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# Intelligent Adaptation and Personalization Techniques in Computer-Supported Collaborative Learning

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# Preface

Contemporary research efforts in the Computer-Supported Collaborative Learning (CSCL) domain have clearly emphasized the need for building flexible, adaptable and intelligibly operating technology systems that could provide a personalized, more productive and satisfactory learning experience to all group learners. The key premise of this endeavor is that intelligent adaptation and personalization techniques can offer the basis for dramatically extending the affordances of the CSCL technology infrastructure and relevant pedagogical design so that learning gains (cognitive and metacognitive) are maximized through elegantly orchestrated peer interaction and support. This perspective lies at the crossroads of Adaptive Educational Hypermedia Systems, Intelligent Tutoring Systems and Computer-Supported Collaborative Learning, expanding the perspective of the fields and setting innovative research agendas which put forward challenging opportunities for constructively exploring the interdisciplinary landscape.

Indeed these research agendas integrate issues which can be approached from different but complementary perspectives and are of interest to researchers of diverse backgrounds such as learning scientists, educators, engineers/computer scientists, instructional designers, the Learning Design community and still others. It is only natural, therefore, that during the last years several research groups internationally have made significant advances in the field, exploring various research questions relevant both to the technological and pedagogical dimension of integrating and promoting intelligent, adaptive and personalization techniques in the CSCL context.

This volume makes a distinctive contribution and further extends our collective experience in the field by bringing together the scientific work and outcomes of fourteen such research groups. Common underlying aspect of all these efforts is the researchers' consistent attempt to empower technology systems with essential flexible functioning that strengthens users in carrying out complex teacher-student and student-student learning interactions. In general, these systems aim to help making pre-task interventions (such as facilitating group formation tasks), support in-task peer interactions and domain specific activities while also offering possibilities for implementing students' post-task assessment that helps modifying the activity flow. This is not, however, a trivial task and the inherent complexity in building and evaluating the efficiency of such systems is highlighted also by current research outcomes indicating that either providing no support at all (i.e. free collaboration) or unwittingly imposing unnecessary restrictions to group

learners (“overscripting”) may have detrimental effects on learning. Thus, to attain beneficial system operation, designers need to carefully consider and investigate a multitude of factors relevant to collaborative learning settings, the complex interactions among them and their possible impact on learning.

Within this framework of considerations the fourteen contributions in this book draw the reader’s attention to different research directions and possibilities in the field; nevertheless, these diverse perspectives could be classified under three major themes: (1) *Design of Adaptive Learning Systems*, (2) *Interactive and Intelligent Learning Systems*, and (3) *Collaborative Learning Systems*.

More specifically:

(1) *Design of Adaptive Learning Systems*: extension of IMS-LD to overcome the limitations of IMS-LD modeling language to express adaptive interventions; use of adaptive techniques for adaptive CSCL scripts; use of collaborative scripting and adaptive patterns; presentation of case studies that use adaptive CSCL scripts.

IMS-LD is primarily a modeling tool which uses the metaphor of a theatrical play for describing a teaching-learning activity. Using IMS-LD developers can formally express a unit of learning, that is, a complete, self-contained unit of learning material and activities, such as a course, a module, a lesson etc. IMS-LD has become a de-facto standard in the CSCL field using concrete syntax and semantics which, however, can not adequately express the complex activity and data flow evident in the collaborative learning activities. Thus, extending the IMS-LD modeling capabilities and supporting interoperability is a major issue in current research agendas. In this volume, six contributions focus on the IMS-LD as well as the adaptive CSCL scripts and patterns to propose (a) the reuse of data flow designs in case of complex and adaptive collaboration scripts (Bordiés, Dimitriadis, Alario-Hoyos, Ruiz-Calleja, and Subert); (b) the combination of a Generic Service Integration system with an IMS Learning Design to provide a Unit of Learning (de-la-Fuente-Valentín, Pérez-Sanagustín, Santos, Hernández-Leo, Pardo, Kloos, and Blat); (c) concrete extensions to the IMS-LD specification, addressing a wide range of problems and omissions (König and Paramythis); (d) a framework for the integration of external and independent software components into IMS-LD through the use of a specific mediator component (Magnisalis and Demetriadis); (e) the implementation of the “adaptation pattern” approach in practice through the design and flexible operation of two prototype tools (Karakostas, Papamitsiou, and Demetriadis); and (f) the implementation of the “Students Team Achievement Divisions” (STAD) collaboration method as an online, adaptive collaborative design-pattern (Kordaki, Daradoumis, Fragidakis, and Grigoriadou).

