Social Personalized E-Learning Framework

By

Fawaz Ghali

Supervisor: Dr. Alexandra I. Cristea

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Acknowledgments

"Gratitude helps you to grow and expand; gratitude brings joy and laughter into your life and into the lives of all those around you."

Eileen Caddy (1917 – 2006)

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Declarations and List of Publications

"One can measure the importance of a scientific work by the number of earlier publications rendered superfluous by it."

David Hilbert

This thesis is presented in accordance with the regulations for the degree of Doctor of Philosophy. It has been composed by myself and has not been submitted in any previous application for any degree.

The work in this thesis has been undertaken by me under the supervision of Dr. Alexandra I. Cristea. Parts of this thesis were published previously on various publications.

To date, 14 peer-reviewed publications[1] have been published from this research:

1. **Ghali, F.** and Cristea, A. Interoperability between MOT and Learning Management Systems: Converting CAF to IMS QTI and IMS CP, AH 2008: 5th Int. Conf. on Adaptive Hypermedia and Adaptive Web-Based Systems. LNCS 5149. pp. 296–299. DOI 10.1007/978-3-540-70987-9_38, 2008. Hannover, Germany.
2. **Ghali, F.** and Cristea, A. Evaluation of Interoperability between MOT and regular Learning Management Systems. 3rd European Conference on Technology-Enhanced Learning EC-TEL. ISBN 978-3-540-87604-5, pp. 104-109. DOI 10.1007/978-3-540-87605-2_12. 2008. Maastricht, The Netherlands.
3. **Ghali, F.** and Cristea, A. Evaluation of Authoring for Adaptation and Delivery

[1] The full list of all peer-reviewed papers published by the author of this thesis can be retrieved from: http://go.warwick.ac.uk/fawazghali

via Learning Management System. The 11th IASTED International Conference on Computers and Advanced Technology in Education, CATE 2008. ISBN 978-0-88986-767-3. pp. 614-126. 2008. Crete, Greece.

4. **Ghali, F.** Sharp, M. and Cristea, A. Folksonomies and Ontologies in Authoring of Adaptive Hypermedia. A3H: 6th International Workshop on Authoring of Adaptive and Adaptable Hypermedia Workshop, AH 2008. Hannover, Germany.
5. **Ghali, F.** Cristea, A. Stewart, C. and Hendrix, M. Collaborative Adaptation Authoring and Social Annotation in MOT, A3H: 6th International Workshop on Authoring of Adaptive and Adaptable Hypermedia Workshop, AH 2008. Hannover, Germany.
6. Gross, T., **Ghali, F.** and Cristea, A. Communication and Collaboration Towards Problem Solving: Evaluation of PILS. 3rd European Conference on Technology Enhanced Learning EC-TEL 2008, IGACLE workshop. CEUR-WS.org/Vol-384. 2008 Maastricht, The Netherlands.
7. **Ghali, F.** Cristea, A. and Stewart, C. (2008). My Online Teacher 2.0. 3rd European Conference on Technology Enhanced Learning EC-TEL 2008, IGACLE workshop. CEUR-WS.org/Vol-384. 2008. Maastricht, The Netherlands.
8. **Ghali, F.,** Cristea, A. and Hendrix, M. Augmenting E-Learning Standards with Adaptation. The 11th IASTED International Conference on Computers and Advanced Technology in Education, CATE 2008. ISBN 978-0-88986-767-3. pp. 614-122. 2008. Crete, Greece. *Nominated for Best Paper Award.*
9. **Ghali, F.** and Cristea, A. Authoring for E-Learning 2.0: a Case Study. The 9th IEEE International Conference on Advanced Learning Technologies, ICALT 2009. ISBN: 978-0-7695-3711-5. pp. 170-174. DOI 10.1109/ICALT.2009.71. 2009, Riga, Latvia.
10. **Ghali, F.** and Cristea, A. MOT 2.0: A Case Study on the Usefuleness of Social Modelling for Personalized E-Learning Systems. Frontiers in Artificial Intelligence and Applications, Volume 200, 2009 Artificial Intelligence in

Education - Building Learning Systems that Care: From Knowledge Representation to Affective Modelling, ISBN 978-1-60750-028-5, pp 333 - 340, DOI: 10.3233/978-1-60750-028-5-333.

11. **Ghali, F.** and Cristea, A. Social Reference Model for Adaptive Web Learning. International Conference on Web-based Learning, ICWL 2009. ISBN: 978-3-642-03425-1. pp. 162-171. DOI: 10.1007/978-3-642-03426-8_21. 2009, Aachen, Germany.
12. **Ghali, F.** and Cristea, A. MOT 2.0: Learning 2.0 Tool. In the 4th. European Conference on Technology Enhanced Learning, EC-TEL 2009, 2009. Nice, France.
13. Cristea, A. **Ghali, F.** and Joy, M. Social, Personalized Lifelong Learning. E-Infrastructures and Technologies for Lifelong Learning, book chapter. IGI Global. ISBN-13: 9781615209835. 2010.
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Abstract

This thesis discusses the topic of how to improve adaptive and personalized e-learning in order to provide novel learning experiences. A recent literature review revealed that adaptive and personalized e-learning systems are not widely used. There is a lack of interoperability between adaptive systems and learning management systems, in addition to limited collaborative and social features.

First of all, this thesis investigates the interoperability issue via two case studies. The first case study focuses on how to achieve interoperability between adaptive systems and learning management systems using e-learning standards and the second case study focuses on how to augment e-learning standards with adaptive features. Secondly, this thesis proposes a new social framework for personalized e-learning, in order to provide adaptive and personalized e-learning platforms with new social features. This is not just about creating learning content, but also about developing new ways of learning. For instance, in the presented vision, adaptive learning does not refer to individuals only, but also to groups. Furthermore, the boundaries between authors and learners become less distinct in the Web 2.0 context.

Finally, a new social personalized prototype is introduced based on the new social framework for personalized e-learning in order to test and evaluate this framework. The implementation and evaluation of the new system were carried out through a number of case studies.

List of Abbreviations and Definitions

AEH	Adaptive Educational Hypermedia
AH	Adaptive Hypermedia
AHA!	Adaptive Hypermedia for All!: An Adaptive Hypermedia System
AHAM	Adaptive Hypermedia Application Model: A framework for Adaptive Hypermedia
AHS	Adaptive Hypermedia Systems
ALE	Adaptive Learning Environment
API	Application Programming Interface
AM	Adaptation Model
CAF	Common Adaptation Format
DM	Domain Model
GAHM	Goldsmiths Adaptive Hypermedia Model
GM	Goal and Constraints Model
IEEE	Institute of Electrical and Electronics Engineers
IMS CP	IMS Content Packaging
IMS QTI	IMS Question and Test Interoperability
LAG 1.0	Layers of Adaptation Granularity: A framework for Adaptation
LAG 2.0	Layers of Adaptation Granularity: An Adaptation language
LAOS	Layered WWW AH Authoring Model and their corresponding Algebraic Operators: A framework for authoring of Adaptive Hypermedia
LMS	Learning Management Systems
LOM	IEEE Learning Object Metadata
MOT 1.0	My Online Teacher: An Adaptive Hypermedia Authoring System
MOT 2.0	My Online Teacher 2.0: An Adaptive Hypermedia Social Authoring and Delivery System.
PM	Presentation Model
SCORM	Sharable Content Object Reference Model
SLAOS	Social LAOS: Social Layered WWW AH Authoring Model and their

	corresponding Algebraic Operators: A framework for authoring of Adaptive Hypermedia
UM	User/learner Model
W3C	World Wide Web Consortium
XAHM	XML-based Adaptive Hypermedia Model
XHTML	Extensible Hypertext Mark-up Language
XML	Extensible Mark-up Language
XSL	Extensible Style-sheet Language

CHAPTER 1

"Research is to see what everybody else has seen and to think what nobody else has thought"

Albert Szent-Gyorgyi (1893-1986)

1. Introduction

1.1. Overview

Over the past decade, the web has constantly evolved in fundamental and innovative ways. The static presentation of information, or the 'one size fits all', was the case of the early web, where the content of a page would appear almost in the same way to all users, regardless of their backgrounds, interests, preferences or even their knowledge.

Conversely, personalization has been an important trend for almost 40 years now, if we speak of *user modelling* (Rich, 1979), almost 30 years if we refer to *intelligent tutoring systems* (Sleeman and Brown, 1982), and almost 20 years since *adaptive web systems* arrived (Brusilovsky, 1996b). In these systems, the content (and the navigation) can be adapted according to the user's interests, preferences or even their knowledge, to what is called the user model.

From the late 1990s, adaptive web systems research took a more systematic approach and a set of reference models have been developed. However, these models do not yet include the recent expansion of *social activities* in their architectures. Since the early 2000s, many applications began to rely on the users and their relations more than on the information itself. A large part of the modern web, the Web 2.0, is powered by the users, as its information is produced by them rather than by web site owners. By means of Web 2.0, every web page can be considered as the focus of a community, and each member of this community can evaluate, edit and share content with others (Wenger, 1998).

In the area of e-learning, the e-learning systems (particularly, Learning Management Systems (LMS)) offer flexible learning environments for the learners (individuals and/or groups) by extending time and place coordinates. However, issues regarding adapting and personalizing the learning environments have been raised. Learners have different learning preferences, knowledge levels, interests, and personalizing the learning environment can offer an enhanced learning experience compared to the traditional 'one size fits all' case.

This introductory chapter illustrates the general research outline of the work presented in this thesis, which overall belongs to the area of *social personalized e-learning*. Section 1.2 provides the motivation of this research and the problem description. Section 1.3 describes the research questions of this thesis. Section 1.4 presents the research aim and objectives of this thesis. Section 1.5 describes the research contribution of this thesis. Finally, Section 1.6 provides an outline of this thesis.

1.2. Motivation and Problem Description

Adaptive Educational Hypermedia Systems (AEHS) offer a personalized learning experience for each learner (Brusilovsky, 1996b). These systems can achieve learning objectives that are difficult to pursue using classical learning methods. Imagine the situation where a teacher needs to repeat the same lesson for each individual learner to fulfil his/her needs. For example, how can this teacher show/hide information for a specific learner? How can the same lesson be presented differently for each learner? This becomes, however, achievable, by using adaptive e-learning systems.

However, when it comes to *authoring of e-learning content for adaptation and personalization*, prior research shows that it is a traditionally difficult task, both for authoring of Intelligent Tutoring Systems (ITS) (Murray, 1999), (Höök et al., 1997), and Adaptive Educational Hypermedia (AEH) especially when performed in the form of 'one author does it all' (Brusilovsky, 2001). Adaptive lessons are normally a great deal more complex than their non-adaptive counterparts, requiring more time and expertise to be authored (Cristea et al., 2007). This problem becomes even more complex when the author needs to use the authored content in different adaptive e-learning systems. In such a scenario, how can the author determine which adaptive e-learning system to use? How can the author reuse the same content with different adaptive e-learning systems?

One solution to solve the previous limitations is to use the *interoperability* between e-learning systems (particularly, LMS). The interoperability works as a bridge between different systems, so that the same learning content can be reproduced, to be used in another system.

Another solution to overcome the difficulties of personalized e-learning authoring is to use the strengths of the Web 2.0, which are: 1) user-generated content; 2) harnessing the power of the users by collaborative authoring and social annotations techniques; 3) generating richer authored materials based on communities of practice (Wenger, 1998). Authors who belong to the same community can cooperate in providing more valuable e-learning content within the community, based on their different backgrounds and knowledge.

Another key issue in adaptive and personalized e-learning systems is that collaborative and social activities are not supported. They are however one of the key factors in e-learning environments. Therefore, these systems would not be able to compete with Learning Management Systems. Furthermore, novel e-learning systems have been benefiting from the strength of Web 2.0 (Anderson, 2007), coining the new term *e-learning 2.0* (Downes, 2005). E-learning 2.0 is a term that refers to the second generation of e-learning, which uses the technologies of the Web 2.0, such as *collaborative authoring* and *social annotation* (Ghali and Cristea, 2009a) (see Chapter 5 and Chapter 6). In e-learning 2.0, learners and teachers are all involved in the content creation process, and thus the strict delimitations between learners and teachers disappear. Moreover, the learners in e-learning 2.0 become active as they interact socially with each other. We believe that solving the interoperability issue and supporting collaborative and social activities would improve adaptive and personalized e-learning, in addition to providing novel learning experiences. In the following section, the main research questions, resulted from the problem described in the current section, are extracted.

1.3. Research Questions

The abovementioned state reveals a major drawback in the design of adaptive and personalized e-learning systems. Despite the advantages of these systems, they are not yet ready for the current state of the Web 2.0. Therefore, this thesis works on investigating the following questions in order to provide solutions for adaptive and personalized e-learning:

Research Question 1: *How can we bridge the gap between Learning Management Systems (LMS) and adaptive e-learning systems?*

This question can be further divided into two research sub-questions, which are:

Research Question 1a: *How can we provide interoperability between adaptive e-learning systems and Learning Management Systems (LMS)?*

Research Question 1b: *How can we augment e-learning standards with adaptation in order to provide novel learning experiences?*

Research Question 2: *How can we harness the Web 2.0 power and its characteristics (i.e., tagging, voting, commenting, and user-generated content) to improve adaptive and personalized e-learning?*

This question can also be further divided into three research sub-questions, which are:

Research Question 2a: *Can the current adaptive e-learning frameworks benefit from the strengths of the Web 2.0?*

Research Question 2b: *Are collaborative authoring and social annotations useful for authors and learners?*

Research Question 2c: *Can learning content recommendations and the expert peer recommendations of the learners enhance learning?*

In the following section, we transform these research questions into concrete objectives.

1.4. Research Aim and Objectives

The overall aim of this research is to improve adaptive and personalized e-learning in order to provide novel learning experiences. This aim is achievable by overcoming the limitations of these systems. The limitations covered in this thesis consist of: lack of interoperability between adaptive and personalized e-learning and LMS, in addition to limited collaborative and social features in adaptive e-learning systems.

The goal of this research is reachable via the use of e-learning standards in order to connect adaptive and personalized e-learning to LMS on one hand, and to enrich adaptive and personalized e-learning with the Web 2.0 features on the other. Hence the primary objectives of this research are:

1. Analysing the state of the art of the next generation of e-learning systems.
2. Finding the problems which are limiting the use of adaptive and personalized e-learning systems by studying the interoperability issue between these systems.
3. Comparing current adaptive frameworks and investigating the limitations of these frameworks.
4. Designing a new framework for social personalized e-learning.
5. Developing and implementing a new prototype based on the proposed framework.
6. Testing and evaluating the implemented prototype in various versions with various features in order to draw useful conclusions.

In the following section, the main contributions of this thesis are summarized.

1.5. Thesis Contributions

This thesis presents:

1) The *interoperability* issue, introduced in this thesis, is covered by two case studies: A). the *first case study* focuses on how to achieve interoperability between adaptive systems and Learning Management Systems using e-learning standards, and B). *the second case study* focuses on how to augment e-learning systems with adaptive features. Thus, a set of e-learning standards converters

were developed and evaluated that facilitate the connections between adaptive systems and Learning Management Systems.

2) *A new social personalized framework for e-learning*: This new framework is designed to overcome the limitations of the current adaptive and personalized e-learning systems. This is achieved by using the benefits of e-learning standards to tackle the interoperability issue, in addition to using the strength of the Web 2.0 to overcome the limited collaborative and social features of the current adaptive and personalized e-learning systems. The new social personalized framework for e-learning is named SLAOS, and the new prototype is named MOT 2.0.

3) *Building a new system, MOT 2.0,* that corresponds to the social personalized framework for e-learning, SLAOS. Moreover, this system has been built in three iterations, each presented and followed by a case study, towards building the combination of features that illustrates the SLAOS framework.

The various collaborative and social features that have been introduced in this thesis are illustrated via a number of case studies, which include pre-design, prototypes and evaluations. The results of the evaluations are further discussed in detail, and interesting findings about collaboration of both authors and learners, are highlighted.

1.6. Thesis Outline

In this section we outline the structure of this thesis, giving a short description of each chapter. Chapter 1, the current chapter, gives an introduction to the thesis, including an overview of this research, in addition to the motivation that led to the research and the problem description. It highlights the research questions, as well as the research aim and its objectives. Finally it mentions the main thesis contributions and the thesis outline. Chapter 2 provides the research background, firstly describing adaptive and personalized e-learning, including the current state of the art of this research area. It also provides an overview of current adaptive e-learning frameworks.

Chapter 3 provides a case study of the interoperability between MOT 1.0 and Learning Management Systems. It also describes the conversion from CAF to IMS QTI and IMS CP, in addition to explaining the utilization of JAXB. Chapter 4 presents a case study of augmenting e-learning standards with adaptation. The case study adapts the IMS QTI and IMS CP standards using the authoring tool MOT 1.0, followed by a scenario and discussion on how to use the adapted learning content in the delivery system AHA!.

Chapter 5 provides a pre-design case study of MOT 2.0. It first describes MOT 1.0 with its restricted collaborative features, and then proposes a method for extending the collaboration features in MOT 1.0. Chapter 6 presents a social reference framework for personalized adaptive e-learning, SLAOS. It explains the state of the art of Web 2.0, personalization and adaptation. Also, this chapter presents the first prototype of MOT 2.0.

Chapter 7 presents the second prototype of the MOT 2.0 system. It describes the features of the second prototype, as well as the tested hypotheses, the case study, followed by discussing the results and summarizing the work. Chapter 8 presents the third MOT 2.0 prototype. It describes the features of this third prototype, as well as the tested hypotheses, the case study, followed by a discussion of the results and summarizing the work. Chapter 9 summarizes the research work in this thesis, in addition to discussing its limitations, as well as the future directions. This chapter also describes the degree to which the research aims and objectives of this thesis were reached, in addition to providing answers to the research questions targeted in this thesis.

To conclude, this chapter presented the motivation that led to the research and the problem description. Moreover, it highlighted the research questions, as well as the research aim and its objectives. Finally it mentioned the main thesis contributions and the thesis outline. The next chapter will provide the research background, by describing adaptive and personalized e-learning, in addition to presenting the current state of the art of this research area. The next chapter will also provide an overview of current adaptive e-learning frameworks, followed by a summary of their common features.

CHAPTER 2

"Keep on the lookout for novel ideas that others have used successfully. Your idea has to be original only in its adaptation to the problem you're working on."

Thomas Edison (1847-1931)

2. Research Background

This chapter provides a background to research in the adaptive and personalized e-learning area. It investigates its advantages as well as its current limitations that have caused it to not be as widely used as expected. Moreover, the chapter explores the architectures of adaptive e-learning frameworks, as well as explaining some of the popular adaptive e-learning systems. Moreover, the chapter also describes the concepts of Web 2.0, e-learning 2.0, and Learning Management Systems. The chapter lists (relevant) related EU research projects, draws conclusions on the main limitations in adaptive e-learning systems, and describes how to overcome these limitations.

2.1. Learning Management Systems

Learning Management Systems are e-learning applications that can be used to facilitate the access to learning content, as well as collaborations between teachers and learners (Hauger and Köck, 2007). Learning Management Systems are powerful e-learning systems that support the needs of teachers and learners. Teachers can use LMS to create e-learning courses, online assessments, quizzes, or even to communicate with learners via collaborative tools such as chat, discussion forums or bulletins. Moreover, Learning Management Systems have scheduling tools, such as calendars and timetables.

Examples of popular Learning Management Systems include Sakai, Moodle and Blackboard:

- *Sakai*: Sakai is a Java-based, service oriented application that is designed to be adaptable, scalable, reliable and interoperable. For *coursework and assignments*, Sakai provides tools to enhance teaching and learning. For *collaboration* and team working, Sakai has the functionality to support communication between students and teachers, and organize collaborative work.
- *Moodle*: Moodle stands for "Modular Object-Oriented Dynamic Learning Environment", and it is an open source LMS. Moodle facilitates course management using the following modules: Assignment Module, Chat module, Choice Module, Forum Module, Glossary Module, Lesson Module, Quiz Module, Resource, Survey Module, Wiki Module and Workshop Module.
- *Blackboard:* Blackboard is a commercial Learning Management System that is developed by Blackboard Inc. Blackboard's features include course management, a customizable portfolio, and a scalable architecture that facilitates integration with student information systems and authentication protocols. Blackboard also includes Communication Announcements, Discussions, Mail, Course content, Calendar, Learning modules, Assignments, Grade Book and Media Library.

Learning Management Systems are further discussed in detail in Chapter 3 and Chapter 4.

2.2. Web 2.0 and E-learning 2.0

Since the early 2000s, many web applications began to rely on the users and their interactions more than on the web content itself. A large part of the modern web, the Web 2.0, is powered by the users, as its information is produced by them rather than by web sites owners. By means of Web 2.0, every web page can be considered as the focus of a community, and each member of this community can evaluate, edit and share content with others (Wenger, 1998). The individual technologies which collectively make Web 2.0 have for several years attracted the interest of educators, and of these, Blogs (Downes, 2004) and Wikis (Lamb, 2004) and (Guth, 2007) have high profiles. More recently, the availability of such technologies on mobile devices has contributed to an interest in mobile delivery of Web 2.0 based educational services (Yau and Joy, 2008).

Web 2.0 is still a controversial term which encompasses a large number of concepts and technologies, each of which has to some extent been applied in an educational context. Whilst a detailed discussion of all of these is beyond the scope of this chapter, the reader should view our research into personalization as one aspect of educational Web 2.0 which inevitably overlaps with other pedagogic research. Figure 1 shows the main functionalities and ideas that are related to the Web 2.0. Web 2.0 sites, such as YouTube, Flickr and Del.icio.us, use content tagging, rating and feedback to facilitate interactions between the users. Some of these web sites interact with each other to provide Mashups, which are web applications that use combined data from two or more sources to create new services (see also Chapter 6).

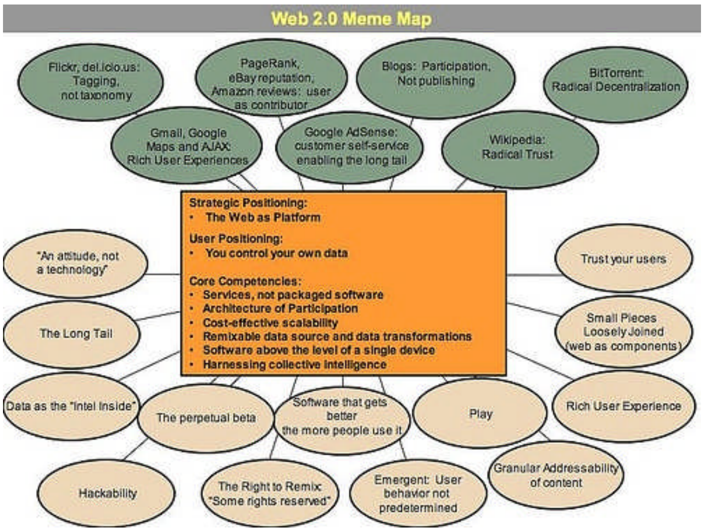

Figure 1 The Web 2.0 Meme Map[2]

E-learning 2.0 (Downes, 2005) is a term that refers to the second generation of e-learning, which uses the technologies of the Web 2.0, such as collaborative authoring and social annotation (Ghali and Cristea, 2009a) (see Chapter 5 and Chapter 6). In e-learning 2.0, learners and teachers are all involved in the content creation process, and thus the strict delimitations between learners and teachers disappear. Moreover, the learners in e-learning 2.0 become active as they interact socially with each other. The Web 2.0 and e-learning 2.0 are further discussed in detail in Chapter 5.

[2] http://oreilly.com/web2/archive/what-is-web-20.html

2.3. Adaptive E-Learning Research Background

The aim of adaptive e-learning systems is to overcome some specific limitations of traditional e-learning systems. These systems can achieve learning objectives that are difficult to achieve using classical e-learning systems, as follows. In e-learning systems, all learners are offered the same learning content, regardless of their knowledge. The knowledge of different learners can vary and can grow in different ways (Brusilovsky, 1996b). For example, a course can be unclear for a beginner learner and at the same time it can be trivial for an advanced learner.

Brusilovsky (Brusilovsky, 2004) classified the work on this research area into three generations. The first generation belongs to the early 1990s, where a number of research groups worked on the problem related to navigation in hypermedia, and other research groups worked on problems related to the presentation. In this generation, a number of Adaptive Educational Hypermedia Systems (AEHS) were launched in the period between 1990 and 1996. These systems can be categorised in two streams. The first stream focused on extending classical learner modelling and adaptation developed in this field to intelligent tutoring systems with hypermedia components. The second stream focused on educational hypermedia, in an effort to make educational hypermedia systems adapt to individual learners.

The second generation began in 1996, the research on Adaptive Educational Hypermedia Systems (AEHS) started to grow. There are two factors behind this growth; the first factor is the increase of research experience in the field, and the second factor is the speedy increase in the use of the Web. Thus the key factor behind the second generation of Adaptive Educational Hypermedia (AEH) was e-learning (web-based learning). Examples of such systems are: InterBook (Brusilovsky et al., 1998), ELM-ART (Weber, 1999), KBS Hyperbook (Nejdl and Wolpers, 1999), TANGOW (Carro et al., 1999a), AHA! (De Bra and Calvi, 1998), and NetCoach (Weber et al., 2001). The research on the second generation of Adaptive Educational Hypermedia (AEH) took place between 1996 and 2002.

The third generation was characterized by the challenge of integrating Adaptive Hypermedia (AH) into the regular educational process. Despite the fact that the systems of the second generation of Adaptive Educational Hypermedia (AEH) research established various methods to integrate Adaptive Hypermedia into e-learning, they failed to influence practical e-learning, mainly because of their lack of ability to answer the needs of practical e-learning (Brusilovsky, 2004). Learning Management Systems are e-learning applications that can be used to facilitate access to learning content, as well as collaborations between teachers and learners (Hauger and Köck, 2007). Furthermore, LMS are powerful e-learning systems that support the needs of teachers and learners. Teachers can use LMS to create e-learning courses, online assessments, quizzes, or even to communicate with learners via collaborative tools such as chat, discussion forums or bulletins. Moreover, LMS have scheduling tools, such as calendars, timetables, etc.

Another key issue preventing adaptive e-learning from becoming popular, is that authoring adaptive lessons is normally a great deal more complex than their non-adaptive counterparts, requiring more time and expertise (Cristea et al., 2007). This problem becomes even more complex when the author needs to use the authored content in different adaptive e-learning systems. One solution to the previous limitations is to enhance the interoperability between e-learning systems (particularly, LMS). Interoperability can work as a bridge between different systems, so that the same learning content can be reproduced to be used in different system.

Another solution to overcome the difficulties of personalized e-learning authoring is to use the strengths of Web 2.0, which are: 1) user-generated content; 2) harnessing the power of the users by collaborative authoring and social annotations techniques; 3) generating richer authored materials based on communities of practice (Wenger, 1998). Authors who belong to the same community can cooperate in providing more valuable e-learning content within the community, based on their different backgrounds and knowledge.

A further issue in adaptive and personalized e-learning systems is that collaborative and social activities are often not supported; therefore, these systems would not be able to compete with popular Learning Management Systems, in which such activities are considered a key factor. Moreover, the e-learning systems have benefited from the strength of the Web 2.0 (Anderson, 2007), to form the new term, "e-learning 2.0" (Downes, 2005). E-learning 2.0 is a term that refers to the second generation of e-learning, employing the technologies of the Web 2.0, such as collaborative authoring and social annotation (Ghali and Cristea, 2009a) (see Chapter 5 and Chapter 6). In e-learning 2.0, learners and teachers are all involved in the content creation process, and thus the strict delimitations between learners and teachers disappear. Hence, the learners in e-learning 2.0 become active, as they interact socially with each other.

Nevertheless, the most popular Learning Management Systems have not yet employed the advantages offered by adaptation, possibly because the expected profit does not yet justify the high effort of implementing and authoring adaptive courses (Hauger and Köck, 2007). However, the majority of adaptive e-learning systems do not support e-learning standards (Paramythis and Loidl-Reisinger, 2004). According to Brusilovsky (Brusilovsky, 2004) the generation that is coming to replace Learning Management Systems will be based on system interoperability and reusability of content to be supported by a number of emerging standards. Hence, the interoperability and reusability of learning contents can be seen as a solution to bridge the gap between adaptive e-learning and Learning Management Systems.

This thesis investigates the interoperability and reusability issue via two case studies. The first case study focuses on how to achieve interoperability between adaptive systems and learning management systems using e-learning standards, and the second case study focuses on how to augment e-learning standards with adaptive features, as well as the limited collaborative and social features in adaptive e-learning systems available at the start of this research. Thus, the next section focuses on investigating adaptive e-learning frameworks, and compares them in relation to the issues highlighted above.

2.4. Adaptive E-Learning Frameworks

Previous research into personalization for the web belongs to the larger category of Adaptive Hypermedia research – the web being an instance of hypermedia, where nodes are pages and links are hyperlinks, and personalization in this context means user-based adaptation. In this section we examine the most important frameworks for personalization on the web, in order to consider the different aspects of adaptation and personalization on the one hand, and on the other, to select a platform on which to base social extensions.

Many adaptive (educational) hypermedia systems have been launched since the early 1990s; however, until the late 1990s, there was no structural design or standard model for learning Adaptive Hypermedia Systems (AHS). One of the first models designed was the Adaptive Hypermedia Application Model (AHAM) (De Bra et al., 1999), followed by the Web Modelling Language (WebML) (Ceri et al., 2000), the Goldsmiths Adaptive Hypermedia Model (GAHM) (Ohene-Djan, 2000), the Munich reference model (Koch and Wirsing, 2001), the XML Adaptive Hypermedia Model (XAHM) (Cannataro and Pugliese, 2002), the LAOS framework (Cristea and de Mooij, 2003c), and the Generic Adaptation Model (GAM) (de Vrieze et al., 2004), among the most well-known ones.

2.4.1. The Adaptive Hypermedia Application Model

AHAM (De Bra et al., 1999) is based on the Dexter model (Halasz and Schwartz, 1994), a reference model for hypertext systems. AHAM divides adaptive (educational) hypermedia systems into three layers: the *run-time layer*, the *storage layer* and the *within-component layer*, connected by the *interfaces presentation specifications* and *anchoring*. The focus of AHAM is the storage layer with its three sub-models (see Figure 2):

1. the *domain model*, consisting of a set of concepts and concept relationships;
2. the *user model*, containing concepts with attributes, used to store user preferences or knowledge-of or interest-in domain model concepts; and
3. the *adaptation model*, which consists of adaptation rules that use the attribute values of concepts in the user model in order to determine if and how to present concepts and links from the domain model.

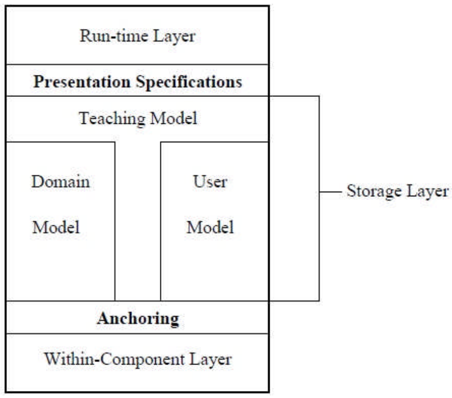

Figure 2 The AHAM Model (De Bra et al., 1999)

The main advantages of AHAM are that it is a relatively simple model, which allows for separation of concerns. The separation into layers helps to define the main components that need to be created by an author. However, AHAM does not make full use of other potential advantages of the separation into layers: for instance, reusability is not supported.

In principle, having separate layers would allow for one domain model to be used in different adaptation or user models. However, this is not possible in AHAM, due to the fact that the adaptation rules apply to concrete domain model concepts, and cannot be re-applied to others. Moreover, reusability would mean that authors could be assigned different roles on each layer, and this would speed up the development process by enabling developers to work in parallel on the different layers – which is not possible in AHAM due to the interdependencies between the layers.

For this reason, after analysing it, AHAM was not chosen as the basis for our new framework for the development. An example system based on AHAM is AHA! (De Bra and Ruiter, 2001) proposed by Eindhoven University of Technology.

2.4.2. The Munich Reference Model

The Munich Reference Model (Koch and Wirsing, 2001), developed at the Ludwig-Maximilians University of Munich, also extends the Dexter storage layer with user and adaptation models, and has a *run-time layer*, a *storage layer* and a *component layer*.

It is very similar to AHAM, but its main differences are (Koch and Wirsing, 2001) that it:

1. uses an object-oriented software engineering approach, whereas AHAM uses a database approach;
2. uses the Unified Modelling Language (UML) specification (AHAM uses an adaptation rule language); and
3. includes the AHAM adaptive engine in the adaptation model, as data and functionality are integrated in the object-oriented method.

The main advantage of the Munich Reference Model is that both (1) and (2) ensure a more widespread approach, in the sense that software engineering and UML are well understood outside the personalization and adaptation communities. On the other hand, the Munich Reference model shares both the other advantages and disadvantages of the AHAM model. For example, just like the AHAM model, the Munich model represents prerequisites in the domain model, and bases its domain structure on pages, adding information about how the content will be presented to the final user directly in the domain model. This makes reuse of any of the layers almost impossible, as they are heavily interconnected. Therefore, after analysing it, this model was also dropped.

2.4.3. WebML

WebML (Ceri et al., 2000) is also a visual language like UML, but is specifically designed for describing the content structure of web applications. The specification of a web site in WebML has four orthogonal perspectives.

1. The *structural model* describes the content in terms of the relevant entities and relationships.
2. The *hypertext model* describes how the contents are published on the application hypertext (Ceri et al., 2000).
3. The *presentation model* describes the layout and graphic appearance of pages.
4. The *personalization model* describes users and their organization in groups in the form of entities called *user* and *group*, and defines personalization based on the data stored in these entities.

The main advantages of WebML as reported in (Wright and Dietrich, 2008) are platform independence, the inclusion of a CASE tool, and messaging capabilities (allowing the WebML model to access query parameters directly). However WebML lacks browser control, lifecycles, UI modelling, standards and meta-models.

However, the main disadvantage is the fact that group interaction is not representable (recommendation of one user to another, for instance). Also, the high-level definition of content and structure is closely related both to a given XML DTD (XML Document Type Definitions)[3] syntax, which makes it less flexible, and to low-level, presentation-driven aspects (such as scroll), despite the fact that WebML includes a separate presentation model. An example of a WebML model-based system is WebRatio (Acerbis et al., 2004), which allows modelling and automatic generation of Java web applications. Due to the issues listed above, however, WebML was not chosen for our framework.

2.4.4. The XML Adaptive Hypermedia Model

The XML Adaptive Hypermedia Model (XAHM) (Cannataro and Pugliese, 2002) is an XML-based model for Adaptive Hypermedia (AH) systems with an *application domain*, a *user* and an *adaptation model*. Here however the similarity with previous models ends. XAHM not only describes the different sub-models from a theoretical point of view, but it also dictates the composition of the instances of these models, e.g. the fact that presentation descriptions need to be in XML, fixed by a DTD.

Moreover, XAHM is highly reliant on mathematical models, graph theory and probability computations. The user model contains, in addition to data on the current profile, probability distribution functions that map a user over a number of profiles. Moreover, adaptation is represented as a function defined on a three-dimensional input-output space: the *user's behaviour*, the *technology* and *the external environment*. Finally, the application

[3] http://www.xmlfiles.com/dtd/

domain is composed of a graph-based layered model for describing the logical structure of the hypermedia and XML-based models for describing the metadata for basic information fragments, as well as elementary abstract concepts connected via weighted, dynamically computed links for navigation between elements.

The main advantage of XAHM is that it is the first attempt to create elegant mathematical modelling of the adaptation process; another advantage is that of allowing the adaptation in three dimensions (Cannataro and Pugliese, 2002): the behaviour of the user (i.e., preferences and activity history); the technology dimension (operating system, internet connection, access device, etc.); and the external environment (weather, time-zone, geographical location, etc.), which are not sufficiently treated and separated in previous models.

However, the main disadvantage is that it hides adaptation and personalization, partially in the user model (via probability density computations), partially in the application domain model (where weights are probabilistically computed between navigational elements), and finally, in the adaptation model. This distribution of adaptation is hard to follow, and tools based on it can be difficult to handle by teachers, for instance. An example of a tool based on XAHM is the Java Adaptive Hypermedia Suite (JAHS) (Cannataro and Pugliese, 2002). Due to the above issues, however, XAHM was not chosen for our framework.

2.4.5. LAOS

The LAOS framework (Cristea and de Mooij, 2003c) is a general framework for authoring Adaptive Hypermedia (see Figure 3), loosely based on the AHAM model, also presenting however some features of the WebML language, with which it shares the presentation model. It consists of a *Domain Model* (DM), a *Goal and Constraints Model* (GM), a *User Model* (UM), an *Adaptation Model* (AM) and a *Presentation Model* (PM).

LAOS differs from other models by introducing the goal and constraints model. This layer supports the original aim of Adaptive Hypermedia from the perspective of the designer (or teacher, in educational environments, hence pedagogic information, or business logics for commercial sites), something that was missing in previous models (Cristea and de Mooij, 2003c).

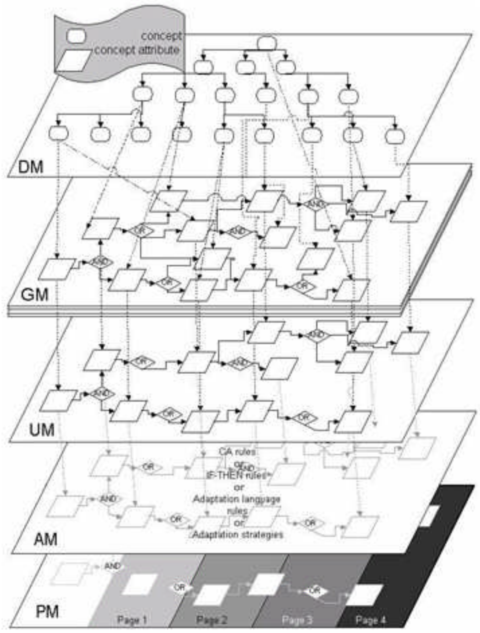

Figure 3 The LAOS Model (Cristea and de Mooij, 2003c)

Furthermore, LAOS's AM is different from that of AHAM. The adaptation model is based on the three layer LAG model (Cristea and Verschoor, 2004) for authoring adaptation, which allows different entry and reuse levels for adaptation specification, depending on whether the author has programming skills or not. Thus, the initial threshold for creating adaptation can be lowered.

The major difference between LAOS and AHAM (and other models) is a higher level of reuse, due to the clear separation of primitive information (content) and presentation-goal related information, such as pedagogical information in educational systems and prerequisites. For instance, since prerequisites are not hard-wired in the domain model, elements of the domain can be used in different settings and sequences to those initially intended. In this way, LAOS facilitates a high degree of information reuse by separating information from its specific context. This separation is expressed by having two different models, instead of one: a domain model (DM) and a goal and constraints model (GM).

Another important difference is given by the notion of 'concept' used in the domain model. In LAOS, concepts have different representations defined via attributes, and are restricted to representing a semantic unity (unlike in AHAM). This is further enforced by allowing only self-contained attributes (without direct or indirect dependencies). This setting allows attributes to be flexibly re-ordered, and links are therefore external and can be dynamic. Unlike some of the other models, such as XAHM or WebML, LAOS does not prescribe a unique representation for each layer, but just specifies its contents. Thus, each layer could be represented by databases, XML, state machines, etc.

Moreover, the adaptation model, LAG, only specifies the different entry levels for reuse (whole strategy, high level adaptation language patterns, or low level adaptation 'assembly' language patterns such as `if-then` rules) but does not enforce a specific language. Due to these advantages, LAOS was used as the base framework for the research presented in this thesis.

2.4.6. Summary of Adaptive E-Learning Frameworks

At present, there is no standardised way to do this comparison, as there are no standards for frameworks comparison. Thus, a number of features have been selected:

- ***Reusability***: If the authored learning content is reusable, or parts of the authored courses can be reused by the original author, as well as by other authors.
- ***User roles***: If the model clearly supports different roles, such as teachers and learners, or different types of authors.
- ***Flexibility***: If the model has a specific format of the content, and how flexible the format is, in order to be recombined.
- ***Standards***: If the model supports standards, which allow importing and exporting of courses.
- ***Pedagogical layer***: The pedagogical layer should contain adaptation rules separated from the learning content, for easy reuse of pedagogical approach.
- ***Grouping*****:** If the model supports user grouping; this can categorize users in

different groups with different roles.

