall, 2005; Burgos & Griffiths, 2005).

The aim of LD is to enable the creation of complete, abstract and portable descriptions of any pedagogical approach taken in a course (or part of a course), which can be realized by a compliant system. The key idea is that it represents the learning activities (performed by learners) and the support activities (performed by teachers), including those comprising multi-role teaching-learning processes and personalized learning routes (Koper & Olivier, 2004). Motivated by the interoperability prospects and the specification declaration of intent, we consider LD as an interesting candidate to computationally represent CSCL scripts.

However, the LD support for formalizing collaborative learning processes is not clear (Caeiro-Rodríguez, Anido-Rifón, & Llamas-Nistal, 2003). This concern is motivated by the fact that the specification is still very recent and it has not been widely adopted in real practice yet (Burgos & Griffiths, 2005). Besides, there is a lack of significant examples and efforts showing the possibilities of LD for CSCL (e.g. description of group hierarchies). Although partial work has been already accomplished (Gorissen & Tattersall, 2005; Koper & Burgos, 2005), a more complete and systematic analysis is needed.

On the other hand, the current LD compliant editors require a high level of expertise on LD and therefore they are not indented for teachers but for expert instructional designers or educational technologists (Milligan, Beauvoir, & Sharples, 2005; van der Vegt, 2005; Miao, 2005; de la Teja, Lundgren-Cayro, & Paquette, 2005; Sampson, Karampiperis, & Zervas, 2005). With the aim of enabling teachers to play the role of script designers, CSCL specific LD-based authoring tools should incorporate (visual) design techniques (Botturi & Stubbs, in press) that hide the details of LD (Griffiths & Blat, 2005) as well as the inherent difficulties involved in modelling scripts. These difficulties are caused by the complex mechanisms and components that comprise the definition of scripts (Kollar, Fischer, & Hesse, 2003), such as the interrelations of groups or the synchronization of collaborative activity sequences.

Furthermore, these authoring tools should implement design processes that guide teachers in the design of potentially effective scripts. This is especially important if the teachers (and students) are

novice in collaborative learning, since putting into practice collaborative learning experiences is not trivial (Johnson & Johnson, 1999) and because of the risks of over-scripting the situations and thus coercing relevant natural interaction (Dillenbourg, 2002). It is important to consider that traditional Instructional Design (ID) approaches (devoted to individual instructional sequences) based on general theories (Reigeluth, 1999) are too rigid and underestimate the complexity of CSCL (Goodyear et al., 2004; Kenny, Zhang, Scwier, & Campbell, 2005). In this sense, CSCL requires more pragmatic design processes grounded in practice (Karagiorgi & Symeou, 2005) which make the critical elements for eliciting productive interaction explicit (Strijbos, Martens, & Jochems, 2004).

We argue that a promising solution to approach this problem is to propose a design process that facilitates the reuse of generalizations of successful collaboration scripts (best/good practices) formulated as design patterns. This would also avoid the costly efforts related to re-inventing script strategies. Despite the fact that the word "pattern" has been used for centuries with slightly different meanings, its use is more known in the fields of Architecture (Alexander et al., 1977) and Software Engineering (Gamma, Helm, Johnson, & Vlissides, 1995). A pattern provides a means of organizing information regarding a contextualized common problem and the essence of its broadly accepted solution, so that it can be repetitively applied. A collection of interconnected (related) patterns which enable the generation of a coherent whole (e.g. a town) is called a Pattern Language (PL). Recently other domain specific patterns have been proposed, including TEL and CSCL (Goodyear, 2005; Derntl & Botturi, 2006; Retalis, Georgiakakis, & Dimitriadis, 2006). However, the existing pattern approaches in TEL, which vary in scope and purpose (e.g. patterns for designing LMSs (Avgeriou, Papasalouros, Retalis, & Skordalakis, 2003) vs. patterns for mathematical games (Learning Patterns, 2005)), do not include any specific proposal devoted to designing scripts.

Therefore, the general problem undertaken in this dissertation refers to the definition of a design process that takes advantage of insights offered by best/good scripting practices (formulated as patterns) for the creation of particularized educationally-sound LD-represented macro-scripts as a means of providing PD approaches which enables teachers to influence in the behaviour and functionality of CSCL scripting environments. In this way, section 1.2 introduces the objectives of this dissertation. The research methodology followed to tackle them is presented in section 1.3. Finally, section 1.4 concludes this introductory chapter.

