UNIVERSITY OF SOUTHAMPTON

Awareness Support for Learning Designers in Collaborative Authoring for Adaptive Learning

by

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ABSTRACT

Adaptive learning systems offer students a range of appropriate learning options based on the learners' characteristics. It is, therefore, necessary for such systems to maintain a hyperspace and knowledge space that consists of a large volume of domain and pedagogical knowledge, learner information, and adaptation rules. As a consequence, for a solitary teacher, developing learning resources would be time consuming and requires the teacher to be an expert of many topics. In this research, the problems of authoring adaptive learning resources are classified into issues concerning interoperability, efficiency, and collaboration.

This research particularly addresses the question of how teachers can collaborate in authoring adaptive learning resources and be aware of what has happened in the authoring process. In order to experiment with collaboration, it was necessary to design a collaborative authoring environment for adaptive learning. This was achieved by extending an open sourced authoring tool of IMS Learning Design (IMS LD), ReCourse, to be a prototype of Collaborative ReCourse that includes the workspace awareness information features: Notes and History. It is designed as a tool for asynchronous collaboration for small groups of learning designers. IMS LD supports interoperability and adaptation.

Two experiments were conducted. The first experiment was a workspace awareness study in which participants took part in an artificial collaborative scenario. They were divided into 2 groups; one group worked with ReCourse, the other with Collaborative ReCourse. The results provide evidence regarding the advantages of Notes and History for enhancing workspace awareness in collaborative authoring of learning designs.

The second study tested the system more thoroughly as the participants had to work toward real goals over a much longer time frame. They were divided into four groups; two groups worked with ReCourse, while the others worked with Collaborative ReCourse. The experiment result showed that authoring of learning designs can be approached with a Process Structure method with implicit coordination and without role assignment. It also provides evidence that collaboration is possible for authoring IMS LD Level A for non-adapting and Level B for adapting materials. Notes and History assist in producing good quality output.

This research has several contributions. From the literature study, it presents a comparison analysis of existing authoring tools, as well as learning standards. Furthermore, it presents a collaborative authoring approach for creating learning designs and describes the granularity level on which collaborative authoring for learning designs can be carried out. Finally, experiments using this approach show the advantages of having Notes and History for enhancing workspace awareness that and how they benefit the quality of learning designs.

Contents

Chapter 1 Introduction **1**
1.1. Motivation and Challenges 1
1.2. Research Objective 2
1.3. Research Questions 2
1.4. Hypotheses 4
1.5. Contributions 5
1.6. Terms and Definition 6
1.7. Structure of Remaining Chapters 7

Chapter 2 Authoring forAdaptive Educational Hypermedia Systems **9**
2.1. The Characteristics of Adaptive Educational Hypermedia 9
2.2. Methods and Techniques forAdaptation 13
2.3. A Comparison of ExistingAuthoring Tools for Learning 14
2.3.1. Knowledge Representation 14
2.3.2. Adaptation Support 16
2.3.3. The Reusability of Output 17
2.3.4. Collaboration Support 17
2.4. Summary 18

Chapter 3 Learning Standards **21**
3.1. Learning Approaches 21
3.1.1. Associative Learning 21
3.1.2. Constructive Learning 22
3.1.3. Situative Learning 23
3.2. Learning Designs 23
3.2.1. The Needs of Learning Design Standards 25
3.2.2. The Advantages of Learning Designs over Learning Objectives 26
3.3. A comparison of Learning Design Standards 26
3.3.1. The Requirements of Learning Standards for Adaptive learning 26
3.3.2. A Comparison of IMS Learning Design and IMS Simple Sequencing 26
3.3.2.1. Pedagogical Expressiveness 26
3.3.2.2. The Requirements of Adaptive Learning Authoring 26
3.4. Summary 26

Chapter 4 Computer-Supported Collaborative Work **35**

4.1. Communication and Coordination 36

4.2. Workspace Awareness 38

4.2.1. Effects of Awareness Support 39

4.2.2. Workspace Space Awareness in Asynchronous Collaborative Authoring 40

4.3. Collaborative Authoring for Learning..41

4.4. Summary..43

Chapter 5 Analysis and Design of Collaborative Authoring Tools of IMS LD...**45**

5.1. The Authoring Scenario...45

5.2. Awareness Information Requirements 47

5.2.1. Workspace Awareness Information 47

5.2.2. Requirements 48

5.2.3. The Authoring Approach..50

5.3. ReCourse 51

5.3.1. Functionalities...51

5.3.2. The Static Model..55

5.3.3. Interfaces..55

5.4. Collaborative ReCourse Prototype...57

5.4.1. Group management...58

5.4.2. History 59

5.4.3. Notes...61

5.4.3.1. Note 61

5.4.3.2. Objects' Notes...64

5.4.3.3. History's Note 65

5.4.3.4. The Static Model 67

5.5. An Additional Feature..69

5.6. Summary...70

Chapter 6 Experiment 1: Workspace Awareness Study **71**

6.1. The Experiment Design 72

6.1.1. Research Methods..72

6.1.2. Experimental Materials...73

6.1.3. Experimental Procedures 75

6.1.4. Questionnaire Designs 76

6.2. Data Analysis Results 78

6.2.1. Participants' Profiles 78

6.2.2. The Importance of Course and Authoring Information 80
6.2.3. Awareness of IMS LD level A 83
6.2.4. Awareness of IMS LD level B.. 86
6.2.5. A Summary: The Influence and the Advantages of Notes and History88
6.3. Summary 91

Chapter 7 Experiment 2: Asynchronous Workgroup Study..............95

7.1. Experiment Design 95
7.1.1. The Experimental Methodology 95
7.1.2. Experimental Materials 98
7.1.3. Experimental Procedures 99
7.1.4. Design 100
7.1.4.1. Participants' Profiles 100
7.1.4.2. The Granularity Level of Collaborative Authoring of Learning Designs 100
7.1.4.3. The Distribution of Tasks 103
7.1.4.4. The Quality of Authoring Output 103
7.1.4.5. Access on Notes and History 104
7.1.4.6. The Efficiency of Authoring 105
7.2. The Observation Result 105
7.2.1. Participant Selection 105
7.2.2. Data Collection 105
7.2.3. Data Categorisation 105
7.2.4. Data Analysis 108
7.2.4.1. The Granularity of the Collaborative Authoring of IMS LD 108
7.2.4.2. The Distribution of Tasks 112
7.2.4.3. The Implications of Notes and History to Authoring Output 108
7.2.4.4. Access of Notes and History 115
7.2.4.5. Data from Written Interviews 116
7.3. Summary 118

Chapter 8 Conclusions 121

8.1. Summary of Findings 121
8.2. Limitations of the Present Study 124
8.3. Future work 126
8.4. Concluding Remarks 127

Appendix A 141

Appendix B 153

Appendix C 171

Appendix D 179

List of Figures

Figure 1.1 Overview of the research approach 6
Figure 2.1 Resources of AEH systems 10
Figure 2.2 A comparison of authoring processes for AEH Systems and regular AEH systems (Brusilovsky, 2003). 11
Figure 2.3 A simple concept-based hyperspace 12
Figure 2.4 An enhanced concept-based hyperspace 13
Figure 3.1 Gagne's nine events for effective learning(Gagné, 1985) 22
Figure 3.2 The learning activity outline (Beetham and Sharpe, 2010) 24
Figure 5.1 Note attached to UoL 48
Figure 5.2 History's Note 49
Figure 5.3 An object'sNote that links to a play with its acts, learning/supportactivities, and activity groups 49
Figure 5.4 The one-to-one relationship between resources and objects' Notes 50
Figure 5.5 One object's Note links to one condition and its underlying condition(s)50
Figure 5.6 An activity diagram of the proposed authoring approach 51
Figure 5.7 An example of a visualisation of some elements of the UoL 53
Figure 5.8 An example of errors appears when publishing the UoL to CopperCore 53
Figure 5.9 Dependencies among ReCourse's modules 53
Figure 5.10 The static model of ReCourse 55
Figure 5.11 (a) The overview page in ReCourse (b) Modules, phases, activities, and completion rules 56
Figure 5.12 (a) The screen of authoring properties (b) The screen of user-defined rules 57
Figure 5.13 The architecture of Collaborative ReCourse 58
Figure 5.14 History and list of updates made by a certain author 60
Figure 5.15 (a) The main screen of Note (b) Recent notes (c) Notes filtered by an author's name 62
Figure 5.17 An object's Note for the phase 'Introduction of OOP Components' 65
Figure 5.15 The History's Note 66
Figure 5.18 The static model of awareness features 67
Figure 5.19 Reuse phase in a former learning object lifecycle 69
Figure 5.20 Gallery of existing learning materials 69
Figure 6.1 Themes, tasks, and affected IMS LD layers or elements in Experiment 1 75
Figure 6.2 The mean scores of participants' experiences in teaching and working with IMS LD or IMS LD authoring tools 79

Figure 6.3 The composition of participants based on their knowledge of biology, web programming, and Java programming for Group 1 and Group 2 79
Figure 6.4 The mean scores regarding the importance of course information to be included in a UoL 81
Figure 6.5 Participants' views on the availability of course information in ReCourse and Collaborative ReCourse 81
Figure 6.6 The rating averages of the importance of authoring process information 82
Figure 6.7 Group 1's views of the information sufficiency in ReCourse........................... 84
Figure 6.8 Group 2 participants' awareness of the collaborative authoring of IMS LD level A 86
Figure 6.9 Users' awareness in collaborative authoring of IMS LD level B 87
Figure 6.10 A comparison of users' understanding between Group 1 and Group 2 participants 87
Figure 6.11 A composition of users' responses to the questionsregarding awareness measurement 88
Figure 6.12 Participants' awareness in early and authoring stages 89
Figure 6.13 Learning designers' level of awareness based on the collaborative features used 90
Figure 6.14 The usefulness and the ease of use of collaborative features 90
Figure 7.1 The summary of participants' updates in authoring IMS LD level A 109
Figure 7.2 Participants' contribution to each group...112
Figure 7.3 (a) A comparison of the number of corrections applied to the authoring output (b) The percentages of corrections compared to the number of updates the groups made 114
Figure 7.4 The number of accesses by participants of the three kinds of Notes 115
Figure 7.5 The frequency of groups looking up Notes (Note, objects' Notes, and History's Note) and History 116
Figure 7.6 The number of notes left in Note, objects' Notes, and History's Note..........116