- ***Social interaction*****:** If the model supports social activities such as tagging, rating and providing feedback.
- ***Data representation***: Defining the model data format that is used to represent the data.
- ***Target area****:* Defining the area that the model can be used in. Generally, the area is adaptive e-learning. However, for example, the WebML model is targeted at general web applications.

Table 1 Comparison between Adaptive E-Learning Frameworks

	AHAM	***Munich***	***WebML***	***XAHM***	***LAOS***
Reusability	TSE[4]	No	TSE	No	Yes
User roles	No	No	Yes	No	Yes
Flexibility	Yes	No	No	No	Yes
Standards	No	TSE	TSE	TSE	TSE
Pedagogic layer	No	No	No	No	Yes
Grouping	No	No	Yes	No	No
Social interaction	No	No	No	No	No
Data representation	DB /XML	Object-oriented	UML	XML	DB /XML
Target	AEHS	AEHS	WebApp	AHS	AEHS

2.5. Current Adaptive E-Learning Systems

This section gives an overview of some popular adaptive e-learning and authoring systems. The presented systems are InterBook (Brusilovsky et al., 1998), AHA! (De Bra and Calvi, 1998), KBS Hyperbook (Nejdl and Wolpers, 1999) and MOT 1.0 (Cristea and de Mooij, 2003a).

[4] To some extent

2.5.1. InterBook

InterBook (Brusilovsky et al., 1998) is one of the first adaptive systems for authoring and delivering adaptive electronic textbooks on the Web. It uses two types of knowledge, knowledge about the course being taught, and knowledge about learners. The domain model presents the structure of an adaptive electronic textbook. The domain model provides a structure for representation of the learner's knowledge. For each domain model concept, an individual learner's knowledge model stores some value which is an estimation of the student knowledge level of this concept.

All learners' actions (page access, problem-solving, answering questions) are stored and used to update knowledge levels for the related concepts. Another component of the student model is the model of student's learning goals. In addition, each learner may have a learning goal. A learning goal is a set of concepts to be learned. According to Brusilovsky (Brusilovsky et al., 1998):

> *"A sequence of assigned learned goals forms an individual order of learning. Adaptive guidance mechanisms will ensure that the student achieves the first learning goal in a sequence, then the second one, and so forth."*

InterBook uses coloured bullets and changed font styles (different font size, bold fonts) to achieve adaptive navigation support via link annotation. In addition to links annotation InterBook provides direct help about the recommended next page the learner should access. Moreover, InterBook also uses navigation support.

2.5.2. KBS Hyperbook

The Knowledge Based Systems Hyperbook (Nejdl and Wolpers, 1999) is a tool for designing open adaptive hyperbook courses on the web. It was implemented in the Institut für Rechnergestützte Wissensverarbeitung, University of Hannover, Hannover, Germany. The open feature means the system is able to integrate distributed information resources. For example, the KBS Hyperbook was used for an introductory course "Introduction to Programming in Java" in the computer science department at University of Hannover, and the course was integrated with pages from the Sun Java Tutorial into a hyperbook. According to Henze and Nejdl (Henze and Nejdl, 1999):

> “*the adaptation techniques used for this course are based on a goal-driven approach. This allows students to choose their own learning goals and to get suggestions for suitable projects and information units covering the knowledge required to reach these learning goals.*”

The learning content (domain model) of the hyperbook consists of *semantic information units* and *project units*. Both of these refer to the real content to be displayed on the Web as pages of the hyperbook (Nejdl and Wolpers, 1999):

- SemanticInformationUnits: refers to information units about Java Objects. They are indexed by KnowledgeItems, which gives for each knowledge item one main information unit.
- ProjectUnits represent project descriptions, and are indexed by those knowledge items which the student needs to know in order to successfully work on these projects.

The learner model in the KBS Hyperbook system is based on a pedagogical component. This pedagogical component consists of the knowledge items and adds a partial sequence between these knowledge items, to describe learning dependencies. The KBS Hyperbook system uses the Bayesian network for modelling the learner's knowledge (Henze and Nejdl, 1998).

2.5.3. AHA!

The AHA! system (De Bra and Calvi, 1998) was developed at the Eindhoven University of Technology. AHA! stands for “Adaptive Hypermedia Architecture”, and provides *adaptive presentation* and *adaptive navigation support*. The architecture of AHA! is presented in Figure 4. The AHA! system uses Java servlets that interact with a combined *domain/adaptation model* and with a *user mode* (De Bra et al., 1999). The *adaptive presentation* in AHA! is based on inserting/removing fragments techniques. Any condition on the user model can be used to make a decision of including or excluding a fragment. Whereas the *adaptive navigation* support in AHA! consists of the following parts:

- The link anchor tag can have a class (style sheet deterring the colour) attribute based on the user model.
- An arbitrary set of icons can be displayed before or after the link anchor, based also on the user model.
- The link destination represents the name of a concept from the domain model.

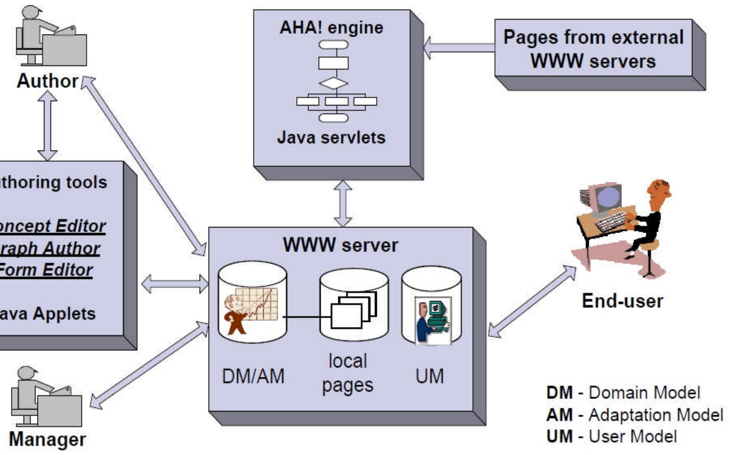

Figure 4 AHA! architecture (Stash and De Bra, 2004)

2.5.4. My Online Teacher (MOT 1.0)

My Online Teacher (MOT 1.0) is an authoring system for Adaptive Hypermedia and adaptive e-learning systems based on the LAOS framework for authoring of Adaptive Hypermedia (Cristea and de Mooij, 2003a), which it maps onto three levels for authoring:

1. **Content level**: a hierarchy of domain concepts, with a number of domain attributes; this level also allows for other relatedness relations between concepts.
2. **Lesson selection level**: also called goal map; filtering and ordering contents at attribute level or above.
3. **Adaptation to student and presentation**: this represents the actual adaptation specification.

The Common Adaptation Format (CAF) (Cristea et al., 2007) reflects part of the actual course structure as in the MOT 1.0 database. However, it uses XML representation, which is more suitable for web conversions. CAF instantiates a representation (Cristea et al., 2007) for two of the static modules of the AEH description (1) and (2) from above: domain and lesson maps – or goal maps). Figure 5 illustrates the structure of the CAF XML; x:y defines the range of objects, i.e., the number of objects are between x and y; m stands for many; thus, each CAF file can have one or more domain models, but only one (or no) goal model; each concept in a domain model has only one name.

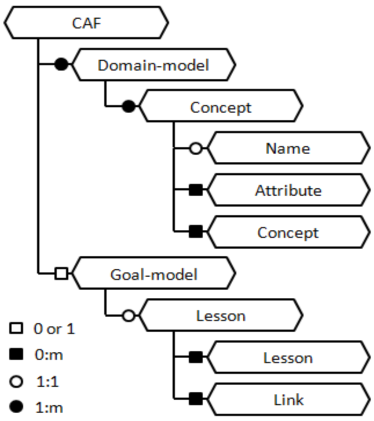

Figure 5 the Common Adaptation Format (CAF)

The Document Type Definition (DTD) of the CAF XML is shown below:

```
<?xml version="1.0" encoding="UTF-8"?>
<!ELEMENT CAF (domainmodel+, goalmodel?)>
<!ELEMENT domainmodel (concept+)>
<!ELEMENT concept (name, attribute*, concept*)>
<!ELEMENT attribute (name, contents)>
<!ELEMENT name (#PCDATA)>
<!ELEMENT contents (#PCDATA)>
<!ATTLIST link weight CDATA "" label CDATA "">
<!ELEMENT goalmodel (lesson)>
<!ELEMENT lesson (link*, lesson*)>
```

Thus, a CAF XML file has:

1. Domain model(s) (one or more): containing a set of domain concept(s), each with a set of domain attribute(s) that describe related concept data (the actual

content). An attribute has a name (representing the name of its type), and a content. A concept may have sub-concept(s) that represent associations to other concepts. The creation of the Domain Model, in the context of Adaptive Hypermedia, refers to content organization (Wu, 2002).

2. Goal model: The goal model represents the actual lesson, which may have a set of sub-lesson(s). Each lesson contains a set of link(s). Importantly, each link points to an attribute in the domain model(s), thus reordering the information contained in the initial model(s). Each link has two attributes: weight and label, which are used to determine the adaptation requirements via adaptation strategies (e.g., show links labelled 'beginner' to beginner users, and links labelled 'advanced' to advanced users).

2.6. Related Research Projects

The research work of this thesis is directly related to three research projects in the area of adaptive and personalized e-learning. This section describes these projects in chronological order.

2.6.1. ProLearn Project

The EU FP6 PROLEARN network of Excellence[5] took place between 2005 and 2009. The project aimed at achieving a better focus on questions of European importance and a better integration of research efforts. Therefore, PROLEARN improved collaboration between various actors of academia and industry in the area of technology enhanced learning. The project mission was to support international collaboration and consequently shape a new understanding of an open network within the research community.

The research of this thesis and the work of PROLEARN have in common the aim of improving adaptive and personalized e-learning. Prolearn went beyond that, targeting

[5] www.prolearn-project.org/

learning in general. In addition, the research of this thesis enhances adaptive and personalized e-learning platforms with new social aspects. See also Chapter 6.

This thesis's contribution to the Prolearn project was to provide a solution for the interoperability issue between different e-learning systems, and the research presented in this thesis gained valuable benefits from the network of excellence, including: online discussions, evaluations, and presenting at worldwide conferences.

2.6.2. Adaptive Learning Space Project

The EU Socrates Minerva project Adaptive Learning Spaces (ALS)[6] took place between 2006 and 2009. The project aimed at providing technological approaches to overcome the lack of face-to-face contact between tutors and learners and amongst learners themselves. The ALS worked towards the following goals:

1. Increasing the range of guidance and support that adaptive and personalized e-learning systems provide to learners and tutors.
2. Providing novel means to support the social cohesion of groups of learners, as well as the engagement of their members in collaborative / team tasks and processes.

This aim of the project was achieved by developing, field-testing and making openly available a software infrastructure that builds upon and goes beyond the state-of-the-art in the fields of e-learning and Adaptive Hypermedia Systems (AHS), to support the creation of active, personalized learning spaces, that will have a clear focus on learning activities, treating learners as active members of, and contributors to, their learning environments, rather than as passive recipients of their contents.

[6] http://www.als-project.org/

The research of this thesis contributed directly to the ALS project. The first goal of the ALS Project is covered in Chapter 3 and Chapter4. The Chapter 3 provides a case study on the interoperability between Adaptive Hypermedia authoring tool, MOT 1.0, and the Learning Management System (LMS), Sakai. The Chapter 4 provides a case study on augmenting e-learning standards with adaptation.

The rest of the chapters of this thesis present work on the second goal of the ALS project, by proposing a new social framework for personalized e-learning, in order to provide adaptive and personalized e-learning platforms with new social aspects. This is not just about creating learning content, but also about developing new ways of learning. For instance, adaptive learning does not refer to individuals only, but also to groups. Furthermore, the boundaries between authors and learners become less distinct in the Web 2.0 context. Finally, a new social personalized prototype is introduced, based on the new social framework for personalized e-learning, in order to test this framework. The implementation and evaluation of the new system were carried through a number of case studies.

2.6.3. GRAPPLE Project

The GRAPPLE[7] project is an EU FP7 STREP. GRAPPLE is an abbreviation of "Generic Responsive Adaptive Personalized Learning Environment". The GRAPPLE project aims at delivering to learners a technology-enhanced learning system that helps them through a lifelong learning experience, automatically adapting to their preferences, knowledge, skills and learning goals.

GRAPPLE includes authoring tools that enable educators to provide adaptive learning content to the learners. Authoring includes creating from scratch or importing other authored learning content, in addition to designing learning activities and defining

[7] http://www.grapple-project.org/

pedagogical attributes of adaptation strategies for the learning content and activities. The current thesis feeds into the GRAPPLE project as well, which is a running project, and will go beyond the extent of this thesis.

2.7. Summary

Adaptive and personalized e-learning systems offer a personalized learning experience for each learner. These systems can achieve the learning objectives that are difficult to achieve using the traditional e-learning methods. A number of studies in this chapter highlighted the significance of augmenting e-learning systems (particularly, Learning Management Systems) with adaptation. Despite the advantages of the adaptive e-learning systems, they are not as frequently used as Learning Management Systems. This chapter investigated a number of reasons that cause this problem, which can be summarized as follows:

- There is a gap between adaptive e-learning systems and Learning Management Systems (see Chapter 3). This gap becomes larger as both adaptive e-learning systems and Learning Management Systems are becoming more complex, adding new features, with little overlap. This gap can be overcome by providing interoperability and reusability between adaptive e-learning systems and Learning Management Systems.
- Another reason is that adding collaborative and social activities is often deficient in adaptive and e-learning systems; therefore, these systems would not be able to easily compete against LMS. This issue can be overcome by improving the current architectures of adaptive e-learning systems, making them benefit from the strengths of the Web 2.0.

Therefore, the interoperability and reusability between adaptive e-learning systems and Learning Management Systems will be the topic of the next chapter.

CHAPTER 3

"Focused, hard work is the real key to success. Keep your eyes on the goal, and just keep taking the next step towards completing it."

John Carmack

3. Interoperability between MOT and Learning Management Systems

This chapter[8] provides a case study of the interoperability between My Online Teacher (MOT 1.0), an Adaptive Hypermedia Authoring tool, and Learning Management Systems (LMS), through the use of e-learning standards. It also describes the conversion from CAF to IMS QTI and IMS CP, in addition to explaining the utilization of JAXB. This is followed by a case study and a conclusion summarizing the research work in this chapter.

3.1. Overview

As mentioned in the previous chapter, there is a gap between research-driven adaptive e-learning systems and Learning Management Systems (LMS) used in practice. This gap becomes larger as both adaptive e-learning systems and LMS are advancing in different,

[8] This chapter is based on the following peer-reviewed papers:

Ghali, F. and Cristea, A. Interoperability between MOT and Learning Management Systems: Converting CAF to IMS QTI and IMS CP, AH 2008: 5th Int. Conf. on Adaptive Hypermedia and Adaptive Web-Based Systems. LNCS 5149. pp. 296–299. DOI 10.1007/978-3-540-70987-9_38, 2008. Hannover, Germany.

Ghali, F. and Cristea, A. Evaluation of Interoperability between MOT and regular Learning Management Systems. 3rd European Conference on Technology-Enhanced Learning EC-TEL. ISBN 978-3-540-87604-5, pp. 104-109. DOI 10.1007/978-3-540-87605-2_12. 2008. Maastricht, The Netherlands.

Ghali, F. and Cristea, A. Evaluation of Authoring for Adaptation and Delivery via Learning Management System. The 11th IASTED International Conference on Computers and Advanced Technology in Education, CATE 2008. ISBN 978-0-88986-767-3. pp. 614-126. 2008. Crete, Greece.

complementary directions. This gap can be overcome by enhancing the interoperability and reusability between adaptive e-learning systems and LMS. One way of achieving interoperability is by using e-learning standards, which can be seen as a connection that allows the same learning content to be reproduced or be reused in other systems. This only caters for the static e-learning content representation, and not for the adaptation or presentation specification.

Moreover, when it comes to the authoring of e-learning content for adaptation and personalization, prior research shows that it is a traditionally difficult task, both for the authoring of Intelligent Tutoring Systems (ITS) (Murray, 1999), (Höök et al., 1997), and Adaptive Educational Hypermedia (AEH) especially when performed in the form of 'one author does it all' (Brusilovsky, 2001). Adaptive lessons are normally a great deal more complex than their non-adaptive counterparts, requiring more time and expertise to be authored (Cristea et al., 2007). This problem becomes even more complex when the author needs to use the authored content in different adaptive e-learning systems.

While (Cristea et al., 2007) considers adaptive authoring a "serious problem", it also provides two applicable approaches to solve it: 1) a *common language*, a lingua franca, used by all authors of Adaptive Educational Hypermedia (AEH); and 2) usage of *converters* between AEH systems. Thus, in our work, we follow a combined approach, by developing novel converters, which use adaptive materials as input and produce standardized material (the most widely accepted lingua franca) as output. Thus, we move one step forward from previous research, by limiting the lingua franca, to the degree it is possible, to existing standards. A large body of research states that standards cannot incorporate all requirements of an Adaptive Hypermedia (Stash et al., 2005a). However, as standards progress, it is unwise to ignore them. Learning Management Systems rely heavily on standards, and are very popular. Therefore, if Adaptive Hypermedia is to move into the large-scale use and commercial market, it has to be able to interface with – or extend – existing Learning Management Systems.

Therefore, this chapter presents a solution of converting material created in MOT 1.0, a relatively well-known and versatile Adaptive Hypermedia authoring environment, to Sakai. As well as importing materials from Sakai into MOT 1.0.

The related tools in Sakai are: Melete[9] (a lesson builder, which allows creating modules) and Samigo[10] (an online assessment tool). These tools support IMS Content Packaging[11] (IMS CP) and IMS Question and Test Interoperability[12] (IMS QTI), respectively. Thus, in order to "export/import" to Sakai from MOT 1.0, we had to "export/import" to these tools – either via internal database representations, or via IMS CP and IMS QTI. We chose the conversion of adaptive materials to IMS CP and IMS QTI for the following reasons:

1) **Independency**: IMS CP and IMS QTI are e-learning standards; therefore the result of conversions can be easily imported to any platform that supports these standards.

2) **Consistency**: Standards are usually agreed upon by much larger communities than the adaptive e-learning community. Their changes are rare, and these standards are well documented. Thus, it is important to use them where possible.

Hence, the ultimate purpose of these conversions is to provide adaptive content on LMS by means of applying learning standards, where possible. This work thus aimed to connect adaptive academia prototypes with existing learning standards. We have started this research by examining the export of e-learning content into existing standards. The following chapter deals with the reverse of the import from e-learning standards. When exporting adaptive content to e-learning standards, we linearize this content, because current standards are not ready for adaptation. However, the reuse of the content is also important and the following sections will show the linearization reuse to two standards.

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[9] http://etudes.org/melete.htm

[10] http://confluence.sakaiproject.org/display/SAM/Home

[11] http://www.imsglobal.org/content/packaging/

[12] http://www.imsglobal.org/question/

3.2. Converting CAF to IMS QTI and IMS CP

The conversion itself is a two step process: first the CAF format is converted into existing standards, such as IMS QTI and IMS CP, respectively. Next, these are imported into a popular LMS, like Sakai. In the following, we will discuss the technical decisions made in the implementation phase, as well as justify them. Needless to say, these technical matters are transparent to an author, who just interacts with the system via simple interfaces, as is partially depicted in the evaluation that follows.

3.2.1. The Utilization of JAXB

To tackle the various requirements and constraints found in our work we used Java Architecture for XML Binding[13] (JAXB), due to the fact that CAF, IMS QTI and IMS CP are defined via XML files. JAXB handles most of the problems raised by traditional mechanisms (e.g., Simple API for XML[14] or Document Object Model[15]) of parsing XML files, as it provides flexible API functions to generate Java classes that match the Document Type Definition[16] of CAF and the XML Schema[17] of IMS QTI and IMS CP. Thus, with JAXB, no pre-conversion into a common representation format is necessary. The internal conversion steps are as follows (see Figure 6).

First we generate Java classes for the files: CAF.dtd, QTI.xsd and CP.xsd. Secondly we parse (a process called *"unmarshalling"*) the CAF XML file and generate Java objects. Thirdly we map the results onto IMS QTI and IMS CP classes accordingly. Finally we generate (a process called *"marshalling"*) IMS QTI and IMS CP. Figure 6 illustrates the use of JAXB in the conversion process. Next we shall describe the conversion of the MOT 1.0 authoring tool output, CAF, to the two e-learning standards, IMS QTI and CP.

---

[13] http://java.sun.com/developer/technicalArticles/WebServices/jaxb/

[14] http://www.saxproject.org/

[15] http://www.w3.org/DOM/

[16] http://www.w3.org/TR/REC-html40/sgml/dtd.html

[17] http://www.w3.org/XML/Schema

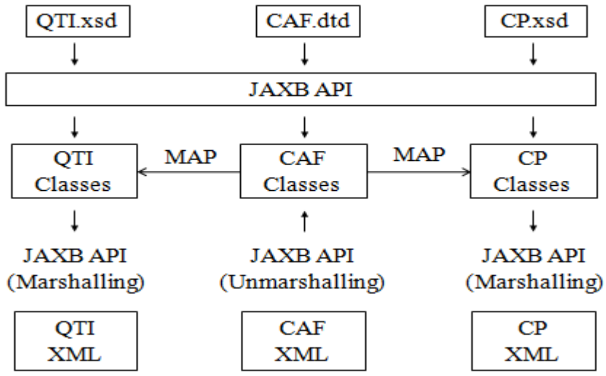

Figure 6 JAXB facilitate converting CAF to IMS QTI and IMS CP

3.2.2. Converting CAF to IMS QTI

IMS QTI is a data model and de facto standard for the representation of questionnaires and quizzes for e-learning systems. Thus being able to allow for compatibility with IMS-QTI is vital for any e-learning system, including Adaptive Educational Hypermedia systems. The structures represented by IMS QTI are:

- **Item**: the smallest data unit in IMS QTI, containing the 'question'.
- **Section**: a section may have item(s) and/or other section(s).
- **Assessment**: an assessment contains at least one section.
- **Object bank**: A collection of data objects (items and/or sections).

Compared to the structure of CAF, we map the main lesson of the GM into one assessment; and the DM into one section. Each attribute in CAF is mapped to one item in IMS QTI. One type of question that is represented in IMS QTI is the "Fill in the Blank" question; an example of presenting this type of question in IMS QTI is shown below:

```
<questestinterop>
    <item title="MOT to IMS QTI">
        <mattext> What is the name of the US
    president?</mattext>
        <varequal>Obama</varequal>
    </item>
</questestinterop>
```

This can be generated by a CAF file exported by MOT 1.0, as below. Each concept in the GM (goal model) should have at least two attributes, one attribute representing the question and the other representing the answer:

```
<concept>
      <name>Question 1</name>
      <attribute>
            <name>question</name>
            <contents>What is the name of the US
            president?</contents>
      </attribute>
      <attribute>
            <name>answer</name>
            <contents>Obama</contents>
      </attribute>
</concept>
```

As JAXB facilitates the mapping process, our algorithm unmarshalls the CAF file, and finds the concepts which contain “question” and “answer” as attributes, then it marshals the generated IMS QTI file with the “question” and the “answer” into “mattext” and “conditionvar” elements accordingly .

The question-answer pairs in the concept are retrieved from the goal model rather than from the domain model, which reflects the effective use of the authoring in MOT 1.0, as the goal model represents the content of the current lesson quizzes. Figure 7 shows the converted CAF file after importing it as IMS QTI into Sakai.

In Figure 7, the converted material, corresponding to the CAF file extract shown above the figure, is visualized with the Sakai tool Samigo, as part of a ‘Web Programming’ course, the ‘Web programming Demos’ section (or tab).

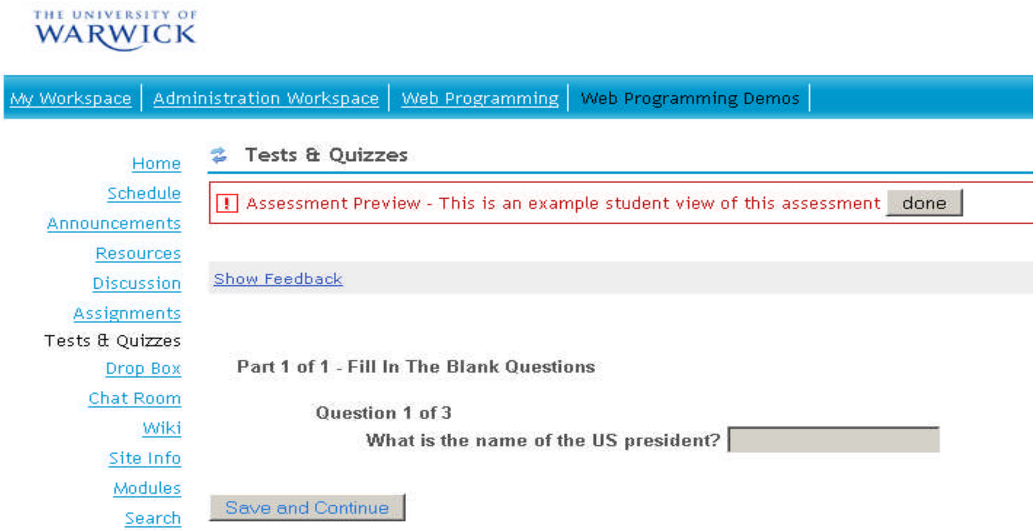

Figure 7 the converted CAF to IMS QTI file, after the import into Sakai

3.2.3. Converting CAF to IMS CP

The IMS Content Packaging (IMS CP) is a de facto standard that describes data structures that are used to provide interoperability for the contents of Learning Management Systems. For this reason, interoperability with this standard was also considered vital for e-learning systems, including Adaptive Educational Hypermedia systems. The structure of IMS CP consists mainly of *Manifest XML file* and *the actual physical files (resources).* Therefore, the manifest consists of a set of items and set of matched resources (e.g., below, the item ITEM1, ‘Introduction’ has a resource called ‘RESOURCE1’).

```
<organizations default="CAF to IMS CP">
    <title>Convert CAF to CP</title>
    <item identifier="ITEM1" identref="RESOURCE1">
      <title>Introduction</title>
</organizations>
<resources>
  <resource identifier="RESOURCE1"
href="introduction.htm">
  </resource>
</resources>
```

IMS CP has more flexibility than IMS QTI, including support for hierarchical structures (in CAF). Moreover, the aim of both IMS CP and CAF is to store courses (only the latter however stores adaptive courses). Therefore, each attribute of each concept in CAF can be mapped to one item in IMS CP with the preservation of the hierarchy (the attribute's name is converted to the title of item and the attribute's content is mapped to the actual resource that matches the item). The steps of the conversion are as follows:

1. Generate CAF Java classes using JAXB.
2. Parse the goal model to retrieve the actual course.
3. Each attribute in each concept is mapped onto an item in IMS CP.
4. Each sub-concept is mapped onto a sub-item in IMS CP.
5. For each generated item and/or sub-item, a new HTML file is generated, which contains the content of the attribute.
6. Finally, a new manifest file is created, which contains all generated items and sub-items.

The output of this conversion can then be visualized in an LMS like Sakai, with the help of the Melete[18] tool, as is shown in Figure 8. After importing the converted CAF to IMS CP, the teacher or author has the option to edit the structure of the lesson, as it is shown; students can then access the lesson after it is published.

The CAF to IMS CP conversion looses all adaptation features. Typing of data could subsequently be interpreted by an adaptation engine, in order to restore some of these features. Thus, they need exported in a different manner. Adaptation strategies can be exported separately, for example, in the adaptation specification language LAG (Cristea and Verschoor, 2004).

[18] http://etudes.org/melete.htm

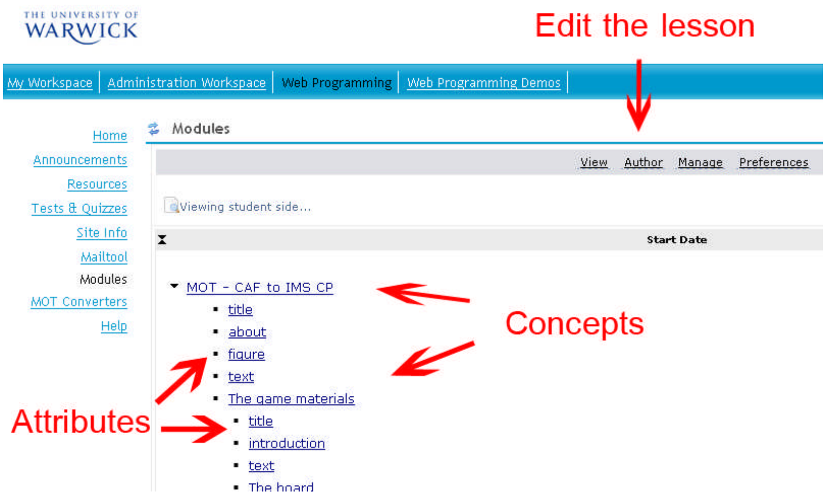

Figure 8 MOT 1.0 lesson in Sakai

3.3. Evaluation of the Converters

3.3.1. Experimental Setup

The implemented converters have been tested with a group of thirty 3rd year students of a course on “Web Programming”, who studied Computer Science (FILS direction) at the Politehnica University Bucharest in 2008. The “Web Programming” course was partially delivered via two weeks of face-to-face lectures, seminars and hands-on labs, and for the rest of the term, delivered via distance learning.

Before the students had to answer the questionnaires, they were made familiar, via lectures, with MOT 1.0 and CAF, Sakai, IMS QTI and IMS CP, and via hands-on experiments, with authoring environments (MOT 1.0) and e-learning environments (Sakai, AHA!). The students collaborated in the creation of new content in MOT 1.0 and visualized their own content within Sakai using the converters.

Conversions from MOT 1.0 to IMS QTI and IMS CP have been performed in two different sessions, on two different days. Each session started with a presentation on how the converter works, followed by a practical demonstration on using the converters. Then, it was the students’ turn to perform the conversions. Finally, the students had to evaluate their experience with the conversion systems, via questionnaires.

Therefore, the students played two roles in these evaluations:

1. The first role is ‘author’, where they created their own additional course materials in MOT 1.0 and converted them to IMS QTI and IMS CP.
2. The second role as ‘student’, where they answered two separate questionnaires prepared in MOT 1.0 and converted to IMS QTI.

For our testing purposes, it was reasonable to use students for the evaluations, as the type of system we envision towards the end of our developments will involve students as co-authors and collaborative annotators of the extant created material, in the sense of exploiting Web 2.0 techniques and trends in order to enrich and adapt material to the current student population. Thus, it is important that not only designers and educational material authors evaluate the authoring and conversion tools, such as we have done in the past, but also, that students can directly work with these tools. See Appendix 1: MOT to IMS CP Evaluation Data and Appendix 2: MOT to IMS QTI Evaluation Data.

3.3.2. Results

Both questionnaires ask for a rationale for each question, where the students were requested to explain their answers. Additionally, question Q11 in each questionnaire covers free comments on the advantages and disadvantages of the converters. Analyzing the qualitative feedback from the experiments, this showed that the converters were mainly understood, easy to use, and useful. The most commonly mentioned advantages of the converters are: the converters are fast, easy to use, convert various types of content in the case of MOT to IMS CP converter, converting precisely (no information is lost in the conversion process), are built based on Java (which makes it easier to plug-in in other Learning Management Systems), and allow interoperability with systems that use learning standards.

A few limitations of the converters were identified; students noted the following drawbacks of the converters: the converters cannot work offline (this is not a requirement, as all of the systems that it works with are online). A bug was found (the system crashed due to a misinterpretation of the file location) in uploading the CAF file, when the students used Internet Explorer v6 (but not for v7 or above; this bug was fixed by updating some libraries). The MOT to IMS CP convertor is slower than MOT to IMS QTI. This depends on the size of the file, and as a rule standards tended to convert larger files into IMS CP, as they contained the whole lessons, whilst the IMS QTI usually contained shorter tests or examinations. There are currently no online help guidelines available at the time of the evaluation.

3.4. Discussion

Converting learning content from the authoring system for adaptation, MOT 1.0, into IMS QTI, was pushing the capacity of MOT 1.0 to some extent, as the authoring system was not initially designed to edit tests and questionnaires. However, this process has its benefits. It is acceptable that using assessments together with personalized learning access has a positive impact on the learning process, because it helps in: 1) checking if the learners have understood the materials correctly or not, and 2) providing feedback for both learners and teachers.

Therefore, adding standard-based assessment potential to Adaptive Educational Hypermedia Systems can enhance the learning process and give students the chance to trace their learning progress (Cheniti-Belcadhi et al., 2004). Moreover, from the Sakai LMS point of view, benefits also exist. The CAF to IMS QTI converter manipulates adaptive content in CAF XML format and generates the matched assessment in IMS QTI format. Here we have two benefits from an adaptation point of view: 1) Utilizing the adaptive features in CAF. 2) Enriching the generated assessment with new adaptive concepts using LOM in IMS QTI. Furthermore, creating adaptive content is considered costly and time-consuming (Conlan et al., 2002). Therefore, reusing already created content is valuable, and this can be done by providing facilities to export (part of) the adaptive content into standardised format, such as IMS CP. The CAF to IMS CP converter performs this by partitioning the adaptive content into unique granular items that can be reused for different learners. Moreover, those items can be enriched with metadata that follow the LOM standard, to give a new dimension to applying adaptation in Learning Management Systems that support IMS CP. The granularity is already handled by concept and sub-concept relations in CAF; however, here we add the compatibility with the IMS CP learning standard.

Finally, complete compatibility, not only for export from adaptive systems via CAF to IMS CP and IMS QTI, but also import, is vital. After the completion of the evaluations, from open discussions with students, as well as from discussions with other designers, it emerged that such a bilateral compatibility is essential. As a result, the import function has in the meantime also been implemented, although the testing has not been so extensive (only peer-tested) as of now. With such a function, extant standard materials can be introduced into an authoring system like MOT 1.0, where additions towards adaptation specification are possible. In this way, enriching standard-based static material from rich repositories with adaptation becomes easier.

3.5. Related Work

Often, Adaptive Hypermedia research ignores standards (Stash et al., 2005b). However, standards are occupying a growing part of the educational market share. Major Learning Management Systems import and export to e-learning standards, and even small, custom designed LMS cannot ignore the push towards standards (Boticario and Santos, 2007).

Consequently it is vital to connect Adaptive Hypermedia to learning standards. (Dolog et al., 2004) and (Kravcik and Specht, 2004) compile e-learning standards used in adaptive e-learning systems, which are mainly targeted at content description; whilst (Stash et al., 2005b) considers a common adaptation language as the only approach to guarantee real interfacing, exchange, and reuse. (Stash et al., 2007) distinguishes between two different types of reuse between adaptive e-learning systems, allowing for adaptation description exchange, dynamic and static. (Cheniti-Belcadhi et al., 2004) and (Gouli et al., 2001) focus on creating an assessment framework for adaptive educational systems via the use of Learning Object Metadata and IMS QTI. In addition, the Alfanet project (Van

Rosmalen et al., 2006) implemented an e-learning environment that provides a certain level of adaptation using IMS standards. Moreover, AHES do not yet have any common accepted language that can be used to state the adaptive functionalities (Cheniti-Belcadhi et al., 2004), although proposals, such as the LAG adaptation language, exist. Therefore, as the analysis of prior research shows, the issue of connecting adaptation and e-learning standards is still open, and there is a pressing need to offer new, viable solutions.

3.6. Summary

Most adaptive learning systems focus on personalizing the delivery of course materials to individual learners. However, not enough work has been performed on applying adaptation to collaborative learning systems, such as popular Learning Management Systems.

Converting adaptive content into learning standards can supply a dynamic learning process which is compatible with all systems that support these standards. In this chapter we present our work of converting CAF into IMS QTI and IMS CP, in which the adaptive materials authored in MOT 1.0 can be imported into well-known LMS such as Sakai. This chapter provided a case study of the interoperability between MOT 1.0 and Learning Management Systems; it described the conversion from CAF to IMS QTI and IMS CP, in addition to explaining the utilization of JAXB

The next chapter will present a case study of augmenting e-learning standards with adaptation. The case study adapts IMS QTI and IMS CP standards using the authoring tool MOT 1.0, followed by a scenario and discussion on how to use the adapted learning content in AHA! that is running in Sakai.

CHAPTER 4

"Productivity is never an accident. It is always the result of a commitment to excellence, intelligent planning, and focused effort."

Paul J. Meyer

4. Augmenting E-Learning Standards with Adaptation

This chapter[19] presents a case study of augmenting e-learning standards with adaptation. The case study adapts IMS QTI and IMS CP standards using an adaptation mechanism with the help of the authoring tool MOT 1.0. Following this, the adapted content is used in a real world case study which uses AHA! in Sakai. It also describes the conversion from IMS QTI and IMS CP to CAF format, in addition to explaining the utilization of JAXB, and presenting the evaluation of the converters, followed by a conclusion summarizing the research work in this chapter.

4.1. Overview

E-Learning standards are considered the skeleton of Learning Management Systems, as they provide reusability of learning objects, as well as interoperability between different LMS. Moreover, LMS provide support for collaborative learning amongst students. Learners can engage in common tasks, in which each individual depends on, and is accountable to others. Furthermore, Brusilovsky (Brusilovsky, 1996a) reports the

[19] This chapter is based on the following peer-reviewed paper:

Ghali, F., Cristea, A. and Hendrix, M. Augmenting E-Learning Standards with Adaptation. The 11th IASTED International Conference on Computers and Advanced Technology in Education, CATE 2008. ISBN 978-0-88986-767-3. pp. 614-122. 2008. Crete, Greece. ***Nominated for Best Paper Award.***

significance of adaptation for e-learning, as the students differ in their learning goals, backgrounds and knowledge, etc. Moreover, the state of the art of adaptation in e-learning platforms, shows that most LMS do not yet benefit from adaptation (Hauger and Köck, 2007).

This chapter presents work within the Adaptive Learning Spaces (ALS) EU Project, which focuses on delivering Adaptive Hypermedia (De Bra et al., 2004) to groups/teams of learners by integrating adaptive tools such as: AHA! (De Bra and Calvi, 1998) (for adaptive delivery); MOT 1.0 (Cristea and de Mooij, 2003b)(for adaptation authoring); and PILS (Gross et al., 2008b) (for adaptive communication) into popular LMS, such as Sakai.

Therefore, this work presents a step towards adaptive collaborative support based on standards, by firstly focussing on applying adaptation to material represented via e-learning standards, in particular, IMS Question and Test Interoperability (IMS QTI) and IMS Content Packaging (IMS CP), and secondly, by extending the classical personalization strategies to adaptive collaboration strategies. The methodology is based on importing these standards into My Online Teacher (MOT 1.0), an authoring system for Adaptive Hypermedia, applying an adapting authoring process on the content, and delivering the result via the AHA! adaptation engine which can run integrated in Sakai. Figure 9 illustrates the process of applying adaptation to collaborative learning environments (or Learning Management Systems).

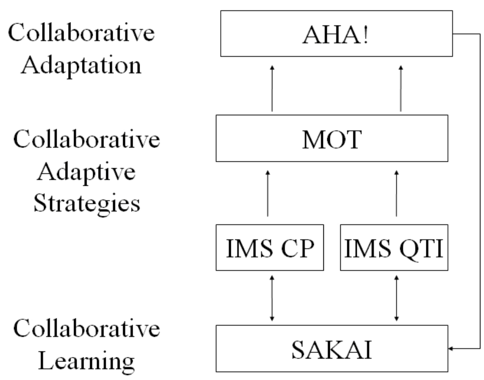

Figure 9 adapting e-learning standards

4.2. Adapting IMS QTI and IMS CP

Next, we show how e-learning standards content can be used in the authoring system MOT 1.0. This represents a novel step towards applying adaptation to e-learning standards, and at same time, it is the reverse work of extending MOT 1.0 to support e-learning standards, which was presented in (Ghali and Cristea, 2008a) and in Chapter 3 of this thesis.

The conversion procedure is a two step process. First we convert both IMS CP and IMS QTI to CAF. In this way, we ensure the independency from the currently used authoring system, as well as the reusability of the authored learning content. Then, we adapt the imported content by defining adaptive variables, and adaptive strategies. Optional steps could be to deliver the adapted content into AHA!, which can run in the Sakai LMS. In the following, we will discuss the technical decisions made in the implementation phase, as well as justify them.