(2) *Interactive and Intelligent Learning Systems*: exploration of the efficiency of interaction analysis methods that empower CSCL systems with adaptive capabilities; implementation of interactive and intelligent systems using agent technologies and formal languages.

Adaptation, when explored in the CSCL context, brings forth many significant and intriguing research questions related both to “behind the scenes” computational techniques (such as educational data mining and learning analytics methods) and also frontend (i.e. interface design) issues for making apparent to the user the results of adaptive operation. Moreover, empowering a system with both interactivity and intelligence and make it meaningful and useful to the user is not a trivial issue. Five chapters in this book cover relevant topics, such as: (a) investigating the relationship between adaptation and interaction analysis, with emphasis on asynchronous discussion platforms (Bratitsis); (b) introducing a specific interaction analysis tool (CoSyLMSAnalytics) to help teacher modify a typical Think-Pair-Share script (Petropoulou, Lazakidou, Georgiakakis and Retalis); (c) exploring the intelligence and interactivity as well as their alignment with the system’s design and feedback so that to model users’ expectations when interacting with the system (Benton, Altemeyer and Manning); (d) presenting the design of an intelligent monitoring agent that collects and aggregates information from a LAMS database (Chronopoulos and Hatzilygeroudis); and (e) presenting a system development approach that supports participants of a distance education forum by getting as input the discussion threads and outputs specific strings modelling the thread messages based on a formal language (Patriarcheas, Papaloukas and Xenos).

(3) *Collaborative Learning Systems*: analysis of collaborative learning interactions; assessment of collaboration quality; effectiveness of communities of practice.

When learners communicate and interact through various technological systems then a multitude of specific interactions emerge that need to be conceptualized and typified before developing computerized models that could enrich system operation and interventions. This theme emphasizes exactly the need for adequately modeling various aspects that concern the complex learner/user context and user-system interactions in a CSCL environment. Three contributions focus on the following topics: (a) Voulgari and Komis explore the massively multiplayer online games through a theoretical framework that helps analyze collaborative learning interactions; (b) Kahrmanis, Chounta, and Avouris employ an alternative analysis methodological approach to propose a rating scheme for the assessment of collaboration quality; (c) Kostas ad Sofos, research the literature and focus on defining a typology of critical elements for successful and sustainable Internet-mediated communities of practice.

# Introduction

Adaptation and personalization have been extensively studied in CSCL research community aiming to design intelligent systems that adaptively support eLearning processes and collaboration. Yet, with the fast development in Internet technologies, especially with the emergence of new data technologies and the mobile technologies, new opportunities and perspectives are opened for advanced adaptive and personalized systems. The adaptation and personalization are posing new research and development challenges to nowadays CSCL systems. On the one hand, the adaptation should be focused in a multi-dimensional way (cognitive, technological, context-aware and personal). On the other hand, it should address the particularities of both individual learners and group collaboration. Therefore, the analysis and design of adaptive systems should deal with these new views in order to better support learners and teachers.

The ultimate aim of this book is to discuss the latest advances and findings in the scope of intelligent adaptive and personalized learning systems as well as the design and their implementation. The book also analyzes the new implementation perspectives for intelligent adaptive learning and collaborative systems that are brought by the advances in scripting languages, IMS LD, educational modeling languages and learning activity management systems. Given the variety of learning needs as well as the existence of different technological solutions, the book exemplifies the methodologies and best practices through several case studies and adaptive real-world collaborative learning scenarios, which show the advancement in the field of analysis, design and implementation of intelligent adaptive and personalized systems.

## Main Contributions of This Book

Overall, the book covers the following research and development topics:

- *Design of Adaptive Learning Systems*: extension of IMS-LD to overcome the limitations of IMS-LD modeling language to express adaptive interventions; use of adaptive techniques for adaptive CSCL scripts; use of collaborative scripting and adaptive patterns; presentation of case studies that use adaptive CSCL scripts.
- *Interactive and Intelligent Learning Systems*: exploration of the efficiency of interaction analysis methods that empower CSCL systems with adaptive

capabilities; implementation of interactive and intelligent systems using agent technologies and formal languages.

- *Collaborative Learning Systems*: analysis of collaborative learning interactions; assessment of collaboration quality; effectiveness of communities of practice.