1.2 Objectives of the dissertation

According to the research problems described in the previous section, the global aim of this dissertation is:

To propose and evaluate a design process based on patterns for facilitating the creation of potentially effective CSCL macro-scripts computationally represented with IMS Learning Design so that they can be interpreted by learning environments such as Learning Management Systems.

This global aim can be divided into the following more specific objectives. These derived objectives and the original contributions of this dissertation are schematically represented in Figure 1.1 and described as follows:

- **To identify the types of patterns and relations between patterns that can be used for generating CSCL scripts.**

  In order to tackle this objective, it will be necessary to have a unifying view of several different representative pattern-based approaches in TEL. That will allow us to situate and describe the scope and audience of what we will define as *CSCL scripting patterns*. An iterative process will be followed. It will include case studies, the experience of the GSIC/EMIC (Intelligent & Cooperative Systems Group / Education, Media, Informatics and Culture) research group (GSIC/EMIC, 1994), the results of TELL (Towards Effective network supported coLLaborative learning activities) project (TELL, 2005b) and a review of the literature with regard to design and, particularly, scripting in CSCL. Once the types of patterns and the relations between them are identified, a method for applying the patterns will be discussed. Furthermore, a CSCL scripting PL (with own and adopted patterns) as well as three CL situations generated using the PL will be provided to illustrate how the patterns can be applied.

  Regarding this objective, the main contributions of this dissertation are the proposal of a conceptual model for describing CSCL scripting Pattern Languages and an actual CSCL scripting PL. Both contributions will be useful within this dissertation to situate the other contributions. They also provide to the scientific community a starting point towards an agreed high-level structure for the production of CSCL scripting patterns and PLs.

  Part of these contributions have been published in (Hernández-Leo, Villasclaras-Fernández, Asensio-Pérez, Dimitriadis, & Retalis, 2006d), which introduces the hierarchical structure for CSCL scripting patterns characterized by the conceptual model, and (Hernández-Leo, Asensio-Pérez, & Dimitriadis, 2006), which presents a real experience that applies a script generated with the proposed pattern language