4.2.1. The Conversion and its Underlying Technology

Thus, JAXB is preferable to XSLT (XSL transformations), or other, home-built processing mechanisms. The (internal) conversion steps are as follows. Firstly we generate Java classes for CAF.dtd, QTI.xsd and CP.xsd. Secondly we parse the IMS CP and IMS QTI files to generate Java objects. Thirdly we map the results onto IMS QTI and IMS CP classes accordingly. Finally we generate CAF files. While this process may sound overly technical, in reality, it works transparently for the author, and due to the advantages as mentioned above, it is useful for the implementer as well.

4.2.2. Adapting IMS QTI

The structure of IMS QTI was described in Section 3.2.2. Compared to the structure of CAF, we map the main assessment of IMS QTI onto one domain model; each question in IMS QTI is mapped to one item concept in the domain model; each concept contains three attributes (question, answer and the score). This conforms to the use of concepts in MOT 1.0 and the use of items in the standard. After creating the domain model, we create the goal model automatically based on the domain model structure. Decisions are based on the analysis of common practice use of the elements of the two representations.

4.2.3. Applying Adaptive Strategies for IMS QTI

The next step is to define adaptive strategies for the imported IMS QTI content. The authors, who are using the authoring environment MOT 1.0, can use the same or other strategies[20] for different scenarios. One possible simple strategy, for illustration, is the 'Type'-based strategy. This strategy shows concepts based on their type (the name of the respective attribute, as shown in Figure 10).

Here, if the learner is ready to see questions, his current user preferred type will be 'question', and thus concepts of type 'question' will be shown. When he is ready to see answers, his current type will be updated accordingly (code not shown here). Finally, when he should see his scores, his current type variable will be updated to 'score'. The main adaptation program snippet that matches concepts types to the current type of the user is the following:

```
IF (GM.Concept.type == UM.GM.currenttype) THEN
  (
      PM.GM.Concept.show = true
   )
```

Furthermore, more complex adaptation and personalization scenarios can be created, even for the same content. The labels and meta-data allow for various type of personalization, according to the author's intent. An author that has imported his IMS QTI content to the authoring system for adaptation does not need, however, to know the intricacies of using the adaptation programming language, if he is content with using strategies created by

[20] http://prolearn.dcs.warwick.ac.uk/strategies.html

others (and documented respectively). In fact, prior tests show that authoring for adaptation without knowledge of programming is possible (Hendrix and Cristea, 2007).

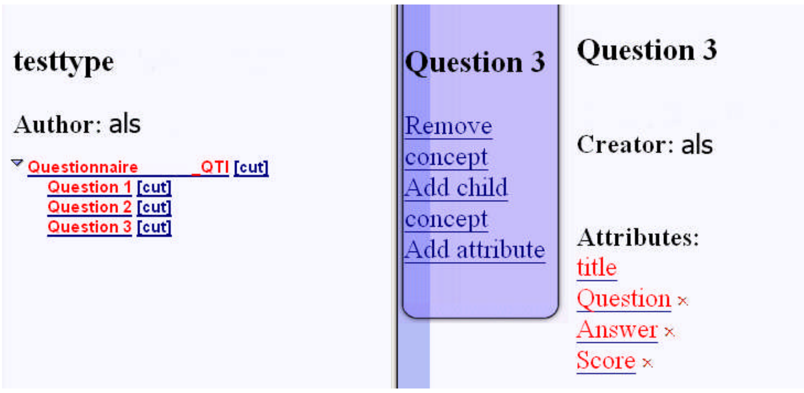

Figure 10 Applying adaptive parameters on IMS QTI

4.2.4. Adapting IMS Content Packaging

The structure of IMS QTI was described in Section 3.2.3. After carefully analysing the structure, it was decided that each item in IMS CP without sub-items, is mapped to an attribute in the domain model of the CAF file; and each item containing sub-item(s) is then mapped to a concept in the generated CAF file. The GM was generated automatically based on the structure of the DM.

4.2.5. Applying Adaptive Strategies for IMS CP

The next scenario shows how to apply the simple, classical Beginner / Intermediate / Advanced strategy[21] on the imported IMS CP (which could also be applied on the imported IMS QTI). This strategy shows material to students only when they are ready for it (i.e., beginner students see only material for beginners, etc). This adaptation strategy is based on the following: if a concept is labelled in the same way as the current knowledge level of the student, that concept should be made visible, as it is ready to be displayed:

[21] http://prolearn.dcs.warwick.ac.uk/startegy/gipfBegIntAdv.lag

```
IF (GM.Concept.label == UM.GM.knowlvl) THEN
(
        PM.GM.Concept.show = true
)
```

To use this strategy, after importing IMS CP into MOT 1.0, a teacher needs to define adaptation parameters (meta-data), as illustrated in Figure 11. A teacher labels material and decides the difficulty level of individual pieces of the course (e.g., the ‘Module Introduction’ is for beginners, etc.).

Figure 11 Defining Adaptation Parameters for IMS CP

A strategy such as Beginner/Intermediate/Advanced is aimed at individual students. However, LMS (e.g., Sakai) offer collaborative learning environments. Thus, if the adapted IMS CP course runs in AHA!, which can run in Sakai, students with ‘beg’, ‘int’, ‘adv’ knowledge level can collaborate via Sakai collaboration tools (such as Blogs, chat tool, forums tool, etc.), as is illustrated in Figure 12.

In such a way, a simple solution of combining collaboration and personalization is achieved. The following scenario goes one step further, and demonstrates how to apply an adaptive collaborative strategy for adaptive collaboration support. As previously mentioned, MOT 1.0, with the use of adaptive strategies, can generate adaptive courses. A snippet of an adaptive collaborative strategy is shown below:

```
IF UM.GM.Concept.access == true
THEN FOREACH GM.User DO
      IF GM.User.GM.Concept.knowledge > 80
      THEN
            GM.User.show = true
```

The above strategy does the following: once a concept is accessed, all students of expert level (knowledge over 80) are listed. Another, largely similar collaborative adaptation strategy would be as follows. The beginner users in the previous strategy could be directed to experts (instead of to their peers) for more information, moving from student-system or student-student interaction to student-expert collaborative interaction. In combination with communication tools that allow for tracking users' interactions, more complex strategies of collaboration and co-operation can be designed.

Generally speaking, a variety of collaborative adaptation strategies can be based on the formula 'FOREACH User DO Something'. For authors, a simple way exists to influence even the most complicated adaptation strategies: via setting of weights and labels in the authoring environment. Therefore, the overall scenarios for authors are as follows:

Scenario 1: adding adaptation to e-learning standards content.

1. Create (or use) material based on e-learning standards.
2. Import this into an adaptation authoring environment (e.g., MOT 1.0).
3. Add new weights and labels (i.e., adaptation variables, or meta-data) according to the desired personalization. For instance, labels of 'beg', 'int' and 'adv' need to be added to content in order to use it in conjunction with the beginner intermediate advanced strategy[22].
4. Optional: modify the strategy; or even create a new strategy, if so desired.
5. Export the enriched content to a platform that can display it adaptively.

---

[22] http://prolearn.dcs.warwick.ac.uk/startegy/gipfBegIntAdv.lag

Scenario 2: exporting content created for adaptation to e-learning standards.

1. Create (or use) material generated via an authoring system for adaptation (e.g., MOT 1.0).
2. Export this material to e-learning standards (e.g., IMS CP or IMS QTI); some intermediary steps are needed here, but as they are not essential for the logical process, they are skipped. Thus, material created for adaptation can be used in delivery platforms that support standards and/or collaboration (e.g., Sakai). Similarly, it can be enriched by tools that allow authoring of content based directly on e-learning standards (that may not provide adaptation).
3. Optional: modified content can be re-imported into an adaptation authoring environment (e.g., MOT 1.0) and enriched with adaptation, as in Scenario 1.

The overall components and responsible entities in the two scenarios are depicted in Figure 12.

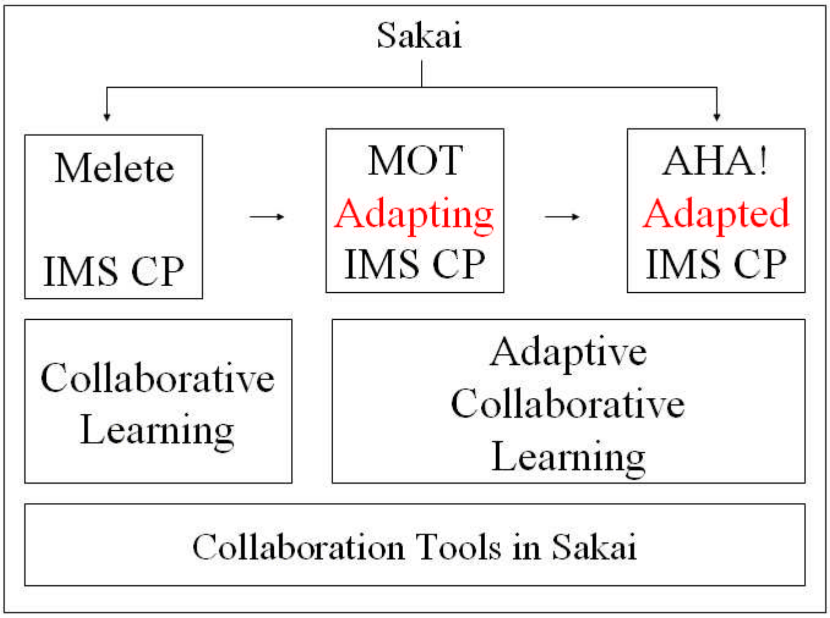

Figure 12 Adaptation in Sakai

4.3. Real World Case Study

A case study was designed to test the ALS components in a real world scenario including the converters developed in this chapter. Learners took part in an online course on the topic of Unified Modelling Language (UML) topic and collaborated on a group-based project. The collected data, in addition to quantitative and qualitative results showed that ALS components can facilitate collaborative learning and learners enjoyed the experience (Weibelzahl et al., 2009). The aim of this case study was to test the integrated ALS components in a real world scenario. Rather than working with the tools separately, we were interested in how learners would perceive the tools in a real online course.

For the purpose of this case study seven lessons on the Unified Modelling Language (UML) topic were converted from SCORM packages into AHA! lessons using the research work presented in this chapter and the developed converters. The lessons comprised a total of 244 pages, including graphics, animations and exercises (Figure 13).

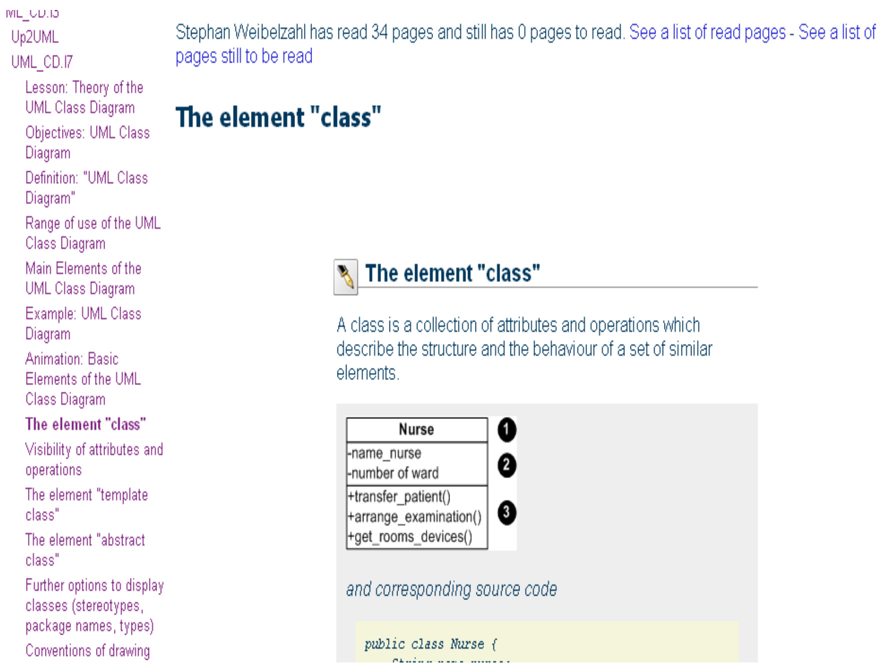

Figure 13 UML course presented in AHA! integrated in Sakai

4.4. Discussion

Converting learning materials from IMS QTI and IMS CP into MOT 1.0 allows applying adaptation to Learning Management Systems. LMS support collaborative learning via multiple collaboration tools, which help the students to communicate and share their experiences. Thus, in this chapter we combine features from Adaptive Hypermedia and Learning Management Systems, adaptation and collaboration & standards, respectively. Furthermore, creating adaptive content is considered costly and time-consuming (Conlan et al., 2002).

Therefore, reusing already created content is valuable, particularly when this content follows standards, which makes the adapting process identical, regardless of the type of Learning Management Systems. Therefore, existing standard materials can be introduced into an authoring system for Adaptive Hypermedia, such as MOT 1.0, where additions towards adaptation specification are possible. In this way, enriching standard-based static material from rich repositories with adaptation becomes easier.

The lessons learned from the case study (Weibelzahl et al., 2009) are two-fold. First of all, the ALS components did facilitate collaborative learning. Although the tools were not used to the extent expected, there is clear evidence that learning took place, and more specifically, that collaboration supported by the ALS components contributed positively to the learning experience. Participants expressed their interest in collaboration and showed their intention of using the tools in future again.

Secondly, the case study also showed that adaptive systems for collaborative learning must not be seen as an isolated system feature, but must be put in the context of existing tools and infrastructure. The tools developed as part of the ALS Project have shown the great potential of adaptation to improve collaborative learning. However, learners are already using existing communication and collaboration tools, though this is not necessarily done for the purpose of learning, but often in order to socialise or in work contexts. These tools set expectations and standards. Newly developed tools need to address these expectations and integrate with existing infrastructure (e.g., enable learners to connect to their friends as well as to their peer learners). From the point of view of the converters built, the lesson learnt was that the content was mainly transferred well. There was a problem in converting special characters, but this problem was solved using the Unicode formatting.

4.5. Related Work

Previous studies report that adaptive systems do not support standards in general (Awerbuch et al., 2005), and e-learning standards in particular (Paramythis and Loidl-Reisinger, 2004). However, Learning Management Systems rely heavily on standards. As a result, it is important to provide a connection from Adaptive Hypermedia to e-learning standards (Ghali and Cristea, 2008b) (see Chapter 3), based on analysis of e-learning standards that are applicable in adaptive systems (Dolog et al., 2004) (Kravcik and Specht, 2004). Pioneers in such work, for example, (Cheniti-Belcadhi et al., 2004) and (Gouli et al., 2001) focus on creating an assessment framework for adaptive educational systems via the use of LOM (Learning Object Metadata) and IMS QTI. Hence, the issue of connecting adaptation and standards is still open, and there is a pressing need to offer new viable solutions.

On the other hand, the research looking into combining adaptation and collaboration is relatively scarce. The ALS Minerva project embarked on addressing this niche. Adaptive collaborative tasks support is addressed in WebDL (Boticario et al., 2000). The system however allows annotations and tagging, and then selects information based on these tags for personal student needs. No specific rules that guide the collaboration process in an adaptive way are envisioned.

Other research (Tsovaltzi et al., 2008) promotes collaborative adaptation based on scripts of interactions of pairs of students. Prompts about contacting the peers and explaining, talking about consensus, etc. are being used. Interestingly, the paper reports that, whilst the students might have perceived the adaptive comments as intrusions, the overall result (in terms of learning) was positive. The approach presented in this chapter and the previous is closer to this study, as the collaborative adaptation process aims at guiding students towards useful interactions with each other and with their teachers.

However, additionally to this, the research in this chapter blends the learning process and the collaboration process. Other researches take an AI-driven approach, and describe processes of adaptive collaboration in peer-to-peer systems (Boticario and Santos, 2007) in terms of players (or agents) with shared or exclusive goals, thus cooperating or competing against each other. Minimization of cost in the process of reaching the goal of the current agent is sought. The overall goal of such research is quite different from the current one in this chapter.

Our aim is to express with as simple as possible rules adaptation processes that can currently be applied in extant Learning Management Systems. This will serve as a framework for future, more complex developments, via a robust and constructive approach. Thus, processes are representing social protocols. Adaptation here however means negotiation, in order to adapt these protocols. Compared to our research, this would be at the level of meta-strategies (Awerbuch et al., 2005), which help in choosing the appropriate strategy. Concluding, our research addresses this particular combination of desirable features, in a realistic manner, which is easy to deploy. We opt for a simple, quick solution, instead of an all-encompassing approach. We also argue that this quick solution presents the ideal basis for future extensions of various kinds.

4.6. Summary

This chapter presented a case study of augmenting e-learning standards with adaptation. The case study adapts the IMS QTI and IMS CP standards using the authoring tool MOT 1.0, and the adapted content is used further in a real world case study that deploys AHA! in Sakai. Most adaptive e-learning systems focus on personalizing the delivery of course materials to individual learners. However, not enough work has been performed on applying adaptation in regular collaborative e-learning systems, such as popular Learning

Management Systems. Adaptation based on e-learning standards can supply a dynamic learning process which is compatible with all systems that support these standards.

In this chapter we present our work of converting IMS QTI and IMS CP to MOT 1.0, in which the e-learning standards content can be adapted in MOT 1.0 by using adaptive variables, as well as adaptive strategies. We also present some simple, illustrative learning scenarios on how to apply adaptive collaborative strategies on the adapted e-learning standards contents.

Finally, adapting e-learning standard content is time-saving, as the process of applying adaptation for collaborative learning requires only applying adaptive parameters, without the need of re-creating this content from scratch.

Hence, the two case studies, the interoperability between MOT 1.0 and Learning Management Systems, and augmenting e-learning standards with adaptation, worked on the interoperability limitation between adaptive e-learning systems and Learning Management Systems.

The following chapters will focus on the issue of improving collaborative and social activities in adaptive e-learning systems, which are often lacking. This deficiency causes adaptive e-learning systems to be unable to easily compete against Learning Management Systems, which are considered the current key factor in the e-learning environments.

This issue can be overcome by improving the current architectures of adaptive e-learning systems, making them benefit from the strengths of the Web 2.0. Moreover, e-learning systems (including Learning Management Systems) are moving towards the next generation of e-learning, “e-learning 2.0”; this requires adaptive e-learning systems to take advantage of Web 2.0 interactions, as it will be described in the next chapter.

CHAPTER 5

"Imagination is more important than knowledge. For knowledge is limited to all we now know and understand, while imagination embraces the entire world, and all there ever will be to know and understand."

Albert Einstein (1879 - 1955)

5. Web 2.0, Personalization and Adaptation

This chapter[23] discusses the topic of introducing personalization and adaptation in the Web 2.0. It provides a pre-design case study of MOT 2.0. It describes MOT 1.0 with its collaborative features, and then proposes a method for extending the collaborative and social features in MOT 1.0, by using the strength of the Web 2.0.

5.1. Overview

Personalization in Web 2.0 brings together a whole new set of requirements and contexts, and to differentiate it from single-user based personalization, we can call it "Adaptation 2.0". Web 2.0 is principally defined by the content and the users. Each user has a profile (such as preferences and interests), which can be represented by a set of attributes. Similarly, the content also has a set of attributes (type, size, etc.). Therefore, Adaptation 2.0 inherits from previous single user personalization approaches matching the user to content attributes (De Bra et al., 1999). Another important feature of Adaptation 2.0 is that

[23] This chapter is based on the following peer-reviewed papers:

Ghali, F. Cristea, A. Stewart, C. and Hendrix, M. Collaborative Adaptation Authoring and Social Annotation in MOT, A3H: 6th International Workshop on Authoring of Adaptive and Adaptable Hypermedia Workshop, AH 2008. Hannover, Germany.

Ghali, F. Cristea, A. and Stewart, C. (2008). My Online Teacher 2.0. 3rd European Conference on Technology Enhanced Learning EC-TEL 2008, IGACLE workshop. CEUR-WS.org/Vol-384. 2008 Maastricht, The Netherlands.

it can be applied to a group of users who share similar profiles, and thus, adaptation is no longer only about the individual, but also about the group.

The increasing rise in popularity of social networks and Web 2.0 applications, means that large number of users must be accommodated, and for some applications millions of users may need to be supported. For example, in May 2009 Facebook[24] (Facebook, 2009) announced that it reached a user base of 200 million people, out of which 70% were outside the US. For such massive applications, introducing personalization and adaptation is a useful way of reducing the overall search space. Furthermore, introducing personalization always raises issues of privacy (Kobsa, 2007), which are out of the scope of the current chapter, but it is sufficient to note here that a balance between personalization and privacy must be struck.

5.2. My Online Teacher 2.0 Pre-design Case Study

Collaborative authoring and social annotation are two faces of same coin: both rely on co-operation, but in different ways. Whilst collaborative authoring (annotation and editing during writing (Marshall, 1998)) creates/modifies the actual web resources, social annotation (annotation during reading (Marshall, 1998)) facilitates the adding/editing/modifying of information in a web resource, without changing the resource itself (Wagstaff, 2006).

The main goal for defining co-operation (collaborative authoring and social annotation) in the MOT 1.0 (Cristea and de Mooij, 2003b) system is to allow multiple authors to contribute in the authoring process. Thus, the authored materials foster a new level of knowledge (both of creation and of use) by aggregating information from many users. In principle, the more users that contribute to the authoring process, the more valuable the final stable material is. It is important to reach such stability, as systems such as

[24] http://www.facebook.com/

Wikipedia show, because only then a consensus of the community is certain. Whilst a resource is still changing, its value is less certain to that community.

5.3. Extending Collaboration in MOT 1.0

MOT 1.0 is an adaptation authoring tool, which already supports some basic collaboration activities such as:

1. General access (visualization) to other author's domain maps and lessons.
2. Keyword-based access (visualization) to existing domain concepts, created by the current author or by other authors.
3. The ability to copy a domain concept from another of the author’s own domain maps, which allows reuse of one’s own previously created materials.
4. The ability to link to concepts from someone else's domain maps, this is analogous to referring in one’s own book to someone else’s book (e.g., adding a full quote).
5. Semi-automatic search and linking functions (with weights and labels) to link to domain concepts from any domain map, whether they are authored by the same author or not, to another related domain concept. This helps the author to find domain concepts that are related to the domain map they are currently authoring, allowing them to reuse material, or refer to it, as necessary.
6. The ability to create a lesson based on someone else's domain map(s): this is analogous to creating a lesson based on someone else’s book(s).
7. The ability to create a lesson that includes other lessons created by other authors: this corresponds to reusing the lesson materials of other teachers on the web, as long as they post it and allow such reuse.

In addition to the above features, the design of MOT 2.0, as initially proposed in this chapter, is focusing on utilizing two aspects:

1. *Collaborative authoring*: where multiple authors can contribute in the authoring process. The question here is at what level in the CAF structure (as shown in Figure 5) this collaboration should be. Possible options are, e.g., collaboration at

the level of a domain concept, domain attribute, lesson, link, whole domain map, whole lesson map, etc. For example, collaboration at the level of a concept in the CAF file would allow a user to edit existed concepts or create new ones (and/or sub-concepts).

2. *Social annotations*: where multiple users (authors and/or students) can annotate the content of the attribute (tag/rate/feedback) and share this annotation with other users. This raises a similar question to that raised by the collaboration aspect: which level of granularity is needed for social annotations? For instance, students rating at the level of the attribute in the CAF file would mean that an author could get feedback of the usefulness of each of the attributes he/she created.

Both collaborative authoring and social annotation will require the introduction of a more refined system of authorization (level of privileges). The question here is again at which level of granularity privileges should be defined. For instance, if privileges for authoring are limited to the level of a whole domain map, then it means that different authors have full editing rights over the whole contents of the domain map. If, however, such privileges are granted at a lower level of granularity, e.g., at the level of a link or a lesson in CAF, then this would correspond to a domain attribute.

In such a way, for each domain attribute, different access rights can be set. For example, user A can grant user B editing rights over the 'keyword' attribute of a specific concept – for instance, 'German pronouns' – but not over the 'text' attribute, which contains the main text of this concept. User A could however also grant editing rights to user C for the 'text' attribute, as well as the 'keyword' attribute – but not over the 'video' attribute. Therefore, users can receive specific rights only for the concepts and attributes that they specialize in. Thus, it seems appropriate to define users and groups at the level of links and lessons in the CAF file.

5.4. Related Work

A variety of research has been done on social annotation in multiple areas such as: *folksonomy* (Wu et al., 2006) which we used to define tags as a part of our research; *visualization* (Dubinko et al., 2007), which we used to visualize the collaboration design; *web search* (Dmitriev et al., 2006), which we planned to use as a feature of MOT 2.0 based on the tags; and *adaptation* (Ahn et al., 2006), where MOT 2.0 will "adapt" adaptive materials based on social annotation.

However, Ahn et al. (2006) used social annotation to enhance information visualization by defining visual pointers that grant information about a users' (and a groups') annotations of web resources; whereas in our work, the system will make recommendations on related materials based on social annotation. For example, if a user annotates a concept, then the system will record this annotation and suggest related materials to the user based on this annotation. Another example is to display recommendations based on the user's group interactions; if the user's group annotates (or contributes in the collaborative authoring) of a concept, then the system will store these collaborations and suggested related materials for all users who belong to that group.

Moreover, Bateman et al. (2006) proposed a structure for combining social annotations (tagging) with natural language ontologies. We argue however, that the tagging system should be based on freely chosen tags rather than applying a pre-defined ontology. Finally, Marshall and Brush (2004) studied the link between personal and shared annotations, defining the user and group aspects of a system. Therefore, based on such studies, MOT 2.0 will be enriched by adaptation material that is based on collaboration between the users.

5.5. Summary

In this chapter we have proposed a collaborative design process for authoring of Adaptive Hypermedia by applying our solutions to the adaptation authoring tool, MOT 1.0. We distinguish between two components of collaboration: *collaborative authoring* (which modifies the actual web resource, i.e., a concept in the domain model by multiple authors) and *social annotation* (which allows the users – Adaptive Hypermedia authors as well as students – to add/edit information without modifying the actual resource).

As a next step, the social annotations generated can be exploited by Adaptive Hypermedia, by reusing this information as possible recommendations for authors and students alike. Therefore, we want to explore the various ways these new annotations can be applied in the adaptation process. In this way, the newly contributed, inexpensive content and annotations can be utilized to generate new forms of adaptation and reasoning, thus enriching both the authoring and the learning experience.

However, as mentioned earlier, collaborative and social activities are not supported by most adaptive and e-learning systems. This issue can be overcome by improving the current architectures of adaptive e-learning systems, allowing them to take advantage of the strengths of Web 2.0, which is the topic of the next chapter.

CHAPTER 6

"It is not enough to have knowledge, one must also apply it. It is not enough to have wishes, one must also accomplish."

Johann Wolfgang von Goethe (1749-1832)

6. Social Reference Framework for Personalized Adaptive E-Learning

The previous chapter presented the need to merge the two concepts of Adaptive Educational Hypermedia and Web 2.0, to lead to a better learning experience. The current chapter[25] discusses in more depth this challenging hot topic in the area of Web 2.0 technologies for e-learning. This topic is how to merge these technologies with research on personalization and adaptive e-learning, in order to provide the best learning experience, customized for a specific learner or group of learners, in the context of communities of learning and authoring.

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[25] This chapter is based on the following peer-reviewed chapter:

Cristea, A. Ghali, F. and Joy, M. Social, Personalized Lifelong Learning. E-Infrastructures and Technologies for Lifelong Learning, book chapter. IGI Global. 2010.

In addition it is based on the following peer-reviewed papers:

Ghali, F. and Cristea, A. Authoring for E-Learning 2.0: a Case Study. The 9th IEEE International Conference on Advanced Learning Technologies, ICALT 2009. ISBN: 978-0-7695-3711-5. pp. 170-174. DOI 10.1109/ICALT.2009.71. 2009, Riga, Latvia.

Ghali, F. and Cristea, A. MOT 2.0: A Case Study on the Usefulness of Social Modelling for Personalized E-Learning Systems. Frontiers in Artificial Intelligence and Applications, Volume 200, 2009 Artificial Intelligence in Education - Building Learning Systems that Care: From Knowledge Representation to Affective Modelling, ISBN 978-1-60750-028-5, pp 333 - 340, DOI: 10.3233/978-1-60750-028-5-333.

Ghali, F. and Cristea, A. Social Reference Model for Adaptive Web Learning. International Conference on Web-based Learning, ICWL 2009. ISBN: 978-3-642-03425-1. pp. 162-171. DOI: 10.1007/978-3-642-03426-8_21. 2009, Aachen, Germany.

Ghali, F. and Cristea, A. MOT 2.0: Learning 2.0 Tool. In the 4th. European Conference on Technology Enhanced Learning, EC-TEL 2009, 2009. Nice, France.

We show how an existing framework for personalized e-learning can be extended, in order to allow the specification of complex new relationships that social aspects bring to e-learning platforms. This is not just about creating learning content, but also about developing new ways of learning. For instance, adaptation does not refer to an individual only, but also to groups, which can be groups of learners, designers or course authors. Their interests, objectives, capabilities and backgrounds need to be catered for, as well as their group interaction. Furthermore, the boundaries between authors and learners become less distinct in the Web 2.0 context.

This chapter presents the theoretical basis for this new framework, as well as its implementation and evaluation, and concludes by discussing the results and drawing conclusions and interesting pointers for further research.

6.1. Overview

The term “Web 2.0” is attributed both to (DiNucci, 1999) and (O'Reilly, 2005), and became more widely known when it was proposed by O'Reilly during the Web 2.0 conference. Currently it broadly refers to a web development stage which harnesses the power of the users, in which (for example) web-based communities and social networking sites, Wikis, Blogs, mashups and folksonomies, are integral parts.

The infrastructure of Web 2.0 (or the “Social Web”) arguably also permits new means of e-learning, where the learners have not only reading, but also writing access (rating, commenting, contributing, etc.) to communities which collaborate in order to achieve specific goals (generally these goals are for the learners to learn and expand their knowledge level). These communities provide not only significant (possibly supplementary) learning material, but also experts and peers (Klamma et al., 2007).

The shift towards the Web 2.0 (read/write) concept is changing the way in which content and services are being produced (Tapscott and Williams, 2006), and in e-learning this change can be seen as a type of communication in which learners can exchange with their teachers the role of being active and leading the processes of learning and knowledge construction (Roberts, 2005). According to (Klamma et al., 2007), some of the key factors of Web 2.0 which make it a good opportunity for e-learning are as follows:

1. **User generated content.** Web 2.0 is based on the users and the content created by them. Thus, learners can add to the knowledge collection using a constructivist learning approach (Duffy and Jonassen, 1995).
2. **Various user types and roles.** Users in Web 2.0 can be learners, teachers, authors, administrators, etc. The Web 2.0 context allows for all of these roles to interact with each other, in an ad-hoc, synchronous or asynchronous manner, appropriate for e-learning.
3. **Facilitating collaborative creation, sharing, and commenting on the content.** This moves peer discussion and learning from the synchronous, curriculum-led classroom environments, to the more informal and socially discursive asynchronous web environments, where learning can take place outside of scheduled times, and thus becomes more amenable for online learning.
4. **Augmenting the content in bottom-up and/or top-down fashion** (Carcillo and Rosati, 2007). In the top-down annotation, the system uses predefined metadata to index and tag the created content. In the bottom-up annotation approach, the system allows the users (individually or in groups) to annotate the content with freely chosen tags (keywords). This approach allows for both teacher recommendations (usually top-down), as well as peer and student recommendations (bottom up).
5. **Emerging groups/communities.** This concept identifies a set of individuals who have similar interests, goals, etc. In the context of e-learning, where collaborative settings are more frequent than competitive settings, students may recognize that they can reach their learning goals if the other students in the learning group also reach their goals (Deutsch, 1962). Whilst there is no guarantee in general that students would recognize this fact, by visualizing the common goal this recognition could be brought forward by the system. Groups also can be adapted to, as will be shown later.

Thus, e-learning and Web 2.0 complement each other: where e-learning is about learning anywhere, anytime, Web 2.0 allows for collaboration during learning, as well as during the creation of the learning content. Additionally, both e-learning and Web 2.0 rely on the users more than the content itself, where the users determine their own learning pace (in e-learning), or create, evaluate (rate) and edit the content (in Web 2.0). Therefore, e-learning 2.0 emerges from the combination of 'regular' e-learning and Web 2.0 technologies.

However, with the massive amount of (general) information available through Web 2.0, it is becoming harder for learners to learn, or even to find, related communities, peers, and content, and this makes the process of e-learning using Web 2.0 less efficient. To overcome this challenge, we perceive adaptive and personalized techniques as the key elements for extending learning activities and making the learning process more effective.

Moreover, personalization, customization and adaptation to the user, are terms frequently used in the areas of user modelling (Rich, 1979) and Adaptive Hypermedia (Brusilovsky, 1996a), and refer to showing each user the exact information they need, when they need it, and where they need it. In addition, adaptation and personalization can be applied to content, in the sense of delivering appropriate information to the user. More importantly for Web 2.0 applications, unlike adaptation in regular personalized e-learning systems where adaptation is focused on the individual, adaptation can take into account the different interacting users of a system.

This means that adaptation can be delivered based on user groups. This can take the form of showing similar content to users with similar interests. Also unlike classical personalization, adaptation can also take the form of bringing users with similar interests together, and allowing them to communicate directly with each other. In educational applications, these users are the learners. Finally, adaptation can be applied to recommend experts or teachers to learners, or inform teachers which students are in need of help.

6.2. The Social Personalized Adaptive E-Learning scenarios

To illustrate the type of adaptation that was initially aimed at by the new framework, we present four social, personalized, adaptive e-learning scenarios using SLAOS (Social LAOS), the new framework for social adaptive e-learning. The first scenario explains the situation of a student helping another student. The second scenario represents the case of recommending peers. The third scenario explains how the system might recommend reading material or another project to an individual student. In the fourth scenario the system content to an author. These scenarios are by no means intended to be exhaustive, and they can be extended with other typical learning situations. The scenarios are used to introduce the Social LAOS framework and its definitions. These scenarios are also related to the screenshots presented in the implementation section.

6.2.1. Scenario 1: Help! I'm lost

Mary is following lessons on an online system with social support, adaptation and personalization, based on SLAOS. She is stuck on the topic of 'Banking crises' (Figure 20). The system could recommend her to contact a specific teacher, or some customized reading material (Figure 20).

Requirements: the system should allow personalization of material (items in a module) to a learner, and recommendation of 'expert students'.

6.2.2. Scenario 2: A group project

Students Mary and Jane later participate in a group project 'writing an essay on theories of Financial crises' (Figure 21). It is a three-person project, so after the two students register for it, the system recommends student Bob as a third person, as he had earlier registered as looking for project partners for the same topic.

Requirements: the system should assist in the organization of group work by recommending peers (students).

6.2.3. Scenario 3: I'm done. What now?

John, a company worker, is studying a subset of modules that have been recommended by his company. He has finished the whole module on 'Financial crisis' (see Figure 21) that Mary was studying before. He is wondering what to do next. The system recommends related modules for him to have a look at. In addition to 'Advanced concepts on Economic crises', the course also suggests 'Famous financial crises in history', as well as some other topics. As John is not yet sure about following the higher level module, he reads a little, for his own amusement and interest, about the famous financial crises in history.

Requirements: the system should allow recommendation of similar topics (modules).

6.2.4. Scenario 4: Has this been done before?

Helen is a teacher of Economics and is authoring some of the material for this course. She has just started creating an item on 'Financial crisis' (see Figure 22). She is wondering whether it has been done before. The system finds for her a publicly available item on 'Strategic complementarities in financial markets'. Helen decides (by skimming through the information provided by the system) that she will be able to use this in her module, and adds it to her module by linking to it.

Requirements: the system should allow personalization of material for authors.

6.3. The Properties of a Social Personalized Adaptive E-Learning system

None of the previous personalization and adaptation frameworks (see Section 2.4) have modelled the social activities from the Social Web, which focus on the relations between the users on the web and their collaborative activities, as outlined in the scenarios above. In addition to the information stored in previous models, the information collected from social annotation can be used to recommend adaptive materials for the delivery/authoring process (see Section 2.4.6).

The aim behind including collaborative authoring and social annotation modelling is to create a comprehensive framework that allows for the definition of improved adaptive materials based on communities of practice (Wenger, 1998), where the learners collaborate actively in the form of groups (communities), rather than being passive in the learning process. The benefit of such a framework is that it is system independent, and thus can be applied to any system wishing to integrate adaptation and Web 2.0 technology. It makes sense, however, not to start from scratch, but to add the social model on top of an existing model for adaptation.

Therefore, based on the reasons highlighted in the previous section, we have built our social model on top of the LAOS framework for authoring Adaptive Hypermedia. This is how the Social LAOS framework (SLAOS) came into existence, and why it has arguably been kept generic enough to be used by any adaptive Web 2.0 system.

In SLAOS (Social LAOS), authors who share the same interests can collaborate to provide more valuable adaptive content within their communities, based on their different backgrounds and knowledge. The collaborative facilities in SLAOS rely on Web 2.0 techniques, such as group-based authoring, co-operation in creating the courses, tagging the content, and rating and providing feedback on the content. The collective content works as a state-based system, as each particular instance of it can be used to improve the authoring process by recommending related content to authors, who then can decide on the next state of the collective content based on these recommendations.

Additionally, related authors can be recommended, who can help in the authoring process. Furthermore, in SLAOS, teachers are no longer the only authors of the content; students are also considered authors. These settings are controlled by a set of privileges set by the teachers. Therefore, similar recommendations can be provided for students. Figure 14 illustrates the smooth transition, in a sliding-scale fashion, between learners (students), teachers, authors and administrators. The X-axis represents the various users of a social e-learning system, whilst the Y-axis represents the rights these users have in the system.

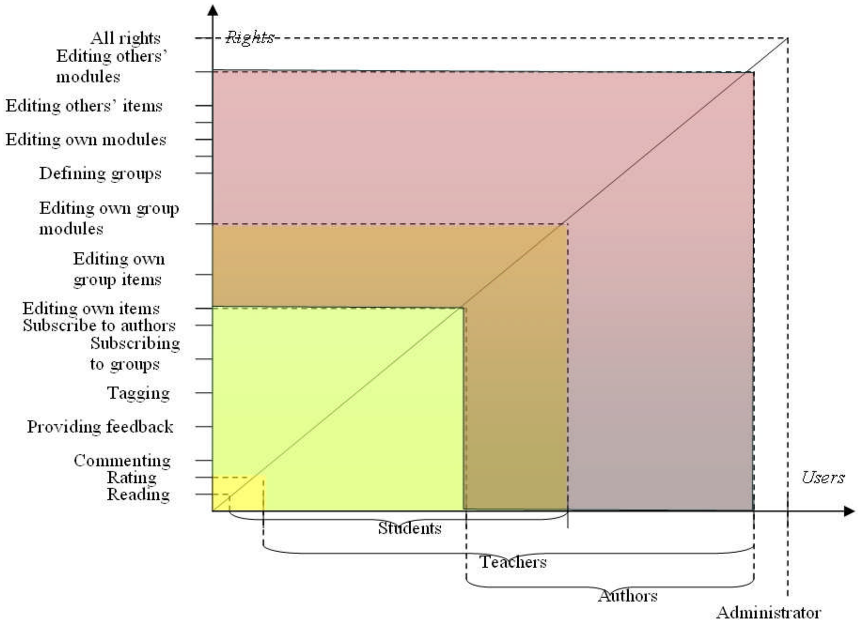

Figure 14 Smooth Transition from Student to Author in Social E-learning

Figure 14 shows that the different categories of users are not represented by a single point in the users-rights space, but that they could be defined anywhere within a segment of the graph. For instance, a student could have only reading rights and nothing more, being at the beginning of the segment of students. However, a student could have tagging rights, or even rights of editing their own or group items – thus being placed at the end of the segment. Similarly, a teacher could just have rating rights, effectively to mark students, or they could have complex authoring rights, being able to edit their own modules or even modules outside of their own group. Authors, by definition, should have at least some authoring rights, e.g. rights for editing their own items. At the end of the scale, authors could author – in group or by themselves – any given items or modules. Finally, the role with maximum rights is that of the administrator, who can do any of the tasks allowed to students, teachers and authors, and any other tasks which are present in the system.

Note that this graph is for orientation only, and it does not represent all possible users or all possible rights. Whilst attempting to order the rights for the figure (Figure 14), other orders are possible, depending on the system they are applied to. Also note that no monotonic increase is assumed.