## Organization of the Book

Consequently, the 14 chapters of this book are organized in three major areas as follows:

### Part I: Design of Adaptive Learning Systems

**Chapter 1:** Osmel Bordiés, Yannis Dimitriadis, Carlos Alario-Hoyos, Adolfo Ruiz-Calleja, Andrés Subert. *Reuse of data flow designs in complex and adaptive CSCL scripts: A case study*

In this chapter the authors present a case study to overcome limitations of current approaches for data flow among CSCL activities. The authors have proposed an IMS LD solution to achieve reusability of data flow designs. The resulting solution is in addition interoperable. In the study a real-world complex CSCL script is considered in order to show the adaptive characteristics of the proposed approach.

**Chapter 2:** Luis de-la-Fuente-Valentín, Mar Pérez-Sanagustín, Patrícia Santos, Davinia Hernández-Leo, Abelardo Pardo, Carlos Delgado Kloos, Josep Blat. *System orchestration support for a collaborative blended learning flow*

The authors of this chapter have analyzed the new types of activities arising in CSCL due to the use of portable and interactive technologies. Then, the authors address the question of how the existing and new scenarios can be integrated to support collaborative processes without adding significant burden to the learners. The objective is therefore to efficiently organize and give structure to new types of complex collaborative blended learning scenarios. To achieve this goal the authors build a solution based on Unit of Learning suitable for instantiation with IMS Learning Design and complemented by a Generic Service Integration system.

**Chapter 3:** Florian König and Alexandros Paramythi. *Adaptive Collaboration Scripting with IMS LD*

In this chapter the authors propose an extension of IMS LD Language to overcome some limitations concerning the lack of support for comprehensive adaptation features. The proposed extension includes explicit representation of groups and corresponding collaboration contexts, flexible integration of communication and collaboration services, among others. The extension also provides a run time model and features to support event- and exception- handling. Examples are provided to show the advantages of the proposed extension for advanced collaboration scripts.



**Chapter 4:** Ioannis Magnisalis and Stavros Demetriadis. *Extending IMS-LD capabilities: A review, a proposed framework and implementation cases*

In this chapter the authors present a framework for the integration of external and independent software components into IMS-LD (Learning Design) based courses that cater for adaptivity. The proposed architecture introduces a mediator component as the key element to facilitate communication between Learning Design compliant e-courses and external tools that support collaborative learning (e.g. a forum, an agent, a service or a software component that provides a specific functionality). The authors provide example scenarios and also discuss some important issues toward integrating the adaptation pattern capabilities in IMS-LD compliant tools for collaborative learning design.

**Chapter 5:** Anastasios Karakostas, Zaharoula Papamitsiou and Stavros Demetriadis. *Prototype Tools for the Flexible Design of CSCL Activities based on the Adaptation Pattern Perspective*

The chapter presents the design and some preliminary evaluation data regarding two prototype tools (namely, FlexCoLab and PPR), which have been designed according to the prescriptions of the adaptation pattern perspective for promoting a flexible design of CSCL activities. Both tools aim to support teachers in the process of developing flexible designs of online collaborative activities by reusing and customizing adaptation patterns, according to the requirements of a particular learning situation. The authors present the theoretical background of the adaptation patterns approach, the design specifications of the two systems and student evaluation data from implementing an in-school collaborative learning activity supported by PPR.

**Chapter 6:** Maria Kordaki, Thanasis Daradoumis, Dimitrios Frigidakis, Maria Grigoriadou *Adapting the Collaborative Strategy “Students Team Achievement Divisions” in an Information Technology Work Place*

This chapter presents an innovative online adaptive collaborative design-pattern that implements the “Students Team Achievement Divisions (STAD)” collaboration method in a real world training-based scenario that takes place at an Information Technology work place, using the LAMS system. The approach used enabled to build a rich learning profile of the user that is subsequently employed to provide him/her personalized training, monitoring, scaffolding and evaluation.

## **Part II: Interactive and Intelligent Learning Systems**

**Chapter 7:** Tharrenos Bratitsis. *Examining the Interrelation between the Interaction Analysis and Adaptation Research Fields within Communication-based Collaborative Learning Activities: Convergence, Divergence or Complementarity?*

In this chapter the relation among two important aspects in CSCL, namely Adaptation and Interaction Analysis, is analyzed. The research question posed in this work is either these two aspects can be seen as complementary or if they would rather converge/diverge at thru long run in CSCL. The author uses AI methods to examine and correlate the main constituents of adaptation and interaction analysis

for the case of asynchronous discussion platforms. The objective is to highlight the similarities and links among adaptation and interaction analysis.