List of Tables

Table 2.1 Examples of hubs which connect concepts and files 12
Table 3.1 Authoring steps and output of the adaptive learning system (Brusilovsky, 2003) 28
Table 3.2 The inclusion of IMS LD and IMS SS in IMS CP 29
Table 3.3 The elements of IMS SS and IMS LD 29
Table 3.4 The adaptation rule format in IMS LD 32
Table 3.5 The adaptation rule format in IMS SS 33
Table 5.1 The data type definitions for author information 59
Table 5.2 The data type definitions for History information 60
Table 5.3 Data type definition of Note 63
Table 5.4 A Java class declaration for a note with two functions to load/save the note from/into the XML-based Note file 63
Table 5.5 A Java class declaration for the general Note with two functions to load/save all notes from/into the XML-based note file 63
Table 5.6 The data type definition of objects' Notes 65
Table 5.7 A Java class declaration for objects' Notes 65
Table 5.8 A Java class declaration of History's Note with a function to retrieve particular notes 66
Table 5.9 Functions to build and save History's Note 67
Table 5.10 A Java class declaration of UoL with a function to perform a UoL 68
Table 6.1 Relationships among the experimental studies, research questions, and hypotheses 72
Table 6.2 A mapping between questions and the targeted information 77
Table 6.3 The MANOVA test result 80
Table 6.4 MANOVA test results for the availability of course information 82
Table 6.5 MANOVA test results for authoring information 83
Table 6.6 A MANOVA test of the influence of development stage on learning designers' awareness 89
Table 6.7 The needs of Notes and History in ReCourse 91
Table 7.1 Evaluation criteria 97
Table 7.2 A GQM description for the evaluation of participants' profiles. 100
Table 7.3 A GQM description for the collaborative authoring approach in authoring non-adapting materials. 101

Table 7.4 GQM for learning designers' participation in creating adapting materials. ...103
Table 7.5A GQM description for evaluating the distribution of tasks 103
Table 7.6 A GQM for the quality of output..104
Table 7.7 A GQM description for the influence of Notes and History..............................104
Table 7.8 A GQM description for gathering learning designers' opinion 105
Table 7.9 Participants' profiles on working experience with IMS LD or IMS LD authoring tools 106
Table 7.10 Categorisation of updates made by Group A and B working with ReCourse 107
Table 7.11 Categorisation of updates made by Group C and D working with the Collaborative ReCourse prototype 107
Table 7.12 The frequencies of participants' actions in authoring IMS LD level A...........109
Table 7.13 The summary of participants' updates in authoring IMS LD level A 109
Table 7.14 A summary of participants' actions on authoring adaptation resources 111
Table 7.15 Participants' contributions 112
Table 7.16 Improvements applied to UoLs 114
Table 7.17 The frequency of participants looking up and leaving notes 115

Declaration of Authorship

I, **Dade Nurjanah,**

declare that this thesis and the work presented in it are my own and has been generated by me as the result of my own original research.

AWARENESS SUPPORT FOR LEARNING DESIGNERS IN COLLABORATIVE AUTHORING FOR ADAPTIVE LEARNING

I confirm that:

- This work was done wholly or mainly while in candidature for a research degree at this University;
- Where any part of this thesis has previously been submitted for a degree or any other qualification at this University or other institutions, this has been clearly stated;
- Where I have consulted the published work of others, this is always clearly attributed;
- Where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
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- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- Either none of this work has been published before submission, or parts of this work have been published as:
  1. Dade Nurjanah and Hugh C. Davis, *Improving the Workspace Awareness of Authors in Asynchronous Collaborative Authoring of Learning Designs*, ED MEDIA '12, Denver - Colorado, USA, 2012.
  2. Dade Nurjanah, Hugh C. Davis, and Thanassis Tiropanis, *Collaborative Authoring of Adaptive Learning Resources: Opportunities and Challenges*, CollaborateCom '11, Orlando, USA, 2011.
  3. Dade Nurjanah, Hugh C. Davis, and Thanassis Tiropanis, *Extending authoring for adaptive learning to a collaborative authoring*, HCI International '11, Orlando – Florida, USA, 2011.
  4. Dade Nurjanah, Hugh C. Davis, and Thanassis Tiropanis, *A framework of collaborative adaptation authoring*, CollaborateCom '10, Chicago, USA, October 2010.
  5. Dade Nurjanah, Hugh C. Davis, and Thanassis Tiropanis, *A computer support collaborative authoring model for authoring adaptive educational hypermedia systems*, Web Science Conference '10, Raleigh – North Carolina, USA, April 26-27, 2010.
  6. Dade Nurjanah, *Collaborative authoring for Adaptive Educational Hypermedia by enriching semantic wiki's output*, User Modeling and Personalization '09 Conference, Trento, Italy, June 22-26, 2009.

Signed:

Date:

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Abbreviations

AEH	Adaptive ducational Hypermedia
AHA!	The Adaptive Hypermedia Architecture
ALE	Adaptive Learning Environment
BSD	Berkeley Software Distribution
CAF	Common Adaptation Format
CAM	Conceptual Adaptation Model
CRT	Concept Relationship Type
CSCW	Computer-supported cooperative work
EML	Educational Modelling Language
GAL	GRAPPLE Adaptation Language
GALE	GRAPPLE Adaptive Learning Environment
GAT	GRAPPLE Authoring Tool
GEF	Graphical Editing Framework
GQM	Goal-question-metric
GRAPPLE	Generic Responsive Adaptive Personalized Learning Environment
IMS CP	IMS Content Packaging
IMS LD	IMS Learning Design
IMS LIP	IMS Learner Information Package
IMS QTI	IMS Question and Test Interoperability
IMS SS	IMS Simple Sequencing
ILE	Intelligent Learning Environment
ITS	Intelligent Tutoring System
LAG	Layers of Adaptive Granularity
LMS	Learning Management Systems
LOM	Learning Object Metadata
MANOVA	Multivariate analysis of variance
MOODLE	Modular Object-Oriented Dynamic Learning Environment
MOT	My Online Teacher

RCP	Rich Client Platform
UoL	Unit of learning
UoLs	Units of learning
VLE	Virtual learning environments
SCORM	Sharable Content Object Reference Model
WCML	WHURLE Chunk Mark-up Language
WHURLE	Web-based Hierarchical Universal Reactive Learning Environment
ZPD	Zona of proximal development

Chapter 1 Introduction

1.1. Motivation and Challenges

Recent developments in the field of learning systems have led to enhanced learning systems which consider learner models when performing pedagogical-related decisions. The improvement produces various adaptations that offer students a range of appropriate learning options. As a consequence, teachers need to prepare a large volume of knowledge space consisting of various elements of domain knowledge, pedagogical knowledge, learner information, learning content, and adaptation rules. A solitary teacher developing learning resources would be time consuming as that teacher would need to spend a great deal of time to review the important aspects of learning, to develop instructional design, and to create learning materials. Furthermore, it requires the teacher to be an expert on all topics covered in the course. The complexity of endeavours needed to establish general and adaptive learning resources has been studied in previous research (Brusilovsky, 2003; Caplan, 2004).

Because of the sheer size and complexity of the learning resources required for adaptive learning, it is difficult for just one or two teachers to develop such a space. Teachers need to work collaboratively to reduce individual effort. Although teachers can work individually on preparing courses, they should team up with other teachers to check material consistency and reliability, or to maintain learning resources not fixed at certain stages, and to be kept continuously updated. The importance of learning resources be developed collaboratively has been studied in previous research studies (Caplan, 2004; Hixon, 2008; Ras et al., 2008; Yuan et al., 2005).

Collaborative work for designing courses is not a new concept in education. Previous research studies have found that, in designing instructional strategies, teachers or instructional designers work together and carry out brainstorming sessions and discussions with their colleagues (Christensen and Osguthorpe, 2004;

Kenny et al., 2005). These studies have also found that such interaction influences teachers' work more than instructional design theories. In the context of adaptive learning, collaborative work is important. The development of learning resources by a single teacher would be time consuming, as the teacher would need to spend a great deal of time for assimilating important aspects of learning, developing instructional design, and creating learning materials. Furthermore, this process requires the teacher to be an expert in all topics covered in the course(Brusilovsky, 2003; Caplan, 2004).

To date, there has been only a little work done on adaptive learning (Brusilovsky, 2003; De Bra et al., 2006; Foss and Cristea, 2010; Hendrix et al., 2008). The produced authoring tools enable authors to reuse other authors' work, but do not support collaboration. Although reuse enables more than one author to contribute to the authoring learning resources, it is not an appropriate approach for group work. Group work is not merely about a collection of people individually working to perform a task. Authors should understand what other authors do, why a learning object should be created, and how the authoring process is proceeding.

1.2. Research Objective

The objective of this research is to investigate computer-supported cooperative work (CSCW) techniques to improve the authoring of learning designs, specifically how learning designers approach the asynchronous collaborative authoring of learning designs, including what features that can enhance their workspace awareness. In order to achieve this objective, a prototype collaborative authoring tool, Collaborative ReCourse, has been developed by extending ReCourse[1] with workspace awareness information within a computer-supported authoring enviroment. This is accomplished by presenting recent information about individual authors' activities and sharing authors' notes. The theoretical basis motivating this research is explained in terms of existing theories of Adaptive Educational Hypermedia (AEH), IMS LD, and workspace awareness for asynchronous CSCW. Through a series of experiments, the effectiveness of the proposed approach and Collaborative ReCourse are tested with groups of people performing co-authoring tasks.

1.3. Research Questions

This research proposes a collaborative authoring approach for adaptive learning resources for a small group of learning designers to work asynchronously. It aims to solve the problem that can be stated as follows:

[1] http://tencompetence-project.bolton.ac.uk/ldauthor/

> How can teachers collaborate on authoring adaptive learning resources so that they can work together and be aware of what each other has done in the authoring process?

This research is focused on studying the influence of collaborative features in authoring adaptive learning resources. The collaborative features should enable authors to communicate with a minimum of effort that authors do not need to identify in which threada particular topic is being discussed. Hence, instant messaging, email, and online conference are not sufficient methods for authors to communicate in collaborative work; features integrated with authored objects are needed (Mueller, 2010).

The usability of collaborative features itself is not new in the field of authoring. A number of research studies have been conducted to investigate the application of various collaborative features in the collaborative authoring of documents and their implications to users' awareness. There are several kinds of awareness; one of them is workspace awareness which include authors' presence, location, and actions, and also the changes that authors made and the objects affected by these changes (Gutwin and Greenberg, 1996). This research focuses on workspace awareness.