Moreover, Figure 14 already displays an extended idea of rights for student, teacher, and author, where teachers and authors are ‘just’ students with more rights. However, in the context of e-learning, it is important to note that these segments can be extended even further, and that the fuzzy difference between the roles could disappear altogether, leaving only one type of user with a set of rights. The progression to a higher level of rights has to be established outside this figure, depending on the goal of the system. For example, if the goal of the system is to teach writers, and ultimately to allow them all to collaborate in a wiki-like manner, a user could progress from initial reading rights all the way to editing other modules, depending, for example, on peer evaluations, trust, etc.

Furthermore, Figure 15 illustrates the addition of a new layer, the social layer, to LAOS, which expresses all social activities within Adaptive Hypermedia Systems. These social activities include, but are not limited to:

1. *Collaborative authoring* (editing content of other users, describing content using tags, rating, commenting on the content, etc.).
2. *Authoring for collaboration* (adding author activities, such as defining groups of authors, subscribing to other authors, etc.).
3. *Group-based adaptive authoring* via group-based privileges.
4. *Social annotation* (tagging, rating, and providing feedback on the content via group-based privileges).

The Social Reference Model, SLAOS, follows the multi-layered approach of its predecessors, for similar reasons: extracting the semantically different layers (or models) of a generic system allows different system components to be mapped onto the different layers, and thus allows a high degree of reuse of these components. For example, a domain model can be reused with different adaptation models. These models represent the normalization axes or principal components of, in our case, a generic social adaptation system.

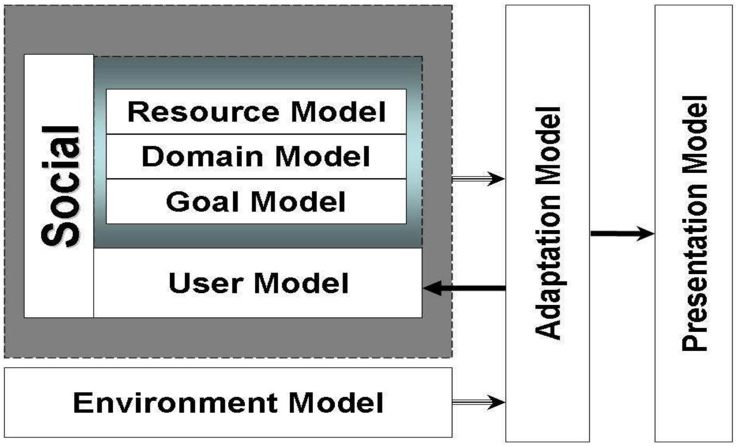

Figure 15 Social LAOS Framework

Besides the social model, the SLAOS framework encompasses two ‘new’ models: the *Resource model* and the *Environment model*. The resource model used is inspired by the Dexter model (Halasz and Schwartz, 1994), to separate resources from their domain, and thus allows for a higher degree of reuse. Similarly, the *environment model* was separated from the *presentation model*, to more clearly separate external factors from what is shown on the screen. The environment model is subsequently refined into a physical device model, a network model and an external environment model.

The overall structure inherits the conceptual model based structure from LAOS. The figure (Figure 15) shows also which models are overlaid, such as the *resource*, *domain*, *goal*, *user* and *environment* models, thus concepts from the resource level are used in the domain or goal model to add additional information to them (see Section 6.4).

The social component acts vertically, and not horizontally, as it affects most of the other layers directly. For example, the resource model layer includes new entities to describe tags, feedback, comments, rating of the actual concepts, and the relations between these concepts. The domain model overlays the resource model, and thus inherits and manipulates the social activity descriptors. The goal model includes new entities to describe the new constraints on the social activities, i.e. determining who can do what. Moreover, the user model contains new entities to describe the groups and the roles (privileges) for these groups, which will be added to the user model. Additionally, the adaptation layer holds new entities to handle the collaborative adaptive strategies. The presentation layer also contains new entities to describe how to present information to groups of users. The adaptation and presentation model uses these elements via data exchange with the package of socially enhanced models.

Finally, Figure 15 also shows the interaction between the individual models: the social resource, domain and goal model provide a content-based, metadata-enriched package to the adaptation model, together with a social user model, and an environment model. The adaptation model specifies how the input from these models is processed, and then how it is output into the presentation model (what the learner gets to see) and the update of the user model (how the information known about a user is updated).

6.4. SLAOS Components

In the following, the composing models of the SLAOS framework are formally defined in turn: the *Social Domain Model*, the *Social Resource Model*, the *Social Goal and Constraints Model*, the *Social User Model*, the *Social Presentation Model* (here represented only by one of its sub-layers, the *Social Physical Device Model*) and *the Social Adaptation Model*.

6.4.1. Social Resource Model

The Resource model is the one storing the items that students are reading at a time, within a module. The social overlay over the resources is represented by meta-data such as ratings, feedback, etc. The Resource Model in SLAOS is represented as a collection of items in the MOT 2.0 system. The item refers to the smallest data entity. For example, the 'Introduction' item described in the previous learning scenario is an item.

This model consists of a set of items; each item represents the smallest data unit. For example, any section in a module can be linked to one item; such as "Banking crises" (see Scenario 1 and Figure 20). This item can have a set of features described as attributes.

Each item can have a set of ratings, tags and feedbacks. For example, the “Leverage” item can have a set of tags (keywords) describing the content of this item, such as “crisis”, “leverage” or “Wall Street” (see Figure 21). Also this item can have feedback (comments), from the authors and/or from the learners. The comments are generally related to the content of the item. Moreover, this item can have a set of ratings to value its content. The content of the “Leverage” item (see Figure 21) has a rating value (typed or not typed; types can include relatedness, interest, correctness, etc.). The rating has a range from 1 to 5, and therefore any user (author or learner) can rate this item according to their point of view. If this item was rated by three users with values of 4, 3, 5, then the total rate will be (4+3+5)/3 = 4 out of 5, or “Very good” (see Figure 21).

Moreover, the item can have a set of attributes that describe this item. For example, the item can be an image (so $type_{all}$ = “image”), thus can have attributes such as resolution, width, height, type (JPEG, TIFF). Each attribute can have a set key-value pairs. For example, an item of an overall type ‘image’ can have a subset of attributes, such as width (type = width and value = 400px), resolution (type = resolution and value = 300dp), image file extension (type = file extension, and value = JPG), etc. As the module may represent a lesson, it should not be empty and should contain at least one item.

6.4.2. Social Domain Model

The Social Domain Model is introduced as a hierarchical representation of items, grouping them into modules. The hierarchical structure permits the reusability as the same item can be used in multiple modules. The module refers to the taught course. For example, the ‘Collaborative Filtering’ module described in the previous learning scenario represents a module.

The collection of all modules is an abstract term, including collections of all modules taught in a social personalized adaptive environment: for example, in a university economics department, these might include “Financial crisis” (see Figure 21), “The Industrial Revolution: Growth and Living Standards” and “Development Economics

(Macroeconomics)". Another example, a lesson on financial crisis can be represented as one module, which can have a set of sections (anchors to items) such as "Types of financial crisis" or "Banking crisis" (see Figure 21). These sections can be interlinked hierarchically or in other ways.

A domain concept (or anchor) links to a resource, for instance, it could point to a content item called "World system theory" (see Figure 21). Keeping domain concepts and content items separately ensures that a different domain concept could also point to the same item, thus effectively reusing the material within a different module.

Items can have hierarchical relations (domain links) between themselves, such as between "Theories of financial crisis" and "Minsky's theory" (see Figure 21). This relation (link) could be used for adaptation purpose, for instance to show the resources related to the item "Theories of financial crisis" before "Minsky's theory".

A module can have a set of attributes, for example, an attribute for the "Financial crisis" module (see Figure 21) could be the details on the author of this module. Another attribute could be the description of the domain contents gathered in the module.

6.4.3. Social Goal and Constraints Model

The framework allows for higher level specifications, such as goals of the adaptation process (here, the learning process) via the Social Goal model. For example, the previous lesson (module) of "Financial crisis" can have a set of adaptive modules, each of these adaptive modules (e.g. Figure 20) can have different pedagogic goals (adapt to user knowledge, personalize for preferences, etc.) which can be expressed as a set of constraints (conditions) in order to deliver adaptive course materials.

Moreover, using this model, a label attribute can be added to the "Speculative bubbles and crashes" item in the lesson on "Financial crisis" (see Figure 20). The label attribute defines the knowledge level required for this item (e.g. beginner, intermediate, or advanced), and based on this label, the item can be part of different views depending on the learner's knowledge level. For instance, in Scenario 3, if 'Financial crisis' is all marked as beginner level, then John can be recommended 'Advanced concepts on Economic crises' and 'Famous financial crises in history'.

6.4.4. Social User Model

The Social User model allows for the storing of data about a learner, teacher or author as well as data about groups, rights of users and groups, etc. Therefore, the social aspects of the user model deal with interaction of multiple users and with groups of users, instead of individual users only. This is an essential deviation from regular Adaptive Hypermedia frameworks and systems, which traditionally deal only with the "current student". The User Model in SLAOS is mapped into user/group variable-value pairs in the MOT 2.0 system. For example, the user Jane in the previous learning scenario can have a user model variable 'requiresHelp' which is set to the value of True.

Each user model has a set of attributes. For example, the set of attributes can include knowledge level, interest, display preferences, age, etc. Links within user models could appear if, for example, an attribute such as interest can be related, via a formula, to the knowledge level of the user. A user of the social adaptive system could be represented by their set of preferences, such as knowledge, interest, etc., and could also be related to other users via various relations, such as friendship or class membership. For example, each attribute could be represented as having the following default values: knowledge level = beginner, interest = 1, display preference = text and images, age = 40.

Moreover, groups are defined in this model as a set of user, and a learner can join different groups such as the ALS group or the Warwick group (see Figure 20 and Figure 19), and in each of these groups, the learner can have different roles. The role can be defined as key-value pairs, such as, read = 1, edit = 0, tag = 1, etc.

6.4.5. Physical Device Model

The Environment Model in SLAOS is thus mapped to the physical device in the MOT 2.0 system. The types of physical device media can be PDA, Desktop Computers, Laptops, etc. There is a need to adapt to the nature of this media, even if the user is the same, as different screen sizes can affect the information transmitted. As an example, in the previous in learning scenario, Jane was using her laptop (with web browser) in order to access to MOT 2.0, as the default physical device. Other environmental factors can be researched in different areas, such as weather, geographic location, eye-tracking, etc.

The device model has a set of attributes, such as screen resolution. The PDA resolution is 240×160, and the computer screen resolution is 1280×1024. When more users are collaborating, the common denominator of the different devices used by the different users is the one that is selected, e.g., the minimum resolution at which all collaborating partners can view the item.

6.4.6. Social Adaptation Model

The Social Adaptation model creates different presentations (specified via the Presentation model), based on the combination of items from the other modules. For instance, if a rating of an item in the Resource module is above a threshold, and the User model shows that the user has a low amount of knowledge about that topic, that item can be recommended by the Adaptation model algorithm, and thus presented via the Presentation model. The Adaptation model in itself can have many components. An example is the LAG model (Cristea and Verschoor, 2004).

An example is a group-based adaptation support using recommendations techniques, such as *recommended learning content* based on the learner's profile (which is represented in the Social User Model). This can be implemented with a function based on the content, the rating, and a personal threshold for a given student for the accepted rating. This will influence which items will be shown.

6.4.7. Presentation Model

The Presentation Model in SLAOS is mapped onto presentation states, such as showing/hiding the recommended learning content and the recommended (expert) learners in the MOT 2.0 system. Overall, the presentation model has the role to decide what, where and how something is being shown to the user. Figure 29, Figure 30 and Figure 31 show the three different screenshots of the MOT 2.0 based on the group.

The presentation model in Figure 15 is used to decide what, where and how something is shown to the user. Attributes of presentation can be as simple as deciding if a specific content is to be shown or not, or if the name of a peer student is to be shown or not. Alternatively, it can be complex, such as in deciding how the screen is to be used for the specific presentation, what is to appear where on the screen, etc. The following diagram summarises the main components of SLAOS:

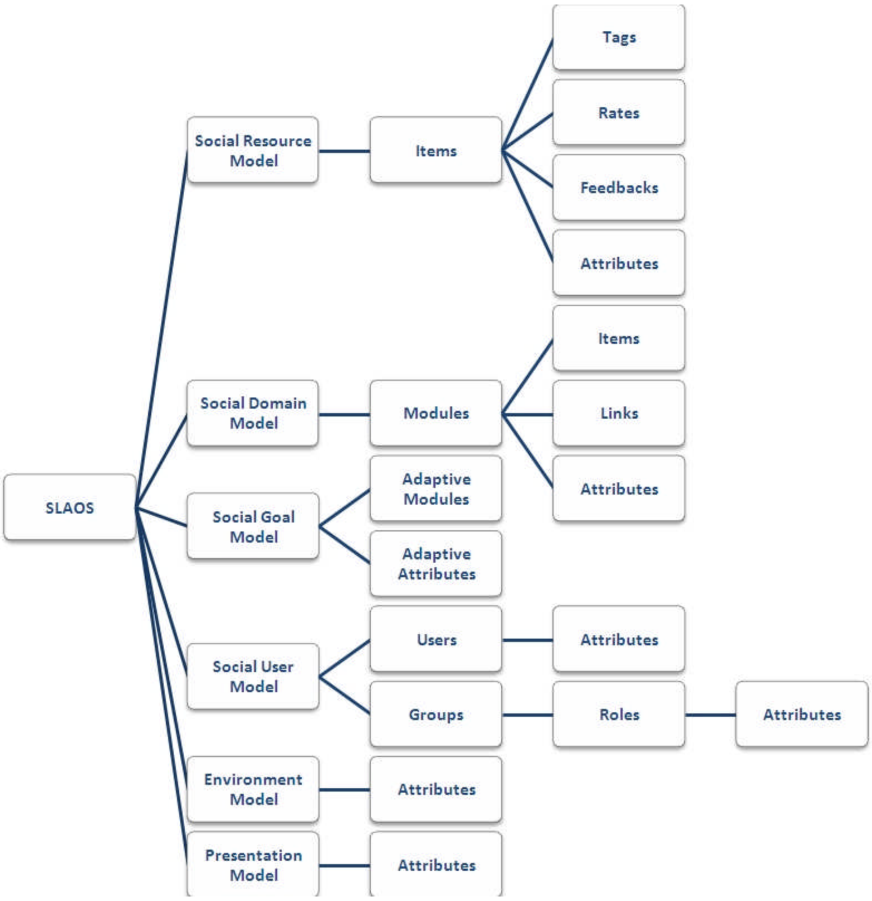

Figure 16 Social LAOS Components

6.5. My Online Teacher 2.0 Prototypes

MOT 2.0 has three iterative prototypes that are built based on each other (i.e., the second prototype is based on the first prototype, and the third prototype is based on the second prototype). In the following, we illustrate different features in different MOT 2.0 prototypes:

6.5.1. First Prototype

The first prototype of MOT 2.0 concentrated mainly on a high level balance of the three roles: *learner*, *author* and *teacher*, and what adaptation meant to each of these roles. The *complexity* of the adaptation was not the issue (thus simple adaptation based on similarity of content was applied), but the *type* of adaptation necessary (or possible). Another issue analysed was *group formation and rights* within a group. Therefore, members of the same group were given similar rights, to begin with, thus keeping one variable constant, in order to focus on the study of the impact of group formation in e-learning 2.0.

One of the main ideas derived by this first research and prototype was that of the permeability of these roles: in a Web 2.0 environment, learners can also become authors, to a degree (for instance, they can add feedback to an item, they can tag items) and thus also implicitly teachers, to some extent (students who come after them benefit from these comments and tags and can learn from them). On the other hand, authors can also be supported in their authoring, by having appropriate content recommended to them.

Moreover, another theoretical result was as follows: if we analyse the balance between the roles from the point of view of the rights in a Web 2.0 environment, authors can be defined by the fact that they have more rights than students, in terms of them being able to edit more items and modules. However, students also contribute. In principle, well-performing students should be able to 'gain' more rights by their 'good behaviour' or good results, and thus be able to achieve editing rights for certain items, or even module creation rights, and therefore becoming 'full-fledged' authors. This idea was implemented and used in the second prototype.

The evaluations of the first prototype analysed the *usefulness of the Web 2.0 features* (such as grouping, tagging, rating, subscriptions) in an e-learning context. These evaluations were performed both with designers and students. A remaining question was that of the usefulness of varying degrees of rights given to students, which was further taken into consideration and implemented in the second prototype.

6.5.2. Second Prototype

The second prototype of MOT 2.0 system was centred on the Learner scenario only. Hence, the adaptation was enhanced with three specific types of adaptation, which we wanted to analyse in more detail:

- two types of *adaptation* (i.e., system-driven adaptation):
    - *adaptive recommendation of learning content*, and
    - *adaptive recommendation of peers.*

The main focus of the second experiment was on the two types of adaptation envisioned above. This allowed us to study the effect of overlaying *adaptive content recommendation* and *peer recommendation*, respectively, over a *Web 2.0 learning environment*.

6.5.3. Third Prototype

This section lists the differences between the second prototype and the third prototype.

1. Group Forming
    a. In the second prototype, there were three groups:
        i. Group one: the first group, acting as a control group, performed the learning activity using MOT 2.0 without any help from the content recommender, or the (expert) learners' recommender.
        ii. Group two: the second group learned using MOT 2.0, with the help of recommended learning content, but without the help of the recommended learners.

iii. Group three: the third group learned using MOT 2.0, without the help of the recommended content, but with the help of the recommended learners.

b. In the third prototype, there were only two groups:

i. Group one: the first group, acting as a control group, performed the learning activity using MOT 2.0 without any help from the content recommender, or the (expert) learner recommender.

ii. Group two: the second group learned using MOT 2.0, with the help of recommended learning content, and the help of the recommended (expert) learners.

c. Therefore, the second group in the third prototype combines the adaptation found in the second and third groups of the second prototype. We expect this to result in a synergetic effect of the two.

2. Item-based fine-grained recommendations of learning contents and (expert) peer learners

a. The granularity of recommendation in the second prototype, for all types of adaptation, was on the whole current module.

b. The granularity of recommendation in the third prototype, for all types of adaptation, is on the current item.

In the following, we summarise the three prototypes as well as their features

Table 2 MOT 2.0 Prototypes

Feature	**1st Prototype**	**2nd Prototype**	**3rd Prototype**
Group based authoring	Yes	Yes	Yes
Content recommendations	Content-based	Module-based	Item-based
Peer recommendations	No	Module-based	Item-based
Implementation	Yes	Yes	Yes
Combined recommendations	No	No	Yes
Quantitative evaluation	Yes	Yes	Yes
Qualitative evaluation	Yes	Yes	Yes

6.6. *My Online Teacher 2.0 Implementation*

The development and implementation of MOT 2.0 is achieved using Java technologies, XML, and MySQL. In addition, it was one of the requirements to connect MOT 2.0 and e-learning standards which was done using JAXB. The application used MVC model (Model-View-Controller) as it is shown in Figure 17

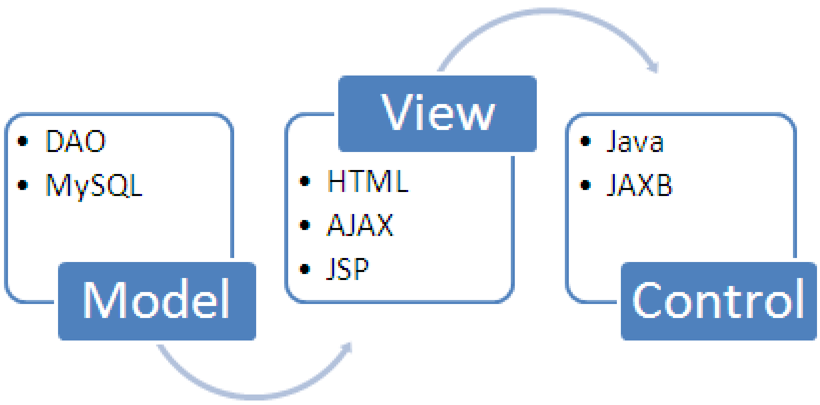

Figure 17 MOT 2.0 architecture

The Model contains the database structure which contains MySQL tables as well as DAO layer. Data Access Object (DAO) layer facilitate connecting the web application to the database, and makes the SQL queries optimized (as it offers caching mechanism). The View contains the presentation of the web application that uses HTML, AJAX and JSP. AJAX is used in MOT 2.0 as it is feature of Web 2.0 applications. The control contains the business logic of the web application that uses Java and JAXB technologies.

Moreover, MOT 2.0 supports a set of activities that are highlighted in Figure 18. These activities are: 1) Register activity: this activity allows the user to register with MOT 2.0 and creates a user profile. 2) Login activity: this activity allows the user to log onto MOT 2.0 and use other activities. 3) Authoring activity: in MOT 2.0, the author prepares a course using the authoring screen as in Figure 22. 4) Learning activity: where the students can learn. 5) Update profile: Figure 19 illustrates how the user can control his profile using MOT 2.0 6) Joining / Leaving groups: when the user joins or leaves a group as in Figure 24.

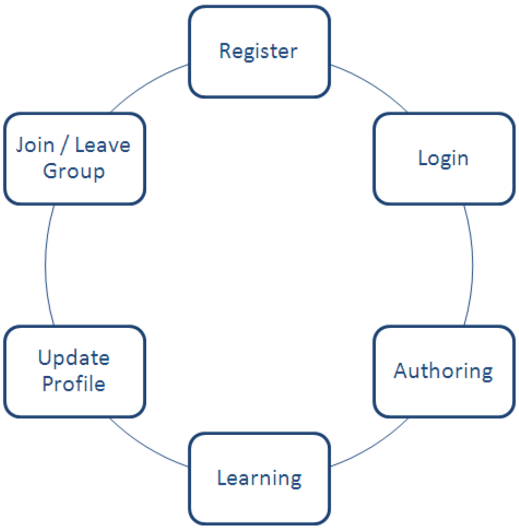

Figure 18 MOT 2.0 user activities

The Register activity is described in details below. The database has a table called “User” which has the following structure:

```
CREATE TABLE `user` (
  `idUser` int(10) unsigned NOT NULL auto_increment,
  `username` varchar(45) NOT NULL,
  `password` varchar(45) NOT NULL,
  `email` varchar(45) default NULL,
  `screen` tinyint(1) unsigned default '1',
  `created` datetime NOT NULL,
  PRIMARY KEY  (`idUser`),
  UNIQUE KEY `unique_username` (`username`),
  UNIQUE KEY `unique_email` (`email`)
) ENGINE=MyISAM AUTO_INCREMENT=23 DEFAULT CHARSET=latin1;
```

The DAO of the user table is listed below:

```
public interface UserDao
{
public UserPk insert(User dto);
public void update(UserPk pk, User dto);
public void delete(UserPk pk);
public User findByPrimaryKey(UserPk pk);
public User findByPrimaryKey(int idUser);
public User[] findAll();
public User[] findWhereIdUserEquals(int idUser);
public User[] findWhereUsernameEquals(String username);
public User[] findWherePasswordEquals(String password);
public User[] findWhereEmailEquals(String email);
public User[] findWhereScreenEquals(short screen);
```

```
public User[] findWhereCreatedEquals(Date created);
public void setMaxRows(int maxRows);
public int getMaxRows();
public User[] findByDynamicSelect(String sql, Object[]
sqlParams);
public User[] findByDynamicWhere(String sql, Object[]
sqlParams);
}
```

The register action handles the registration process as follows:

```
public class RegisterWebAction extends WebAction  {
public void execute(WebController servlet,
HttpServletRequest request, HttpServletResponse response)
throws ServletException {
try {
action = parseString(request, "action");
message = null;
rd = request.getRequestDispatcher("index.jsp");
if (action != null && action.equals("register")) {
username = parseString(request, "register_username");
password = parseString(request,"register_password");
register_email = parseString(request, "register_email");
UserDao dao = UserDaoFactory.create();
String sqlParams[] = {register_username};
User users_login[] = dao.findByDynamicWhere("username= ? ",
sqlParams);
int i = users_login.length;
if (i == 0) {
      User user = new User();
      Date now = new Date();
      user.setCreated(now);
      user.setEmail(register_email);
      user.setUsername(register_username);
      user.setPassword(register_password);
      dao.insert(user);
      } else {
            message = "Username already exist!";
            rd = request.getRequestDispatcher("login.jsp");
       }
       request.setAttribute("register_message", message);
  }
rd.forward(request, response);
  } catch (Exception e) {
 throw new ServletException("Failed to process request", e);
        }
    }
}
```

6.7. My Online Teacher 2.0 First Prototype

In the following, we illustrate the definitions of the Social Layer for a specific new system developed at the University of Warwick: the MOT 2.0 system, an adaptive Web 2.0 authoring and delivery system for Adaptive Hypermedia, first mentioned in (Ghali and Cristea, 2009b) and in Chapter 5. It is a completely new system, designed and implemented from scratch. Figure 19 illustrates the fact that the social user model captures the results of all actions the users made using MOT 2.0; these action results include which groups the user has already subscribed to, what modules the user has created/edited, and what tags the user has already used and for which module. In a future version (MOT 2.0 second prototype, see Chapter 7, and MOT 2.0 third prototype, see Chapter 8), MOT 2.0 will capture more information, such as the user's own ratings, etc.

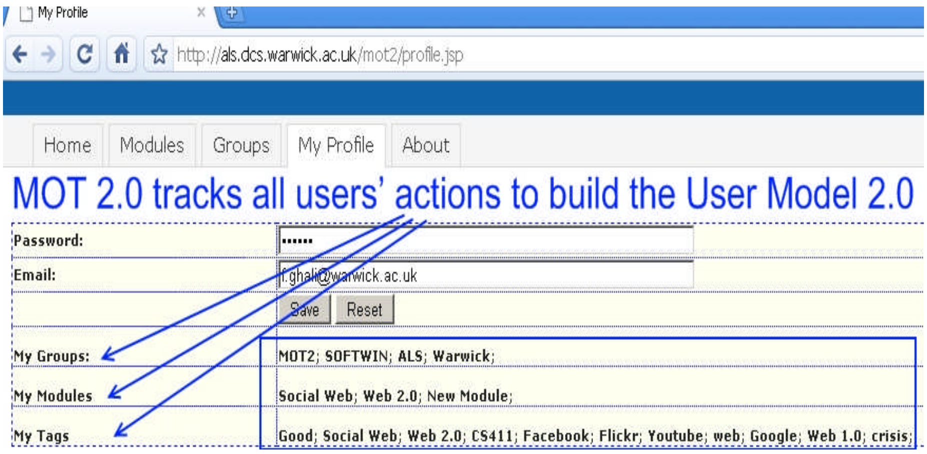

Figure 19 MOT 2.0: User model 2.0

The group affiliation shown in Figure 19 is used in Scenario 2, where Mary, Jane and Bob eventually belong to the same group who are working on a common project, and in Scenario 4, where Mario moves between two groups before finally reaching a group that is better matched to him.

Figure 20 expresses the adaptive view of the lesson, which shows other related recommended materials for further reading based on the similarity of the tags (keywords that label the content). This is also in view, to some extent, of Scenario 1, which requires that adaptation of items and modules should be supported, and Scenario 3, which requires only recommendation of other modules.

The content is based on an overall social goal and constraints model, with a hierarchical structure, which in this simplified version directly reflects a similarly social structured domain model and social item model. In the following implementation round, the initial plan was to both extend the implementation to more fully reflect the flexibility allowed by these content-based layers, as well as apply other adaptive strategies, as the specification of the strategy will be external and exchangeable, according to the LAG model (Cristea and Verschoor, 2004). This was replaced by the recommendations strategies, described in Section 7.2.3 and Section 7.2.4.

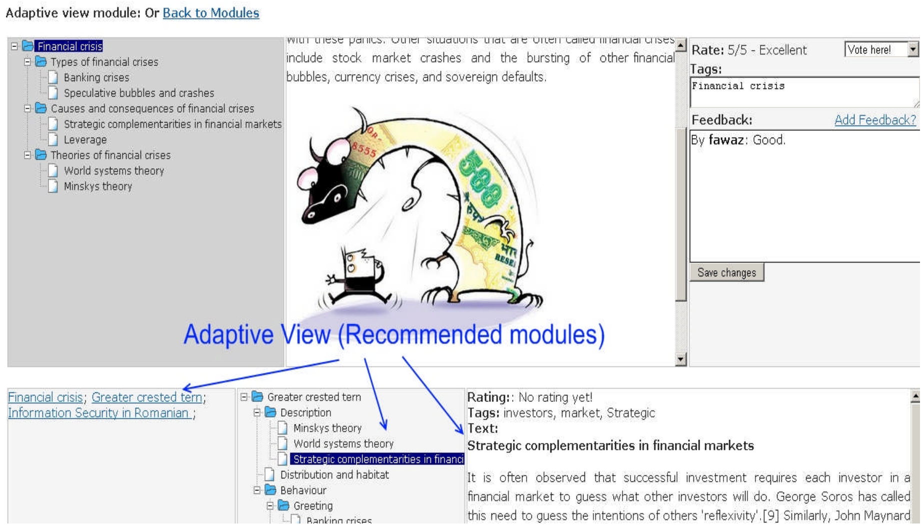

Figure 20 MOT 2.0: Adaptive reading

Figure 21 describes the social annotations of the current lesson, viewable based on the user's viewing privileges for the selected group/course. These social activities include rating the item content, feedback, and tagging items with a set of keywords. These activities are captured and added to the user model in order to provide more adaptive features, and thus more flexibility in the adaptation process. This ensures that the recommended content is based not only on the background and trace of the user, as in classical Adaptive Hypermedia, but also on social activities, e.g., on how popular the item is with other readers, or who recommends it (trusted users versus unknown users). This is also used in Scenario 1 for recommending content, as well as in Scenario 2 for grouping the work for students.

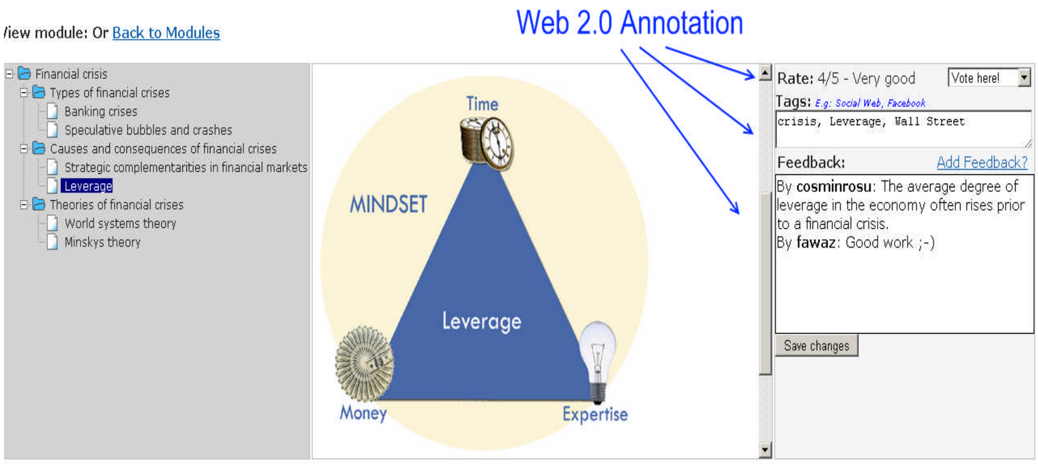

Figure 21 MOT 2.0: Social and Web 2.0 annotation

Figure 22 shows how the adaptive authoring works, by displaying other related recommended courses which can be used when creating the course. Scenario 4, with Helen putting together a course based on system recommendations, is directly reflected here. The fact that something is presented or not is based on the pedagogical adaptation strategy, which influences the presentation model (e.g., a Boolean value overlaid over an item that is to be shown is set to True). The plan was to allow, in a future version, different adaptive strategies as defined by the LAG model to be used in the authoring process. This was replaced by the recommendations strategies, described in Section 7.2.3 and Section 7.2.4.

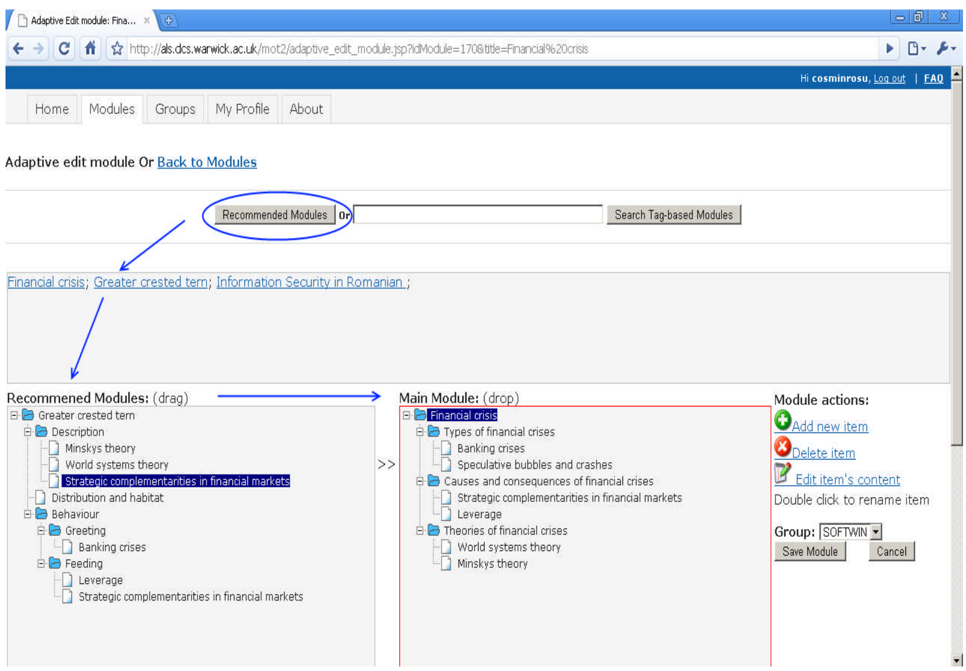

Figure 22 MOT 2.0: Adaptive authoring

Figure 23 is about merging the authoring and the delivering processes, as the users may still change the content of the course during or after the delivery, or they may annotate it during its creation. This explains why adaptive strategies can be applied not only for the delivery process, but also for the authoring process. The view shows both goal and constraints maps in viewable (‘view’) and editable (‘edit’) form, as well as the result of overlaying two different adaptation strategies over each of these maps (in this case, editing the adaptation strategy for authors, and viewing the adaptation strategy for the student role).

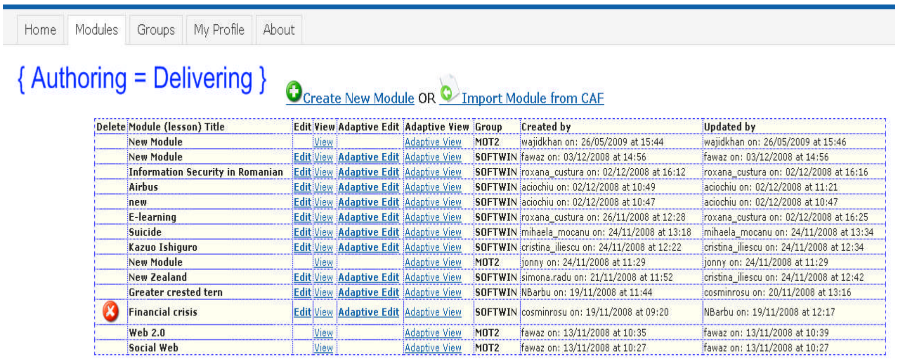

Figure 23 MOT 2.0: Authoring versus delivering

Figure 24 shows the group-based authoring concept, where users can create groups, and have different privileges for different groups (as in Scenarios 2 and 4). This setup allows the definition of advanced levels of the relation between tutors and learners based on the latter’s user model. The screenshot only shows the functionality of joining/leaving the group, but the system can also allow the creation of groups and the definition of different types of privileges on different groups.

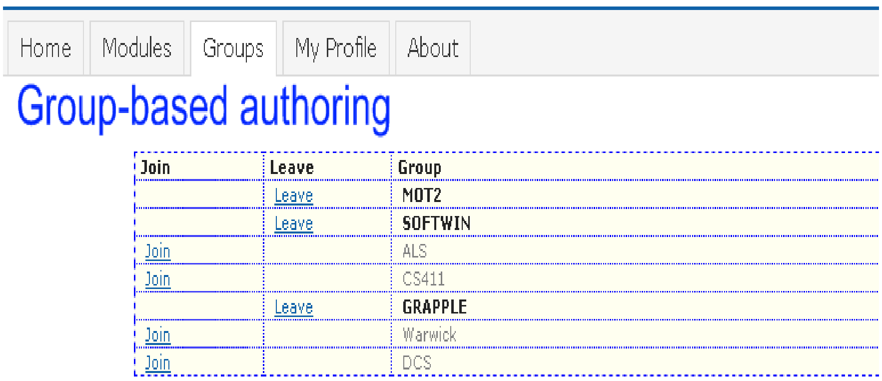

Figure 24 MOT 2.0: Group based authoring

6.8. Case Study of Using MOT 2.0 First Prototype

The new social layer and MOT 2.0 as presented above have been evaluated with:

- Seven students studying 'Dynamic Web-based systems' module at the Department of Computer Science at the University of Warwick, UK.
- Eight course designers from Softwin, an e-learning company in Bucharest, Romania.

The two evaluations happened at different times (October – December 2008 and January – March 2009 respectively) and took place in two different countries, Romania and the UK. The common features of the two evaluations are as follows: The course designers and the students were separately introduced to the system after they had been given a few lectures on Adaptive Hypermedia, user modelling, the Semantic Web and the Social Web.

The aim was to find out what added value the instantiation of the Social Layer in LAOS could bring to an authoring system. Therefore, they compared MOT 1.0 – the prior authoring-only environment for Adaptive Hypermedia engineering based on LAOS – with MOT 2.0, which is based on the Social LAOS and includes the Social Layer. For evaluating authoring environments, the ideal is to use course designers, who are experts in e-content-based courses. This group of users was represented by the group of designers from Softwin. However, as MOT 2.0 blurs the borders between authoring and learning, it was necessary to get feedback from the other end of the spectrum as well, the students, as represented by the Warwick group of students.

The evaluations (see Appendix 4: MOT 2.0 First Prototype Evaluation) reported here are based on the comparative analysis of two stages of experiments. The first stage involved two separate experiments, one was carried out by the course designers and one by the students, each experiment consisted of participants following four scenarios within MOT 1.0 (Cristea and de Mooij, 2003b). Similarly, the second stage involved two experiments, also carried out by the course designers and the students respectively, this time using MOT 2.0 (Ghali and Cristea, 2009b) (see Chapter 5).

The results of stage one were collected before the start of the second stage in both cases. In the second stage, the course designers and the students were asked to use the MOT 2.0 system to perform the same standard authoring tasks that they performed in MOT 1.0, as well as specific new tasks that highlighted the new Social Layer. These tasks involved also reusing the adaptive lectures that they had created previously, as well as creating material from scratch, and using the social tools.

After performing each experiment, participants in all experiments were asked to respond to specially neutralized questions (i.e., questions starting with 'what do you think of …?' instead of 'Do you like ..?') as shown in Figure 25, Figure 26, Figure 27 and Figure 28. The bulk of the questions were kept identical in the two stages of the experiments, in order to compare the two systems. A few extra questions were added in the second stage in order to extract feedback on some specific issues related to the social aspects.

However, here we concentrate only on the identical set of questions and its comparative results. Figure 22, Figure 26, Figure 27 and Figure 28 also show the mean values of their responses on a scale of 1-5 (1: not at all useful, 5: very useful), as well as the variance of the results. The scale was kept numerical for further interval processing. These questions are:

What do you think about…:

- **Q1.** *browsing other authors' domain maps / modules?*
- **Q2.** *browsing other authors' lessons?*
- **Q3.** *keyword-based access for other authors' content?*
- **Q4.** *copying a domain concept / items across domain map(s) / modules?*
- **Q5.** *linking to concepts from someone else's domain map(s)?*
- **Q6.** *creating a lesson based on someone else's domain map(s)?*
- **Q7.** *creating a lesson based on lessons created by other authors?*
- **Q8.** *adding collaborative authoring(i.e. tagging, rating)?*
- **Q9.** *adding authoring for collaboration (i.e. defining groups of authors, subscribing to other authors)?*

Note that questions 1-7 are general functionality questions. Questions 8 and 9 address collaboration functionality – MOT 2.0 had this functionality, whereas MOT 1.0 did not have it. Thus, the question was kept generic, in order to refer to the possibility of future extensions, in the case of MOT 1.0, and to actual implemented features, in MOT 2.0.