**Chapter 8:** Ourania Petropoulou, Georgia Lazakidou, Petros Georgiakakis, Symeon Retalis. *Making Adaptations of CSCL Scripts by Analyzing Learners' online Behavior*

The authors present a study on how to support teachers to create customized learning scripts in order to match needs of different learning strategies. These scripts are more appropriate to the learners' preferences and the learning context. To that aim, the authors suggest the use as a source for the scripts the learners' interaction data that is collected during an online learning process and analyzed using interaction analysis. A tool, called CoSyLMSAnalytics, is provided to support teachers at creating and modifying the learning scripts.

**Chapter 9:** Stephen Benton, Boris Altemeyer and Bryan Manning. *Behavioural Prototyping©: making interactive and intelligent systems meaningful for the user*

The authors in this chapter explore the intelligence and interactivity and their alignment with system's design and feedback. The concept of Behavioural Prototype© is introduced to characterize the interactive expectations and behaviour of users with the system.

**Chapter 10:** Themistoklis Chronopoulos and Ioannis Hatzilygeroudis. *The design of a teacher-driven intelligent agent system for supervising lessons in LAMS*

The authors of this chapter have presented an agent-based approach to support teachers in supervising and evaluating learners and activities in the Learning Activity Management System (LAMS). The activity monitoring is done through intelligent agents from LAMS data-base. On the other hand agents are used to notify users to support awareness. Finally the Systems feeds-back users with reports on ongoing activity.

**Chapter 11:** Kiriakos Patriarcheas, Spyridon Papaloukas and Michalis Xenos. *The text-based computer-mediated communication in distance education fora: A modelling approach based on formal languages*

The authors in this chapter are concerned with automating the interpretation of threads in asynchronous discussions. The proposed system is based on using content categories as a unit of analysis. The aim is to support participants of the discussion forum with updated information on the discussions carried out at the asynchronous forum.

## Part III: Collaborative Learning Systems

**Chapter 12:** Iro Voulgari, Vassilis Komis. *Antecedents of Collaborative Learning in Massively Multiplayer Online Games*

Massively Multiplayer Online Games is one important type of implementing collaboration processes for goal-oriented activities and collaborative and social interactions. The authors of this chapter have presented a theoretical framework for linking

learning and collaborative learning principles with MMOGs. The authors also investigate through an exploratory and qualitative approach, features of the tasks, groups, and player interactions that may support the emergence of collaborative interactions and learning. Based on that analysis, the critical factors of effective collaboration are identified.

**Chapter 13:** Georgios Kahrmanis, Irene-Angelica Chounta, Nikolaos Avouris. *Validating empirically a rating approach for quantifying the quality of collaboration*

The authors in this paper study the issue of how to effectively assess the success of the collaboration in CSCL by quantifying some indicators of collaboration processes. The authors have proposed a rating scheme for the assessment of collaboration quality by identifying first about 228 collaborating dyads in synchronous collaboration taking place in a problem-solving task.

**Chapter 14:** Apostolos Kostas, Alivisos Sofos. *Internet-mediated Communities of Practice: Identifying a Typology of Critical Elements*

Communities of practice have been identified in CSCL as means to achieve specific goals on informal learning and professional development. However there is a lack of a systematic theory or a blueprint for design of online communities. The authors define a basic typology of various critical elements for successful and sustainable Internet-mediated communities of practice, via a meta-analysis and critical synthesis of related literature.

## Targeted Audience and Last Words

The chapters of this book cover an interesting set of research and development issues in CSCL aiming to better support intelligent and effective collaboration processes. The book is suitable to researchers, developers and practitioners in CSCL community interested in the analysis, design and use of intelligent techniques for an effective collaboration among learners and groups of learners. The book also covers the implications of the latest developments in networking and communication technologies such as mobile computing as well as advanced AI techniques to design and build blended learning scenarios. One salient feature of the book is dealing with the complex nature of collaboration from different angles and achieving thus a comprehensive view of the different intelligent techniques van be used altogether to analyze, design, develop, use and assess the collaboration. Therefore the book is useful for a wide range of researchers and developers in CSCL and especially those interested in the multi-facet nature of the collaboration.

Finally, academic researchers, professionals and practitioners in the field can also be inspired and put in practice the ideas and experiences proposed in the book for their specific goals.

We hope that the readers find this book useful and help accomplish their goals. Enjoy the reading!

## Acknowledgements

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