In terms of authoring for adaptive learning systems and interoperability of learning resources, two sub-questions were defined:

- Sub-question 1: What are the advantages and the disadvantages of existing learning authoring tools?
- Sub-question 2: In terms of support for reusability, adaptation, and collaboration, which learning standard would be the most appropriate?

Reusability is a big problem in authoring since the output of one authoring tool cannot be reused in other authoring tools. In addition, authors' skills and experience will be useless when they have to work with new tools that apply different languages, leading to waste time in order to learn those new languages. Hence, reusable output is required (Ras et al., 2008; Stewart et al., 2005). Reusability has been demonstrated in former studies when output from an authoring tool can be repurposed in other authoring tools through transformation functions (Meccawy et al., 2008). However, transformation is complicated since destination authoring tools have their own languages that may not be compatible with the language of the source authoring tool, thus causing some objects to become lost in the transformation processes. Hence, the use of a learning standard is essential. In addition, to support reusability, domain resources (learning content) must be managed separately from pedagogical resources (Ras et al., 2008).

Another question that was defined is about collaborative work methods that are appropriate for collaborative authoring of learning designs.

- Sub-question 3: From previous research studies on CSCW, what authoring approaches, communication and coordination methods, and features to enhance workspace awareness are needed which may be applied in collaborative authoring for adaptive learning designs?

Sub-questions 1 to 3 were answered by a study of the research literature and it is discussed in Chapters 2, 3, and 4. From the study of learning standards, it is concluded that IMS LD is the most suitable learning standard for adaptive learning resources. On the other hand, it is hypothesised that Notes, features in which authors can write comments, and History, a feature which is used to maintain provenance information, can somehow improve authoring. Our study leads to several new sub-questions as follows:

- Sub-question 4: With IMS LD, in which level of granularity (play, act, activity, property, rule, resource, et cetera), is the collaborative authoring carried out? This is analogous to studying the level at which collaboration happens in a software design project.
- Sub-question 5: Do Notes and History improve workspace awareness of authors in authoring adaptive learning resources in IMS LD?
- Sub-question 6: Does the use of Notes and History in the authoring process improve the quality of authors' work and the quality of the learning designs produced?

1.4. Hypotheses

The research takes into account how learning designers work and the fact that they like to create learning designs collaboratively. This chapter presents a plan of an experiment study to answer research question 4 regarding which level of granularity (play and act level, activity design level, resource selection level, et cetera) that the collaborative authoring of IMS LD takes place. The study is carried out through a qualitative research in a form of a workgroup evaluation that involves several groups of participants. There is no hypothesis defined for this case. The experiment would simply observe how learning designers approach the collaborative authoring. The UoL has been created with four topics available with some explanation in Notes. Learning designerswould possibly practice a Process Structure approach where they structure the UoL, and write or follow guidance in Notes. This is carried out either with or without a coordinator. In the former, the first learning designer plays a role as the coordinator and forms the structure; in the latter, there is no learning designer who forms the whole structure of authoring tasks which means that no one plays a role as coordinator.

It is hypothesised that the addition of collaborative work features can improve authoring since learning designers can work collaboratively rather than individually and simply reuse other learning designers' work. Regarding workspace awareness, the higher the learning designers' workspace awareness, the better quality of output they may produce. Based on previous research studies, it is hypothesised that Notes and History canimprove the workspace awareness of learning designers in authoring adaptive learning resources in IMS LD. Hypothesis 1 was defined regarding research question 5:

> *In authoring learning designs for adaptive learning resources, learning designers who work with a collaborative authoring tool that provides Notes and History will have higher workspace awareness than those working with an authoring tool that does not provide Notes and History.*

The advantages of Notes and History cannot be measured only from how wellthe learning designers understand what has been done in the past, but also from how well learning designers produce output. This means that Notes and History are required to not only inform past actions, but also to give learning designers the guidance or direction needed to work efficiently. Hypothesis 2 was defined regarding research question 6:

> *Measures of the soundness of the learning resources produced will be higher for learning designers working with an authoring tool which supports workspace awareness.*

1.5. Contributions

The research approach applied in this research is shown in Figure 1.1. With the approach and findings of this thesis, it is believed that the key contributions of this research can be summarised as follows:

- Contribution 1: This research produces an asynchronous collaborative authoring tool prototype, Collaborative ReCourse. It improves ReCourse[2] by adding Notes for communication and implicit coordination. With History, Notes provide workspace awareness information for authors.
- Contribution 2: This research presents a demonstration that asynchronous collaborative work with implicit coordination and workspace awareness features-Notes and History- are suitable for authoring learning designs by small groups of learning designers.

[2]http://tencompetence-project.bolton.ac.uk/ldauthor/

- Contribution 3: This research presents evidence that Notes and History give positive implication to the quality of learning designs produced in asynchronous collaborative authoring.

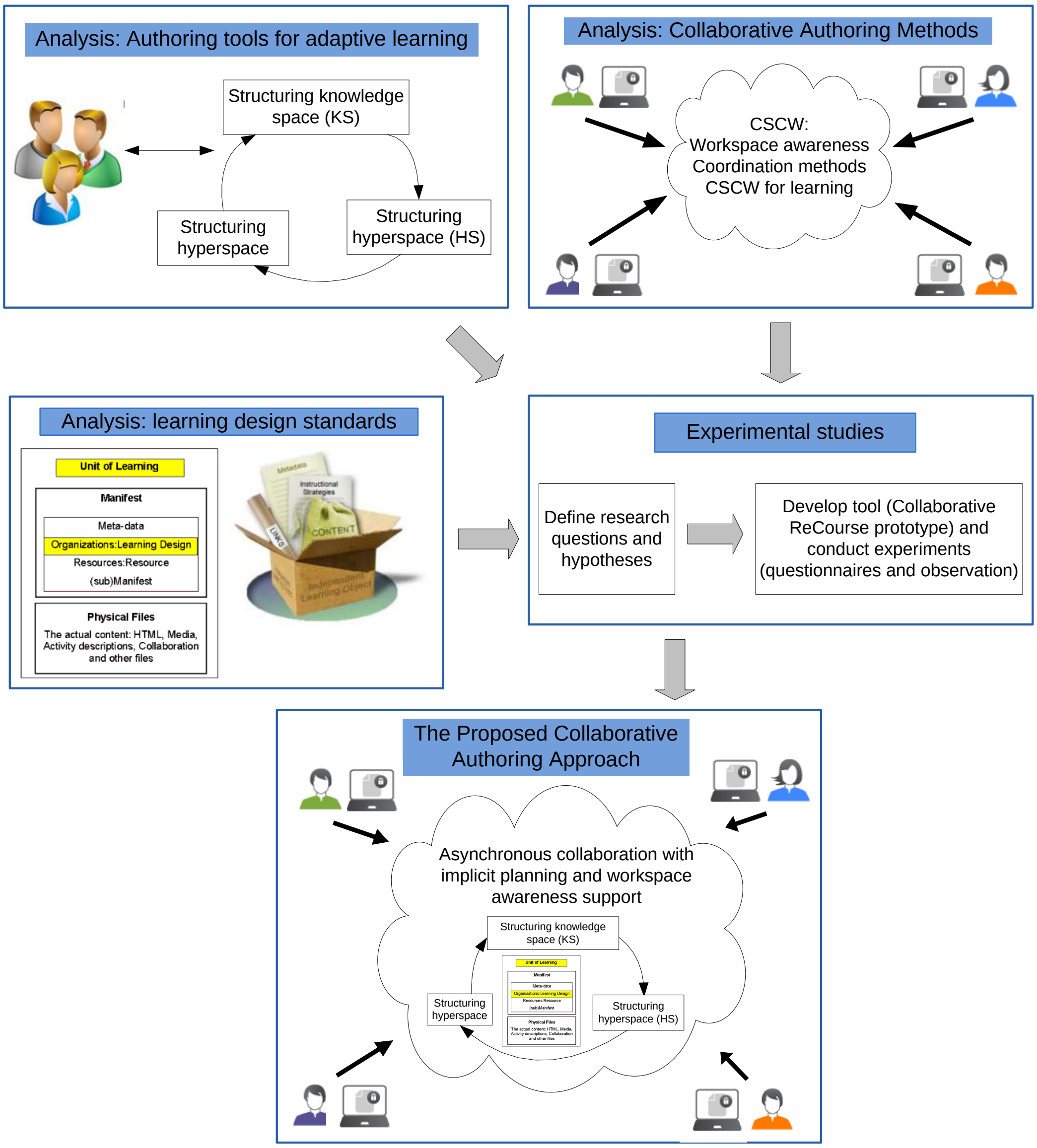


Figure 1.1 Overview of the research approach

1.6. Terms and Definition

The following is a list of terms that are often used in this thesis.

- Learning resources: all resources which contribute directly or indirectly to successful learning (British of Columbia Ministry of Education, 2008). Included in learning resources are pedagogical approaches, question banks of multiple choice items, content management systems, e-learning resources, learning materials in paper and electronic formats, tools, learning objects, et cetera; buildings and human resources are not included.

- Learning materials: learning content, that is part of the learning resources. Included in learning materials are worksheets, presentations, problem sheets and study materials, descriptions, et cetera (Thomas and Rothery, 2005).
- Knowledge space: a network of concepts, that is a pedagogical model of adaptive learning systems or AEH systems. There are two spaces maintained in such systems: knowledge space and hyperspace (Brusilovsky and Paylo, 2003). Knowledge space is the difference between AEH systems and Hypermedia systems.
- Learning design: "a plan of learning activities for learners that can engage them and provide an experience from which learning would results"(Beetham and Sharpe, 2010). A learning design involves descriptions of learners, activities, environments, and materials. The term 'learning design' refers to a general concept, while 'Learning Design' (with capital 'L' and 'D') refers to a particular learning design specification, such as IMS LD (Britain, 2004).
- Learning designers: this term is used to refer to teachers, learning/course designers, lecturers, or any person who is responsible for designing learning.

1.7. Structure of Remaining Chapters

Thisreport presents the literatures relevant to the problem of collaborative authoring for adaptive learning resources in IMS LD format, states hypotheses for the research, and concludes with a proposed solution to prove the hypothese with a list of the research contributions needed to draw conclusions. The remains of this report are organised in the following way:

Chapter 2 discusses authoring approaches and tools for AEH. It describes the characteristics of adaptive learning and lists the methods and techniques used to gain adaptation and the issues that have emerged in the provision of the adaptive learning resources. This chapter closes with a comparison of the current authoring tools based on four aspects: knowledge representation, adaptation support, the reusability of authoring output, and collaboration support.