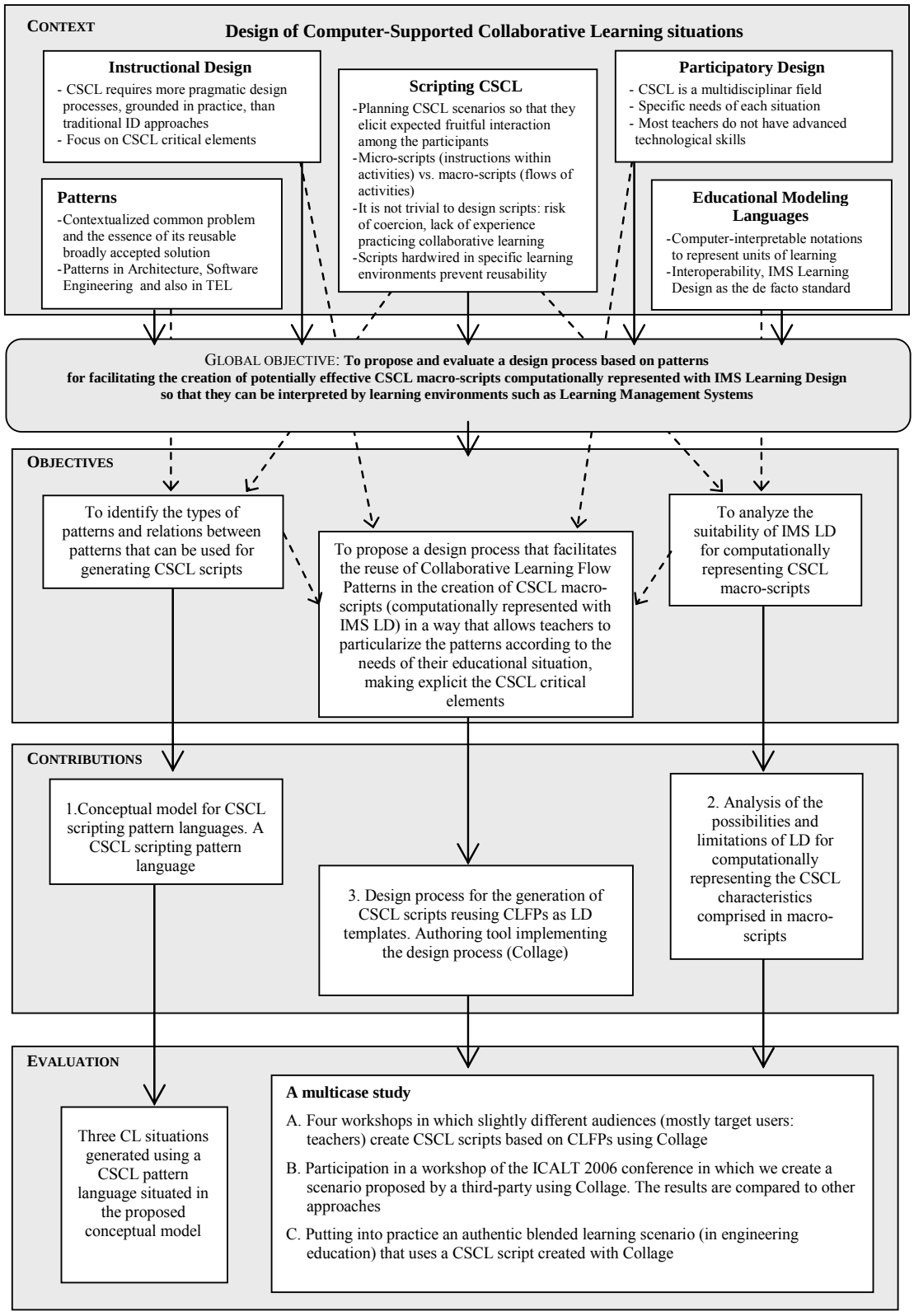

Figure 1.1 General schema of the dissertation including its context, the aimed objectives, the original contributions as well as the accomplished evaluation

- **To analyze the suitability of IMS LD for computationally representing CSCL macro-scripts.**

  The first step so as to fulfil this objective will be to identify common CSCL characteristics in CSCL macro-scripts. The importance of these characteristics will be justified according to the literature and related work such as the CoSSICLE project (CoSSICLE, 2005) as well as the experience based on real context of the GSIC/EMIC research group (GSIC/EMIC, 1994). After that, LD-represented scripts including the identified characteristics will be developed. That will allow us to clarify the possibilities of LD for computationally representing CSCL macro-scripts, differentiating the LD notation itself from related specifications and supporting tools.

  On this topic, the contribution of this dissertation is the analysis of the possibilities and limitations of LD for computationally representing the CSCL characteristics comprised in CSCL macro-scripts. The global conclusions have been submitted for publication (Hernández-Leo, Burgos, Tattersall, & Koper, submitted) and are currently under review. However, significative partial results have been already published in (Hernández-Leo, Asensio-Pérez, & Dimitriadis, 2005), extended version of (Hernández-Leo, Asensio-Pérez, & Dimitriadis, 2004) which received a "Best Paper Award" in the conference where it was presented, and (Hernández-Leo et al., 2005a), extended version of (Hernández-Leo et al., 2005b).

- **To propose a design process that facilitates the reuse of CLFPs (Collaborative Learning Flow Patterns, a particular type of CSCL scripting patterns) in the creation of CSCL macro-scripts (computationally represented with IMS LD) in a way that allows teachers to particularize the patterns according to the needs of their educational situation, making explicit CSCL critical elements.**

  Having the aforementioned proposals as a starting point, we will describe an approach facilitating the reuse of CLFPs for the generation of CSCL scripts computationally represented with LD. The design process will meet the following requirements. Firstly, it will achieve a satisfactory trade-off between particularizations of CLFPs so that the resulting LDs are contextualized according to particular CL situations and the loss of the meaningfulness captured in CLFPs. Secondly, it will allow teachers to focus on CSCL critical features (e.g. learning objectives, task type, level of pre-structuring, group size). Finally, it will not require high technical knowledge, particularly of LD. An important element, in this sense, will be the implementation of the design process in an authoring tool (*Collage*) in order to prove its feasibility and to enable its proper evaluation.