Figure 25 shows the mean response of the authors (the Softwin designers) for the two systems, whilst Figure 26 shows the variance. Due to the small number of designers used in this study, we cannot speak directly about statistical significance. Instead, we can observe the general preferences. Overall, both systems scored above the expected average of 2.5 (in fact, they scored above 3).

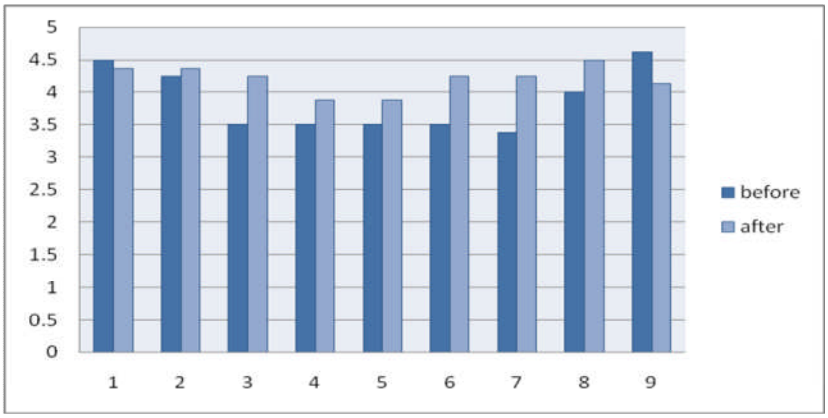

Figure 25 The Means 'before' (MOT 1.0) and 'after' (MOT 2.0) by the authors

There is a slight preference for the functionality of the new system in all aspects (lesson browsing, keyword access, copying, linking of concepts, lesson creation and reuse, and collaborative authoring). Moreover, the variance for most of these questions is lower for the new system, showing a higher level of agreement between testers. The mean is very slightly higher for the first question for the first system. Looking at the qualitative comments, the only criticism is about the domain maps not being in alphabetical order. In the follow-up implementations, we have already introduced various ways of ordering the domain maps beside the default method. More worrisome for the MOT 2.0 implementation is the fact that Q9 about authoring for collaboration was scored lower, suggesting that at least some of the expectations of the designers had not been fulfilled.

One designer who had given it a score of 3 was complaining about the rights related to these groups and the exact procedure for forming them, as she stated:

> "*It is useful that authors collaborate to create good content. In my opinion a good approach would be creating "working groups" for developing modules. Every member of a working group should have full access to create, edit, tag, rate, comment, etc each item of the specified module. This way you know that the content is develop by known authors which form a developing team and collaborate to create the content. The team should be decide by a supervisor and should include teachers, developers, testers, etc (all roles involved in content development)*".

In this version we had given them to test, groups were pre-formed and joining and leaving groups was open to all. An administrator role is necessary for allowing group formation, since people could otherwise be inviting others into their own groups, as well as restricting unwanted users from joining specific groups.

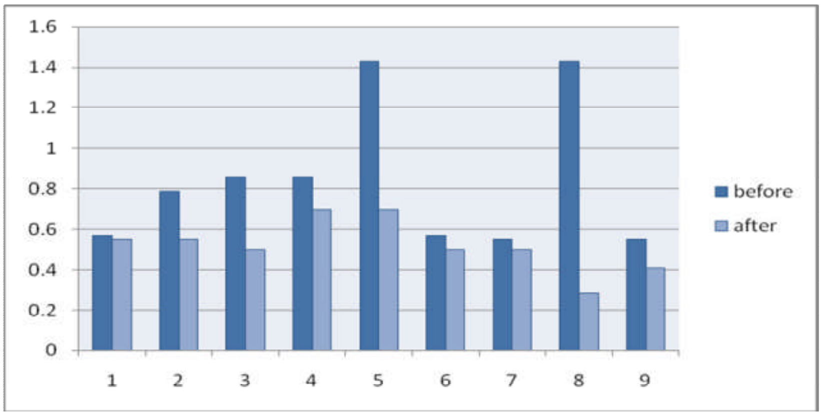

Figure 26 The Variance 'before' (MOT 1.0) and 'after' (MOT 2.0) by the authors

Our other set of testers was the students (Figure 27 and Figure 28) who, according to the overall philosophy presented here are simply authors with fewer rights. In fact, the students who performed the evaluation had identical rights to the designers – they merely used another version of the system at a different time. In the initial experiment all users (learners and course designers) had the same rights (i.e., full rights), for the purpose of the evaluation only.

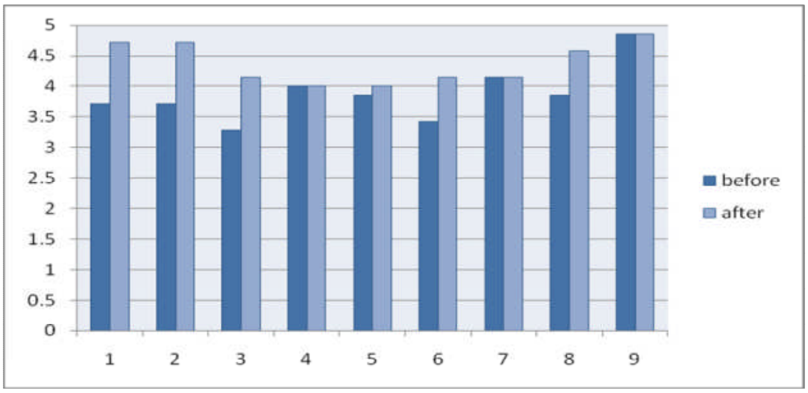

Figure 27 The Means 'before' (MOT 1.0) and 'after' (MOT 2.0) by the students

The first observation that can be made about Figure 27, which shows the mean estimation of the student's satisfaction with the system, is that they also score both systems above 3.

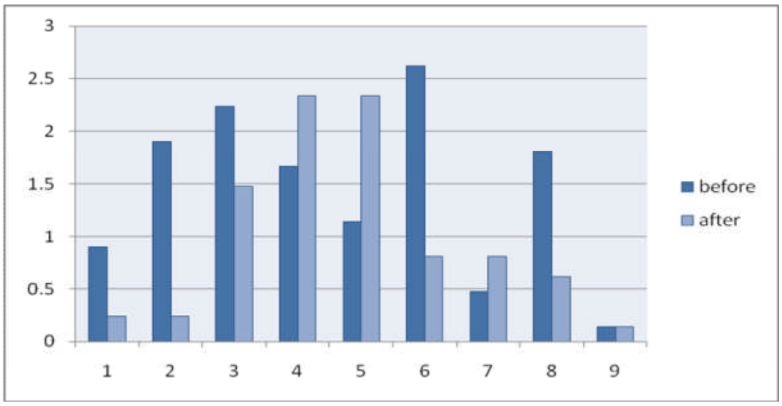

Figure 28 the Variance before (MOT 1.0) and after (MOT 2.0) by the students

In Q4 (about copying domain concepts within one's own domain), one student was worried about "what … you do if their item doesn't fit exactly in to your module … Can I edit their work …?" He further realizes editing is possible, but then raises the issue of copyright. This is a fair point and is something that was intentionally not addressed. In the first version of the system group members had full rights over the content, in order to allow them to test the various functionalities. Another issue is that the question referred in MOT 1.0 to an author's own items, whilst in MOT 2.0, items belonged to a group. The MOT 2.0 second prototype (see Chapter 7), will set various rights within a group, having members only allowed to edit or to read, or copy and change the item.

6.9. Discussion

Moving personalization for e-learning into the realm of Web 2.0 raises interesting issues. Personalized environments have in the past been centred on a single user. In the new type of environment the way that users interact and collaborate can lead to the adaptation to one user influencing the adaptation process for another.

Other issues that have been picked up by our experiments and evaluations are the issues regarding copyright and rights of use in general: when we consider the case of a single user, there are no problems in allowing that user to edit, change, move or link their own material. However, when there is a co-operative effort, the issues of ownership appear. Editing rights need to be carefully granted, in order to disallow destruction (removal, or permanent change and damage) of content created by others. Even in an ideal, co-operative world, there needs to be a clear differentiation between linking to an item created by others, and editing the item. Since items are reused in different contexts, changing an item for one context may render it unusable in another context.

This is in contradiction to Web 2.0 techniques, such as in Wikipedia, where the content is permanently changing, stopping only when it represents a common denominator. In adaptive, personalized systems, the constant change is useful, but the ultimate contents cannot be a common denominator. Personalization also means addressing the outliers, creating versions of content for various types of users, usage and context. Therefore, in such a case, if changes are desired for a particular type of context, a user would have to copy the original item and edit this copy, instead of the original. Only in the case in which no changes are necessary could a user link to the original item. This however inherits the same issue as there is in linking to Internet pages: the owner might change the content, thus changing the relevance to the source of the link, or even remove the concept, in which case empty links could appear.

Another issue that is inherent in Web 2.0 applications, and which personalized, adaptive e-learning enhancing Web 2.0 applications share, is that of the quality of content. In this chapter, we have shown how this issue can be solved by a progressive increase in contribution rights (be tagging, rating, commenting, or even editing new items), depending on the overall quality of an individual's (e.g., student's) contribution. Therefore, poor contributors would loose their contributing rights, and may at some point only be allowed to read content, whereas high quality contributors could potentially achieve similar rights to authors, or even teachers.

The focus here was on personalization and adaptation as a key strategy to support e-learning, but we should not lose sight of the other technologies and pedagogic developments which will be important in the future. For example, the use of Learning Management Systems in institutions and beyond is pervasive, and effective delivery of educational tools typically takes place through such systems. However, the effective incorporation of educationally rich tools and frameworks (such as those presented in this chapter) within such systems is mainly unsolved (Rößling et al., 2008). The integration between "mainstream learning platforms" and "advanced- (often AI-based) solutions" is beyond the scope of this chapter, but is the main scope of the research that is targeted by our group and its partnerships in EU projects such as ALS and GRAPPLE.

Web 2.0, as a representative of the information society, can provide more information and knowledge to a broader audience and the audience does not have to be in a classroom. This makes Web 2.0 an optimal candidate for e-learning, where we do not have to depend only on schools, libraries and experts to gain deeper understanding. However, e-learning is not a means to an end, and schools, libraries and experts are still very important. The two approaches will have to work together more in the future. For instance, in the context of Web 2.0, experts play an important role as part of the Web 2.0 e-learning system, since they can help students, interact with them and provide other assistance. The added benefit is that of bypassing distance issues, but also allowing software systems to more easily (automatically, adaptively) pair needs with offers (between learners and experts), to perform scheduling functions.

Moreover, Web 2.0 could be said to be one of the means of 'levelling the playing field', in that it creates equal opportunities for different learners from different backgrounds and conditions. Also, specifically in the context of e-learning, it creates opportunities for people who have no time to participate in formal learning settings. Finally and interestingly, the specific features of e-learning, of allowing people to communicate via various information channels, allow for a broader, more informative and people-richer access to such classic learning paradigms as the Socratic dialogue.

From a broader Social Web perspective, the user model that is created in MOT 2.0 can be extended towards a distributed user model, which is able to track users' activities not only within one system (MOT 2.0), but also on the broader Web 2.0. These types of mash-ups would harness the power of several different Social Web systems. From a modelling point of view, the Social LAOS framework is perfectly compatible with such an extension. It would simply mean that user model variables may be set by calls to external sites, instead of locally, which are implementation details and do not interfere with the framework.

6.10. Related Research

The related research looking into supporting adaptation and personalization in collaborative learning environments is relatively limited. Adaptive collaborative tasks support is addressed, for instance, in WebDL (Boticario et al., 2000). The system allows annotations and tagging, and then selects information based on these tags for personal student needs. No specific rules that guide the collaboration process in an adaptive way are provided.

Other research (Tsovaltzi et al., 2008) promotes collaborative adaptation based on scripts of interactions between pairs of students. Prompts about contacting the peers and explaining, talking about consensus, etc., are used. Interestingly, the paper reports that, whilst the students might have perceived the adaptive comments as intrusions, the overall result (in terms of learning) was positive. Our approach is closer to this study, as the collaborative adaptation process aims at guiding students towards useful interactions with each other, and with their teachers (recommended learners), as well as guiding students towards useful recommended learning content based on their profiles. However, additionally to this, our research blends not only the learning process and the collaboration process, but also the learning and authoring process.

Other researchers take an AI-driven approach, and describe processes of adaptive collaboration in peer-to-peer systems (Awerbuch et al., 2005) in terms of players (or agents) with shared or exclusive goals, thus co-operating or competing against each other. Their system is not directly aimed at learning, and its focus is on how to minimize the cost for an agent in a world of threats (e.g., from dishonest 'players'). Whilst this work may be useful for collaborative and competitive systems in general, it is less applicable in the context of learning, where learners might try to 'beat the system', but would usually gain little from being dishonest to each other. The aim in this chapter is to define a new social personalized adaptation model that can currently be applied to extant Learning Management Systems, in which learners and teachers can engage in a multi-role, personalized, adaptive learning environments to enhance the learning and authoring processes.

In the context of lifelong learning, the APOSDLE project (Lindstaedt and Mayer, 2006) introduced new ways to support informal learning activities (work, learn, collaborate) for the workers in their working environments, which provides learners with support for self-directed searching and learning within the working environment; experts get support, by allowing social interaction between learners, and making the results of this interaction available to other learners in their own learning environments; and workers get support, in which the learning process happens within the working context, and the learners access the learning content without the need to change the working environment. The approach here is slightly similar as it supports recommendations techniques, such as recommended learning content based on the learner's profile and recommended expert learners, also based on the learner's profile. The differences appear in the target: we target not just workers, but lifelong learners, as well as students in formal education.

Additionally, Telme (Sumi and Nishida, 2001) is a communication tool that acts as a moderator between people with different levels of knowledge. The personalization in Telme occurs by presenting information from a knowledge base customized according to the user's profile. The system is effective when the user cannot question others directly by concluding the context of the conversation from predefined conceptual spaces.

Moreover, the personalization in the work of (Pinheiro et al., 2008) is based on a profile of a mobile, where the context-aware profiles permit mobile users to state their personal preferences for particular situations when using web-based systems. The preferences vary based on the current context. A filtering process is then applied to the user's current context and the user's preferences for this context. Firstly, the process selects the context-aware profiles that match the user's current context, and then it filters the available informational content based on the selected profiles. The work of (Barkhuus and Dey, 2003) argues that context-aware applications are preferred over personalized ones, where personalization in the sense of adaptability is used. Thus, the application allows the user to specify their settings for how the application should behave in a given situation.

The learning environment described by (Yang, 2006a) consists of three systems: 1) peer-to-peer content access and adaptation system; 2) personalized annotation management system; and 3) multimedia real-time group discussion system. It uses the ubiquitous learning paradigm, with features such as identifying the right collaborators, right contents and right services in the right place at the right time, based on a learner's surrounding context such as where and when the learners are (time and space), what the learning resources and services available for the learners are, and who the learning collaborators are that match the learners' needs (Yang, 2006a). The approach in the current chapter does not rely on the context of the learner, but it employs user profiles to provide recommended learning contents and recommended users. On the other hand, the context aware ubiquitous learning environment does not have recommended learning materials nor recommended collaborators.

LearnWeb 2.0 (Samenvatting Marenzi et al., 2008) is a platform for sharing and discussing as well as creating knowledge resources that allows for the integration of social networks, such as Facebook and Flickr. The integrated infrastructure in LearnWeb 2.0 relies on external Web 2.0 applications. Therefore, one of the platform's main challenges is determining which Web 2.0 tool should be used, as not all Web 2.0 applications are open source, and not all of them actually provide an Application Programming Interface (API) to connect to LearnWeb 2.0. In MOT 2.0, the concepts of Web 2.0 (rating, tagging and feedback) are applied within the system, and are not enabled by integrating external existing Web 2.0 systems.

In addition, StudyNet (Glover and Oliver, 2008) moves away from lecturers to harness the power of connections of the social networks, as it provides the learning materials in a social network environment. StudyNet allows connections not only between staff and students, but also with university alumni. However, due to licence restrictions, StudyNet is only available to enrolled students and academic staff at the University of Hertfordshire. In contrast, MOT 2.0 can be used by anybody, as it is open to the public with no restrictions. Moreover, StudyNet does not provide recommended learning content nor recommended experts.

Furthermore, (Bilge et al., 2009) investigated the possibility of attacking social networks to gain access to personal information. Whilst the work proved that it is easy to forge user profiles and create a cross-site cloning profile, it did not provide a solution to this issue. The paper advises us to raise the awareness among users of social networks about privacy and security risks. In MOT 2.0, the privacy and security risks are minimised, as the platform does not support the sharing of personal information.

Finally, the work of (Mislove et al., 2008) describes the detailed growth of data in Flickr, by crawling the Flickr sites to find out how the links are constructed, in order to predict how new links will be created. The study concludes that users tend to respond to incoming links by creating links back to the source, and that users link to other users who are already close within the network. Such work shows the popularity of Web 2.0 applications, and the fact that it is timely to invest in researching the potential such applications bring, including for the important area of e-learning.

6.11. Summary

The emergence of Web 2.0 is changing the way in which people communicate with each other, as well as the methods of creating and sharing knowledge. In particular, learners in higher education institutions are using social tools in their everyday life to support their learning needs. Moreover, mature people engaged in e-learning are gradually beginning to use social networks and applications in their work and daily activities. Therefore, the Web 2.0 has a potential to support both learners in higher education. However, research on personalizing and adapting social e-learning has not yet been extensively researched.

In this chapter we aim to close this gap with this ongoing study on personalized adaptive social e-learning. We have created a new social personalized framework for e-learning. The new framework SLAOS blends the authoring and delivering phases by removing the barrier between tutors, learners and authors, all of whom become authors with different sets of privileges. Our approach allows students to contribute to the authoring phase with different sets of privileges, and distinguishes between collaborative authoring and authoring for collaboration.

Encouraged by the first set of experiments, we have already started adding more adaptation functionality into MOT 2.0 via recommended learning contents and recommended experts based on the user profile. Another new feature is that the users within the same group can have different sets of privileges. Moreover, a new communication tool has been added to the system in order to facilitate the collaboration among learners. The chat tool recommends expert users who can help in answering questions and give feedback. Moreover, the system can now track the reading activity of the learners, which can be used to update the user profile. All of these new features will be discussed, in more details, in the next chapter.

CHAPTER 7

“Sometimes when I'm talking, my words can't keep up with my thoughts. I wonder why we think faster than we speak. Probably so we can think twice.”

Bill Watterson (1958 -)

7. My Online Teacher 2.0 Second Prototype

As previously discussed, Web 2.0 is potentially a great force that can generate a vast wealth of knowledge, based on the collection of information from different individuals and communities, effectively representing a collective intelligence. This chapter presents several essential steps from an overall study on shaping new ways of learning and teaching, by using the synergetic merger of three different fields: Web 2.0, e-learning, and adaptation. The previous chapter has evaluated a first version of MOT 2.0, which introduced Web 2.0 features and adaptations, in comparison with MOT 1.0, which had mainly adaptive features, and very primitive social features.

This chapter discusses follow-up research, which beside solving some of the issues detected during the deployment of the first MOT 2.0 prototype, concentrates on a new dimension, that of the learning outcome. In particular, this chapter focuses on a study of *how to more effectively use and combine the recommendation of peers and content adaptation to enhance the learning outcome in e-learning systems based on Web 2.0*. In order to better isolate and examine the effects of peer recommendation and adaptive content presentation, we designed experiments inspecting collaboration between individuals based on recommendation of peers who have greater knowledge, and compare this to adaptive content recommendation, as well as to ‘simple’ learning in a system with a minimum of Web 2.0 support.

7.1. Overview

In this chapter, we extend the MOT 2.0 system, in order to establish the best balance between *Web 2.0 features*, *personalization* and *adaptive peer recommendation*, respectively. Therefore, we focus on the following research questions:

- Is an e-learning 2.0 environment enhanced by the addition of content-based adaptation? (i.e., is there a *positive learning outcome* in an environment based on collective intelligence enhanced with personalization of content?)
- Is an e-learning 2.0 environment enhanced by the addition of peer recommendation? (i.e., is there a *positive learning outcome* in an environment based on collective intelligence enhanced with recommended peers?)

The questions above can be answered both via *experimental analysis* and *objective measurements* (such as knowledge tests). Moreover, for all the above questions, additionally, we want to find out what the *perceived learning effect* and usability of the paradigm is. We differentiate here between *learning outcome*, which is an objective measurement, and is done via tests, and *perceived learning outcome* that is reflecting students' opinions. The latter needs are established via subjective feedback, such as in the form of a questionnaire. For the purpose of this analysis, a new version of MOT 2.0 (second prototype) was created, significantly extending the previous version that had already been evaluated.

The remainder of this chapter is organized as follows. The following section introduces a generic scenario, which encompasses the overall scale of functionality desired from the learner perspective. This scenario is then transformed in a set of overarching, generic requirements. Next, in Section 7.3, the research hypotheses examined within this chapter are presented, followed by the case study designed for their examination (Section 7.4). The results of the evaluation are then presented on Section 7.5, and the implications are discussed in Section 7.6. Related research is considered in Section 7.7, and finally, conclusions are drawn in Section 7.8.

7.2. Overall Collaborative Adaptive Learning Scenario

In order to understand the full range envisioned by MOT 2.0 (second prototype) for a learner, we illustrate it by one hypothetic generic learner scenario, below. For easy comparison, this scenario is, to the extent possible, reflected in the concrete examples of the actual tool, presented in Figure 29, Figure 30 and Figure 31. However, this learning scenario is *more generic* than the ones used in the real life classroom evaluations. These classroom evaluations are aimed at a sub-set of specific desirable features only, and thus will later on (see Sections 7.4, 7.5) be described via targeted evaluation scenarios. The generic scenario presented in this section is created based on feedback from previous evaluations of the first prototype of the tool, as well as by expanding the desired functionality to better represent our overall goals.

7.2.1. The New (e-learning 2.0) Learner scenario

Jane is a student of a course on 'Data Mining', and she has just reached the module (equivalent here to a chapter) on 'Collaborative Filtering'. Jane feels at an impasse and would like some help. Unlike in a regular learning situation, where she would need to find herself the relevant literature to review, via various channels, or the appropriate people to talk to (teachers, colleagues, etc.), in the MOT 2.0 system (second prototype), she can request help directly from her learning system, or, alternatively, the system could automatically detect her problematic state.

The system can then recommend to Jane a specific item to read, e.g., the 'Introduction' from the same module. Alternatively, the system could recommend her another whole module to read, which would have been an optional prerequisite, but she may have missed it, or just a related module, such as the module on 'Data Mining for Web personalization'. Furthermore, the system could recommend a certain item in another module, for instance, the 'Data Mining for Web personalization' module, which would be most relevant for her current situation.

At the same time, or alternatively, the system can find Jane a peer to help her. This peer could be John, who is a student of the same course, and is (perhaps only slightly) more advanced than Jane. The fact that John is more advanced can be determined by the system via *non-intrusive methods* (such as page visits, and the fact that John has simply read more than Mary on this module), or via (more precise) *intrusive methods* (such as prior test results). The system facilitates for Jane to contact John (via a procedure in which both Jane and John can allow/deny the contact: e.g., Jane may contact John only if she is in the same group as he is; or Jane may request the contact, and John may receive this request and be able to allow/deny it; or John may state if he is generally willing to help people with incoming requests – as exemplified in (Fetter and Gross, 2009), where a user can set his state to 'ReadyToHelp'; etc.). An incentive needs to be created for John to help Jane (either just group membership entitles group members to ask for help, or reputation within or outside the system, etc.)

Also at the same time, or as an alternative, the system could recommend Jane to join a certain group (e.g., the 'Collaborative Filtering' group). This group could be useful because many discussions on Collaborative Filtering have already taken place, and joining will allow Jane to access these; or it could be useful because this group is working on a project on the same topic, and collaborating with them will give Jane better insight in the topic; etc. In the latter case, the system could also recommend a work distribution to Jane.

7.2.2. Conclusions and Required Features Deriving from the Learner Scenario

1. The first desired feature is that of *user-centred approach*: the student should be able to select if the adaptation is triggered by the system or by herself, thus selecting between *adaptivity* and *adaptability*. Both approaches are known to have advantages and disadvantages. Amongst the most known are the fact that adaptive systems require little or no effort from the user, whereas adaptable systems allow the user to be in control. However, as (Fischer, 2001) shows, implications reach the knowledge representation, which is internal in adaptive

systems, and external (extended to the human user) in adaptable systems, thus requiring different mechanisms (more complex in the case of the adaptive systems). Here we take the pragmatic approach that both types should be possible, as well as any combination on the axis ranging from full system control to full user control (as supported by (Tsandilas and schraefel, 2004), and (Cristea et al., 2007), amongst others).

2. One of the other desired features is that of *adaptive content recommendation*, at *various levels of granularity*: recommendation of whole modules, recommendation of items in modules, etc. This idea is similar to some of the adaptive educational hypermedia systems, but not identical, as most recommend only items in the current module. However, the granularity of the recommendations is a less explored area. Moreover, the recommendations should be also based on the relation between the current item (or module) and another item (or module). This relation can be the prerequisite relation, a similarity measure, or something else. Triggers of recommendation can be user triggers (such as asking for help, selecting some options) or system triggers (tracking of user's clicks, scrolling, time spent on a subject, tracking of completion: e.g., recommending another module if the current one is finished very early on, etc.). It is to be noted here that, whilst we use the term 'recommendation' when we talk about content that is suggested to a learner, one of the major differences between recommender systems and adaptive educational systems is that the latter usually presume (implicitly or explicitly) an order between the recommended elements (a path through the content, relations between more than two modules/items/steps), and thus the most frequently used relation is the prerequisite, whilst the recommender systems usually do not presume any order or multi-dimensional relation. Moreover, content model-based recommendations are inspired by recommender systems and not usually found in Adaptive Hypermedia (Brusilovsky, 1996a), which use simple user model-based recommendations. Here, we envision a combination of the two.

3. Another desired feature is that of *peer recommendation*. The recommendation of

peers can also take place at different granularity levels, such as recommending a peer that is generally more advanced in the topic, at the level of the whole module, or at the level of the current item, for instance. The triggers for peer recommendation are similar to the ones for content recommendation.

4. The system should allow for *communication channels between peers*. These may be a simple chat tool, or a more complex VoIP tool, with or without video or image transmission. However, these communication channels should be monitored in order to be able to use this data in recommendation of peers. Thus, the communication data (including the people communicating) is to be annotated for its potential use (e.g., user John is annotated 'ReadyToHelp', as in (Fetter and Gross, 2009)).
5. The system should allow for *group formation and dissociation*, for *meta-data describing the groups* (e.g., in terms of members, modules that are read by given groups, tasks group perform, interests, etc.).

Below, a simplified version of the algorithms created for this second prototype, corresponding to the two types of adaptation and the one type of adaptability, are presented.

7.2.3. Recommended learning contents

Recommending learning contents is the typical endeavour of Adaptive Hypermedia. Various techniques have been analysed and implemented (Brusilovsky, 1996a). However, most Adaptive Hypermedia systems are a 'one-player-game', i.e., they adapt to only the current user, usually without any external influence from other users. Here, the purpose was not to use a content-based recommendation method only, but to use a method that also utilized the Web 2.0 characteristics of the environment: in this case, average rating given to an item by users who have read it. Thus, the resulting mixed methodology uses content-based parameters in the form of the similarity measure (here, at the granularity of whole modules) as well as the rating of the module to be recommended.

```
RM = ∅;
If ((Similarity (M, Mi) > Value_1) &&
     (Rating (Mi) > Value_2))
      RM = RM ∪ Mi;
```

Where:

- *RM*: is the Recommended Modules set for the current module, M.
- *Similarity (M, M_i)*: is the cosine similarity between the current module M, and any other module M_i stored in the MOT 2.0 system (second prototype). The similarity is calculated between two strings, each string representing the tag (keyword) set that best describes the module. Each item is represented as a set of keywords describing the content of this item. As each module consists of a set of items, therefore, the module's tags represents the union of all items' tags. We have used this simplified formula, as currently we were not aiming at obtaining necessarily the best module recommendation – a good enough solutions suffices – the main target is the comparison of these recommendations in the context of Web 2.0 features whilst adding peer recommendations in the same context. Other possible formulas can be used, which would take into account the fact that the rating (value) of a module can be different from the average rating of its components.
- *M_i*: refers to the other modules in MOT 2.0 (second prototype); the variable i is the module identifier.
- *Value_1*: is the desired threshold value of the similarity, which can be any value between 0 and 1. This is a simple adaptive content recommendation procedure, where modules are recommended to users, depending on where they click (thus depending on what items they have selected). Value_1 is determined by the teacher to match the course requirements.
- *Rating (M_i)*: represents the average rating of the items in the module. Each module consists of a set of items, and each item has a rating.

- *Value_2*: the desired threshold value of the average rating, which can be any value from 1 to 5 (between the maximum and minimum values). Value_2 is also determined by the teacher to match the course requirements. Concluding, content is recommended to learners (as per requirement (2) in the Learner scenario) when the content is similar to the current module, only if, however, the rating of that content is high. This means that the behaviour of other users influences the possibility of content to be recommended.

7.2.4. Recommended (expert) peer learners

A specific advantage in e-learning 2.0 is the fact that the *collective knowledge* of other users can be exploited: the user is not a singular entity anymore, and other users can help him that corresponds to requirement (3), see Section 7.2.2 (and implicitly, (4), see Section 7.2.2) in the Learner's scenario, and has been implemented additionally in the second version of MOT 2.0. Various algorithms could have been used, but for the purpose of this study, just a simple one based on recommending users of higher (in fact, 'acceptable') knowledge has been implemented, as follows below.

```
RU = ∅;
If (knowledge (User, M) == Value)
    RU = RU ∪ {User};
```

Where:

- *RU*: the Recommended Users set for the current module, M.
- *M*: the current module.
- *knowledge (User, M)*: the User's knowledge level for the current module, M.
- *Value*: is the desired category for the knowledge level, which can be one of "beginner", "intermediate", or "expert".

The value used in the experiments was Value = "expert", thus recommending expert learners to other users. The inclusion of a user to a certain category was determined automatically, via tests. Moreover, the application of the two recommendation strategies (content and peers) is based on the group the student belongs to. For example, learning content recommendation is used for group 2, and recommended expert learners are solely recommended to group 3. In turn, group membership is derived based on individual user characteristics (here: knowledge level, as explained in Section 7.4.1).

7.2.5. User's privileges based on the knowledge

Finally, the following adaptable strategy was selected to determine the user rights in the e-learning 2.0 environment. Based on a test, the user knowledge could be determined, and thus the exact set of rights for a user could be set. Every time the user takes the test, these rights would be updated – therefore the procedure was entirely user-driven (as per requirement (1) in the Learner scenario).

```
If (knowledge (User, M) == Value)
{
      CanView = V1;
      CanRate = V2;
      CanTag = V3;
      CanFeedback = V4;
}
```

Where:

- *M*: the current module.
- *knowledge (User, M)*: the User's knowledge level from the current module, M.
- *Value*: is the value of the knowledge level, which can be "beginner", "intermediate", or "expert".
- *V1, V2, V3, V4*: is a Boolean value of 0 or 1, which determines if the user has a privilege or not.

For instance, an expert was allowed to view, rate, tag and feedback – as his opinion was considered to count more than that of an intermediate or a beginner. The exact settings are further detailed in the case study. To test the appropriateness of content and peer recommendation in the e-learning 2.0 setting, we have separated the two types of adaptation, and formed an e-learning 2.0 control group. However, the adaptive conference of rights could not be entirely separated. This is due to the fact that Web 2.0 rights (annotation, rating, feedback) affect not only the user on which they are bestowed, but also the other users as well. Hence it was considered important to bestow these rights in proportion to the knowledge the learner demonstrated, as further explained in Section 7.4.1. With these overall algorithms implemented in the system, we could form a number of hypotheses to be tested, which are introduced in the following.

7.3. Hypothesis

The overall motivation for the second version of the MOT 2.0 system is the assumption that the recommendations of other learners and learning contents will increase the learners' effectiveness, efficiency, and satisfaction in the learning process. Thus, in short, we have the following:

- **Purpose of adaptation**: the adaptation can be used to increase the learning outcome using the Social Web.
- **Method of adaptation**: the adaptation can take place by using the recommended learning content and recommended peers (experts).
- **Method of evaluation**: by a case study followed by a questionnaire to evaluate the hypotheses. MOT 2.0 (second prototype) will be used with real users in real world use.

Therefore, the main Null-hypothesis that we are trying to refute is:

- **H0**: MOT 2.0 (second prototype) does not influence the learning outcome.

The counter-hypotheses to refute H0 are:

- **H1**: MOT 2.0 (second prototype) increases the learning **outcome** (for the learners who need help by further reading of related recommended content or by being helped by recommended peers).
- **H1.1**: MOT 2.0 (second prototype) increases the *effective* learning **outcome**.
- **H1.2**: MOT 2.0 (second prototype) increases the *perceived* learning **outcome**.

- **H2**: MOT 2.0 (second prototype) decreases the learning **effort** (for the learners who need help by further reading of related recommended content or by being helped by recommended peers)

Further hypotheses we are analysing are:

- **H3**: MOT 2.0 (second prototype) increases the **satisfaction** (for the learners who need help by further reading of related recommended content or by being helped by recommended peers).
- **H4**: MOT 2.0 (second prototype) is **easy to learn and use** (i.e., MOT 2.0 (second prototype) functions and screens are easy to understand).
- **H5**: MOT 2.0 (second prototype) is **easy to remember** (i.e., MOT 2.0 (second prototype) functions and commands are easy to remember so that the learners do not have to learn it again when they log on again).

7.4. Case Study of MOT 2.0 Second Prototype

7.4.1. General Description of the Case Study

The case studies are the main evaluation methods of MOT 2.0 (second prototype). They are used to field test the system components. In particular, the overall aim of the current case study is to explore: *recommended learning conten*t and *recommended users (peers).* These two adaptation mechanisms need to be analysed separately, in order to make sure that their distinct characteristics are measured, and in order not to obtain skewed or correlated results. However, the two adaptation mechanisms are not applied in a 'simple' e-learning system, but integrated in an e-learning system with Web 2.0 functionality.

The measures and the criteria of this case study are: usefulness of the recommendations of users and learning contents, which includes the efficiency and effectiveness of the recommendations of users and learning contents, as well as the satisfaction of the learners about the recommended learning content and the recommended learners. The aim for the case study is to analyse the validity of the hypotheses introduced in the previous Section.

We have performed the evaluations with 24 students in Computer Science at the University of Warwick. These students were studying a module entitled ‘Dynamic Web-based Systems’. The students were a mixture of 4th year MEng and 1st year MSc students. The scenario (described below) was applied to these students during their regular studies, as one of the seminars/lectures, with the topic of ‘Collaborative Filtering’. The time allocated for the seminar was of two hours, but students could spend less (or more) on their study, depending on their needs.

The case study was performed in the students’ program (normally, between 4-6pm) and thus students do not have any other class afterwards to rush to, and can spend as much (or as little) time as they wish. Participation in this type of study was treated as any participation in a seminar or lecture: therefore, it was not compulsory. Students would be able to leave at any time, even if they had not finished their work, or stay beyond the two hours allocated, if necessary for them to finish.

Also, students were clearly told that, whilst the topic is part of their curriculum, and thus is useful to learn for the final exam, none of the work they performed during the class is marked in any way, or affects in any way their final grade (including, specifically, negative feelings for the tools, methodology, etc.). The teacher in charge of the class was not present, in order not to add any pressure on students.

7.4.2. Scenario Steps

In order to establish the effect of recommendations of content, peers, or the lack of recommendations in the context of Web 2.0, MOT 2.0 (second prototype) can recommend content, as an Adaptive Hypermedia system, but at the same time, it can recommend peers that can help with the learning process. This effect of recommendations or lack thereof is further evaluated for different types of students, grouped by their knowledge level. Thus, the participants take a pre-test to determine their knowledge level (for a selected domain) out of: *beginner*, *intermediate*, *advanced*.

Next, this knowledge level is to be used in two types of adaptation: one is peer recommendation, and the other one is adaptation of user privileges. Therefore, based on the knowledge level, the participants are given a different set of privileges:

- *Beginner* users can only read the learning material.

- *Intermediate* users can read the learning material, as well as add comments.

- *Advanced* users are allowed to read the learning material, edit the tags, rate the content, and add comments. Additionally, advanced learners are expected to act as peer experts on the topics that they were classified as "advanced" on, and thus be able to answer questions from their peers.

- The participants are asked to accomplish a learning goal using MOT 2.0 (second prototype) (i.e., to learn a specific lesson on "Collaborative Filtering").
- In order to achieve the learning goal, the participants are divided into three sub-groups, see Figure 32:

  - *Group one*: the first group, acting as a control group, would perform the learning activity by using MOT 2.0 (second prototype) without any help from the content recommender, or the (expert) learners' recommender. However, this group, just like the others, would benefit from Web 2.0 support. Therefore, e-learning 2.0 is the starting point for this research. Arguments of how e-learning 2.0 is useful for learning are to be found in prior research (Ghali and Cristea, 2009a) (see Chapter 6). Moreover, this group also benefited from adaptive user privileges, dependent on their knowledge level, as described in Section 6.5.2.

  - *Group two*: the second group would learn by using MOT 2.0 (second prototype), with the help of recommended learning content, but without the help of the recommended learners. Thus, this group has been created to evaluate the *benefits of recommended content, in the context of e-learning 2.0*.

  - *Group three*: the third group would learn by using MOT 2.0 (second prototype), without the help of the recommended content, but with the help of the recommended learners. Therefore, this group's role is to inspect the *benefits of peer recommendations, in the context of e-learning 2.0*.

Additionally, efforts were made to balance the groups, as follows. The process used for division into groups aims at distributing participants of each of the three knowledge levels, beginners, intermediate and advanced, as evenly as possible between the three groups. This is done in order not to have one group outperforming the other due to its 'lucky' repartition of students. The repartition is based on the pre-test.

The three screenshots below show the different views upon the learning environment available to the three groups. All groups view the learning content in the middle part of their screens (see Figure 29, Figure 30, Figure 31). Social actions such as rating, tagging and feedback (typical of Web 2.0 settings) are available to all users in all groups (as long as their knowledge level permits it). This means concretely that all screens present on the right side of the screen *rating*, *tagging* and *feedback*.

The module structure is available for all three groups. The differences are that group 1 and 2 also see other modules (see Figure 29, Figure 30), on the lower left side of the screen (all modules in the case of group 1, with no adaptation; and recommended modules only, in the case of group 2). Moreover, the last figure (Figure 31) shows that in the case of group 3, experts are recommended (right middle side of the screen) and communication facilities are available (right side of the screen, lower part of the screen, chat window). Therefore, the learning environments of Group 1 and 3 differ in two aspects: "All Modules" and "Chat tool".

The design decision in this case study was mainly focusing on comparing the learning outcome between these three groups. Therefore, the design decision was focusing on excluding the recommendations for Group 1 (see Figure 29), adding only the recommended learning content for Group 2 (Figure 30), and adding only the recommended learners and the chat tool for Group 3 (see Figure 31), in order to isolate the impact of the recommendations. However, all groups benefited from *adaptive user privileges*. As there were evenly distributed among groups, it is reasonable to assume that this adaptation does not influence the differentiation process.