Chapter 3 presents an analysis of knowledge representation and learning standards for adaptive learning. Firstly, it discusses some learning approaches: associative, constructive, and situative learning. Secondly, it discusses learning designs and the advantages over learning objects, the needs of learning design standards, and a comparison of two learning design standards: IMS LD and IMS Simple Sequencing (IMS SS).

Chapter 4 describes the techniques and methods in CSCW. This chapter introduces synchronous and asynchronous collaborative systems, techniques for communication and coordination, and how these techniques can affect the authoring process. In addition, it discusses the workspace awareness in asynchronous CSCW and suggests features to improve it. This chapter concludes with the implementation of collaborative work for learning.

Chapter 5 discusses the analysis and design of Collaborative ReCourse. It starts by givingan explanation of the authoring process, by the means ofa collaborative authoring scenario. Afterwards, it describes the existing ReCourse, and then the requirements and the design of Collaborative ReCourse.

Chapter 6 discusses the first experiment that applied between-group questionnaires. It compares responses of two groups: one working with ReCourse and the other with Collaborative ReCourse. The chapter discusses the experiment overview, materials used, procedures, and data analysis methods and results.

Chapter 7 presents the second experiment that applied observation and structured interview. It compares the quality of units of learning produced by four groups of three members: two groups working with ReCourse and the others working with Collaborative ReCourse. The chapter discusses the experiment overview, materials used, procedures, data collection methods, and data analysis methods and results.

Chapter 8 presents the summary of findings in respect to the reseach questions, the limitation of the research, and potential future work. This is the last chapter of the thesis and closes with concluding remarks.

Chapter 2 Authoring for Adaptive Educational Hypermedia Systems

This research refers to previous research studies conducted on related fields. This chapter discusses related work on adaptive educational hypermedia (AEH), including methods and techniques for adaptation, open issues in the provision of adaptive learning materials, and a comparison of existing authoring tools for learning.

2.1. The Characteristics of Adaptive Educational Hypermedia

The main characteristics of AEH are adaptation and personalisation in learning. AEH systems combine the intelligent tutoring system (ITS) for adaptive learning and the learning environment for personalised learning (Brusilovsky, 1996). They envisage navigation and presentation functionalities that enable personalised access to educational resources. As it supports personalisation and adaptation, AEH systems maintain large learning resources with various elements that, in various terms, consist of domain related knowledge, content, and pedagogy-related knowledge including adaptation support (Brusilovsky, 2001, 2003; Dolog et al., 2007; Pahl and Holohan, 2009).

The resource of an AEH system is an interconnection between two networks: a network of concepts (knowledge space) and a network of content (hyperspace). Navigation is implemented within the hyperspace layer, which in turn relies on a knowledge space layer. The knowledge space makes AEH systems different from regular hypermedia systems in that they only have the hyperspace. They combine knowledge types, knowledge formats, and objectives of the maintained knowledge (Pahl and Holohan, 2009) and consists of domain-related knowledge, content, and pedagogy-related knowledge including adaptation support (Brusilovsky, 2001, 2003). The larger the knowledge space, the better adaptation and personalisation will be. However, developing a large knowledge space is complicated and time consuming. The development process is performed by authoring knowledge space and hyperspace. Afterwards, structuring and linking knowledge to content will be completed (Brusilovsky, 2003; Kravcik and Specht, 2004).

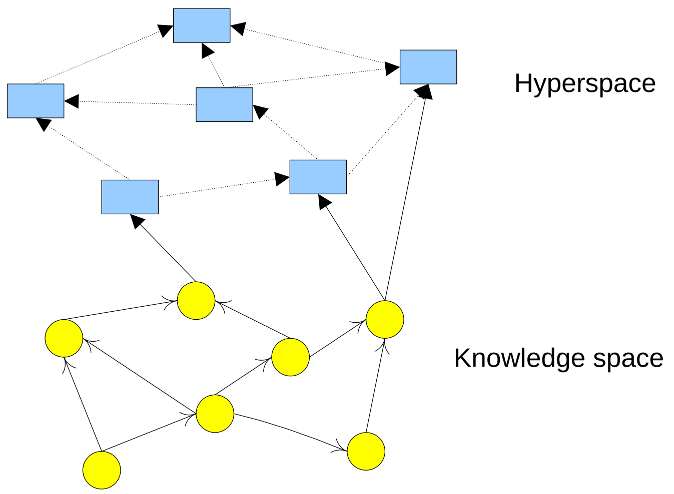


Figure 2.1 Resources of AEH systems

The development of an AEH system consists of two phases: designing and authoring. The first phase addresses the structuring of knowledge space and hyperspace, and connecting the knowledge space and hyperspace as presented in Figure 2.2. The knowledge space construction concerns the development of domain concepts, the relationships among concepts, and the concepts' attributes. AEH systems adapt to the structure of knowledge space from ITSs and the hyperspace of hypermedia systems. It is possible to have various relationships among concepts in the knowledge space, but pre-requisite is the most common relationship that represents the requirements needed for learners to progress to the level in order to begin study on a particular topic. Adaptation is performed in the knowledge space level, while the hyperspace layer enables learners to explore learning content.

Another task in the designing phase is the development of learner model. A learner model consists of learners' profiles that are commonly implemented in a stereotype which represents a set of common attributes of people (Kay, 2000), and in learners' knowledge in an overlay model that is adapted from an ITS (Wenger, 1987).The basic overlay model has been successfully implemented in an early version of AHA!. It applied boolean values to each concept to log the learner's progress and whether he has learned the concept or not. The majority of AEH systems use weighted overlay models that distinguish the levels of learners' knowledge in qualitative categories (Grigoriadou and Papanikolaou, 2006). In the improved overlay model, a pair of concept-weights are applied to each domain concept. A learner's knowledge of a concept is represented in a floating point number ranged from 0 to 1. The learner model is then improved by the inclusion of historic information, such as how many times a learner has accessed a particular page. This is implemented in the adaptive learning environment (ALE) approach (Kravcik and Specht, 2004), but the majority of AEH systems only use this data as supplementary information.

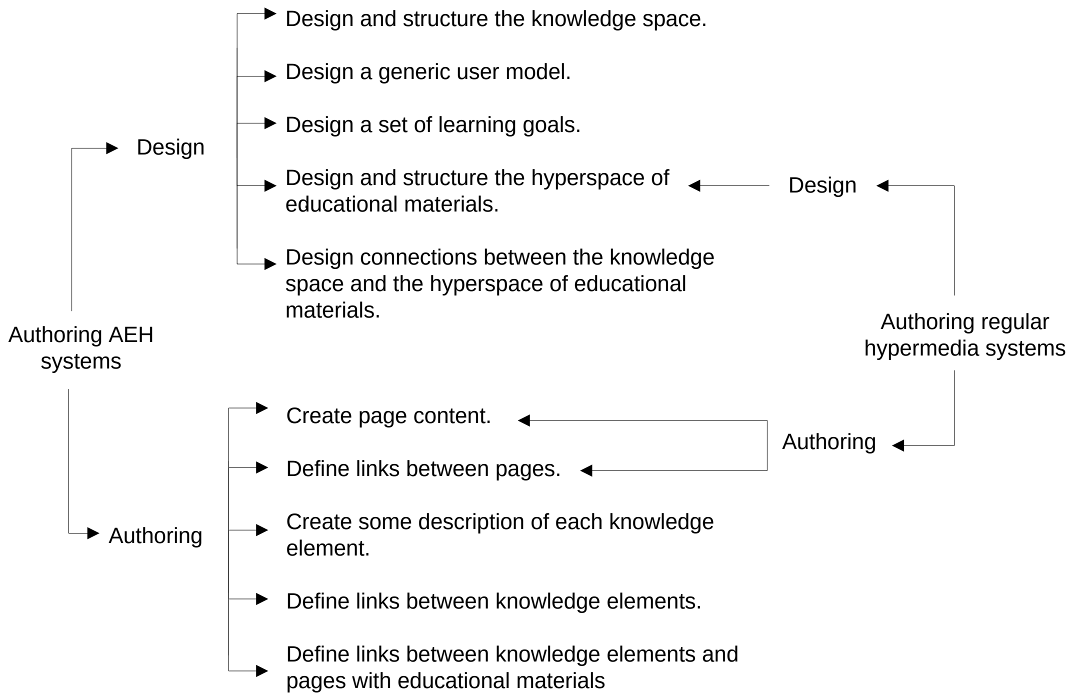


Figure 2.2A comparison of authoring processes for AEH Systems andregular AEH systems (Brusilovsky, 2003).

In addition to domain model and learner model, other artefacts that are created in the Design phase are the learning goals. Different learning goals are created in order to provide various adaptations for learners. All learning goals require learners to learn subsets of domain knowledge and to gain different levels of knowledge regarding these concepts. Learners may not explicitly choose which learning goals they attain. They naturally choose different activities that lead to certain learning goals (Henze et al., 1999).

The next step of the design phase is structuring the hyperspace. How the hyperspace is structured depends on which approach is applied to link the hyperspace and the knowledge space. The hyperspace can be kept unstructured if the concept-based hyperspace approach is applied (Brusilovsky, 2003). The well-structured hyperspace produced from the approach does not require any other structure to be applied to the hyperspace. Structuring pages, in addition to structuring concepts, is necessary when the content needs to be divided among several pages or hierarchically structuredin ascendant-descendant relationships, such as books. On the other hand, AHA! applies a difference approach (De Bra and Calvi, 1998a). AHA! does not make a strict distinction between the hyperspace and the knowledge space. Both concepts and learning content are organised in the same XHTML files.

The final step of the design phase is linking the knowledge space to the hyperspace. One technique for connecting the knowledge space to the hyperspace is concept-based hyperspace (Brusilovsky, 2003). There are two variants of this technique. One is simple concept-based hyperspace which is one concept in the knowledge space links to exactly one page in the hyperspace. With this technique the structure of the hyperspace is a true replica of the knowledge space. Additional links between pages are not required because learners learn by following the links in the knowledge space.