The design process for the generation of CSCL scripts reusing CLFPs is the central contribution of this dissertation since it links several of the previous specific objectives. The design process together with its implementation in *Collage* has been published in (Hernández-Leo et al., 2005; Hernández-Leo, Villasclaras-Fernández, Asensio-Pérez, & Dimitriadis, in press; Hernández-Leo et al., 2006e) and has been also co-honoured with the 2006-2007 European Award for Excellence in the Field of CSCL Technology. The "create-by-reuse" framework in which the process is situated has also been published in (Hernández-Leo, Harrer, Dodero, Asensio-Pérez, & Burgos, 2006a).

- **To evaluate the proposed pattern-based design process for CSCL macro-scripts computationally represented with IMS LD.**

  In order to evaluate the design process, we will carry out three different case studies:

A. The first case study will comprise four workshops in which participants (mainly potential users: teachers) will create LD-represented CSCL scripts based on CLFPs following the proposed design process integrated in *Collage*. These experiences will allow us to value to which extent the design process implemented in *Collage* facilitates the reuse of CLFPs in the creation of particularized LD-represented scripts, in a way that allows teachers to focus on CSCL critical elements.

B. The second case study will involve the participation in a workshop where several researchers proposing related approaches design a scenario proposed by the workshop organizers. Therefore, this experience will provide indications regarding whether our proposal can be used for creating a script representing a scenario proposed by a third party. Moreover, the workshop will represent a good opportunity to compare our contributions with related work. Partial conclusions of the this case study are published in (Hernández-Leo et al., 2006b)

C. The third case study will deal with a real situation in engineering education where students will experience a CSCL script created according to the design process. This case study will allow us to show that the scripts are meaningful and can be applied in authentic educational situations. The results of this case study have been accepted for publication (Hernández-Leo et al., in press).

Furthermore, this evaluation will allow us to extract conclusions that will be useful for future research.

1.3 Research methodology

The objectives of this dissertation are framed within a multidisciplinary problem domain. This fact demands a hybrid methodology that includes elements of diverse research approaches (Adrion, 1993) and highlights the need to consider the social context (Stahl et al., 2006). Multiple domain knowledge, combining theory and praxis, is the key factor of the methodology, which focuses on real practitioners' needs.

Therefore, research and practice evolve together in the applied research approach. It uses four phases: informational, propositional, analytical and evaluation (Glass, 1995). Several iterations, in which the findings of each phase (essentially the analytical and evaluation phases) feed earlier phases, are accomplished until "satisficing" results are achieved. (Satisficing is a concept coined by Herbert Simon which identifies the decision making process whereby one chooses an option that is, while perhaps not the best, good enough (Simon, 1982).) That expresses the significance of the evaluation phase, which is also critical for validating the proposals.

Within each phase of the research approach, the applied research methods are described as follows (Glass, Vessey, & Ramesh, 2002; Zelkowitz & Wallace, 1998):

- **Informational phase**

  The aim of this phase is to gather information in order to, on the one hand, identify and clearly formulate the research questions and, on the other hand, have an outline of the current knowledge involved in the problem domain.

  The main methods involved in this phase include tasks belonging to both the scientific (observing the world) and the engineering (observing existing solutions) approaches:

  - The search, review and analysis of literature regarding the topics of the problem domain: CSCL with emphasis in design and scripting problems, pattern-based approaches in TEL and EMLs.
  - The participation in the GSIC/EMIC multidisciplinary research team (GSIC/EMIC, 1994) whose field of expertise (including research and practice) is collaborative learning and its computer support. Particularly, the experience and findings of two case studies investigated by the group constitute an important legacy for this research work (Martínez-Monés et al., 2005; Ruiz-Requies, Anguita-Martínez, & Jorrín-Abellán, 2006).
  - The participation in several conferences and projects whose topics include the keywords related to this research work. The projects are TELL e-Learning project EAC/61/03/GR009, Kaleidoscope Network of Excellence FP6-2002-IST-507838, Spanish Ministry of Education and Science projects TIC-2002-04258-C03-02 and

TSI2005-08225-C07-04 and Autonomous Government of Castilla and León, Spain, projects VA009A05, UV46/04 and UV31/04. Particularly, the outcomes of TELL project (TELL, 2005a; TELL, 2005a) represent a significant input to this dissertation. This phase has been also largely benefited by the informal but active involvement in the UNFOLD (Understanding New Frameworks Of Learning Design) project (UNFOLD, 2004; Burgos & Griffiths, 2005) (related to IMS LD specification) as well as the participation in two workshops offered by the Kaleidoscope Virtual Doctoral School and organized by the multidisciplinary European Research Team CoSSICLE (CoSSICLE, 2005).