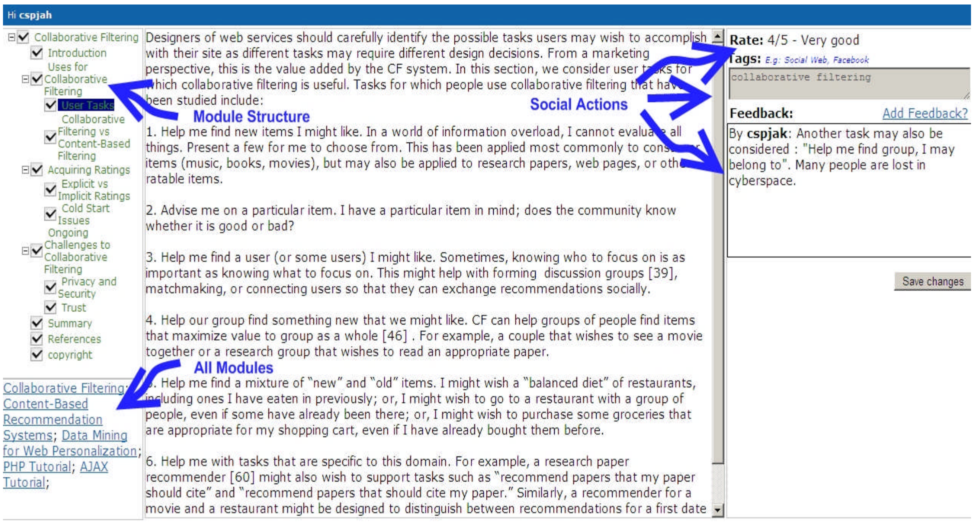

Figure 29 Screenshot of learning environment of Group 1

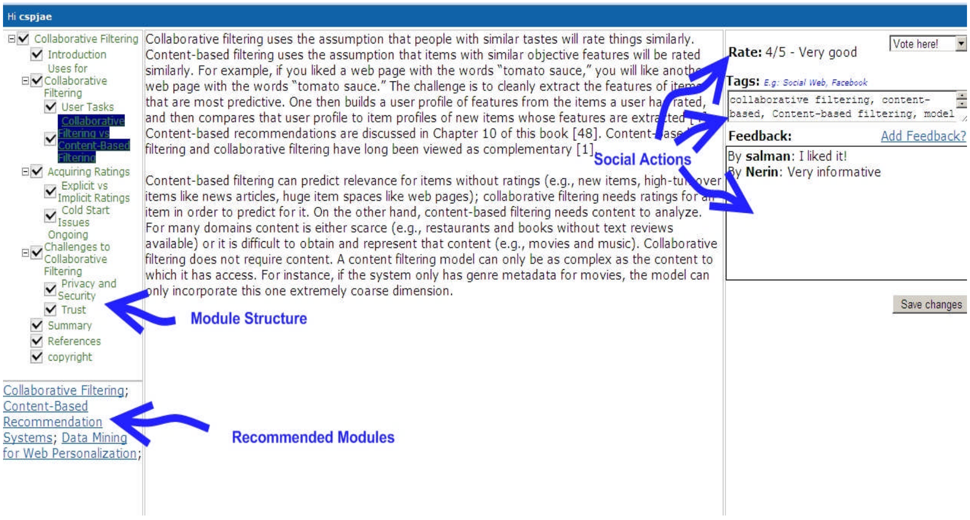

Figure 30 Screenshot of learning environment of Group 2

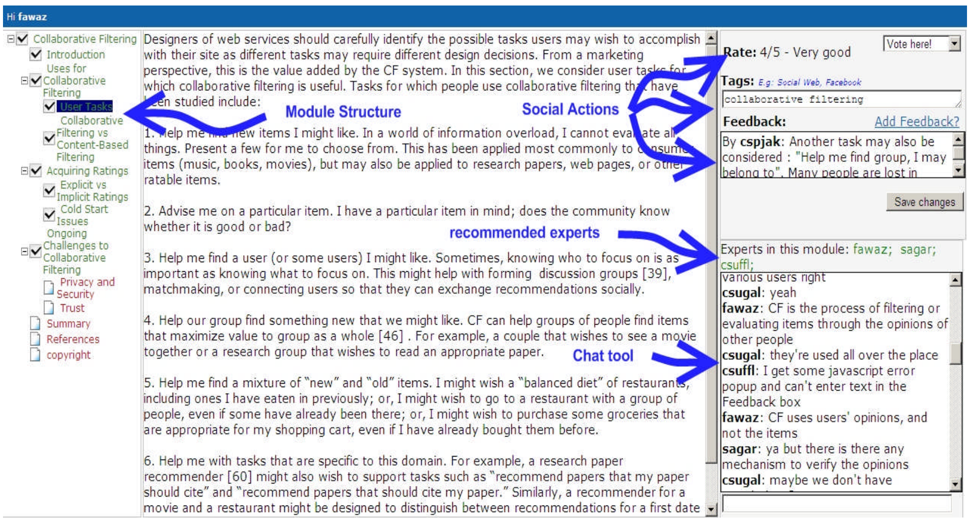

Figure 31 Screenshot of learning environment of Group 3

After learning, the participants take a post-test (which is identical to the pre-test) to determine the learning outcome by comparing the pre-test and post-test answers for each learner. The effectiveness of the previous three groups (in terms of learning outcome) is to be determined by comparing the pre-test and post-test answers for each group. Finally, the participants answered a questionnaire about the system usability.

During the learning activity, the system can log the following activities of the participants: Date and time of the following: reading the learning content (items), reading the recommended learning content (items), answering the pre-test, answering the post-test. In addition, comments of the participant, tags and ratings added by the participants. Based on the answers of the post-test, the learner's knowledge level is updated accordingly. After updating the user profile, the learner's privileges are updated as well.

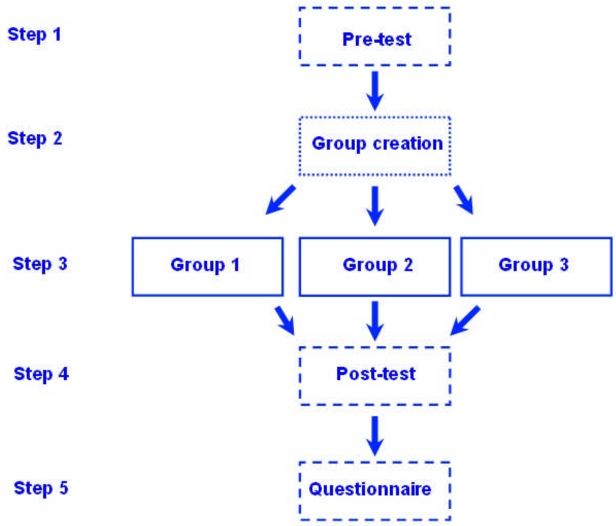

Figure 32 Scenario Steps

7.5. Results

In order to establish the validity of the hypothesis H1.1, we analyse the actual learning outcomes of the students. Overall, the students performed better in the post-test, when compared to the pre-test, and only in a very few (24%) cases they performed similarly, as can be seen in the figure below. The post-test average was 8.38, and 2.17 marks higher than the pre-test, on a scale from 0 to 10 (0-worst, 10-best mark).

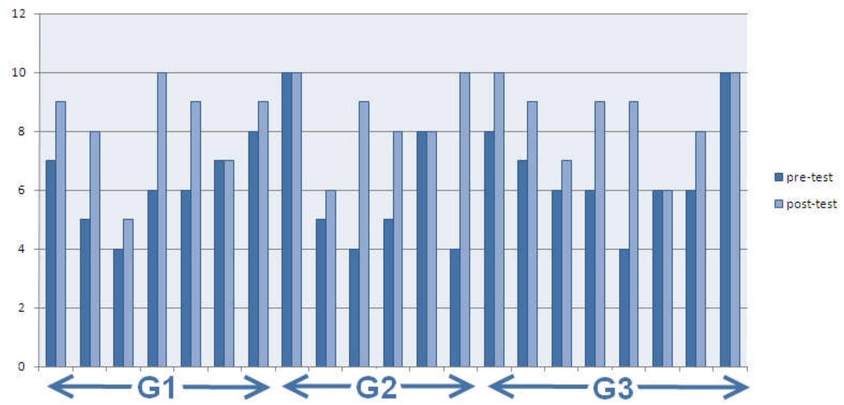

Figure 33 The pre- and post-tests of all students, and their respective groups

In the following, we analyse first overall, and then based on groups and initial levels (beginner, intermediate, advanced) the statistical significance of the student results.

7.5.1. Comparison of pre-test and post-test for all students

Firstly, we analysed if there is a significant difference in the learning outcome for all students in all three groups learning with MOT 2.0 (second prototype). The results are shown below. The test used is the paired T-Test, as the marks for all students were compared before and after the learning took place and the data was checked for normal distribution with the Anderson-Darling test.

Table 3 Paired T for pre-test - post-test

	N	Mean	StDev	SE Mean
Pre-test	21	6.29	1.79	0.39
Post-test	21	8.38	1.47	0.32
95% CI for mean difference: (-2.92, -1.27)				
T-Test of mean difference=0(vs not=0)			T-Value= -5.29	P-Value = 0.00

From the initial 24 students that took the pre-test, only 87.5% took the post-test. This is due to the fact that the whole activity was not strictly compulsory. The three students that did not take the post-test had a very wide spread of initial marks (4, 6 and 7, respectively), so the decision cannot be attributed to their knowledge level. They were also from different groups; thus, the group distribution cannot be associated with their choice. As students were allowed to stay as long as they wished (there were no other classes after the one they took), it also was not a matter of running out of time (at least, from the point of view of allocated time; personal timing reasons may have played a role there).For the remaining 87.5% students that took both pre-test and post-test, the P-value clearly shows that significant learning took place for all students (the post-test average value is higher than the pre-test average mark with 2.17, and the difference is significant with confidence interval 95%). Next, we analyse the learning that took place in each group (G1-G3).

Table 4 Paired T for pre-test G1 - post-test G1

	N	Mean	StDev	SE Mean
Pre-test G1	7	6.14	1.35	0.51
Post-test G1	7	8.14	1.68	0.63
95% CI for mean difference: (-3.30, -0.69)				
T-Test of mean difference = 0 (vs not = 0)			T-Value = -3.74	P-Value = 0.01

Table 5 Paired T for pre-test G2 - post-test G2

	N	Mean	StDev	SE Mean
Pre-test G2	6	6.00	2.45	1.00
Post-test G2	6	8.50	1.52	0.62
Difference	6	-2.50	2.59	1.06
95% CI for mean difference: (-5.22, 0.22)				
T-Test of mean difference = 0 (vs not = 0)			T-Value = -2.37	P-Value = 0.06

Table 6 Paired T for pre-test G3 - post-test G3

	N	Mean	StDev	SE Mean
Pre-test G3	8	6.63	1.77	0.63
Post-test G3	8	8.50	1.41	0.50
Difference	8	-1.88	1.64	0.58
95% CI for mean difference: (-3.25, -0.50)				
T-Test of mean difference = 0 (vs not = 0)			T-Value = -3.23	P-Value = 0.01

The students of groups G1 and G3 have shown statistically relevant increases in their marks (with 2 and 1.8 respectively, in the confidence interval 95%). The students of group G2 have an average increase in the mark (2.37) but this is not statistically significant for the 95% interval – but only in the 90% interval.

7.5.2. Students' Perception Questionnaire

The following questions were used to elicit the students' subjective perception of the tool. Questions appear paired with the hypothesis they target:

Q1. I believe that MOT 2.0 changes the learning outcome. ***(****Increases/ Decreases/ No influence).* ***(H1.2)***

Q2. Compared to other learning systems, MOT 2.0 is: Easier / More difficult / Neither easier nor more difficult.). ***(H2)***

Q3. Compared to other learning systems, MOT 2.0 is: Better / Worse / Neither better nor worse. ***(H3)***

Q4. I believe that the interaction with the system is: Easy to learn / Hard to learn / Neither easy nor hard. ***(H4)***

Q5. I believe that the interaction with the system is: Easy to remember / Hard to remember / Neither easy nor hard. ***(H5)***

The answers were mapped over the numerical values of {-1, 0, 1}, with '-1' representing the negative answer (e.g., for question Q1, 'Decreases learning outcome'), '1' representing the positive answer (e.g., for question Q2, 'Easier') and '0' representing the neutral answer (e.g., for question Q3, 'Neither better nor worse'). The assumption underlying this mapping is that there is an implied monotonicity in the answer range, as well as a symmetric, equidistant relation between the positive and the negative answer. This is a relatively strong assumption, but which we consider compatible with the type of answers we have selected. From the 24 students that took the pre-test, 87.5% took also the questionnaire (the same 87.5% that performed the post-test, as the two were linked in a sequence in the testing environment), see Figure 34.

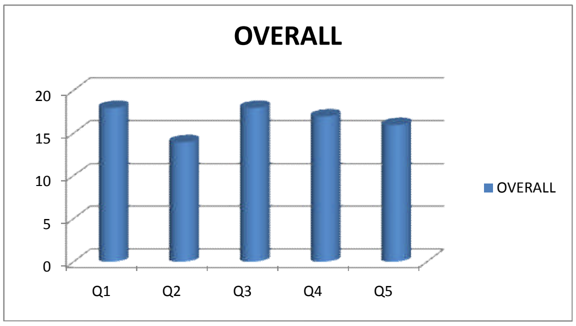

Figure 34 The overall answers to the subjective perception questionnaire

The questionnaire results represent the students' subjective perception about the MOT 2.0 system (as opposed to the test results, which are representing the objective measure of the learning outcome). 85.7% students have declared that the MOT 2.0 system (second prototype) increases the learning outcome, and only 14% have declared it has no influence on their learning outcome. Students were also asked to comment on their answers, but not all of them did. Out of the 14% that declared that the system has no influence on their learning outcome, only added a comment, as follows: *"I don't know, I didn't get to see the group 1 or 2 tracks."* Clearly here the issue was that the student believed the question to refer to the learning experience of all groups, and not just his own. Q2 directly asks the students to compare MOT 2.0 (second prototype) with other learning systems in terms of difficulty of use. Q1, on the learning outcome, was left on purpose somewhat open – we did not mention improving learning with respect to something specific (as in Q2), leaving it up to the students to compare with what is most familiar to them – which is not necessarily the traditional learning method, because students learn in a variety of ways at our university.

We also had to define the notion of learning outcome for them, as not all students would know what this means. These precautions unfortunately did not prevent all possible misconceptions – and having done evaluations with students for many years, we are aware that it is practically impossible to remove (or think in advance of) every possible misconception. We do know however that the students at our university are very much used to answer questionnaires, and know not to be afraid of any consequences – so if their perception would have been negative, it would have clearly shown.

Overall, a statistically significant majority felt the system helped in learning, regardless of the group to which they belonged, thus accepting hypothesis H1. The next question of equal majority of opinion (85.7% of the students) is the one concerning user satisfaction, which is increased by using the system. The statistically significant positive result confirms hypothesis H3. For Q4, corresponding to hypothesis H4, 81% of the students believe that the interaction with the system is easy to learn.

Only one student selected ‘hard to learn’, but s/he did not comment on the answer to explain why s/he felt that way. The same student was the one that selected later for Question 5 that the system is hard to remember (thus showing consistency of opinion). The same student also considered that the system has no influence on the learning outcome. In terms of learning to use the tool, and the negative feelings of this student, a colleague in the same group G3 (with recommended peers), who actually selected ‘easy to learn’ may be shedding some light on the potential issues with using the tool and learning how to use it, as follows from her comment:

> *“Some elements aren't as obvious as they could be but it's generally very easy. I wasn't sure how to use the chat function immediately and it would help if the feedback box had a text input to start with. Red/green on the topic tree isn't useful to red/green colour-blind (1 in 10 men?) but the icons serve the same purpose it seems so that's ok.”*

Overall, however, a statistically significant majority confirmed that MOT 2.0 (second prototype) is easy to learn, and thus hypothesis H4 is accepted. Fewer students (76%), but still a statistically significant majority believe that the system is also easy to remember. Only one student very briefly commented on this question, as follows: *“few elements so easy”*. Only 67% students believe that MOT 2.0 (second prototype) is easier to use than other systems, the other 33% believing it is neither easier nor more difficult. Overall, all five hypotheses were accepted, based on statistically significant results, as shown below:

Table 7 One-Sample T: Q1, Q2, Q3, Q4, Q5

Variable	N	Mean	StDev	SE Mean	95% CI	T	P
Q1	21	0.86	0.36	0.08	0.69, 1.02	10.95	0.00
Q2	21	0.67	0.48	0.10	0.45, 0.89	6.32	0.00
Q3	21	0.86	0.35	0.08	0.69, 1.02	10.95	0.00
Q4	21	0.81	0.51	0.11	0.58, 1.04	7.25	0.00
Q5	21	0.76	0.54	0.11	0.56, 1.01	6.48	0.00

Next, we attempted to evaluate the questionnaire results from the point of view of the group that a respective student has been placed in.

Table 8 One-Sample T: Q1_G1, Q2_G1, Q3_G1, Q4_G1, Q5_G1, ... Q5_G3

Variable	N	Mean	StDev	SE Mean	95% CI	T	P
Q1_G1	7	1.00	0.00	0.00	1.00, 1.00	*	*
Q2_G1	7	0.57	0.54	0.20	0.08, 1.07	2.83	0.03
Q3_G1	7	0.71	0.49	0.18	0.26, 1.17	3.87	0.01
Q4_G1	7	0.85	0.39	0.14	0.51, 1.21	6.00	0.00
Q5_G1	7	1.00	0.00	0.00	1.00, 1.00	*	*
Q1_G2	6	0.83	0.41	0.17	0.41, 1.26	5.00	0.00
Q2_G2	6	0.67	0.52	0.21	0.13, 1.21	3.16	0.03
Q3_G2	6	1.00	0.00	0.00	1.00, 1.00	*	*
Q4_G2	6	0.83	0.41	0.17	0.41, 1.26	5.00	0.00
Q5_G2	***6***	***0.50***	***0.55***	***0.22***	***-0.08, 1.08***	***2.24***	***0.08***
Q1_G3	8	0.75	0.46	0.16	0.36, 1.14	4.58	0.00
Q2_G3	8	0.75	0.46	0.16	0.36, 1.14	4.58	0.00
Q3_G3	8	0.88	0.35	0.13	0.58, 1.17	7.00	0.02
Q4_G3	8	0.75	0.70	0.25	0.16, 1.34	3.00	0.02
Q5_G3	8	0.75	0.70	0.25	0.16, 1.34	3.00	0.02

The results above thus confirm all hypotheses for all groups with a confidence of 95%. There is one exception (in Italics above), question Q5 about hypothesis H5 predicting that the learning effort required to use MOT 2.0 is low, for group G2, which is the one that received help in the form of recommended content, which can only be confirmed with a confidence of 90%. Three students in that group claimed the learning effort is less than for other systems, and another three claimed that it is similar. A possible explanation is the fact that the students had already seen other adaptive systems based on content recommendation previous to this experiment, earlier on in their study, and may have thus felt there is a similarity there – similarity which was not so obvious for the students that were being recommended peers (which they had not seen before) or the ones not benefiting of either of those recommendations. These positive results however do not inform on any significant differences between the groups. Therefore, we have also examined the time the learners spent in the various activities. The results are presented below.

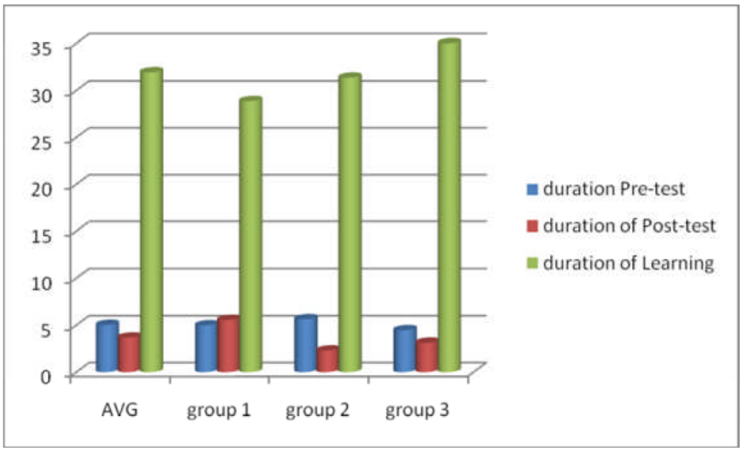

Figure 35 The Durations of Pre-test, Post-test and Learning session (in minutes)

Overall, as can be seen in Figure 35 and data below, the students have spent around half an hour (out of the allocated 2 hours) studying the module on ‘Collaborative Filtering’ via the MOT 2.0 system (second prototype) – although some clear outliers exist (a student spending only 13 minutes, and one 58 minutes). Therefore, the more representative middle value is the median, of 26 minutes.

Variable	Mean	SE Mean	StDev	Minimum	Median	Maximum	Mode
Duration of Learning	31.90	2.68	12.30	13.00	26.00	58.00	26

Although the overall allocated time was of two hours, the results show however that the average time spent really learning (as opposed to answering questionnaires of tests) was around half an hour – with large variations between 13-58 minutes). This leads to the question: if such a relatively short learning session is not detrimental to collaboration. For instance, if someone would have to perform a learning task in half an hour and at the same time have to help someone else, he might not be so willing to help. Whereas if he would have the same assignment spread over a whole week, he might be more inclined to assist others as well.

A short term study thus may lower the amount of collaboration, whereas spread-out learning sessions would perhaps increase the amount of collaboration. Generally speaking, whilst this type of longitudinal studies might reveal interesting aspects of collaboration, they are much harder to perform. Moreover, a counter-argument would be that an intensive learning session with clear synchronous presence (and thus a higher guarantee of a quick answer) may be conducive to a higher level of collaboration, whereas a spread-out learning session may lower the same collaboration, due to the uncertainty regarding the speed (and thus the timeliness) of the result. This is similar to a forum site that has had no activity for a while, and might be less conducive to posting questions to.

Therefore, we believe that, whilst a longitudinal study may reveal indeed other aspects of collaboration, in fact, it would be a different type of collaboration altogether (geared towards a synchronicity, as opposed to the synchronous collaboration we have explored). This is allocated to future research, as commented later on in the discussion (see Section 9.4). However, our main focus is on how adaptation can be used in this context, and not ‘simply’ on how to use Web 2.0 methods in e-learning.

From our experience in monitoring the case study, the students in the groups that were allocated communication tools were quite happy to use them, even if the overall time they spent in the case study is relatively short. The very fact that there were no immediate effects of their learning results in terms of marks meant that they did not feel too much pressure, and could explore at leisure all the features of the tool. Nevertheless, even withstanding the effect of the novelty of the tool, and the added learning curve of learning how to use it, the students clearly showed a positive learning outcome.

Interestingly, on average, the students in the control group (group G1) spent less time studying than the ones in groups G2 and G3. As the studying time was up to them (they all had to finish within two hours, but other than that, no fixed time was set), this could indicate an increase in interest in studying for the students that benefit from recommended content or recommended peers.

However, the interesting element was that there was no compulsion in following the system's recommendations, as the user is in charge. Therefore, this means that the students may have opted to follow the system's recommendations out of their own will. We have also traced if this was the case, and found that 62.5% of the learners followed the recommendations of the system for group 2 (with recommended content). We do not have this data on the students of group 3, but clearly they spent extra time continuing their discussion with their recommended peers, ending up spending the longest time. The students in Group 3 were using random usernames, thus the factor of knowing each other well was less influential.

It was noted, students that did not belong to the control group opted to work longer with the system, and learn for a longer period of time. Also remarkably, whilst their learning time is longer than that of the control group, their test response time grew shorter. Indeed, students in the control group spent more time in their post-test than in their pre-test – clearly thinking their answers over carefully. Moreover, students in groups G2 and G3 spent a significantly lower amount of time in their post-test (P-Value = 0.1 for the latter two groups), group 2 students halving their test time. This result is clearly based on the students' choice, as students could remain as long as they wished to complete their activities.

The overall results show that learning has taken place in all three groups, with statistically significant increase in learning outcomes (with 90% or 95% confidence inerval). The results of the timing of learning and tests shows that students like to spend more time in learning environments with peer recommendation and adaptive content recommendation, and that they are more confident in their test answers as a consequence of this extra time spent. Moreover, the decrease in time spent on the test shows that the longer time spent in the system was having a learning effect, and not just being based on other reasons, such as more overhead or distraction.

7.6. Discussion

As educators, arguably, we keep investigating better ways to persuade students to learn and spend more time on their learning activities, and less on their extra-curricular activities. As this initial results show, it appears that environments that encompass the power of features of the Web 2.0, building learning communities and adaptive learning systems may be the answer to this aim. Offering students environments that are close to what they use every day in their extra-curricular life makes learning more attractive. After the experiment was over, students have very expressly conveyed their wish for us not to take the system offline, as they still want to use it later on. Clearly, although none of the students had benefited from a full-blown system with all features, the system was functional and interesting enough to make them want to use it again.

We can also conclude that guided interaction with their peers, in communities and groups, is a very popular feature. It visibly made students spend more time in their learning environment than the students with adaptive content recommendations, and these, in turn, spend noticeably more time than their colleagues in the control group. As great care was taken in order to place students of various expertise and knowledge levels in the three groups in an even manner, the results can thus only be attributed to the system features and to the students themselves. Moreover, whilst the students might have been, to some extent, ‘gaming’ with the new features, the extra time spent in the system helped them to do their tests faster, thus learning took place during this extra time.

It should be noted that in the experiment we have only tested the short term memory, as the test followed immediately after the learning session. We expect this to be the reason that the learning outcomes of the students in the different groups do not differ that much from each other. We also expect that the students that have put the effort into the longer learning sessions may benefit from the knowledge acquired in the long term.

One feature which was introduced but not analysed in detail in the questionnaires is that of adaptive user privileges. Therefore, advanced users benefited from having more rights of Web 2.0 nature in the learning environment when compared to their intermediate level and beginner peers. Revisiting the results of the learning outcome evaluation, they showed that whilst all students benefited from the MOT 2.0 system (second prototype), the highest benefit was for beginner students. This demonstrates at least that having less privileges did not affect them in a negative way and perhaps allowed beginner students to concentrate better on their learning task. However, these results are not conclusive, and the effect of adaptive privileges, both on tool acceptance, as well as on the learning outcomes, needs further research (see Section 9.4).

There was an indirect success of the repartition into groups and the adaptation of privileges based on knowledge level, as there was no obvious dissension due to the fact that some users had more rights (such as feedback, tagging, rating) or duties (such as answering peer questions) than others. However, these results cannot be seen as conclusive, and more research of adaptive rights and privileges needs to be done (see Section 9.4).

Also, the design decision in this case study was mainly to focus on comparing the learning outcome between the *social environment* (Figure 29), the social environment with recommended learning content (Figure 30), and the *social environment with recommended expert learners (*Figure 31).

Therefore, the design decision was focusing on excluding the recommendations for Group 1 (Figure 29); adding only the recommended learning content for Group 2 (Figure 29); and adding only the recommended learners and the chat tool for Group 3 (Figure 31), in order to isolate the impact of the recommendations. Thus, the learning environments of the group G1 and G3 differ in two aspects: “All Modules” and “Chat tool” (for talking to recommended expert learners). Group 2 has “Recommended Modules” instead of showing “All Modules”, like group G1, but it has no “Chat tool”. All groups had rating, tags and feedback.

Finally, we consider that the main added value of Web 2.0 applications is to allow users to interact with each other in various ways, beyond the classical discussion groups, chat and VoiP: to allow rating, tagging, commenting on contributions, and thus to some extent to become co-authors of systems. This is the aspect of Web 2.0 that we use in this chapter. Additionally, openness, as in other Web 2.0 systems, is also possible (in the form of links to external resources). This allows for a certain degree of remix of data from multiple sources (OReilly, 2007). Moreover, features such as self-organization are also supported, as students and teachers all contribute to the system, determining thus the transfer of the system from one state to another, till convergence occurs (at least in terms of content).

7.7. Related Research

The Social LAOS framework and the MOT 2.0 system bridge the gap between three different research areas: *Adaptive Hypermedia*, *e-learning* and *Web 2.0*. As there is little research that encompasses all, we look at some relevant research in the overlapping areas, as follows:

1) **Web 2.0 in e-learning**
2) **Adaptive e-learning**
3) **Peer recommendations in e-learning**
4) **Adaptive collaborative learning.**

By looking at the research on **Web 2.0 in e-learning**, we can mention the work of (Isaías et al., 2009), which mainly focuses on combining learning management systems and social networks. (Isaías et al., 2009) argues that the use of social networks is critical, as they provide a method of interaction between students themselves and between students and teachers. Beyond this, in our work, MOT 2.0 (second prototype) focuses on the novelty in the area of collaborative personalized learning and Web 2.0 based adaptation, as well the interaction that occurs between the users within the system. The decision to provide the various tools in an integrated Learning Management System (LMS), as opposed to connect it to other Web 2.0 applications on the Internet is typical especially in the area of learning, in order to have more control over the teaching/learning process. Although here we have created an LMS, we also allow for the fact that it is a potentially controversial matter and, in some cases, instead of building from scratch, interfacing of various applications may be very helpful (Ankolekar et al., 2008).

On the other hand, we found that not all social network applications provide a usable interfacing mechanism (public API, web services, etc.), meaning that some social networks cannot be integrated with an LMS. An example of an extremely popular Web 2.0 application that has interfacing issues is Facebook – as Google CEO Eric Schmidt noted (Schmidt, 2009):

> *"If we can't get the data, it's very, very difficult for us to rank it. Facebook has chosen to keep much of its data behind a wall, that's what it has decided to do. We favor openness, because we think that works best for the users."*

Further related work is that of (Bateman et al., 2006), who designed a new approach for creating metadata for learning resources. This was not done by using Semantic Web ontologies, but by allowing the creators (i.e., the students) to add new metadata via collaborative tagging web sites. Our approach relies on the students not only for creating the metadata (tags in the case of MOT 2.0), but also for other social features, such as rating, feedback, as well as collaborative authoring.

On the other hand, work such as that of (Alexander, 2006) tried to answer questions about how Web 2.0 can be used to create new ways of teaching: such as Wikis, Blogs and social bookmarking. For example, the social bookmarking feature in Web 2.0 can be used in the universities between staff, students and teachers, to quickly find the shared bookmarks of other users. In our work, MOT 2.0 (second prototype) uses other Web 2.0 features inside the system, rather than adding Wikis, Blogs, etc to MOT 2.0.

Moreover, the work in (Rollett et al., 2007) focused on using Blogs as a new way of learning, and concluded that it will be hard to pass on some Web 2.0 features – such as trust, openness, voluntariness and self-organization – to the traditional existing learning method. In our approach, we control this aspect of the system by defining sets of groups, and assigning different privileges for different users in different groups.

Finally, the work in (Franklin and van Harmelen, 2000) concentrated on content sharing via Web 2.0 mechanisms in Higher Education, and reported some problems, which are out of the scope of this chapter but worth considering:

> *"The introduction of Web 2.0 systems into HE is not without problems, as there are ramifications in the areas of the choice of types of systems for institutional use; external or institutional hosting; integration with institutional systems; accessibility; visibility and privacy; data ownership, IPR and copyright for material created and modified by university members and external contributors; control over content; longevity of data; preservation; information literacy; staff and student training; and appropriate teaching and assessment methods."*

Looking at **adaptive e-learning** and its related research, such as adaptive educational hypermedia, intelligent tutoring systems, etc, we find a great body of research, and numerous applications have been written and implemented.

Our work on the adaptive aspects of e-learning follows prior research and implementations, such as the work of (De Bra, 2002), who has been creating the adaptive engine AHA! that tracks user's browsing behaviour to decide the user's knowledge, background and interests. However, AHA! does not support social features such as tagging, rating, feedback as in MOT 2.0 (second prototype). The Personal Reader in (Dolog *et al.*, 2004) uses Semantic Web technologies to enrich and personalize the learning resources. This work is very interesting, but is still in progress. Our approach does not rely heavily on Semantic Web techniques, although import from RDF, for instance, is possible. Furthermore, the work in (Carro et al., 1999) describes a way of creating adaptive Web based courses. Adaptivity in (Carro et al., 1999) is implemented by displaying different HTML pages based on the students' profile, their previous actions and the active learning strategy. However, no social interaction between the students and the system is provided, as in MOT 2.0 (second prototype).

A part of the work has focused on benefiting from the adaptivity in e-learning via standards, as in (Paramythis and Loidl-Reisinger, 2004), who defined adaptive learning as follows:

> *"a learning environment is considered adaptive if it is capable of: monitoring the activities of its users; interpreting these on the basis of domain-specific models; inferring user requirements and preferences out of the interpreted activities, appropriately representing these in associated models; and, finally, acting upon the available knowledge on its users and the subject matter at hand, to dynamically facilitate the learning process."*

There is also a significant body of work on **peer recommendations**. The work in (McCalla, 2004) argues that e-learning systems can be adapted continuously, as the external environment changes. The external environment includes *learners*, *teachers*, the *learning subject*, and the *technology* that is being used in the e-learning system based on the "ecological approach".

In the ecological approach, the information about the web content is attached to the content as the users access it. This approach can underlie the design of applications such as: 1) “a *help seeker*”, to find a learner who can help in solving another learner’s problem; 2) “a *recommender system*”, to recommend learning content to a learner that is relevant to the learner’s task. In our work, we use the concept of the “ecological approach” to recommend expert learners and learning content based on the user profile. On the other hand, the work in (Zheng and Yano, 2007) proposed the use of context awareness to support peer recommendations in e-learning systems. The context awareness model has three dimensions: *knowledge potential*, *social proximity* and *technical access*. Our approach does not rely on the context of the learner, but it uses instead user profiles to provide recommended learning contents and recommended users.

Last but not least, the work on **adaptive collaborative learning** is important, but not yet well represented. Whilst collaborative learning is a major strand, applying adaptation to such learning is less represented. A related work is that of (Meccawy and Blanchfield, 2008), who reported a case study for delivering adaptation through Moodle. However, their approach does not yet adapt to social aspects of the LMS, nor to the group of learners. In MOT 2.0 (second prototype), we do cater to groups and social aspects – however, we do not connect to any LMS directly, but we provide a set of converters (Ghali and Cristea, 2008a) (see Chapter 3 and Chapter 4) which can *import from*, or *export to* e-learning standards.

The social aspects in MOT 2.0 can be used in the recommendation process (i.e., recommend expert learners, recommend content with rating greater than a threshold, recommend a group with content that has highest rating, etc.). Other work (Kumar et al., 2007) reported that students learned significantly more when they worked in pairs, than when they worked alone, which reflects the importance of adaptive collaboration learning support. Similarly in MOT 2.0 (second prototype), we focus on the adaptive collaborative learning support by using social and grouping features.

Additionally, the work in (Gaudioso and Boticario, 2003) described how to build user models in a web-based collaborative learning environment. Their user models allow for a combination of machine learning and knowledge-based techniques. In our work, we build the user model based on the user knowledge as well as their actions in MOT 2.0 (second prototype).

Furthermore, the work in (Alfonseca et al., 2006) suggested the possibility of improving collaborative learning, by grouping students in specific ways, based on information stored in their user models. In MOT 2.0 (second prototype), the grouping mechanism is slightly different, as it is based on the given course. However, it is more flexible, as the teacher can create multiple groups and assign different privileges to different users based on their knowledge, or other parameters.

Summarizing, whilst there are clearly many other important works in these four research areas, our work's uniqueness and novelty are based on bringing these areas together, and benefiting from this synergetic approach, as it is illustrated in a succinct way in the following figure.

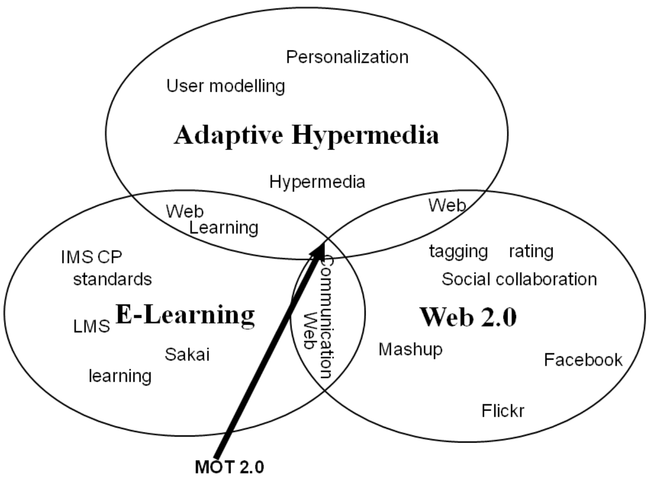

Figure 36 MOT 2.0 Adaptive E-Learning 2.0

7.8. Summary

Considering the initial research questions that were the driving force behind this chapter, we can conclude that:

- An *e-learning 2.0* environment may be *enhanced by the addition of content-based adaptation*, not perhaps in terms of increased learning outcome, but in terms of attractiveness and time spent learning by students; additionally, exam time is significantly decreased.
- Moreover, such an environment is *enhanced by the addition of peer recommendation*, as the time spent learning is even higher than for content-based adaptation; similarly, exam time is significantly decreased.

For all the above paradigms, the perceived learning effect and usability of the paradigm are significantly higher than other systems; however, no differentiation in perception between the paradigms could be established. Additionally, we have shown this type of system to help all students, but to help beginner and intermediate students more than advanced ones.

To conclude, we can say that we have performed another step towards harnessing the power of collective intelligence, and Web 2.0 functionality, augmenting and extending it with the specific type of personalization and adaptation that it allows. These results feedback in the areas of Web 2.0 development, but, also importantly, in the area of adaptation, illustrating the new possibilities created by the social paradigm.

In the next chapter, as all of these features were considered separately useful, we merge them all together, as per the overall scenarios presented in this chapter, and analyse their usefulness both in a quantitative and qualitative manner.

CHAPTER 8

“I know the price of success: dedication, hard work, and an unremitting devotion to the things you want to see happen.”

Frank Lloyd Wright (1867-1959)

8. My Online Teacher 2.0 Third Prototype

In this chapter, we aim to continue improving the learning content recommendation and peer recommendation, which has so far proven satisfactory, as illustrated by the second prototype (see Chapter 7). However, the second prototype only showcased the features of adaptive content, adaptive peer recommendations and adaptive privileges separately. Since all of these features were evaluated separately and considered useful, in this chapter, we aim at introducing them all together, by an overall scenario (Section 8.1), and analyse their merged usefulness in both a *quantitative* and *qualitative* manner (Section 8.6).

Additionally, we change another variable, which may have influenced the lack of significant difference between the groups with or without recommendation, which is that of *granularity*. Previously, we have used *low granularity recommendations*, i.e., recommendations based on whole modules. Next, we concentrate on *fine-grained recommendations*, i.e., recommendations based on items in a module. These extensions are built on top of the e-learning 2.0 paradigm, i.e., e-learning enhanced with Web 2.0 features, as systematically illustrated by the MOT 2.0 system. Therefore, in this chapter, we focus on the following generic research question:

- *Is an e-learning 2.0 system enhanced by using the fine-grained content-based adaptation and the fine-grained peer recommendation?*
- *Is an e-learning 2.0 system enhanced by combining content-based adaptation and peer recommendations?*

The first question investigates the *granularity* of the recommended learning content and recommended learners based on the current item; whereas the second question investigates the *combination* of both *fine-grained* content-based adaptation based on the current item and the *fine-grained* peer recommendation based on the current item.

These research questions are to be answered in this chapter via experimental analysis, based both on *subjective measurements* (such as questionnaires) as well as *objective measurements* (such as knowledge tests). For the above questions we also aim to establish what the perceived *learning effect* and *usability* of the paradigm is, via the analysis of subjective feedback, e.g. a questionnaire.

The newly implemented prototype 3 of the MOT 2.0 system will be used to answer the previous research questions, by breaking them down into a set of research hypotheses to be answered, as will be further shown in Section 8.3.The next section will describe the motivating collaborative learning scenario for the merged fine-gained adaptation in the e-learning 2.0 context.

8.1. Collaborative Learning Scenario

In the following, we shall illustrate the principles of computer supported collaborative learning in the Web 2.0 environment, enhanced with the types of adaptation guidance that we target, by describing the learning scenario of a fictional student in our desired environment. For the sake of grounding the scenario in realism, we stay as close as possible to the actual implementations and screenshots as shown in Section 8.5. However, this scenario should be seen as our motivating hypothetic generalized initial scenario, containing all potential adaptive behaviour. In reality, a student's learning would reflect various (potentially repetitive) subsets of this motivating scenario:

Sebastian is a student of Computer Science. He is studying an optional module about Dynamic Web-based Systems in his 4th year at the University of Warwick. One of the lessons in this module is about the topic of Collaborative Filtering. He does not know much about the material, he is a *beginner*, so he would like all the help he can get with it. Whilst he is learning about ‘Collaborative filtering vs. Content-based filtering’, the system recommends him other related items, such as ‘Content-Based Recommendation Systems’, ‘User Profiles’ and ‘Personalization vs. Customization’ (see Figure 36). Moreover, the system recommends him to ask Fawaz, who has studied this material earlier, is more advanced and could answer his questions (see Figure 39). Therefore, Sebastian asks Fawaz about ‘Personalization vs. Customization;’ and receives answers. He also further visits related topics, and starts understanding more about the subject.

After he feels confident enough with his study of Collaborative Filtering, Sebastian takes a test provided by the system. He answers relatively well, and he is pleased with himself. He returns to read about the parts he did not answer so well about, and notices that his status has been promoted to *intermediate*, and that he can now comment on the items he is re-visiting. He can now write about the possible misunderstandings that he felt could result from the way one of the topics is presented. He is pleased to see later during the course that the teacher has rephrased that particular content, based on his feedback.