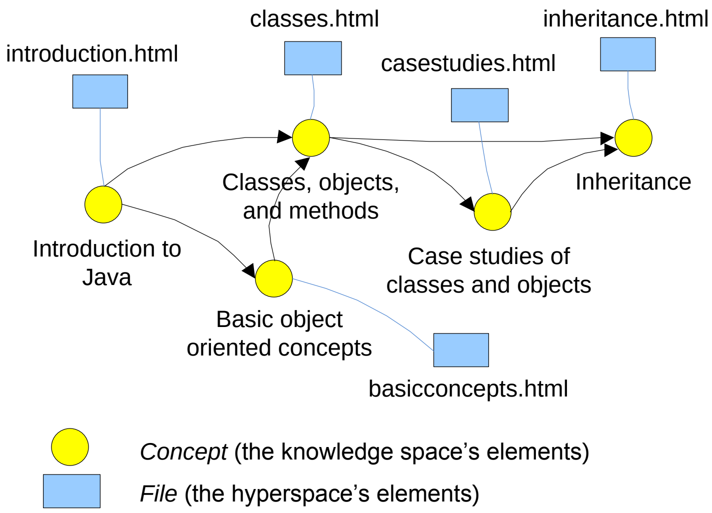


Figure 2.3 A simple concept-based hyperspace

The other technique is called enhanced concept-based hyperspace, and is when one concept links to one or more pages in the hyperspace. In this technique, hubs are implemented in order to link concepts in the knowledge space to pages in the hyperspace. Learners navigate from concepts to pages and vice versa through hubs. Table 2.1 presents some examples of hubs in Figure 2.4.

Table 2.1 Examples of hubs which connect concepts and files

Hub	Connect	
	Concept	File
2	Classes, objects, and methods	concept and classes.html
3	Classes, objects, and methods	objects.html
4	Classes, objects, and methods	methods.html
5	Case studies of classes and objects	classes.html
6	Case studies of classes and objects	objects.html

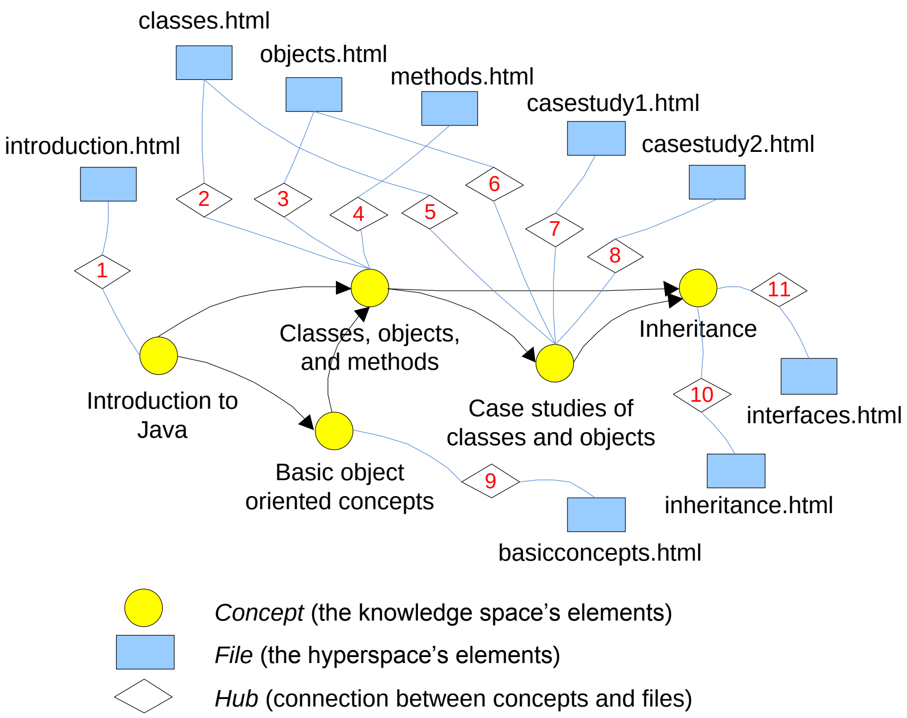


Figure 2.4 An enhanced concept-based hyperspace

2.2. Methods and Techniques forAdaptation

Adaptation is generally based on learners' profiles and progress. Originally adaptation was grouped into two types: content-based adaptation or adaptive presentation, depending on what is shown to the user, and link-based adaptation or adaptive navigation, which refers to where the users can go (Brusilovsky, 2001, 2007). An adaptive presentation aims to hide any information which is not relevant to a user. It offers, for example, various content with different levels of depth for the different characteristics of learners. It provides both basic information for all learners and additional specific information for particular learners. Furthermore, it provides variants of explanations such as defines prelude explanation for some authors, or presents the same materials but in different orders (Brusilovsky, 2000). Adaptive presentation is performed in the concept fraction or at the content level.It is different from adaptive navigation that is performed at the concept/topic level.

Adaptive navigation, on the other hand, is implemented by providing the guidance needed for a user to choose the next material. The guidance, for example, is implemented in colours, sizes, numbers, or by other means that can distinguish the high priority pages from the low priority pages. Earlier research implemented adaptive navigation support in these various way (Brusilovsky, 2007; De Bra, 2009). The simplest technology is adaptive direct guidance which suggests the next best node. In a concept-based knowledge space, nodes are concepts, topics, or other parameters comprised in the learner model. Another approach is link ordering which presents a sorted list of pages from the highest to the lowest priority material. A variant of link ordering keeps the pages unordered, but they are supplemented with annotation. In these kinds of adaptive linking technique, learners still have an opportunity to choose unimportant links; these are pages which have a low ranking. Another approach, link-hiding, keeps links which are not considered relevant invisible from the student's perspective .

2.3. A Comparison of ExistingAuthoring Tools for Learning

Until recently, there has been a few studies on authoring for adaptive learning systems. Existing authoring tools span from stand alone authoring tools to authoring modules integrated with virtual learning environments (VLE), from those which are to serve general learning to those which are to serve adaptive learning. A comparison was made on the WHURLE editor (Brailsford et al., 2002; Moore et al., 2004), AHA! editor (De Bra et al., 2006; De Bra and Calvi, 1998a; De Bra and Calvi, 1998b), MOT (Cristea, 2003; Cristea et al., 2005; Stewart et al., 2005), MOODLE[3], GRAPPLE Authoring Tool or GAT[4], and ReCourse project[5].

ReCourse and MOT are pure authoring tools that produce learning resources andboth need players or learning management systems (LMSs) in order to deliver the artefacts. Both players and LMSs can deliver lessons, but LMSs have supporting features for course delivery that players do not have, such as features for scheduling, discussion, and the gathering learner feedback. Other characteristics of learning tools are presented in WHURLE and AHA!. Both are AEH systems that have authoring modules as well as players to deliver the artefacts. Similar functionscan be found in MOODLE and GRAPPLE; both are LMSs that havetheir own editors.

2.3.1. Knowledge Representation

Knowledge representation is essential for adaptation and the interoperability of output. Our analysis found that WHURLE, AHA! Editor, MOT, and GAT define their own languages. In WHURLE, learning resources are organised in the forms of domain knowledge and pages with chunks as the smallest unit. WHURLE maintains its authored objects in an XML based representation called WHURLE Chunk Markup Language (WCML). XML based format are also used in AHA! to represent structure. In addition, AHA! Uses XHTML files to represent concepts in which adaptation rules for the concepts are embeded. When students retrieve a file, the AHA! engine will execute student models along with the adaptation rules in order to perform the adaptive content and presentation.

[3]http://moodle.org
[4]http://pcwin530.win.tue.nl/GAT
[5]http://tencompetence-project.bolton.ac.uk

MOT implements a five-layer authoring model, LAOS, that consists of a domain model to represent concepts, a goal Model to represent lessons, a learner model to represent learners, an adaptation model to support adaptation in learning, and a presentation model (PM) (Cristea and Mooij, 2003). The output of MOT is XML based Common Adaptation Format (CAF), a generic format to be delivered in any AEH system, which consists of a concept map and a lesson map (Ghali and Cristea., 2008). It is produced from inferencing all information in the domain model, goal model, adaptation model, and student information recorded in user model. MOT defines Layers of Adaptive Granularity (LAG) that introduces the granularity of adaptation in three levels: direct adaptation or rules as the lowest level, adaptation language as the medium level, and adaptation strategies as the highest level (Cristea and Calvi, 2003).

Another authoring tool, GAT (GRAPPLE authoring tool), is a module of GRAPPLE and isa project which aims to integrate the learning management system and AEH (De Bra, 2009; Harrigan et al., 2009). GAT supports the interoperability of learning resources by providing a generic intermediate language. Authoring in GRAPPLE is carried out in order to establish the domain model and concept relationship type (CRT) model. The former consists of concepts, properties, and pedagogical relationships. An inferenceof user model, domain model, and CRT performs a conceptual adaptation model (CAM). The final output of GAT is GRAPPLE adaptation language (GAL) and GRAPPLE adaptive learning environment (GALE).

The uniqueness of GAT lies in the implementation of CRT. Like AHA! Editor and MOT, GAT allows authors to define concepts and relationships between instances of concepts. Nevertheless, relationships in GAT can also be generalised into links between concepts, not only instances of concepts. Adaptation is implemented in form of constraints added into concepts, rules to control which and when concepts must be displayed, and pedagogic strategics for serialist and holistic learners.

All of these authoring tools support interoperability by representing objects in an XML based format. Since each defines their own languages, conversion functions are required when artefacts are to be reused in other tools. A potential problem that may occur is when the meanings of terms are lost in translation. This problem could be diminished by the application of learning standards. Two examples of authoring tools which apply learning standards are MOODLE, which uses SCORM[6], and ReCourse, which uses IMSLD. However, since SCORM does not support adaptation, it can not be used to develop adaptive learning resources.

[6]http://www.scorm.org

2.3.2. Adaptation Support

AEH systems vary in their capabilities of providing suitable learning materials for various models of learners.The more versatile the AEH system to tailor to different learner models, the better. Among all the tools mentioned above, MOODLE is the only one that does not support adaptation, while the others support various types of adaptations. WHURLE supports adaptive navigation and adaptive presentation implemented in adaptive links and adaptive chunk/fragments in XHTML files. On the other hand, AHA! (De Bra et al., 2006; De Bra and Calvi, 1998a) implements navigation adaptation at the concept level andpresentation adaptation on the sub-concept level (Calvi and Cristea, 2002). Navigation adaptation in AHA! is implemented by the use of various colours in order to indicate which topics a student has learned. On the other hand, in order to reach presentation adaptation, adaptation rules are added into learning materials in the form of assertion. AHA!'s engine then executes the rules and the student model in order to perform the adaptation.