- **Propositional phase**

In this phase we propose and formulate the solutions to the identified research questions using the information aggregated in the previous phase.

- The core of the first and the third contributions of this dissertation (as numbered in Figure 1.1) are sketched in this phase, namely the conceptual model for CSCL scripting patterns languages and the design process for creating CSCL scripts based on CLFPs. Regarding the formulation of the patterns included in the example of the CSCL scripting PL, two kinds of pattern mining methodologies are employed (Baggetun, Rusman, & Poggi, 2004; Retalis et al., 2006): deductive or top-down (using best or good practices in structuring collaborative learning) and inductive or bottom-up (using the conclusions of case studies).
- The proposal of computationally representing the CSCL macro-scripts and CLFPs using IMS LD is also a result of this phase.

- **Analytical phase**

The purpose of this phase is to analyze and explore the proposals which may lead to a demonstration or formulation of principles.

- A concept implementation (proof of concept) is performed in order to analyze the proposal related to the first contribution. It consists in providing a feasible CSCL scripting pattern language, which can be described with the proposed conceptual model, and in theoretically generating CSCL scripts that illustrate how the patterns might fit together. The concept implementation is complemented with examples of how the patterns can be applied. Whilst these tasks are realized, several iterations proceed back to the propositional phase as far as the first contribution is concerned.
- The analysis of the possibilities and limitations of IMS LD for computationally representing significant CSCL scripting characteristics that appear in CSCL scripts is

also accomplished in this phase. The applied method consists mainly in trying to develop LD-represented scripts that code these CSCL characteristics. Part of this work is realized at OTEC (Educational Technology Expertise Centre) in the OUNL (Open University of the Netherlands) during a three-month research stay (OTEC, 2006).

- **Evaluation phase**

This phase is devoted to evaluating the proposals and the analytic findings by means of several case studies (Zelkowitz et al., 1998; Lundgren-Cayrol, Marino, Paquette, Léonard, & de la Teja, 2006; Jorrín-Abellán, Dimitriadis, Rubia-Avi, Anguita-Martínez, & Ruíz-Requies, 2006) organized as a multicase study (Stake, 2005). The case studies aim at assessing the same contributions but from a different perspective:

- A case study comprising four workshops in which different audiences create CSCL scripts using the proposed design process. The audience is mainly the target users, i.e. teachers of two different universities (University of Cádiz and University of Valladolid, both in Spain) with interest in applying CL and ICT in their practice, but also experts in the field of research: educational technologists (UNFOLD members) and CSCL practitioners and researches (members of the GSIC/EMIC group). Some of the CSCL scripts that they create in the workshops are designed beforehand in laboratory experiments, in which the corresponding UoLs are created and validated using the reference LD engine, CopperCore (Martens & Vogten, 2005).
- A case study in which we design a scenario proposed by a third-party using our approach. It involves the participation in an ICALT 2006 (6th IEEE International Conference on Advanced Learning Technologies) conference workshop (Vignollet, David, Ferraris, Martel, & Lejeune, 2006). We create a script reflecting the scenario using *Collage* and further execute it using Gridcole (Bote-Lorenzo, 2005).
- A case study in which a real-world educational situation uses a CSCL script created according to the proposals of this dissertation. The experience is part of an eligible course on Network Management within Telecommunication Engineering studies at the University of Valladolid.