8.2. MOT 2.0 Third Implementation

The scenario above reflects the goals set for the functionality desired for the third prototype of the MOT 2.0 system. The third prototype is based on the evaluation feedback from the first and second prototypes, as well as on the exploration of new research ideas. Concretely, in the third prototype, *fine-grained content-based* and *peer-based adaptations* were introduced. Simplified versions of the procedures used are shown below, for the three strategies of recommended learning items, recommended expert peers, and adaptive user privileges.

Strategy 1. Recommended learning contents (items):

```
RI = ∅;
If (
Similarity (I, Ii) > Value_1   &&
   Rating (Ii) > Value_2 &&
```

```
knowledge (User, I) == Value_3
 )
RI = RI ∪ {Ii};
```

Where:

- *I:* is the current item.
- *RI:* is the set of Recommended Items for the current item, I.
- *Ii:* refers to an arbitrary item in MOT 2.0 (third prototype); where the variable i is the item identifier.
- *Similarity (I, Ii):* is the Euclidean Distance between the current item, and any other item in MOT 2.0 (third prototype). The similarity is calculated between the two strings, with each string representing the tag (keyword) set that describes the item.
- *Rating (Ii):* represents the average rating of the item, as decided by previous users with rating rights.
- *knowledge (User, I):* is the User's knowledge level for the current item, I.
- *Value_1:* is the threshold value of the similarity, which can be any value between 0 and 1. The MOT 2.0 (third prototype) system is flexible in that the value can be changed every time a module is taught. This value is normally set by the teacher, or course technician.
- *Value_2:* is the value of the average rating threshold, which can be any value from 1 to 5. This value is also set by the teacher or course technician.
- *Value_3:* is the user's knowledge about a specific item, which can be either 1 or 0. For instance, a learner just starting to learn about the topic of 'Implicit and Explicit rating' can be sent back to read more about 'Collaborative filtering' (see Figure 38).

Thus, the content-based adaptation recommends another item to a learner, if his knowledge on the current item is insufficient, and there exists another item *Ii* with an acceptable level of similarity to the current item, and a good rating from peers. Therefore, this content-based adaptation is fine-grained both in items of input (the current content item, instead of a whole module) and output (a recommended item, and not the whole module). In the following, we introduce a simple version of the peer-based adaptation.

Strategy 2. Recommended expert peers / learners:

```
RU = 0;
If (knowledge (User, I) == Value)
   RU = RU ∪ {User};
```

Where:

- *I*: is the current item.
- *RU*: is the Recommended Users set for the current item, I.
- *Knowledge (User, I)*: is the User's knowledge level for the current item, I.
- *Value*: is the value of the knowledge level, which can be "beginner", "intermediate", or "expert". For instance, an expert learner on the subject of "Uses of Collaborative Filtering" in the course on "Collaborative Filtering" would be recommended as a knowledgeable contact to another learner who is just starting to learn about that subject (see Figure 39).

The strategy simply states that if a user's knowledge about an item is above a certain threshold, this user will be recommended to all other users. Moreover, the strategy above illustrates a fine-grained recommendation of peers in terms of input (the recommended user's knowledge of the current item) and in terms of output (the recommended user of the current item). This strategy moves completely away from traditional Adaptive Hypermedia, as it does not focus on classical content recommendation, but on peer recommendation.Next, we describe a simplified version of the third strategy of adaptive user privileges.

Strategy 3. User's privileges based on the knowledge:

```
If (knowledge (User, I) == V1)
{
   CanRate = V2;
```

```
        CanTag = V3;
        CanFeedback = V4;
    }
```

Where:

- *I*: is the current item.
- *knowledge (User, I)*: is the User's knowledge level of the current item, *I*.
- *Value*: is the value of the knowledge level, which can be "beginner", "intermediate", or "expert".
- *V1, V2, V3, V4*: can be either 0 or 1 to determine if the user has a privilege or not.

The strategy states that privileges are granted, for each item, to each user depending on the user's knowledge about that item. Therefore, an *expert* user can be given all privileges, of rating, tagging and giving feedback, whereas an *intermediate* user is only allowed to add comment, and a *beginner* user is restricted to reading only. Similarly, the adaptation is fine-grained, at the level of the items and not the modules. This strategy moves away from both Adaptive Hypermedia systems and recommender systems, and introduces adaptivity to the Web 2.0 context.

Therefore, the main difference between the strategies presented in this chapter and the previous chapter is the granularity level. Previously, we have used low granularity recommendations, i.e., recommendations based on whole modules and recommendations of whole modules. Here, we concentrate on fine-grained recommendations, i.e., recommendations based on items within a module.

Moreover, whilst we have introduced these three axes of adaptation via their representative separate strategies, one of the main features of the third prototype is the merger of all these three types of adaptation. Therefore, all these types of adaptations are to be applied at the same time, as will further be detailed in the next section.

8.3. Hypotheses

The overall motivation for the third prototype of the MOT 2.0 system is the assumption that the joint recommendations of other learners and learning content will increase the learners' effectiveness, efficiency, and satisfaction in the learning process.

Therefore, the Null-hypothesis that we are trying to refute is:

- **H0:** MOT 2.0 (third prototype) does not influence the learning outcome.

The counter-hypotheses to refute H0 are:

- **H1:** MOT 2.0 (third prototype) with recommendations of fine-grained content and peers *increases the learning outcome* (for the learners who need help by further reading of related recommended content or via recommended experts, or social interaction) to a greater degree than other e-learning systems.
- **H2:** MOT 2.0 (third prototype) with recommendations of fine-grained content and peers *decreases the learning effort* (for the learners who need help by further reading of related recommended content or via recommended experts, social interaction) to a greater degree than other e-learning systems.
- **H3:** MOT 2.0 (third prototype) with recommendations of fine-grained content and peers *increases the satisfaction* (for the learners who need help by further reading of related recommended content, social interaction, or recommended experts) to a greater degree than other e-learning systems.
- **H4:** MOT 2.0 (third prototype) with recommendations of fine-grained content and peers is easy *to learn and use* (i.e., MOT 2.0 (third prototype) functions and screens are easy to understand) to a greater degree than other e-learning systems.
- **H5:** MOT 2.0 (third prototype) with recommendations of fine-grained content and peers is *easy to remember* (i.e., MOT 2.0 (third prototype) functions and commands are easy to remember, so that the learners do not have to learn about it again when they log on next time) to a greater degree than other e-learning systems.

8.4. Case Study of MOT 2.0 Third Prototype

The following case study is the main evaluation methods of MOT 2.0 (third prototype). It is used to field test the system components. In particular, the overall aim of this case study is to explore:

- Recommended learning content (per item) based on the learner's profile.
- Recommended users (peers) based on the learner's profile (per item).

The measures and the criteria of this case study are: *usefulness of the recommendations of users and learning contents*, which includes the efficiency and effectiveness of the recommendations of users and learning contents, as well as the satisfaction of the learners about the recommended learning content and the recommended other learners. The overall aim for the case study is to analyse the validity of the hypotheses introduced in the previous section.

We have performed the evaluations with 21 Computer Science students at the Politehnica University of Bucharest. The work was part of the regular seminar work within the module of 'Web Application Development', and the topic learnt was part of their curriculum. However, the participation in the evaluation was not compulsory. The majority of this course is taught online. Therefore, students are used to e-learning tools and methodology. In the following, the scenario steps of this case study are explained.

8.5. Scenario Steps

MOT 2.0 (third prototype) can recommend content as an Adaptive Hypermedia system, but at the same time it can recommend peers who can help with the learning process (e.g., recommending more experienced peers, who could help the student with the current questions). The scenario created to determine the appropriateness of the hypotheses is designed as follows, see Figure 37.

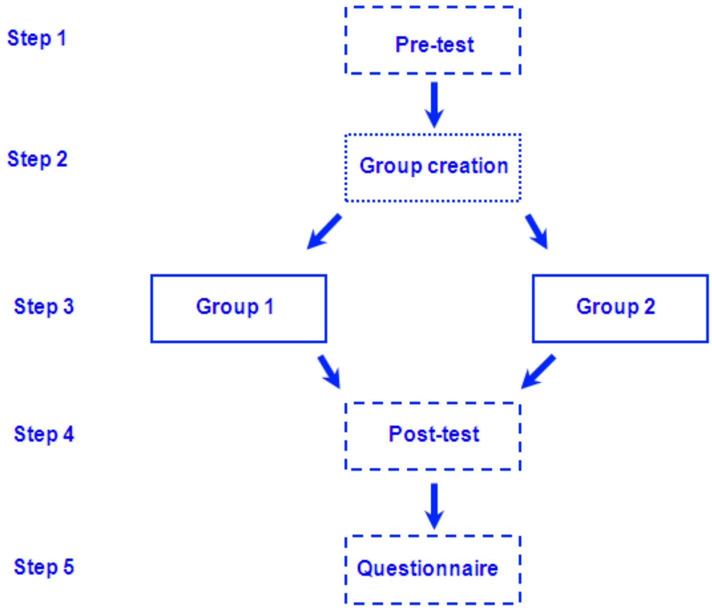

Figure 37 Scenario Steps

The participants (students) take a *pre-test* to determine their knowledge level (for a selected domain) out of: *beginner*, *intermediate*, *advanced*. Based on the knowledge level extracted from the pre-test, the participants are given different sets of privileges, as per Strategy 3 in Section 8.2, which can be expressed, in natural language, as follows:

- *Beginner* users can only read the learning material.
- *Intermediate* users can read the learning material, as well as add comments (feedback).
- *Advanced* users are allowed to read the learning material, edit the tags, rate the content and add comments (feedback).

After this initial classification, the participants are asked to accomplish a learning goal using MOT 2.0 (third prototype) (i.e., to learn a specific lesson on "Collaborative Filtering"). In order to achieve the learning goal, the participants are divided into two sub-groups: *Group one*: the first group (see Figure 38), acting as a control group, has to perform the learning activity by using MOT 2.0 (third prototype) without any help from the *content recommender*, or the *(expert) learners recommender*. This group however can still benefit from all Web 2.0 social environment facilities, depending on their set of privileges, as above. Figure 38 shows a screenshot of an intermediate learner of group G1. He can give feedback but cannot rate or add tags (right frame). The centre displays the learning content of the current item. The menu and recommendations are displayed on the left frame. As this user belongs to the control group, all items are shown as recommended.

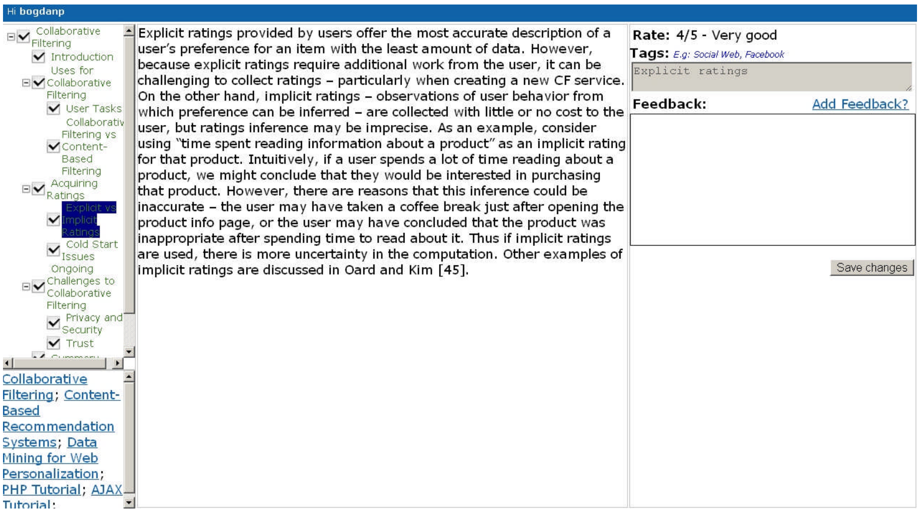

Figure 38 Screenshot of learning environment of Group 1

Group two: the second group (see Figure 39) has to learn by using MOT 2.0 (third prototype), supported by both the help of *recommended learning content* (per item; i.e., the content related to the current item is recommended, as per Strategy 1 in Section 8.2), as well as with the help of the *recommended learners* (per item; i.e., the expert for a given content item is recommended to learners, as per Strategy 2 in Section 8.2).

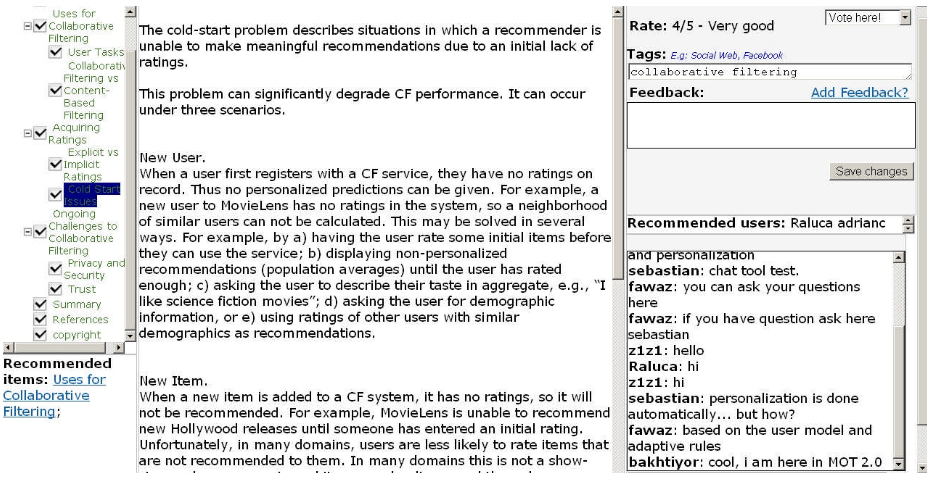

Figure 39 Screenshot of learning environment of Group 2

Similarly to the previous prototype, the division into groups makes sure that participants of each of the three knowledge levels, beginners, intermediate and advanced, are distributed as evenly as possible between the two groups. This is done to ensure that no group outperforms the other two, due to its 'lucky' division of students.

Figure 39 shows a screenshot that is similar to the screenshot for group G1 (see Figure 38), with item content in the middle frame, a menu and recommendations on the left frame, and Web 2.0 features on the right frame. The difference is that this user is an advanced learner, so he can rate, tag and provide feedback. Additionally, as the learner belongs to group G2, only the recommended items are displayed in the left frame. Moreover, peer recommendations are displayed in the right frame.

The two screenshots above show the different views of the learning environment that are available to the two groups. Social actions such as rating, tagging and feedback (typical of Web 2.0 settings) are available to all users in all groups (as long as their knowledge level permits it). These features provide the benefits of e-learning 2.0 (as have been explained previously Section 6.5.2 and Section 8.2), and therefore represent the minimal functionality offered by MOT 2.0 (third prototype), even in the version stripped of all adaptation. After learning, the participants take a *post-test* (which is identical to the *pre-test*) to determine the learning outcome, by comparing the pre-test and post-test answers for each learner.

The effectiveness of the two groups (in terms of learning outcome) is to be determined by comparing the results of the pre-test and the post-test, and calculating an average for each group. We are aware that this only evaluates the short-term learning effect, and longer term evaluations would be needed to compare the long-term learning effect. However, it does accurately compare this effect for students who have benefited from rich adaptation (the combination of content-based adaptation and peer recommendations) with students who were provided with no adaptation, in an otherwise similar setup.

Moreover, both environments are fully functioning modern learning environments, featuring social Web 2.0 functionality (such as tagging, commenting, etc.) customized to the experience level of the user. Previous chapter research has shown that learners find such functionality helpful so these features did not need to be isolated in the current case study.

Finally, the participants answered a questionnaire about their *perception* of the system functions, their *relevance*, and finally, the *system usability*. Based on the answers to the post-test, the learner's knowledge level is updated accordingly. After updating the user profile, the learner's privileges can be updated as well. This means that – just as in the introductory scenario in Section 8.1 – the learners can see their rights updated, based on the number of the tests they are willing to take during their learning process.

8.6. Results

Both sets of students performed better in the post-test, when compared to the pre-test, and there were only very few cases (19%) where they performed similarly, as can be seen in Figure 40. The post-test average was 7.75, which was 2.25 marks higher than the pre-test, on a scale from 0 to 10 (0-worst, 10-best mark).

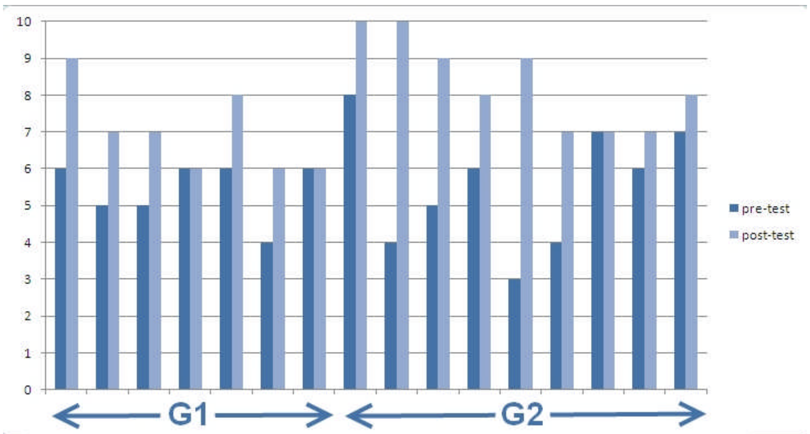

Figure 40 Post-test versus Pre-test for Group 1 and Group 2

In the following, we analyse first the statistical significance of these results for all students, and then we analyse the results based on the groups.

8.6.1. Comparison of pre-test and post-test

To validate the statistical significance of the differences in learning outcomes for all students who have used MOT 2.0 (third prototype) we have performed a T-Test. The results are shown below. The test used is the paired T-Test, as the marks for all students were compared before and after the learning took place and the data was verified as a normal distribution with the Anderson-Darling test.

Table 9 Paired T-test for pre-test and post-test for two groups

	pre-test	post-test
Mean	5.50	7.75
SD	1.32	1.34
SEM	0.33	0.34
N	16	16

The P value (0.00 < 0.05) shows statistical significance with a 95% confidence interval. The values used in these calculations are: t = 4.88, degree of freedom (df) = 15 and standard error = 0.46. From the initial 21 students who took the pre-test, only 16 took the post-test. This is due to the fact that the whole activity was not compulsory. Four of the five students who did not take the post-test had a very wide spread of initial marks (3, 6, 5, 6 respectively), whilst the fifth student did not take the post-test nor the pre-test. For the remaining students, 76% took both the pre-test and the post-test, the P-value clearly shows that significant learning took place for all students. This is demonstrated by the fact that the average post-test mark is 2.225 higher than the average pre-test mark with 2.25, and the difference is significant within the confidence interval of 95%).

Next, we analyse the learning that took place in the two groups.

Group 1:

For Group 1, the difference between post-test and pre-test is 1.57, for which the two tailed P value (0.01 < 0.05) shows statistical significance with a 95% confidence interval. The values used in these calculations are: t = 3.67, degree of freedom (df) = 6 and standard error = 0.43.

Table 10 Paired T-test for pre-test and post-test for group 1

Group 1	pre-test	post-test
Mean	5.43	7.00
SD	0.79	1.15
SEM	0.30	0.44
N	7	7

Group 2:

For Group 2, the difference between post-test and pre-test is 2.78, for which the two tailed P value (0.01 < 0.05) shows statistical significance with a 95% confidence interval. The values used in these calculations are: t = 3.85, degree of freedom (df) = 8 and standard error = 0.72.

Table 11 Paired T-test for pre-test and post-test for group 2

Group 2	pre-test	post-test
Mean	5.56	8.33
SD	1.67	1.22
SEM	0.56	0.41
N	9	9

The students of groups 1 and 2 have shown statistically relevant increases in their marks (with 1.57 and 2.78 respectively, in the confidence interval 95%). Thus, whilst learning occurred with statistical significance in both groups, Group 2, the group with the added mixture of item-grained content and peer recommendations, learned almost twice as much more than the control group, Group 1.

8.6.2. Students' Perception Questionnaire

In the following, the students' perception questionnaire is presented, as well as the hypothesis that each respective question is aimed at verifying. In the design of the questions, we have taken care not to insert any bias:

1. *I believe that, generally speaking, MOT 2.0 changes the learning outcome.* ***(H1)***
    - *Increases learning outcome (learning the selected lesson).*
    - *Decreases learning outcome (learning the selected lesson).*
    - *No influence on learning outcome.*
2. *I believe that, generally speaking, MOT 2.0 changes the learning outcome.* ***(H2)***
    - *Easier.*
    - *More difficult.*
    - *Neither easier nor more difficult.*

3. *I believe that, generally speaking, MOT 2.0 changes the learning outcome.* ***(H3)***
   - *Better.*
   - *Worse.*
   - *Neither better nor worse.*
4. *I believe that, generally speaking, the interaction with the system is:* ***(H4)***
   - *Easy to learn.*
   - *Hard to learn.*
   - *Neither easy nor hard.*
5. *I believe that, generally speaking, the interaction with the system is:* ***(H5)***
   - *Easy to remember.*
   - *Hard to remember.*
   - *Neither easy nor hard.*

The answers were further mapped, for numerical analysis, over the integer values of {-1, 0, 1}, with '-1' representing the negative answer (e.g., for question Q1, 'Decreases learning outcome'), '1' representing the positive answer (e.g., for question Q2, 'Easier') and '0' representing the neutral answer (e.g., for question Q3, 'Neither better nor worse'). The assumption underlying this mapping is that there is an implied monotonicity in the answer range, as well as a symmetric, equidistant relation between the positive and the negative answer. This is a relatively strong assumption, which we consider compatible with the type of answers we have selected, and which is in regular use in such questionnaires for learning systems. Out of the 16 students who took the post-test, 94% of the students also took the optional questionnaire as described above, see Figure 41.

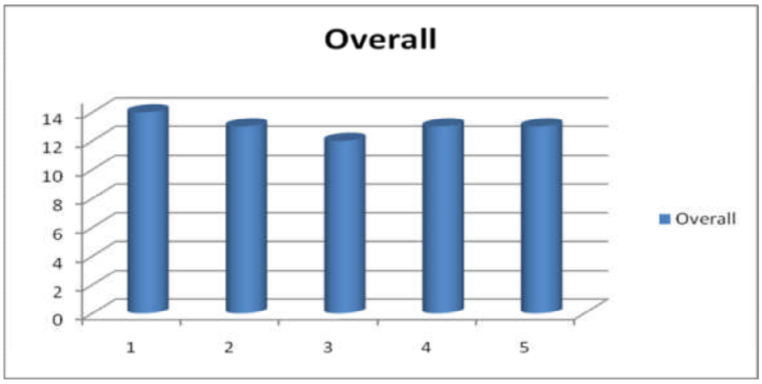

Figure 41 The overall answers to the subjective perception questionnaire

The questionnaire results represent the students' *subjective* perception about the MOT 2.0 system (as opposed to the test results, which represent the *objective* measure of the learning outcome). Therefore, 93% of the students declared that the MOT 2.0 system changes the learning outcome, and only one student declared that it has no influence on the learning outcome. Students were also asked to comment on their answers, but not all of them did, as comments were not obligatory. The only two students commenting (which we further anonymize by calling them students A and B) added the following comments: Student A: "*I like the way i can view the structure and see which is a subpart of which*."; Student B: "*much faster*". Clearly the two students perceive that the system has helped them, although in different ways.

Overall, a statistically significant majority felt that the system helped in learning, regardless of the group to which they belonged, thus confirming hypothesis H1. The next question, with a similar majority of opinion (87% of the students) concerns user satisfaction, which is increased by using the system, thus validating hypothesis H2. For question 3, 80% of the students believe that MOT 2.0 (third prototype) has increased their learning outcome. Therefore, the statistically significant positive result validates hypothesis H3. For question 4, corresponding to hypothesis H4, 87% of the students believe the interaction with the system is easy to learn. Overall, hypothesis H4 is thus confirmed. For question 5, fewer students (76% of the students), but still a statistically significant majority, believed that the system is easy to remember. Therefore, the statistically significant positive result validates hypothesis H5. Overall, all five hypotheses were confirmed, based on statistically significant results, as shown below:

Table 12 One-Sample T: Q1, Q2, Q3, Q4, Q5

Questions	**N**	**Mean**	**StDev**	**SE Mean**	**95% CI**	**T**	**P**
Q1	15	0.93	0.26	0.07	(0.79 to 1.08)	14	0.00
Q2	15	0.87	0.35	0.09	(0.67 to 1.06)	9.539	0.00
Q3	15	0.8	0.41	0.11	(0.57 to 1.03)	7.483	0.00
Q4	15	0.87	0.35	0.09	(0.67 to 1.06)	9.539	0.00
Q5	15	0.87	0.35	0.09	(0.67 to 1.06)	9.539	0.00

Next, we attempted to evaluate the questionnaire results from the point of view of the group that a respective student has been placed in. Thus, for each group (G1, G2), we re-examined the answers to the questions (Q1 – Q5) and thus the rejection/confirmation of the respective hypotheses (H1-H5). The results of this analysis are shown below. Thus, a result of $P<0.05$ for Qi_Gj confirms that for group Gj hypothesis Hi remains valid, as for all questions Qi the results were on average positive, and close to 1 (see the Mean column in Table 13).

Table 13 One-Sample T: Q1_G1, Q2_G1, Q3_G1, Q4_G1, Q5_G1, ... Q5_G3

Question	H	N	Mean	StDev	SE Mean	95% CI	T	P
Q1_G1	H1	6	0.83	0.41	0.17	(0.40 to 1.26)	5	0.00
Q2_G1	H2	Cannot compute T-test. All values are the same (value is 1).						
Q3_G1	H3	6	0.5	0.55	0.22	(-0.07 to 1.07)	2.2361	0.07
Q4_G1	H4	6	0.83	0.41	0.17	(0.40 to 1.26)	5	0.00
Q5_G1	H5	6	0.83	0.41	0.17	(0.40 to 1.26)	5	0.00
Q1_G2	H1	Cannot compute T-test. All values are the same (value is 1).						
Q2_G2	H2	8	0.78	0.44	0.15	(0.44 to 1.12)	5.2915	0.00
Q3_G2	H3	Cannot compute T-test. All values are the same (value is 1).						
Q4_G2	H4	8	0.89	0.33	0.11	(0.63 to 1.15)	8	0.00
Q5_G2	H5	8	0.89	0.33	0.11	(0.63 to 1.15)	8	0.00

As can be seen in the table, all hypotheses H1 to H5 were confirmed for group G2, which is the group with all the added adaptive content and recommended peers. However, H3 (about learner satisfaction) could not be confirmed for group G1 in the 95% interval (only in the 90% interval). The rest of the hypotheses were confirmed for group G1. Looking at the differences in the opinion between the two groups, group G2 slightly outperforms group G1 (the control group) on hypothesis H1 (about increased learning outcome; with a difference of 0.17), clearly on H3 (about increased learning satisfaction; with a difference of 0.5), slightly on H4 (about ease of learning and using; with a difference of 0.06), and similarly slightly on H5 (about ease of remembering; with a difference of 0.06). The only hypothesis where group G1 outperforms group G2 is H2 (about decreasing learning effort; with a difference of 0.22). This may indicate that recommendations have helped in every way, but may be perceived as added effort on the part of the student.

Further on, we have examined the time the learners have spent on the various activities. On average, the students in the control group G1 spent less time (seven minutes less) studying than the ones in group G2. As the studying time was up to them (they all had to finish within two hours, but other than that, no fixed time was set), this could indicate an increase in interest in studying for the students who benefited from recommended content and recommended peers.

8.7. Discussion

The case study compared a rich, personalized, adaptive system with a ‘simple’ baseline Web 2.0-based system. The ‘rich’ aspect is represented by the various facets, including the combination of the collaborative filtering based approach and the personalization approach. Moreover, Web 2.0 features, such as rating and tagging, are used in a collaborative filtering recommendation style, side-by-side with recommendations based on the user profile (here, the knowledge of the user is categorized as being one of *beginner*, *intermediate* or *advanced*). Furthermore, content-based adaptation methods, such as recommendations based on the content of the currently read item, are combined with peer recommendations. We can conclude that this combination of adaptive content and peer recommendations outperform “simple” Web 2.0 e-learning setups, from the point of view of actual and perceived learning outcome, ease of use and learning, and ease of remembering how to use the system, but not on the perceived learning effort.

Furthermore, in the second prototype (see Chapter 7), analysing the learning outcome (by comparing pre-test and post-test results) for the second group (recommended learning contents based on the current module) was not statistically significant with a 95% confidence interval. We have also traced if this was the case, and found that 62.5% of the learners followed the recommendations of the system for group 2.

In the second prototype, for the students' perception questionnaire, all hypotheses were statistically significant, except for the second question for the second group (recommended learning contents based on the current module). The question was related to the ease of use of MOT 2.0 (third prototype). The matched hypothesis was: "MOT 2.0 decreases the learning effort (for the learners who need help by further reading of related recommended content, or by recommended experts, social interaction)." This hypothesis was not confirmed as the answers to this question were not statistically significant. Thus, this hypothesis needed to be re-evaluated in the context of the improved third prototype. However, the new result also showed that the perceived learning effort with adaptive support is greater. It is important to note here that, although the third prototype was an improvement on the second prototype in terms of granularity and functionality, it still shares the main principle of adaptation: that of added information, instead of filtering of adaptation. Most Adaptive Hypermedia adaptation works as a filter on the available content, reducing the search space by guiding the learner step by step. For this, a relatively expensive structure needs to be created by hand. Instead, we opted for an automated mechanism, which functions by adding information. In the case of content-adaptation, more items are recommended, and in the case of peer-recommendation, talking with peers is recommended, to supplement the current learning process. Thus, to some extent, it is to be expected that learners who benefit from these extra recommendations will spend slightly more time on the learning process. Unfortunately, this does not come across the difference in marks obtained points clearly to a benefit in learning outcome.

Thus, in the third prototype of the MOT 2.0 system, the learners spent more time on their learning activities, and less time on their extra-curricular activities, as shown in the previous section. This suggests that by utilizing Social Web features to build learning communities that are based on adaptive learning systems may be the answer to engaging students more within learning environments. Therefore, offering students environments that are close to what they use every day in their extra-curricular life makes learning more attractive, but personalization added to these environments enhance the learning process.

We can also estimate that the recommended learning content and the recommended expert learners per item (as are proposed in the third prototype of the MOT 2.0 system) are more efficient and useful, compared to the recommended learning content and the recommended expert learners per whole modules (as was proposed in the second prototype of the MOT 2.0 system), as the evaluation results in the third prototype are showing more confidently statistical significance in the 95% interval. However, as no direct comparison between the two systems, version 2 and 3, has been performed, no direct data are available.

8.8. Summary

This section will summarize the findings of the research presented in this chapter, in addition to answering the research questions presented in this chapter. We can conclude that the third prototype of the MOT 2.0 system is enhanced by the *fine-grained* content-based adaptation based on the current item and the *fine-grained* peer recommendation based also on the current item, in terms of increasing the learning outcome, as well as in terms of attractiveness and time spent learning by students. Moreover, the third prototype of the MOT 2.0 system is enhanced by *combining* the *content-based adaptation* and the *peer recommendation*.

To conclude, we can say that we have performed another step towards harnessing the power Web 2.0 functionality, augmenting and extending it with the specific type of personalization and adaptation that it allows. These results feedback into areas of Web 2.0 developments, but also, importantly, in the area of adaptation, illustrating the new possibilities created by the social paradigm mainly for the education community.

In the next chapter, we will summarize the research work presented in this thesis, and give some directions for future research. Moreover, the next chapter will summarize the main findings of the main research aims and objectives, (see Section 1.4), in addition to answering the research questions (see Section 1.3) analysed via the research work presented in this thesis.

CHAPTER 9

"Without continual growth and progress, such words as improvement, achievement, and success have no meaning."

Benjamin Franklin (1706-1790)

9. Summary, Conclusions and Future Work

This chapter summarizes the research work and findings presented in the previous chapters of this thesis, and it also gives some directions for future research.

9.1. Overview

This thesis has studied the topic of *how to improve adaptive and personalized e-learning, in order to provide novel learning experiences*. As highlighted in Chapter 1 and Chapter 2, the review of the literature revealed that adaptive and personalized e-learning systems are not widely used, as they lack interoperability with learning management systems, in addition to having at most limited collaborative and social features.

Chapter 3 and Chapter 4 investigated the *interoperability issue* using two case studies. The first case study focuses on how to achieve the interoperability between adaptive systems and learning management systems using e-learning standards, and the second case study focuses on how to augment e-learning standards with adaptive features. A set of e-learning standards converters were developed, implemented, and evaluated that helped to tackle the interoperability issue.

Chapters 5, 6, 7, 8 investigated the limited *collaborative and social features* issue in adaptive and personalized e-learning systems. This thesis proposed a new social framework for personalized e-learning, SLAOS, in order to provide adaptive and personalized e-learning platforms with new social aspects. Based on this framework, a new social personalized prototype was introduced, in order to test and evaluate this framework. The implementation and evaluation of the new system were carried through a number of case studies. The research work was covered by a series of continuous case studies, as follows: firstly, the pre-design case study, followed by the first prototype case study, then by the second prototype case study, and finally by the third case study. The evaluation of these case studies reveals interesting and important findings regarding authors' and learners' collaboration.

In the following sections, we show how these two main investigations and their case studies, have allowed us to answer to the research questions, as mentioned at the beginning of this thesis.

9.2. Conclusions

This section will summarize the findings regarding the fulfilment of the research aim and objectives, (see Section 1.4), in addition to answering the research questions (see Section 1.3), about the research work presented in this thesis.

Research Question 1: *How can we bridge the gap between Learning Management Systems (LMS) and adaptive e-learning systems?*

This question can be divided into two research sub-questions, which are:

Research Question 1a: *How can we provide interoperability between adaptive e-learning systems and Learning Management Systems (LMS)?*

In Chapter 3, we analysed this question and presented a novel set of converters from MOT 1.0, My Online Teacher, to Sakai, a popular learning management system, using e-learning standards such as IMS QTI and IMS CP. The design and implementation of these converters were evaluated through a case study. A set of findings from the case study can be summarized as follows:

It is possible to bridge the gap between Learning Management Systems and adaptive e-learning systems, especially at the level of content conversion. For instance, mapping onto the XML format simplifies such a process, as many LMS use such a format. More importantly, mapping onto e-learning standards is essential, as LMS support these standards.

E-learning standards are the key factor in this interoperability issue because they allow for conversion due to the following features:

A). *Independency*: all LMS use e-learning standards such as IMS CP and IMS QTI, therefore the result of conversions can be easily imported to or exported from any platform that supports these standards.

B). *Consistency*: Standards are usually agreed upon by much larger communities than the adaptive e-learning community. Their changes are rare, and these standards are well documented. Thus, it is important to use them where possible.

The conversion to e-learning standards is useful for adaptive authoring systems, such as MOT: e-learning standards are vital in LMS. For example, the IMS QTI is used for tests and quizzes, and IMS CP is used for learning contents. Moreover, the converters proved to be easy to learn and easy to use.

The interoperability format issue can be solved using XML, as most learning management system support e-learning standards which are XML-based. This is simplified by the fact that many adaptive systems also use an XML-based data format.

Thus, the answer to the question “How can we provide interoperability between adaptive e-learning systems and Learning Management Systems (LMS)?” is “by using e-learning standards”. We have shown this by implementing the CAF to IMS QTI converter, and the CAF to IMS CP converter. It was also shown how these converters can be used to bridge the gap between learning management systems and adaptive e-learning systems.

Research Question 1b: *How can we augment e-learning standards with adaptation in order to provide novel learning experiences?*

In Chapter 4 we analysed this question and have shown how to accomplish this task using a set of converters from IMS CP and IMS QTI to MOT, in order to make it possible to use content defined via e-learning standards with an adaptive engine (such as AHA! that can furthermore run in Sakai).

The answer was created within the Adaptive Learning Spaces (ALS) EU Project, by converting an online course on the topic of the Unified Modelling Language (UML), which was used by a group of students that collaborated on a group-based project. The content was transformed from SCORM packages into AHA! lessons, based on the research work presented in Chapter 4, and the developed converters. The tools developed as part of ALS have also shown the great potential for adaptation to improve collaborative learning. Therefore, the answer to research question 1b is "by converting learning materials from IMS QTI and IMS CP into MOT 1.0, the process allows adding adaptive metadata and thus applying adaptation to content defined via e-learning standards, and hence adding adaptation to the LMS which use these standards."

Research Question 2: *How can we harness the Web 2.0 power and its characteristics to improve adaptive and personalized e-learning?*

This question also can be divided into two further research sub-questions, which are:

Research Question 2a: *Can the current adaptive e-learning frameworks benefit from the strengths of the Web 2.0?*

This question examines whether the current adaptive e-learning frameworks are able to model the Web 2.0 features (i.e., tagging, voting, commenting, and user-generated content). We have shown in Section 2.4.6 that these frameworks, with their current architectures, cannot directly model Web 2.0 interactions or benefit from the Web 2.0 advantages. Thus, the answer to this question is "No".

This further led to the development of a new framework, SLAOS, which extended a "pure" Adaptive Hypermedia framework, with the layers necessary to model social interaction. This framework and the system built based on it, were further used to answer the following research questions.

Research Question 2b: *Are collaborative authoring and social annotations useful for authors and learners?*

This question has been answered in Chapter 5 and Chapter 6, and the answer to this question is "Yes". The pre-design case study revealed the importance of collaborative authoring and social annotations for both the authoring and the learning process, and for both learners and authors/teachers. We distinguished between two components of collaboration: *collaborative authoring* (which modifies the actual web resource, i.e., concept in the domain model by multiple authors) and *social annotation* (which allows the users - Adaptive Hypermedia authors as well as students – to add/edit information without modifying the actual resource).

Moreover, the SLAOS framework and the MOT 2.0 prototype have proven the usefulness of collaborative authoring and social annotations for both authors and learners. The SLAOS framework blended the authoring and delivering phases (i.e., removing the barrier between tutors, learners and authors, all of whom become authors with different sets of privileges).

Research Question 2c: *Can the learning content recommendations and the expert peer recommendations of the learners enhance learning?*

This question has been answered in Chapter 7 and Chapter 8, and the answer to this question is "Yes". The second and third prototypes of MOT 2.0 have revealed the importance of the learning content recommendations and expert learners' recommendation. The granularity of the recommendation in the second prototype was on the whole current module; whereas, the granularity of the recommendation in the second prototype was on the current item.

9.3. Summary of Contributions

This thesis presents a new social personalized framework for e-learning, SLAOS. This new framework is designed to overcome the limitations of the current adaptive and personalized e-learning systems. This is achieved by using the benefits of e-learning standards to tackle the interoperability issue, in addition to using the strength of the Web 2.0 to overcome the limited collaborative and social features of the current adaptive and personalized e-learning systems. Moreover, this research and framework have been reflected in many iterations of a new prototype, the MOT 2.0 system.

The *interoperability* issue, introduced in this thesis, is covered by two case studies. The first case study focuses on how to achieve the interoperability between adaptive systems and LMS using e-learning standards, and the second case study focuses on how to augment e-learning systems with adaptive features. Thus, a set of e-learning standards converters were developed and evaluated, which facilitate the connections between adaptive systems and LMS. The collaborative and social features introduced in this thesis are described along with their implementation and evaluations via a series of case studies, starting with the pre-design case study, followed by the first prototype case study, then by the second prototype case study, and finally by the third prototype case study.

9.4. Reflection and Critical Analysis

The thesis works on improving adaptive and personalized e-learning, mainly by targeting the interoperability issue and the lack of social and collaborative features in adaptive systems. However, there were some drawbacks and limitations that are identified in this section.

In Chapter 3 and Chapter 4 there are deficiencies in the hypotheses and questionnaire design. Despite the fact that the converters were tested and evaluated, the questions did not fully match the hypotheses in all cases. This was because of limited research experience in the early stage of this research. This has however evolved and enhanced as is noted in Chapters 7, 8. Some questions in the questionnaires needed to be more carefully designed, such as the question that asked about the users' opinions of what types of questions should be covered by the converters. This issue could probably be solved by surveying popular LMS and investigating what types of questions are being used.

Moreover, the work carried out towards achieving interoperability has the drawback that perfect compatibility is not achievable, because adaptive systems are much richer than their linear e-learning counterparts. Therefore, whilst the content is easily convertible into e-learning standards, the adaptive specification is not transferable and is lost in translation. Nevertheless this should not be a deterrent to aiming at compatibility and interfacing at that level because this gives adaptive systems a much richer pool of content which they can access.