More types of adaptation can be found in the MOT that supports the three kinds of basic adaptation. Adaptive presentation is implemented in the goal and constraint (GandC) layer. It is performed by filtering elements of content that produces, for example, various ways of explanation and exercises to be presented to the learners (Cristea and Mooij, 2003; Stewart et al., 2005). On the other hand, adaptive navigation is implemented in the form of adaptive concepts and adaptive concepts' attributes are presented to learners. All adaptation in MOT is based on learners' progress and search activities. MOT uses intelligent computation to automatically generate a sequence of concepts.

Adaptation is presented in GAT in the form of a learning-flow-based adaptation. It is comprised of defined patterns of rules for adaptive sequences in CRT. CAM is then generated based on CRT and concepts in the domain model(Hendrix et al., 2008). For example, some conceptsare definedin domain model:

- Course
- Algorithm | Programming | Software Engineering *is–a* Course

On theother hand, a relationship is defined in CRT:

- Course pre-requisite-of Course

The possible content of CAM:

- Algorithm pre-requisite-of Programming
- Programming pre-requisite-of Software Engineering
- Any other combinations of the courses.

Other types of adaptation are found in ReCourse. Since it uses IMS LD for representing learning resources, ReCourse enables authoring for adaptive learning resources to support content-based, learning flow-based, and interactive problem solving-based adaptation. The explanation regarding adaptation supported in IMS LD is presented in Chapter 3.

2.3.3. The Reusability of Output

Adaptive learning needs a number of resources, such as domain knowledge, pedagogic knowledge, learning content, and learner model. A set of concepts (or topics) with their attributes is the main element of the domain knowledge, whereas learning goals, concept relationships, constraints, and adaptation rules are those which are generally maintained in the pedagogic knowledge (Brusilovsky, 2003; Cristea and Mooij, 2003). Those elements can be found in WHURLE, MOT, AHA!, and GAT, but they are implemented in different names with different low level designs and implementation techniques. With some simmilarities among the designs, it is possible to reuse or extend objects created in one authoring tool to the others.

There are two major approaches for learning resources interoperability. The first approach employs conversion functions to map the syntax and the meaning of terms between authoring tools. In past research studies, conversions have been introduced between AHA! and MOT, WHURLE and MOT, and that it has been applied, not only to domain knowledge, but also to learner model (De Bra et al., 2003; Ghali et al., 2008; Stewart, 2006; Stewart et al., 2005). In the second approach, reusability and extensibility are enabled if the authoring tools use the same learning standard as a common language. For adaptive learning, IMS LD is one suitable learning standard as it supports adaptation. Authoring IMS LD is provided in ReCourse which offers authoring functions for IMS LD level A, B, and C. Learner information is used as parameters and an author can have her own design of thelearner model or refer to a learner profile standard, IMS Learner Information Package (IMS LIP) for example. To conclude, the main advantage of ReCourse for authoring adaptive learning lies in the use ofIMS LD as its output format.

2.3.4. Collaboration Support

Collaboration is included in this comparison due to the facts that learning designersmostly work collaboratively (Christensen and Osguthorpe, 2004; Kirschner et al., 2003). In a non-computerised environment, teachers work collaboratively through face-to-face meetings or other media that enable them to communicate. In addition, they repurpose or extend instructional designs that have been created by other instructional designers.

All of the authoring tools mentioned above offer object reuse. They enable authors to work individually and reuse other authors' work. An advantage for teachers is found in MOODLE as it provides some communication features, such as email/internal messaging, synchronous chat, and asynchronous discussion. The features are not specifically dedicated to teachers for authoring, but also for students or students-teachers for carrying out discussions. Nevertheless, teachers can use the facilities to discuss learning design tasks.

2.4. Summary

Effective authoring tools require user friendly features for domain experts, not technical tools which only administrators can use. In addition, past studies show that instructional designers or course designers always work collaboratively (Christensen and Osguthorpe, 2004; Kenny et al., 2005), and as such authoring systems should provide features for collaborative work. Until recently the availability of such systems still remained a challenge.

In this chapter, the concept of AEH and adaptation were discussed to illustrate what kinds of resources which must comprise adaptive learning systems. This chapter also described the various types of adaptation as a basis for a comparison study of the existing authoring tools for learning. From the comparison study that involved MOODLE, AHA!, MOT, GRAPPLE, and ReCourse, a problem was found in that, to date, the lack of collaborative authoring for adaptation support remains a significant issue. From analysis of past research studies, three main issues emerge in terms of interoperability and collaboration.

- Efficiency. Considering that authoring is a complex process and the learning resources that must be established are wide ranging, the use of existing authoring tools will make the authoring process more efficient. For example, authoring can employ existing tools for developing domain-related knowledge and learning content, hence new authoring tools can focus on the authoring of pedagogy-related knowledge. All aforementioned authoring tools enable authors to reuse existing learning materials (Section 2.3.4). On the other hand, the difference in their knowledge models becomes a problem in reusing existing domain knowledge (Section 2.3.1).
- Interoperability. Since each AEH system is unique, authoring systems generally only produce courseware that can be delivered by specific AEH systems. Not only is it the authored objects that cannot be reused, but also authors' efforts. This means that authors need to learn new skills or knowledge every time they intend to contribute to an authoring process. As described in Section 2.3.3, WHURLE, AHA!, and MOT apply transformation functions to provide the

interoperability of the authoring output. However, some information is potentially lost in the translation because of their different knowledge models. Therefore, applying learning standards is considered better.

- Collaboration. Current authoring tools for AEH systems do not support collaborative work. As discussed in Section 2.3.4, they support object reuse and annotation, but do not provide any function for collaboration. Collaboration that facilitates authors to communicate and coordinate is considered better than reuse.

As this research focuses on collaboration and interoperability of output, Chapter 3 will discuss learning standards and Chapter 4 will discuss potential improvements for authoring adaptive learning resources that can be taken from CSCW. The discussion is comprised of techniques and methods that have been successfully applied in collaborative authoring in different fields, especially regarding communication techniques and workspace awareness in asynchronous collaborative work.

Chapter 3 Learning Standards

This chapter discusses learning standards and some related learning theories. First, it discusses learning approaches from different perspectives: associative, constructive, and situative perspectives, and which of them comprised in learning designs. Afterwards, it discusses the advantages of learning designs in comparison with learning objects, and the needs of learning design standards. In the last discussion, a comparison of two learning standards, IMS LD and IMS SS, will be carried out to find the most suitable learning design standard for adaptive learning.

3.1. Learning Approaches

To date, a number of learning approaches have been developed. They address different types of learning, such as individual, collective, or collaborative learning, as well as general (offline), online, or blended learning. In this section, we describe three learning approaches based on how learners gain knowledge.

3.1.1. Associative Learning

In assosiative learning, learners build their knowledge and understanding gradually through tasks that provide stimuli and response from which learners can find associations. In this way, teachers play a vital role as they are required to give proper and continuous stimuli. Associative learning applies the theory of cognitivism by Gagné that defines nine steps that are suggested to be taken into account when designing instructions (Gagné, 1985).

Associative learning also applies the theories of behaviourism defined by Skinner (Magliaro et al., 2005) that defines a principle that children are likely to be in a blank state without any knowledge about anything. They will be shaped by their environment through various repeated activities. Skinner also stated that learning for children can be programmed as teachers can design step-by-step reinforcement. From Skinner's view, learning is orientated towards learning goals structured into a learning tasks hierarchy that comprises competences from the lowest level (memorization) to highest (analysis and synthesis). Each task corresponds with one competence or skill and it must be mastered independently.

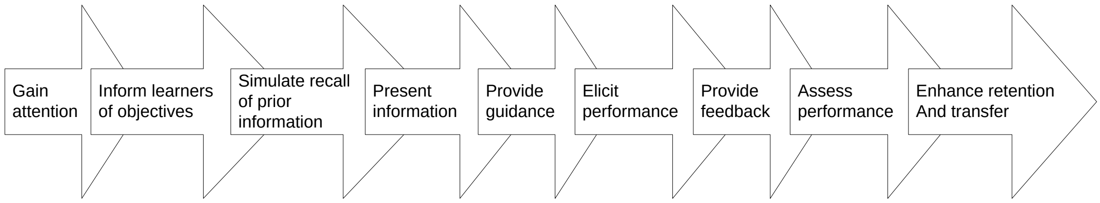


Figure 3.1 Gagne's nine events for effective learning (Gagné, 1985)

3.1.2. Constructive Learning

Constructivism is a learner-centered learning method in which learners actively participate. Different from instructional approaches where learners are directed by teachers' instructions, constructivism provides a framework of learning processes where learners construct their own understanding through the learning activities they engage in. In constructivism, learners engage in learning activities in which they apply their current knowledge and combine it with new knowledge gained from other learners or teachers. Teachers play a role as facilitators, coaches, guides, or co-learners.

Constructivism is greatly influenced by Piaget who defined cognitive-constructivism as focusing on children's intellectual development (Beetham and Sharpe, 2010; Laurillard, 2002; Pask, 1988). In Piaget's Theory, children construct their own knowledge through their experiences in their own ways and through their own means (Piaget, 2001). They undergo successive-discrete stages of cognitive development; for each stage, what children can or cannot do are defined. Children explore the world around them, receive feedback, and draw conclusions in each stage. When a learner is participating in activities, the new knowledge that the learner gaines will be integrated into existing knowledge.

Another constructivism called social-constructivism theory was defined by Vygotsky (Beetham and Sharpe, 2010; Vygotsky, 1978; Vygotsky and Luria, 1993). In Vygotsky's theory, learning is a collaborative process in which learners' knowledge is gained from social interaction. Vigotsky defines a scenario of placing unexperienced learners with experienced learners in the same activities or environments, thus the unexperienced ones can learn from the others. He divides competences into three areas: cannot yet do, can do with help, and can do by self. The second area is recognised as the zone of proximal development (ZPD), which is the difference between what a learner can do without assistance and what the learner can do only with assistance. According to Piaget's and Vygotsky's theories, learners will not make use of concepts and ideas unless they put them to use through activities, that is, learners only master those activities they actually practice.

3.1.3. Situative Learning

Community-based learning is a social theory of learning in which a group of people form what called 'communities of practice (CoP)', a community in which people engage in collaborative learning through interacting and learning together. In CoP, members share interests in something and learn from other members. Situative learning was first proposed by Jean Lave and Etienne Wenger (Lave and Wenger, 1991) as a learning model in whichlearning takes place in the same social context in which it is applied.