In the case studies, a mixed method combining quantitative and qualitative data collection techniques is employed (Goubil-Gambrel, 1992; Jorrín-Abellán, Rubia-Avi, Anguita-Martínez, Gómez-Sánchez, & Martínez-Monés, in press; Martínez-Monés, Dimitriadis, Rubia-Avi, Gómez-Sánchez, & de la Fuente-Redondo, 2003). The emphasis is more on qualitative than on quantitative research, which is only considered useful for showing trends and indicating probabilities. In contrast, qualitative research is used to identifying salient features or variables in particular representative settings according to which the results can be interpreted (Denzin & Lincoln, 2005).

1.4 Structure of the dissertation

The rest of this dissertation is structured as follows:

- After this introduction, Chapter Two focuses on the domain problem related to the design of CSCL situations. With this purpose, it reviews CSCL as a multidisciplinary field of research within TEL and analyzes important design approaches in TEL and CSCL. In this sense, the chapter describes the role of Instructional Design (ID) in CSCL, focuses on the scripting CSCL approach and discusses the importance of Participatory Design (PD) in the design of this type of ICT applications. The analysis leads us to formulate three challenges around the problem of enabling participatory modes of design in which teachers create their own CSCL macro-scripts embedded in software environments. Besides, Chapter Two also explores research directions that envisage solutions to tackle the identified challenges. These directions include the use of design patterns and Educational Modelling Languages (EMLs) as well as their combined application through design processes integrated in authoring tools for the creation of computer-interpretable scripts.
- Chapter Three is devoted to the research direction referred to the use of design patterns. Its main function is to identify the types of patterns and the relationships between them that can be jointly applied in the design of CSCL scripts. In this sense, it presents a model for CSCL scripting pattern languages and discusses a specific pattern language (PL) which is compliant with the model. To illustrate that the PL enables the generation of many scripts, the chapter also includes three authentic situations that apply a sequence of interconnected patterns selected from the PL.
- Chapter Four in turn analyzes the suitability of IMS Learning Design (LD) specification, the most significant EML at the moment, for computationally representing CSCL macro-scripts. In this sense, it points out important requirements of the scripts and studies the possibilities and limitations of the specification to support them. In the analysis, which is illustrated by means of relevant cases, the scope of the LD notation is confronted to the role of related tooling facilities and eventually complementary specifications.
- Chapter Five proposes a design process that combines the contributions of the previous chapters. In particular, the design process facilitates the reuse of CLFPs (Collaborative Learning Flow Patterns, a particular type of CSCL scripting patterns) in the creation of CSCL macro-scripts represented with LD. The proposed design process is situated and compared to related work by means of a framework that conceptualizes different (existing and yet-to-come) approaches that drive the creation of full-fledged LD Units of Learning (UoL) by reusing different types of design solutions. Our proposal, targeting teachers without high (LD) technical knowledge, aims at achieving a satisfactory trade-off between particularizations of CLFP-based templates according to specific CL situations and the loss

of the solutions captured in CLFPs. Besides, the design process allows teachers to focus on CSCL critical features that are involved in the elicitation of expected interaction processes. The chapter also presents *Collage*, an authoring tool that implements the design process proving its feasibility and enabling its proper evaluation. Moreover, the creation of LD scripts using this authoring tool is illustrated with several examples.

- In Chapter Six the evaluation of the proposed design process is accomplished by means of a multicase study. The multicase study comprises three cases which aim at assessing the same contributions but from different perspectives. The first case is devoted to workshops where the target audience use the design process implemented in *Collage*. The second case implies the design of a scenario proposed by a third-party using our approach and its comparison with related approaches. The last case analyzes an authentic educational situation where students follow a script created according to the design process. The chapter finishes with a cross-case analysis which emphasizes the combined results of the studied cases as the global assumption of the evaluation.
- Chapter Seven draws together the main conclusions of the dissertation listing its main contributions and pointing out future research directions.
- Appendix A contains the CSCL scripting pattern language cited in Chapter Three.
- Appendix B includes three well-known CSCL scripts, two of which (Universanté and ArgueGraph) are also formulated as narrative use case descriptions and UML activity diagrams since they are used to illustrate the analysis of Chapter Four. The appendix also shows screenshots of their LD representations (UoLs) running with an LD engine. The ready-to-run UoLs are available in a CD-ROM attached at the end of the dissertation.
- The remaining appendixes (C and D) collect support data employed in the multicase study presented in Chapter Six. The raw data is also available in the attached CD-ROM.

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