For Chapters 5, 6, 7, 8, it would be more useful for the case studies to check how much social activities (rating/tagging) were used. One feature which was introduced but not analysed in detail in the questionnaires is that of adaptive user privileges. Thus, advanced users benefited from having more rights of a Web 2.0 nature in the learning environment when compared to their intermediate level and beginner peers. Revisiting the results of the learning outcome evaluation, they showed that whilst all students benefited from the MOT 2.0 system, the highest benefit was for beginner students. However, these results are not conclusive and the effect of adaptive privileges, both on tool acceptance, as well as on the learning outcomes, needs to be further evaluated.

The case studies were limited due to time constraints. In an ideal world, the MOT 2.0 system would have been used during the whole teaching term, resulting in a better use of the system. Nevertheless, the system usability questionnaires provided useful information on the use of MOT 2.0. Our results mostly focus on short term memory, and it might be useful to evaluate instead long term effects of working with the system.

Moreover, the collected data could be more useful if other research techniques were used, such as interviewing the users individually to lead to a better understanding of their answers. For example, what does it mean if learners are connected to their social networks while taking the course in MOT 2.0? To what extent does this potentially affect the learning outcome? Or is it affecting the learning process in a way leading to students losing their concentration on the taught course? Another issue was a lack of testing and comparison between MOT 2.0 (with its three different prototypes) and traditional class teaching (offline learning), and investigating the learning outcome in both learning environments.

9.5. Future Research

There are several guidelines where enhancements and future work to the research presented in this thesis can be made. They are summarized here:

The converters from MOT 1.0, CAF into IMS CP and IMS QTI have shown some limitations regarding converting all required information from CAF. The answer of Research Question (1a) showed that the conversion looses the adaptive parameters, as it was not possible to convert them. A possible way to achieve a solution for this limitation would be investigating extent possible for the conversion of the adaptive parameters in CAF into the meta-data used in IMS CP and IMS QTI.

In addition, the converter from CAF to IMS QTI should cover all types of questions, and not just fill-in-the-blanks, as in our research. A workable direction to achieve a solution for this limitation would be extending the current converters to cover all types of questions. For example, a concept with a set of attributes can represent a multiple choice question in IMS QTI, and the attribute matching the correct answer can be marked with a specific text.

Another future trend needs to address integrating MOT 2.0 with existing Web 2.0 infrastructures (e.g., enable learners to connect to their friends through social networks as well as to their peer learners). A possible way to achieve a solution for this limitation would be investigating a possible use of the APIs provided by these networks.

Moreover, another future direction can consider the possibility of implementing various types of adaptive strategies and not only recommended learning content and recommended learners. This would mean for MOT 2.0 to be able to import external specifications of adaptation, as for instance from the LAG (Cristea and Verschoor, 2004) language. However, this also requires extensions of this language in order to support social interactions. Thus, more research is essential in order to extend the current adaptive strategies to cover social aspects as we did in SLAOS. A possible method to achieve a solution for this limitation would be extending the current recommendations strategies and express them in an extended LAG language.

Finally, the ultimate goal of conducting the research presented in this thesis is to improve adaptive and personalized e-learning, to provide novel learning experiences. By addressing the limitations of adaptive and personalized e-learning systems as described in this thesis, such systems will become more commonly used in modern e-learning.

This was achieved by:

1) By addressing the *interoperability* issue. This is covered by two case studies.
    a. The first case study focuses on how to achieve the interoperability between adaptive systems and Learning Management Systems using e-learning standards,
    b. and the second case study focuses on how to augment e-learning systems with adaptive features. Thus, a set of e-learning standards converters were developed and evaluated that facilitate the connections between adaptive systems and Learning Management Systems.
2) *Creating a new social* personalized *framework for e-learning, SLAOS*.
3) *Building a new system, MOT 2.0*, that corresponds to the social personalized framework for e-learning, SLAOS. Moreover, this system has been built in three iterations, each presented and followed by a case study, towards building the combination of features that illustrates the SLAOS framework.

Appendix 1: MOT to IMS CP Evaluation Data

Number of Submission: 28
Number of Questions: 12
Q1. I consider that allowing conversion to and from the CP standard is vital for any system that uses tests, quizzes and questionnaires.

A. Both ways (to and from) is important. (18 Response)

B. One way (from any system to CP – e.g., MOT to CP) is important. (9 Responses)

C. One way (to any system from CP– e.g., CP to MOT) is important. (1 Response)

D. It is not important. (0 Response)

Q2. I learned to use the converter very quickly

A. Yes. (28 Responses)

B. No (0 Response)

Q3. After learning to use it, I believe the converter is easy to use.

A. Yes (28 Responses)

B. No (0 Response)

Q4. The converter is

A. Slow (6 Responses)

B. Fast (22 Responses)

Q5. The conversion took the following number of seconds:
Answers: 5

15, 8, 1, 7, 11, 6, 7, 5, 7, 10, 2, 5, 2, 2, 5, 5, 5, 3, 6, 1, 5, 6, 3, 2, 5, 5, 9.

Q6. The converted CP file matches exactly the imported CAF file

A. Yes (19 Responses)

B. No (9 Responses)

Q7. Does the conversion cover ALL the necessary information?

A. Yes (25 Responses)

B. No (3 Responses)

Q8. Should the converter run within MOT rather than as a separate application?

A. Yes (10 Responses)

B. No (18 Responses)

Q9. Should the converter run within Sakai rather than as a separate application?

A. Yes (10 Responses)

B. No (18 Responses)

Q10. Does the CAF to CP converter need to convert the adaptation parameters (weight, labels) in the Goal Model?

A. Yes (15 Responses)

B. No (12 Responses)

Q11. Overall, how do you evaluate this converter? Explain your answer by mentioning the advantages and disadvantages:

Answers:

CP is a standard for uploading data of e-learning systems so the main advantege is that it can transfer any knind of data(docs quizzes pictures questionnares)Compared to CAF this is slower but it is logic because it converta a grea amount of data.

----

a) very quickly;(about 8 seconds) very easy to use; every text such as test,quizzes or just plain text can be converted to a standard that can be used by other programs; b) no disadvantages from my point of view;

Advantages:

- the converter is very good because it interprets local data in a format that is widely recongnized in e-learning systems and interoperability is a key issue in this field

Disadvantages:

- the converter might slow down or crash given large ammounts of data to process...of course i haven't witnessed this but it is a possbility given the environment it has to work with

----

Advantages:

- easy to use;
-fast;

disadvantages:

-i don't see any disadvantages in the actual converter;

One big advantage is that it converts various types of data

It's easy to use. I only needed about 3 clicks to get the results file. It's fast: only took about a second to process the file.

It is a very useful tool because you convert the MOT quizzes into CP, that can have any content.

The disadvantage is that it is slow and you have to wait a lot to convert the file.

----

it is great that it also deals with pictures and movies, this is a great advantage

----

It is better than MOT-QTI because of its complexity and functionality; the drawback is the larger time it takes to compile

----

The converter is a very useful tool for performing these tasks.

Adavantages:

1.easy to use
2. very fast
3.very flexible

Disadvantages

1. I needs constant optimization in order to be up to the users' demands which are permanently changing

----

works fast and easy to understand and pluged in converter
which is huge advantage.

Disadvantages:

- it seems to be slow, but maybe it is the fastest way it can be.

Advantages:

- It converts to CP which makes it be used from many other systems.

The convertor is very usefull. The advantages are that the converion is very good, it converts all the useful data. It is user friendly.

The converions takes more time and the import is more difficult.

As an advantage i would mention that the convertor is fast. The file
was rather big but the result was obtained almost immediately.

Because Cp is a more general standard than QTI, it is very usefull to have a good and correct convertor to Cp.This convertor correctly converts all the usefull information.

The only disadvantage that i can observe is its impossibilty to be used offline.

It is a very useful converter.

Advantages:quick and easy to use.

Very good : because it if fast, easy to use and precise (no information is lost - I GUESS)

A very easy to use, fast converter.

As advantage I would mention its user friendly interface and its logical menu , witch makes it very easy to understand by students , and that it converts the xml files perfectly.
As for disadvantages , it takes more time to convert than CAF to QTI .

Advantages:
- Easy to use (click and wait)
- Java-based
Disadvantages:
- Slow like hell
- Firefox needed (I love IE, sorry)
- Account needed
- Internet required (I wonder that all the world is cover with Internet connection)
----
a) Usefull both in practical and learning purpose.
b) It should not depend on oher online applications.
----
advantages: it is easy to use, it makes the conversion quite quickly
disadvantages: if the server is not powerful enough or the files are very large, it can be slow
----
It is a good converter since it ensures conversion in quite a short interval of time. Also it gives the information in a different matter, it changes only the structure, not also the content. One isadvantage might be the fact that we could only use it with a version of mozilla firefox and not with internet explorer.

Advantages
-Java-based - portability
-fast execution time
Disadvantages
-Hard to find
-not enough user help information

It was fast enough when I tested. It seems flexible enough.
----
a)Advantages: fast, easy to use
b)Disadvantages: i found no faults while using the converter

Advantages:
- Java-based - portability
- Simple to use
- Doesn't require user to know the detailed file structure of the file he is converting, just the content he has packed.
Disadvantages:
- Java-based - slow execution time
- A registration is needed to access it

Advantages:
1) the converter is fast because it uses Java Architecture for XML Binding.
2) it has a friendly user interface
3) interoperability concept
Q2.12. Which converter is more appropriate? (I.e., which converter makes more sense if we want to export MOT contents in standard format?)
A. CAF to CP (24 Response)
B. CAF to QTI (3 Response)

Appendix 2: MOT to IMS QTI Evaluation Data

Number of Submission: 30
Number of Questions: 11
Q1. I consider that allowing conversion to and from the QTI standard is vital for any system that uses tests, quizzes and questionnaires.

> A. Both ways (to and from) is important. (18 Responses)
> B. One way (from any system to QTI – e.g., MOT to QTI) is important. (9 Responses)
> C. One way (to any system from QTI– e.g., QTI to MOT) is important. (1 Response)
> D. It is not important. (2 Responses)

Q2. I learned to use the converter very quickly.

> A. True. (29 Responses)
> B. False (0 Response)

Q3. After learning to use it, I believe the converter is easy to use.

> A. True. (29 Responses)
> B. False (0 Response)

Q4. The converter is:

> A. Slow. (1 Response)
> B. Fast. (28 Responses)

Q5. The conversion took the following number of seconds:
Answers: 2

> 3, 3, 15, 1, 9, 2, 3, 1, 8, 1, 3, 2, 2, 1, 5, 5, 1, 3, 1, 5, 1, 2, 3, 5, 5, 1, 1, 10, 1.

Q6. The converted QTI file matches exactly the imported CAF file.

> A. True. (15 Responses)
> B. False (14 Responses)

Q7. Currently, CAF to QTI covers “Fill in the Blank” questions. What are the other types of questions that should be converted in the future? (Multiple choice)

> A. Multiple Choices. (27 Responses)
> B. True/False. (25 Responses)
> C. Ordering the answers. (16 Responses)
> D. Other. (15 Responses)

Q8. Should the converter run within MOT rather than as a separate application?

> A. True. (13 Responses)
> B. False (16 Responses)

Q9. Should the converter run within Sakai rather than as a separate application?

> A. True. (14 Responses)
> B. False (14 Responses)

Q10. Does the CAF to QTI converter need to convert the adaptation parameters (weight, labels) in the Goal Model?

> A. True. (11 Responses)
> B. False (17 Responses)

Q11. Overall, how do you evaluate this converter? Explain your answer by mentioning the advantages and disadvantages, as follows (1-2 sentences for each is enough, but if you have more to say, do so): a) Advantages: b) Disadvantages:

> Answers:
> a) it easily allows anybody to create their own questionnaire;
> -----------------
> a) Advantages:* A clear advantage is the fact that it takes a small amount of time to run ;
> b) Disadvantages:* It only converts content relevant and appliable in the virtual learning environment.
> -----------------
> Advantages:
> - like i said before the converter to QTI is good for uniformity and interoperability between the systems that use this standard
> Disadvantages:

- the single disadvantage i can see right now is again regarding performance in huge data processing because this kind of a system must be somewhat flawless in this area

----

a) The convertor is fast, but I didn't have the chance to test it large files. Also I do believe that what it does iti is important becausse it saves time for teachers.

b) One big disadvantage that i find is that it doesn't convert untill now only the "Fill in the Blank" questions. In the future it shoul convert many other.

----

a)-easy to use;

b)-not being able to go back after completing the question;

Since i haven`t used any other converters at the moment I would have to say that it a pretty good one, its advantage being that it is easy to use and it is fact enough.The disadvantage could be that then trying to convert very large amount of data it is slow

----

The advantage is that although it seems very fast it might not be fast enough when you use a great amount of data.

----

a) Advantages:We exchange content between MOT and the other systems using QTI and because it is an international standard data model so other people that don't use the MOT learning may also use this quizzes because it provides questions to users regardless no matter what virtual learning environment.

----

a) - easy to use

- very useful for reporting results (statistics);

- very clearly stated,organized such as questionnares

b) - as i observe it has a bug regarding to browsers such as Internet explorer. In such cases it is recommended to use Firefox.

I think the main advantages are its ease of use and its speed. You can get your assessments imported in no time.

The converter is overall very useful, because it allows the users of different types of files to communicate. It also helps for the information to become more portable - a test constructed in the CAF format can be used by a user that uses the QTI standard.

Advantages:

1. its' very fast

2. you gain a lot of time in comparison with other methods uf upploading this type of information

3. it's easy to use

Disadvantages

1. it needs permanent modification in order to be up to the demands of the learning system, of the new methods of tests

----

a)advantages :

converter is works fast and effective.

converts in optimum way without data loss.

Disadvantages:- it is slow, not too much, but it's still slow, perhaps it is because of the server.

Advantages:- it converts MOT to QTI which make files be standardized.

----

a) It is easy to use (user friendly), it converts correct and it can be used by everybody due to the fact that it is online and free.

b)I haven't worked enough with it in order to see disadvantages. Everything worked and seemed OK until now.

----
a)Advantages: The convertor is very fast. I think it would perform very good on bigger input files too.
b)Disadvantages The convertor is not very portable and cannot be used offline
----
I think it is very useful.
a)Advantages: has an easy to use interface

A) Advantages : speed, quality of service, ease of use
----
a) It allows migration from one system to the other, which is of great help. Also it is fast and easy to use.
b) It still has bugs and its conversion capabilities are limited. Also, integration within the two systems would be of great help.
----
a) As advantages I mention that it is user friendly and has a nice and logic
----
Advantages:
- Java-based
Disadvantages:
- Cannot work with IE-base browser (anti Microsoft?)
----
a)It is an unsefull application for both learning and practical purpose.
b)It is online and has too many dependences... It should be a standalone program.
----
a) advantages : -this data-model is a standard, so it can be used to create questionnaires available in many contexts
b)disadvantages : it doesn't support any kind of standard conversion
----
a)Advantages
-Java based
b)Disadvantages
-not popular (lots of people do not know about it)

The converter it's fast and easy to use

Advantages:
- Simple to learn and to use.
Disadvantages:
- It runs as a separate program. It should be available for other programs to use.
----
a) Advantages: fast, easy to use.
b) Disadvantages: i could not find any flaws in the converter in the time i've spent using it.
----
a)
- It converts home made questionnaire formats into widely used ones.
- Quite fast from what I have met.
- Simplifies greatly the creation of questionnaires, converting from the concise domain model file format into the detailed QTI based format.
b)
- Has bugs on certain browsers (luckily only on the ones nobody uses :).
- A C/C++ implementation is always faster.

Advantages:
2) it has a friendly user interface
3) interoperability concept
Disadvantages:
1) It is not yet very well known

Appendix 3: MOT 2.0 Pre-design Evaluation

1. Collaborative Authoring in MOT should be designed in such a way that it uses (standards, where applicable) and technologies from:
    a. 14 Responses: Social Web/ Web 2.0.
    b. 1 Response: Semantic Web.
    c. 15 Responses: Both.
    d. 0 Responses: None of the above (it should be proprietary systems only).
2. Social Authoring facilities in MOT is useful if we use annotations in the form of:
    a. 0 Responses: Rating.
    b. 1 Response: Feedback.
    c. 3 Responses: Tags (keywords).
    d. 0 Responses: Editing content.
    e. 26 Responses: All of the above.
3. Collaborative Authoring facilities in MOT via Social annotation should be done by:
    a. 2 Responses: Feedback at the level of the concept.
    b. 3 Responses: Rating at the level of the concept.
    c. 4 Responses: Tagging at the level of content of attributes.
    d. 20 Responses: All of the above.
4. Social annotation: Feedback, rating & tagging should be applied by
    a. 5 Responses: Student
    b. 1 Response: Authors
    c. 24 Responses: Both.
5. Collaborative Authoring in MOT is important for:
    a. 0 Responses: Collaboration between authors.
    b. 0 Responses: Collaboration between students.
    c. 5 Responses: Collaboration between students and authors.
    d. 24 Responses: All of the above.
6. For collaborative authoring, interaction is needed at the level of:
    a. 4 Responses: users.
    b. 4 Responses: groups.
    c. 21 Responses: Both.
7. User privileges should be defined at the level of:
    a. 1 Response: attribute.
    b. 5 Responses: concept.
    c. 5 Responses: domain model.
    d. 7 Responses: lesson.
    e. 2 Responses: link.
    f. 10 Responses: lesson and link.
    g. 0 All of the above.
8. Group privileges should be defined at the level of:
    a. 1 Response: attribute.
    b. 6 Responses: concept.
    c. 4 Responses: domain model.
    d. 7 Responses: lesson.
    e. 2 Responses: link.
    f. 10 Responses: lesson and link.
    g. 0 All of the above.

Appendix 4: MOT 2.0 First Prototype Evaluation

Q1. What do you think about browsing other authors' domain maps / modules?

MOT 1.0 (authors and course designers)		
A1	**4**	Browsing other author's domain maps is very useful because is very important to see what other users create but the lessons are not in alphabetic order and thus are difficult to be read.
A2	**5**	you can rapidly find similar or related information
A3	**5**	Very useful because you can find related information, read it and so you can develop something that hasn't been created yet. Thus you can use the existent information as a starting point.
A4	**5**	One may find related courses and lessons.
A5	**5**	You can discover relevant information and use it for your courses. You can also learn from lessons developed by other authors.
A6	**5**	
A7	**4**	
A8	**3**	
MOT 2.0 (authors and course designers)		
A1	**5**	Browsing other author's modules gives users the opportunity to discover new topics, to improve their knowledge on various topics and to acknowledge new points of view.
A2	**5**	It gives you the possibility to discover new information.
A3	**4**	Useful to know what your colleagues developed and what you already have in terms of reusability. You can also find related information, read it and you can use the existent information as a starting point.
A4	**3**	It is useful to access other's authors content if the society or company's policy is not base on copyrights.
A5	**4**	It's useful because you'll see another way of structuring a module, identify useful information and see other points of view.
A6	**5**	
A7	**5**	
A8	**4**	
MOT 1.0 (students)		
S1	**4**	You can avoid making duplicate topics by being able to see existing domain maps.
S2	**2**	The lack of organisation in the domain maps and poor formatting for readability (small text, probably too much white space, frames) is somewhat frustrating, and make the task of locating a given topic of interest almost impossible.
S3	**5**	Collaborative authoring will be impossible without it
S4	**4**	
S5	**4**	Useful when browsing data.
S6	**4**	
S7	**3**	Knowing what the author's field of expertise is
MOT 2.0 (students)		
S1	**5**	Helpful when creating content.
S2	**5**	Essential
S3	**5**	
S4	**5**	
S5	**4**	Friendly interface
S6	**4**	
S7	**5**	More flexibility

Q2. What do you think about browsing other authors' lessons?

MOT 1.0 (authors and course designers)		
A1	**5**	Browsing other author's lessons is very useful because I could use some

		lessons as a model.
A2	**5**	The fact that one can see other authors' lessons is great as it keeps you up to date with others point of view and / or structure of a certain point of view or theory aspects. It also can be of great help in case there are some aspects you forget to consider for example or why not, didn't know.
A3	**5**	I consider being quite useful to see other author's lessons, to see how others structure the information, how they use adaptive techniques. On the other hand collaboration among authors has to be more developed, so that they can send each other comments about how to improve their work.
A4	**3**	Usually, viewing other's work is helping. If there are more trainers, teachers using MOT they may add value to their courses by studying each other's work.
A5	**4**	Useful to see different structures, to use information as reference, to see others' points of view.
A6	**5**	
A7	**4**	
A8	**3**	
MOT 2.0 (authors and course designers)		
A1	**5**	Browsing other author's modules gives users the opportunity to discover new topics, to improve their knowledge on various topics and to acknowledge new points of view.
A2	**5**	It gives you the possibility to discover new information.
A3	**4**	Useful to know what your colleagues developed and what you already have in terms of reusability. You can also find related information, read it and you can use the existent information as a starting point.
A4	**3**	It is useful to access other's authors content if the society or company's policy is not base on copyrights.
A5	**4**	It's useful because you'll see another way of structuring a module, identify useful information and see other points of view.
A6	**5**	
A7	**5**	
A8	**4**	
MOT 1.0 (students)		
S1	**5**	You can use existing lessons as a base for new lessons (consistency across lessons).
S2	**3**	Again, browsing other authors' lessons is a feature that might prove useful when constructing your own, if you are able to find it.
S3	**1**	not important for a single author
S4	**4**	
S5	**4**	easy to find other lessons of the same author.
S6	**5**	
S7	**4**	For ideas about your own lessons
MOT 2.0 (students)		
S1	**5**	Helpful when creating content.
S2	**5**	Essential
S3	**5**	
S4	**5**	
S5	**4**	Friendly interface
S6	**4**	
S7	**5**	More flexibility

Q3. What do you think about keyword-based access for other authors' content?

MOT 1.0 (authors and course designers)		
A1	**4**	The keyword-based access for other authors' keywords is very useful but is very hard to route because the list is very long and for example, the concepts called "Honey and Mumford, Learning Styles" that are used with the keyword "activist" aren't numbered and so I do not know that I opened, because they are all equally, I do not know how to make a difference

		among them.
A2	**5**	Access by keywords allows you to rapidly find the information of the same type. It also enables to develop a more creative course by the fact that you already know the extent to which a subject has been developed.
A3	**4**	It's good to have keywords and the fact that you can see all authors' keywords is even better. Nevertheless, the list seems to be huge and the more authors the higher the list, so maybe there should be found a way not to multiply keywords when linking concepts from one author to another. Another thing is to introduce rules about how to complete the keywords (exactly as in the scenarios that you sent) in order to avoid an incorrect filling in of these keywords.
A4	**3**	Using just keywords is not enough. You have to be sure that everyone completes the keyword section correctly and comprehensive. Maybe using search in texts or other metadata (age range, discipline, etc) will help
A5	**4**	Seems very useful as it helps you to find relevant content with the same etiquette. But clicking on every attribute of that concept is time consuming. It should have been of greater help if you could see that concept as a student view on the right side of the screen.
A6	**3**	
A7	**2**	
A8	**3**	
MOT 2.0 (authors and course designers)		
A1	**5**	That makes finding and exploring others' modules much easier.
A2	**5**	One can find more information much easier.
A3	**4**	Very useful to identify information. It's nice that others can add tags so in the end you can find information easier. Things can complicate when you have the same tags for too many modules and have to loose too much time to identify the useful information.
A4	**3**	It is very important to tag correctly every module, otherwise the search isn't useful. The search engine could be looking in texts as well, than the number of results may be higher.
A5	**4**	These keywords are useful primarily for the search function. It is easier and more convenient to type a keyword (if you do not know exactly what approaches the same subject with yours) and to find more materials.
A6	**4**	
A7	**5**	Easy to find content
A8	**4**	
MOT 1.0 (students)		
S1	**3**	Accuracy of searching by keyword depends on the author. Full text search may be more useful in some cases
S2	**1**	The keywords feature is completely broken. The repetition of terms is daunting, and initially confusing. It's hard to tell if the keyword feature is not working, or if there's simply incorrect keywords in many categories; "Absorbing" and "Activists" have exactly the same links, for example.
S3	**5**	useful for searching through the lessons
S4	**5**	
S5	**3**	Keywords are somewhat useful.
S6	**2**	
S7	**4**	Keywords are a fast way to find authors lessons related to a particular subject.
MOT 2.0 (students)		
S1	**5**	Can avoid duplicating content
S2	**2**	
S3	**5**	
S4	**5**	
S5	**5**	Efficient & fast
S6	**3**	
S7	**4**	Better to find tags

Q4. What do you think about copying a domain concept / items across domain map(s) / modules?

MOT 1.0 (authors and course designers)		
A1	**5**	The copying of domain concept (insert link) across from another of the author's own domain map (s) is very useful. Nevertheless, it should be nice that once I succeeded to add one link to another author's concept, when I try to make the second operation in the same place to receive a notification message that I already did that, which it already exists there.
A2	**3**	It's useful to see other domain maps, but making easy to copy with no restrictions from other authors' work can't be very good. It should be nice that when you copy something (introduce another domain map into your goal map/domain map) to automatically introduce the initial source.
A3	**4**	It is good if you want to start your lesson from that domain concept already created and introduce it into your goal map. Unfortunately, I can't think of a situation when I just copied one concept and introduced it into my course. It is true that working for corporate customers who have different content, high policy of confidentiality, copying won't be possible. Maybe it is useful when you try to explain something else and that domain is of help when explaining.
A4	**2**	There are situations in which you find related courses but, you do not need it all.
A5	**3**	Useful to see what other's have to say about a certain subject, but time consuming as you have to click on all concepts of interest and view attributes to reach relevant information.
A6	**4**	
A7	**3**	
A8	**4**	
MOT 2.0 (authors and course designers)		
A1	**4**	It's an economical way of dealing with contents as long as the copying is made responsibly and constructively.
A2	**4**	It is ok, if it is made responsibly and creatively.
A3	**3**	It is useful to copy it but the copyright has to be taken into consideration. Original sources should be clearly seen or mentioned.
A4	**3**	It is useful to copy other's authors content if the society or company's policy is not base on copyrights.
A5	**3**	This helps you fill in and improve the module with the possibility of finding information easy as long as everything is done in a responsible manner.
A6	**5**	
A7	**5**	Very easy
A8	**4**	
MOT 1.0 (students)		
S1	**3**	As Q1a, but it would be better if you could really copy a domain map rather than just link so you could edit it
S2	**2**	The system handles copies in an unusual way; I think it is creating a fresh copy of the material every time someone includes it in their domain/goal map/lesson plan.
S3	**5**	it should be useful for cross-referencing
S4	**5**	
S5	**5**	Make information accessible from various domains.
S6	**3**	
S7	**5**	Re-use of your own concept into another domain
MOT 2.0 (students)		
S1	**5**	Can avoid duplicated content
S2	**1**	Duplication of information is not useful. Should cross-link instead.
S3	**5**	
S4	**5**	
S5	**5**	**Helpful, much easier then old version**
S6	**4**	

S7	**3**	Found more of them really applied. However, may be useful in the future

Q5. What do you think about linking to concepts from someone else's domain map(s)?

MOT 1.0 (authors and course designers)		
A1	**4**	About linking to concepts from someone else's domain map (s) I think it is very useful, but you need to specify the rules about how to fill in keywords in a specific manner.
A2	**5**	You can rapidly find similar or related information.
A3	**4**	Useful, but rules about filling in the keywords should be specified.
A4	**3**	I think this helps managing the content.
A5	**5**	It's very good from the collaboration perspective and management of the content.
A6	**2**	
A7	**2**	
A8	**3**	
MOT 2.0 (authors and course designers)		
A1	**4**	It's an economical way of dealing with contents as long as the copying is made responsibly and constructively.
A2	**4**	It is ok, if it is made responsibly and creatively.
A3	**3**	It is useful to copy it but the copyright has to be taken into consideration. Original sources should be clearly seen or mentioned.
A4	**3**	It is useful to copy other's authors content if the society or company's policy is not base on copyrights.
A5	**3**	This helps you fill in and improve the module with the possibility of finding information easy as long as everything is done in a responsible manner.
A6	**5**	
A7	**5**	Very easy
A8	**4**	
MOT 1.0 (students)		
S1	**2**	The weighting system was unclear and did not seem all that useful
S2	**4**	Quite useful. Intra-linking significantly adds to the utility of knowledge bases. If an author chooses to link to material someone else has submitted, there's a high chance that information will be useful to users browsing the topic where that link has been placed.
S3	**5**	useful for referencing
S4	**5**	
S5	**3**	
S6	**4**	
S7	**4**	More links can make easier navigation for users
MOT 2.0 (students)		
S1	**5**	Can avoid duplicated content
S2	**1**	Duplication of information is not useful. Should cross-link instead.
S3	**5**	
S4	**5**	
S5	**5**	**Helpful, much easier then old version**
S6	**4**	
S7	**3**	Found more of them really applied. However, may be useful in the future

Q6. What do you think about creating a lesson based on someone else's domain map(s)?

MOT 1.0 (authors and course designers)		
A1	**5**	Creating a lesson based on someone else's domain map (s) is very useful because in case you need the exact content another author developed you just link to it. These parts should be written or should appear differently even in student view to see that it is another author.
A2	**3**	Can't be good neither for the one who copies the domain map nor for the

		one who has been copied. There are little situations when you need the exact theory included into your lesson, presented in the same way as another author did.
A3	**3**	That's a good start for your lesson because you need to know what other lessons have been created on a certain subject. But to insert a whole domain map it's not very likely. You need to allow adding or modifying attributes even for the inserted links.
A4	**3**	You should consider modifying other's work. Or else there will be few cases when a teacher really uses this facility.
A5	**4**	Nice to see this kind of cooperation, and I think it applies very well for a company / institution where there are different authors but they share the same data base and no copyright is at stake.
A6	**3**	
A7	**3**	
A8	**4**	
MOT 2.0 (authors and course designers)		
A1	**5**	The possibility of creating a module based on someone else's module is very useful in that it gives the user a starting point for his new module and also the opportunity to update the existing content.
A2	**5**	You can extend a topic taking into consideration the work of your colleagues.
A3	**4**	Very useful if the author permits this. It is also possible to generally agree that once you use MOT, all that you create with it can be used by other authors.
A4	**3**	It is useful to base own content on other's authors content if the society or company's policy is not base on copyrights.
A5	**4**	Often you have the information necessary to create a way but it is not clear shaped structure. Therefore, it is much easier when you start creating a module and a point which you can use both as a model (for inspiration) and you can borrow some chapters of this structure. Also, you have the opportunity to update the module.
A6	**4**	
A7	**5**	
A8	**4**	
MOT 1.0 (students)		
S1	**5**	Similar to Q1, again you can avoid duplicating work and useful if for e.g. the teacher for a lesson changes
S2	**1**	A better mechanism might be the ability to selectively link to others' content in one's own lesson, rather than simply duplicating it all. Sensible linking is (nearly?) always more useful than duplicating material.
S3	**5**	if more than one author is working on the same goal map, this might be useful
S4	**3**	
S5	**3**	
S6	**5**	
S7	**2**	The domain map may be inaccurate / incomplete and so the lessons could be affected.
MOT 2.0 (students)		
S1	**5**	Can avoid duplicating content
S2	**5**	
S3	**5**	
S4	**4**	
S5	**4**	**Helpful, much easier then old version**
S6	**3**	
S7	**3**	Could be useful, however a bit lazy. Repetitive lessons

Q7. What do you think about creating a lesson based on lessons created by other authors?

MOT 1.0 (authors and course designers)

A1	**5**	The lesson that includes a lesson (s) created by other authors is very useful but should be written differently to see that it is also another author involved.
A2	**3**	This should be possible only if you clearly specify lesson's title, author, date when the course was created. These elements should be seen by every user as in a book when you have footnotes including author name, book, chapter and even page.
A3	**3**	I see it just as a start or as part of a course developed by a team. From my experience I never used this kind of import before. What we did till now was to link one course by another, for example a student could start a course about Change Management only after he finished a course about Management in general.
A4	**3**	It would be more useful if you can modify the lesson that you imported. Based on my experience is very difficult to find a lesson that match exactly with your need. In many cases, a minor chance (technically speaking) may induce a major change in meaning. Maybe you consider letting teachers modify text, title, attributes (or more).
A5	**4**	Depending of your activity this could be useful. The users should see that another author has developed part of the lessons. It is useful in case you want to send users to a concept that they had to see before and thus to help them to remember the concept.
A6	**3**	
A7	**3**	
A8	**3**	
	MOT 2.0 (authors and course designers)	
A1	**5**	The possibility of creating a module based on someone else's module is very useful in that it gives the user a starting point for his new module and also the opportunity to update the existing content.
A2	**5**	You can extend a topic taking into consideration the work of your colleagues.
A3	**4**	Very useful if the author permits this. It is also possible to generally agree that once you use MOT, all that you create with it can be used by other authors.
A4	**3**	It is useful to base own content on other's authors content if the society or company's policy is not base on copyrights.
A5	**4**	Often you have the information necessary to create a way but it is not clear shaped structure. Therefore, it is much easier when you start creating a module and a point which you can use both as a model (for inspiration) and you can borrow some chapters of this structure. Also, you have the opportunity to update the module.
A6	**4**	
A7	**5**	
A8	**4**	
	MOT 1.0 (students)	
S1	**5**	Similar to Q2. In particular this would be useful for e.g. revision lessons
S2	**4**	Avoids repetition, so many benefits all round. May cause problems if both authors want to edit the lesson in a different way; you'd have to provide some sort of fork function.
S3	**3**	It may be good for referencing, but there should be a mechanism for consent to be given by the referred author
S4	**4**	
S5	**5**	
S6	**4**	
S7	**4**	Saves time creating your own lessons if its similar to someone else's already.
	MOT 2.0 (students)	
S1	**5**	Can avoid duplicating content
S2	**5**	
S3	**5**	

S4	**4**	
S5	**4**	**Helpful, much easier then old version**
S6	**3**	
S7	**3**	Could be useful, however a bit lazy. Repetitive lessons

Q8. What do you think about adding collaborative authoring (i.e. tagging, rating , commenting on content)?

MOT 1.0 (authors and course designers)		
A1	**2**	I believe that adding content to other users has to be well reglemented.
A2	**3**	To rate a paper or to comment on it involves a certain expertise on the subject.
A3	**5**	Will help authors to identify good stuff from not so good and to improve and modify what already exists.
A4	**5**	This will help in choosing the best content to use, and get value from minor change in content (in order to fit best in certain lesson/course).
A5	**5**	I think that rating content and comments is of great help because when you want to link to some concept you will know from the start what to expect from it.
A6	**4**	
A7	**5**	
A8	**3**	
MOT 2.0 (authors and course designers)		
A1	**4**	Collaborative authoring techniques represent a modern and democratic way of evaluating and improving both one author's own work and other authors' work as long as the users are well intended.
A2	**5**	It is a good idea to have such tools inside the collaborative authoring because it gives you the possibility to find out and give new information.
A3	**5**	I see it as an advantage because the feedback and ranking conduct to improvement.
A4	**4**	I think it is very useful, except using other's content to develop your own (copying or editing other's content). Tagging, rating and commenting other's content may help end-users choosing the right content for their needs.
A5	**4**	It is very important that the authors could work together, make the transfer of information or comment on the content of the module to another author. These are some modern techniques of cooperation as long as the authors are well intended.
A6	**4**	
A7	**5**	
A8	**5**	
MOT 1.0 (students)		
S1	**4**	At the moment group collaboration is too limited; this suggestion is like a Wiki with anonymous editing disabled (good)
S2	**2**	
S3	**5**	It should be useful so that more than 1 author can work on a single project
S4	**5**	
S5	**5**	
S6	**2**	
S7	**4**	This kind of open source authoring has done well in examples such as Wikipedia.
MOT 2.0 (students)		
S1	**5**	Team based creation is very useful & not available in MOT 1.0
S2	**5**	Peer review drives whole process, and it is useful. However I could not see how to edit other users' content
S3	**5**	
S4	**5**	
S5	**5**	Make it easier for users

S6	**3**	
S7	**4**	

Q9. What do you think about adding authoring for collaboration (i.e. defining groups of authors, subscribing to other authors)?

MOT 1.0 (authors and course designers)		
A1	**5**	It would definitively improve the collaboration among authors in order to develop better courses.
A2	**5**	This will facilitate communication and cooperation among those who develop an authoring program. It is of great benefit both for personal information and for developing better and complex courses.
A3	**5**	This is the essence of collaboration. It should be very nice to be implemented in MOT.
A4	**5**	It supports the working team (described previously). Group of authors may work together creating courses, and they benefit of each other experience and expertise.
A5	**5**	I've already tested working in teams using a LMS and it is better to speak with another author when you work together on a course for example.
A6	**5**	
A7	**4**	
A8	**3**	
MOT 2.0 (authors and course designers)		
A1	**4**	This would give the authors the chance to communicate better and work together efficiently as long as they are somehow supervised by a system administrator who would moderate these activities lest each author’s work and interests are respected.
A2	**4**	Communication between authors is a good way to share experience, but I don`t agree to subscribing to other authors because this activity could turn out to be abusive.
A3	**5**	I think this should be encouraged so that an entire team can create content.
A4	**3**	It is useful that authors collaborate to create good content. In my opinion a good approach would be creating “working groups” for developing modules.
A5	**4**	This allows authors the opportunity to communicate and work better in working groups.
A6	**4**	
A7	**5**	Good to keep track of new content
A8	**4**	
MOT 1.0 (students)		
S1	**5**	Another big problem is the lack of communication tools in MOT, as well as the lack of access control as mentioned earlier
S2	**5**	Very useful. The site is very community orientated, with a high degree of interoperation between users, and ideally, a high level of trust between users.
S3	**5**	
S4	**4**	
S5	**5**	
S6	**5**	
S7	**5**	Would allow delegation of tasks, better communication and speeding up of completion.
MOT 2.0 (students)		
S1	**5**	Team based creation is very useful & not available in MOT 1.0
S2	**5**	Aids communications & collaboration
S3	**5**	
S4	**5**	
S5	**5**	Useful as you won’t see all the irrelevant data from other groups
S6	**4**	
S7	**5**	Great idea, kind of like open sourcing

Appendix 5: MOT 2.0 Second Prototype Evaluation Data

User	Group	pre-test	post-test
54	1	7	9
62	1	5	8
63	1	4	5
66	1	6	10
67	1	6	9
68	1	7	7
69	1	8	9
75	1	4	
55	2	10	10
57	2	5	6
58	2	4	9
60	2	7	
65	2	5	8
70	2	6	
72	2	8	8
74	2	4	10
1	3	8	10
56	3	7	9
59	3	6	7
61	3	6	9
64	3	4	9
71	3	6	6
73	3	6	8
76	3	10	10

Final test – system usability

User	Q1	Q2	Q3	Q4	Q5
54	1	0	0	1	1
62	1	0	0	1	1
63	1	1	1	1	1
66	1	1	1	1	1
67	1	1	1	1	1
68	1	1	1	0	1
69	1	0	1	1	1
75					
55	1	1	1	1	1
57	0	0	1	1	1
58	1	1	1	0	0
60					
65	1	1	1	1	0
70					
72	1	0	1	1	0
74	1	1	1	1	1
1	1	1	1	1	1
56	1	1	1	1	1
59	1	1	1	1	1
61	0	0	0	1	1
64	1	1	1	1	1
71	1	1	1	1	1
73	1	0	1	-1	-1
76	0	1	1	1	1

Appendix 6: MOT 2.0 Third Prototype Evaluation Data

Pre and post tests

User	Group	pre-test	post-test
2	1	6	9
5	1	5	7
7	1	5	7
9	1	3	
10	1	6	6
11	1	6	8
16	1	4	6
17	1	6	
19	1	5	
20	1	6	6
1	2	8	10
3	2	4	10
4	2	5	9
8	2	6	8
12	2	3	9
13	2	4	7
14	2	7	7
15	2	6	
18	2	6	7
21	2	7	8

Final test – system usability

Group	User	Q1	Q2	Q3	Q4	Q5
1	2	1	1	1	1	1
1	5	1	1	1	1	1
1	7	1	1	0	1	1
1	10	1	1	0	0	0
1	11	0	1	0	1	1
1	20	1	1	1	1	1
2	1	1	1	1	1	1
2	3	1	1	1	1	1
2	4	1	1	1	1	1
2	8	1	1	1	1	1
2	12	1	1	1	1	1
2	13	1	1	1	1	1
2	14	1	0	1	1	1
2	18	1	0	1	0	0
2	21	1	1	1	1	1

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