Like in social learning, a learner builds knowledge in social environments (Beetham and Sharpe, 2010; Lave and Wenger, 1991). It takes place in the ZPD of Vygotsky's model in which learners gain new knowledge with guidances from the more knowledgeable ones, such as from teachers who play a role as mentors. One difference between constructive learning and associative learning is that in situative learning, contexts are comprised in the environment in which the learner practices the learning process. That means that learning is tied to a particular situation and it is cultural. For example, languages used in children's learning and youths' learning are different. In addition, children living in South-East Asia will learn different concepts than children living in African countries; in this case, learning is influenced by cultural values.

3.2. Learning Designs

To date, learning technologies have offered new opportunities to meet the growing demand for new, constructivist ways of learning, such as collaborative or adaptive learning. On the other hand, until recently, learning object specifications have addressed implementation technology and reuse issues at a rather low infrastructure level, such as learning objects and metadata. Pedagogical frameworks at a higher infrastructural level, such as at the complete course level, that focus on the pedagogical values are needed. Learning design specification offers such a framework.

When discussing learning designs, it is required to discuss two key concepts covered in the topic: learning activities and learning designs. Learning activities are tasks in which learners are engaged in order to achieve a set of intended learning outcomes. Learning activities, for example, might include sourcing learning materials from the web, running a simulation using certain data, or summarising papers on a particular topic. Learning activities can also be considered as a specific interaction of learners, teachers, and learning materials. Learning activities are specific interactions of learners with other learners or teachers and with learning environments, which are orientated towards learning outcomes (Beetham and Sharpe, 2010).

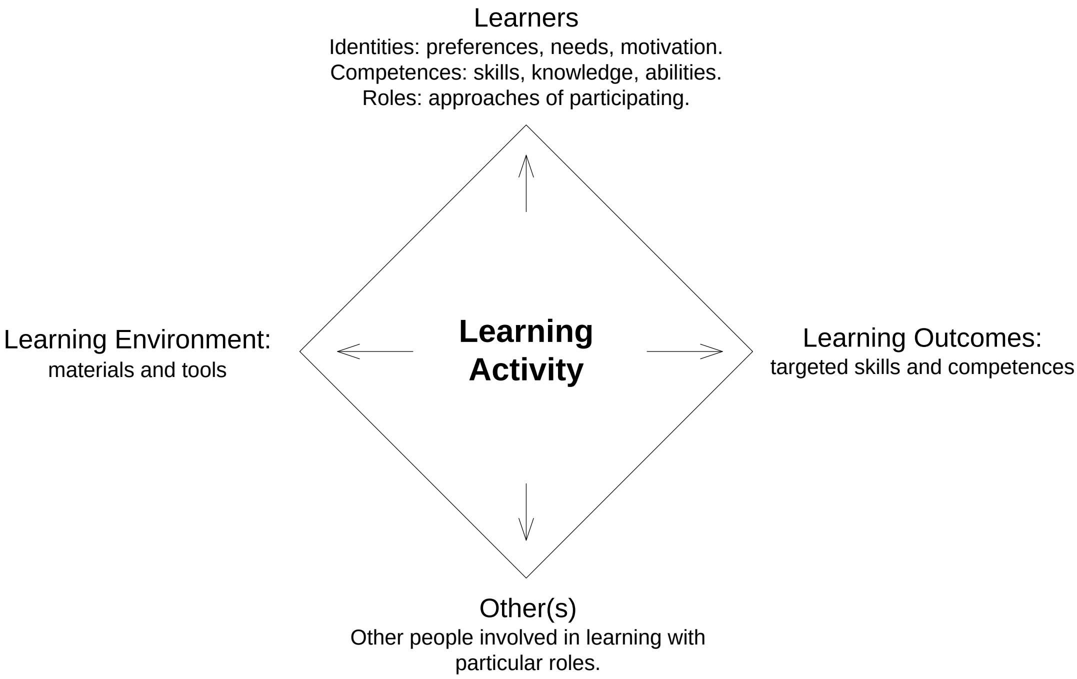


Figure 3.2 The learning activity outline (Beetham and Sharpe, 2010)

Learning design refers to a processof planning and structuring learning activities and the products of the design process. It focuses on the inclusion of pedagogy rather than the attachment of content in activities for students. When developing learning designs, teachers have to think not only about activities that students need, but also consider how learners can engage in the activities as active participants and how they interact with other elements in the activities, such as teachers, environments, and content.

Learning design as a term has been recognised in the learning and technical community since being introduced by the Open University of the Netherlands in 2004. This is the advanced research of a learning standard called Educational Modelling Language (EML) that was created in the late 1990s. EML offers a framework for various instructional models, such as competency based and problem based instructional models. It models what is called ‘unit of learning’ (UoL) that is an atomic or composite unit that provides learning with interrelated learning objective. Learning designers can use learning design and comprise a behaviourist, cognitivist, constructivist, or another approach(Grocott et al., 2012); they can design activities that require learners to work separately or collaboratively, with or without teachers. Those studies became a basis for the development of a technical specification of learning design by the IMS consortium.

There are several definitions of learning designs. Like syllabus, the term 'learning design' is used to refer to a plan of teaching and learning which aims to achieve learning outcomes. However, there is an essential difference between syllabus and learning design. A syllabus comprises a hierarchical set of topics covered in a course. A learning design, on the other hand, does not present only a set of topics or concepts, but also structured sets of learning activities that comprise concepts, materials, tools, and users' roles (Beetham and Sharpe, 2010). The term is also used for technical references related to a set of documents that explain formats, guidance, and tools to help teachers to prepare learning materials. Learning design is also used to refer to approaches that learning designers apply to design and structure learning activities. The term 'learning designers'is used to describe those who perform learning designs, such as course designers, lecturers, teachers, and trainers.

With such differences, however, all understandings of learning design are related to the plans of teaching and learning. Learning design helps learning designers share pedagogical insights. It guides course designers or teachers not to start by structuring content in designing learning plans, but to start by designing learning activities in order to achieve learning objectives. One motivation beyond learning design is that learning is not only content delivery. Learning design provides facilities for course designers to design active learning, not passive learning that learners just receive instructions and materials from teachers.

3.2.1. The Needs of Learning Design Standards

Standardisation is an important factor in computer- or web-based learning environments. The quick growth of open learning content systems and authoring systems has been advantageous to the development of learning resources. Since there is a lot of learning content, teachers can reuse this content for their courses. On the other hand, a problem of interoperability has arisen since the resources are represented in various languages. In previous research, interoperability could be gained in two ways: by imposing a transformation function to translate one language to other languages or by conducting a standard as a common language. The former was applied to previous AEH systems and for interoperability between two AEH: MOT and WHURLE (Stewart, 2006) or MOT and AHA! (Cristea et al., 2005). The transformation translates a list of terms introduced in one authoring tool into other terms which have other equivalent terms with have similar meanings in the target authoring tools. This approach requires authors, teachers in this case, to know both languages. The lack of knowledge causes authors to have different understandings of similar terms. Another drawback arises when there are terms in the source language that do not have equivalents in the target language.

A learning standard solves this problem as it offers not only the interoperability of syntax, but also of meanings. Until recently, there have been a number of learning standards, such as IEEE Learning Object Metadata (LOM) (Hodgins et al., 2012), (Poltrack et al., 2012; Rustici, 2004) and some learning standards produced by the IMS Global Learning Consortium including IMS Content Packaging (IMS CP) for representing learning content/objects, IMS Learner Information Package (IMS LIP) for representing learner profiles, IMS Question and Test Interoperability (IMS QTI) for representing tests, and IMS SS andIMS LD for structuring learning activities (Campbell et al., 2004; Grocott et al., 2012).

3.2.2. The Advantages of Learning Designs over Learning Objects

To date, there has not been any learning standard that satisfies all users' requirements. The advantages of learning standards can be considered from different perspectives. This section discusses a comparison of learning object standards and learning design standards for different perspectives.

Learning objects refers to sets of learning materials that can be deconstructed into context independent fragments. From the learning object perspective, learning is viewed as a selection of suitable materials for learners, a delivery of a sequenced learning content from teachers to learners, and an assessment of learners' progress. There are a number of learning object/content standards: IEEE LOM, SCORM, and IMS CP standards enable authors to assemble learning objects into a flow of learning objects/content, but without pedagogical strategies the flow cannot be considered as a learning flow. A way to solve the problem is by combining learning objects and learning designs. This solution is presented in IMS CP and can include learning design, such as IMS LD or IMS SS, and also SCORM that has enabled to include IMS SS.

Learning design is motivated by a pedagogic consideration that learning is not merely about a set or a sequence of learning objects, or simply content to be presented to learners, but learning is also about how the materials are delivered to learners and how learners can gain knowledge. People learn better if they are actively involved in learning processes (Bonwell and Eison, 1991); hence learning is carried out according to a flow of learning activities, called learning design, which consists of a structured set of learning activities to be done by learners and support activities to be carried out by teachers. Learning design, learning content/objects, and environments are organised in a unit of learning, such as content packaging.

The need for learning design standards emerges along with a need to keep learning designs consistent for all students. In addition, the use of technology for learning has raised the need for digital learning design which is reusable and interoperable considering. Learning design standards, such as IMS SS and IMS LD, present some advantages as they are well-structured and they have an ability to include learning objects such as SCORM as materials in order to support lessons or learning activities. Along with such advantages, a drawback arises when a UoL modelled in IMS LD has many topics and learning activities included, thus complicating the learning design. In this case, the availability of authoring tools which can hide the complexity of learning designs from teachers, especially those who do not have technical backgrounds, is compulsory.

3.3. A comparison of Learning Design Standards

This section discusses the requirements which must be fulfilled by learning designs. Furthermore, it describes a comparison of two learning designs, IMS SS and IMS LD, from two perspectives: the pedagogical expressiveness and the suitability with the adaptive learning authoring process.

3.3.1. The Requirements of Learning Standards for Adaptive Learning

Selecting an appropriate learning standard for adaptive learning is one issue in authoring adaptive learning resources. The selected learning standard has to meet requirements as described below:

1. The requirements of pedagogical expressiveness

Every learning standard has its own advantages and drawbacks. One criterion that can make differences among learning standards is pedagogical expressiveness. It refers to the ability of learning design standards to accommodate different learning theories and models, to use various learning content, and to accommodate personal, groups', or classes' needs. Pedagogical expressiveness is related to three kinds of aspects (van Es and Koper, 2006):

- Pedagogical flexibility, a learning standard's ability to represent UoL based on various learning methods.
- Completeness a learning standard's ability to represent digital as well as non-digital UoL, including learning objects, the relationship between the objects and the activities, and workflows of learners' and teachers' activities.
- Personalisation, a learning standard's ability to personalise learning, so that content, activities, and the learning flow can be adapted to learners' profiles.

2. The requirements of adaptive learning resource authoring

In terms of authoring adaptive learning resources, learning design standards must provide elements to support adaptive learning systems' components. Furthermore, it is required to support the three steps of adaptive learning resource authoring. As shown in Chapter 2, design and authoring steps for adaptive learning are divided into three steps: creating the knowledge space, structuring hyperspace (learning content), and linking the knowledge space and the hyperspace. The following table presents the summary of authoring steps and the output.

Table 3.1 Authoring steps and output of the adaptive learning system (Brusilovsky, 2003)

Top level steps	Low level steps	Output
Structuring knowledge space	Creating knowledge elements	Domain model Learner model Learning goals Adaptation model
	Creating learner model	
	Creating learning goals	
Structuring hyperspace	Creating page content	Learning content
	Creating links between pages	
Linking knowledge space to hyperspace	Linking knowledge elements	Concept-based hyperspace
	Linking knowledge elements to learning content	

3. Support for the development of learning designs

In the previous chapter, a method for planning instructional designs was discussed. Learning design standards must provide elements that support every step of the development process. Based on the development method of instructional design planning, learning standards must provide elements that support to represent learners' characteristics, various types of learning artefacts (Play, Act, Activities, adaptation rules, learning content, content related interpersonal skills), instructional objectives, the sequence (learning flow), and evaluation test.

3.3.2. A Comparison of IMS Learning Design and IMS Simple Sequencing

The main element of learning designs is learning activity, that is a unit of knowledge, assessment, or instruction which is pedagogically neutral. How effective learning activities depends on which learning methods are applied for organising learning activities with learning roles, resources, and environments. This section describes two learning design standards: IMS SS (Anderson et al., 2012)and IMS LD (Grocott et al., 2012).

3.3.2.1. Pedagogical Expressiveness

Both standards provide modelling languages for creating and organising learning activities, roles, resources, and environments. IMS SS, as well as IMS LD, is packaged in IMS CP under *<organizations>* element. Table 3.2 presents how IMS SS and IMS LD are embedded in IMS CP.

Table 3.2The inclusion of IMS LD and IMS SS in IMS CP

IMS SS	IMS LD
<manifest identifier = " "> <organizations default = " "> <organization identifier = " "> <item identifier = " "/> **<imsss:sequencing IDRef = "IMSSS 1"/>** </organization> </organizations> <resources/> <imsss:sequencingCollection> **<imsss:sequencing ID = "IMSSS. 1">** <!-- Sequencing info goes here --> </imsss:sequencing> </imsss:sequencingCollection> </manifest>	<manifest identifier = " "> <organizations> **<imsld:learning-design identifier = "IMSLD 1">** </imsld> </organizations> <resources/> </manifest>

Along with such simmilarity, there are some essential differences between IMS SS and IMS LD. First, IMS LD provides various elements that have pedagogical meanings, such as objective, pre-requisites, activities, roles, environments, and methods. On the other hand, IMS SS has a very limited number of pedagogical elements since it is more focused on branching learning flows. Table 3.3 shows the difference between IMS SS and IMS LD.

Table 3.3 The elements of IMS SS and IMS LD

IMS SS	IMS LD
| imsld:sequencing | controlMode sequencingRules limitConditions auxiliaryResources rollupRules objectives randomizationControls deliveryControls #wildcard	*| imsld:learning design |* title learning-objectives pre-requisites components roles learner* staff* activities learning-activity* environment-ref* activity-description support-activity* environment-ref* activity-description activity-structures* environment-ref* environments environment* method

	play* act* role-parts* metadata

Second, IMS SS supports only individual learning for one single learner, while IMS LD supports individual learning as well as collaborative learning which involves a number of learners. Collaborative learning is implemented by designing learning activities for different roles and one learning activity can be designed for one student, a group of students, or an entire class. Another advantage of IMS LD is that it supports blended learning as learning designers can specify online as well as offline learning or support activities in one UoL.

Third, a difference between IMS SS and IMS LD emerges on the learning personalisation. It is related to the support for adaptation in learning that is based on learners' profiles and the support for sharing control among learners, teachers, and learning systems. IMS SS supports learning flow branching. It seems similar to learning flow-based adaptation provided in IMS LD. Nevertheless, they are not same as the branching in IMS SS is not based on a learner's profile or achievements as it does not support learner modeling.

IMS LD offers wider adaptation and personalisation. It supports learning flow-based adaptation like IMS SS, and it also supports content-based adaptation and interactive problem solving-based adaptations (Kravcik et al., 2008). Content-based adaptation in IMS LD is implemented in an adaptation of resources to be presented to learners. Similar to learning flow-based adaptation, content-based adaptation is also represented in adaptation rules by applying 'Hide' and 'Show' to lessons, activities, or resources. Learning flow-based adaptation is gained when adaptation rules were applied to hide or show lessons or activities, thus causing the learning flow changes.

On the other hand, content-based adaptation is gained when an adaptation rule hides or shows content based on one or some properties' values. Another way to implement content-based adaptation is by hiding/showing XHTML elements under elements CLASS and DIV or replacing the content of predefined properties on the fly. Adaptation rules with properties are also applied for adaptation in interactive problem solving. It is considered as an extension of learning flow-based adaptation by giving incremental-adaptive help. Teachers, for example, can apply time and/or the number of remediation that a learner has done in order do design what kind of help the learner needs.

With such differences in their support for adaptation, however, both IMS SS and IMS LD support control sharing. In IMS SS, control sharing is limited as it is applied only to a learner to choose a learning activity. In IMS LD, control sharing is wider as there are probably several roles involved in learning and control is not only limited to learning activities, but also to support activities, plays, acts, or content.

3.3.2.2. The Requirements of Adaptive Learning Authoring

Are both learning standards appropriate for adaptive learning systems? The question can be answered by mapping the essential components of adaptive learning systems' components to learning designs' elements. It refers to AEH systems' main components that include domain model, goal model, learner model, and adaptation model. This section describes how IMS LD and IMS SS support those models.

A. Domain Model and Goal Model

Domain model in IMS LD is represented in plays and acts; they are similar to topic and sub-topics. On the other hand, goal model is represented in forms of learning objectives, pre-requisites courses, learning roles, and learning and support activities that link learning content, roles, and environments. Another component of IMS LD, 'Property', can be used to keep learning parameters, such as the time required to learn a module or the minimum mark that learners have to achieve. As it is possible to define various roles in IMS LD, different types of learners can be accommodated in one UoL. One learning flow can be performed for each type of learners; hence branching in IMS LD is pedagogically expressive.

Both IMS LD and IMS SS use an IMS CP's element called 'Resource' to maintain learning content. The content was attached in an 'Act' or activity element in IMS LD and in an 'item' element in IMS SS. Unlike IMS LD that provides elements that have pedagogical meaning, IMS SS does not provide elements to represent the pedagogical model. IMS SS just provides a number of predefined rules to be applied to 'item'elements of IMS CP. On the other hand, while it provides a limited number of elements to represent learning parameters, they are parts of rules or can be applied only to rules, as in the use of the 'attemptLimit' attribute of the 'limitConditions' element to determine how many times the learner can access an item.

B. Learner Model

Modelling learner is supported in IMS LD in forms of properties classified in six types. They cover all possible scopes such as whether the value is valid for a particular person or for all users, for a particular role or all roles, and for a particular course or all courses. The six types of properties are described in the following list.

1. loc-property: this property is valid for a UoL and it has the same value for all learners. This property, for example, can be used to store the time limit for learners and teachers when doing a learning activity.
2. locpers-property: this property is valid for a UoL and it may have different value for every learner. This property, for example, can be used, for keeping track of the mark gained by a learner in a course.
3. locrole-property: this property is valid for a UoL and it has the same value for all learners in a particular role. This property, for example, can be used to record a passing grade minimum that must be achieved by learners in a particular course.
4. globpers-property: this property is valid across UoL. It may have different values for every learner. This property can be used for storing specific information about a learner that can be referred to in all courses, such as learning profile information including age and education background.
5. glob-property: this property has a unique value for all users and it is valid across UoL and roles.
6. property-group: this property combines all other types of properties.

Learners can be modelled using a combination of these properties, especially using those that store individuals' information, i.e. locpers and globpers properties. Learner model can be made global, that is valid for all courses or local, that is valid only for a particular course. The learner model can also be created by combining global and local personal properties. Because of these properties, learner profile information, which is domain independent, can be recorded in global personal properties (globpers-property) and a learner's achievement information, which is domain dependent, is represented in local personal properties (locpers-property).

Contrary to IMS LD, IMS SS does not support learner model. IMS SS provides properties as attributes of elements/rules that do not aim to keep learner's information. Each type of rules in IMS SS has properties that instructional designers can use in order to keep values needed to run or stop particular rules, for instance, 'rollupObjectiveSatisfied'and 'rollupProgressCompletion' attributes are needed to control the 'rollupRules' rule.

C. Adaptation Model

Adaptation rules in IMS LD are explicitly expressed in the conditional form of IF-THEN-ELSE which uses 'property' variables. The format of rules in IMS LD, as shown in Table3.4, is understandable for those who have a little background in logics. With this format, teachers can freely declare 'property'variables, choose the suitable types, and use them in rules. The user-defined rules are then attached to plays, acts, or learning/support activities.

Table 3.4 The adaptation rule format in IMS LD

```
<imsld:conditions>
  <imsld:title>
  <imsld:if>
     <imsld: [operator: and, or, …]>
       <imsld: [operator]>
         <imsld:property-ref ref="…"/>
         <imsld:property-value>…</imsld:property-value>
       <imsld: [operator]>
         <imsld:property-ref ref="…"/>
         <imsld:property-value>…</imsld:property-value>
  <imsld:then>
     <imsld: [run method: show, hide, …]>
       <imsld: play-ref ref="…"/>
  <imsld:else>
     <imsld: [run method: show, hide, …]>
       <imsld: play-ref ref="…"/>
```

Contrary to IMS LD, IMS SS does not provide rules in an explicit IF-THEN-ELSE format, but it provides an element to facilitate adaptation, named sequencingRule, which consists of preConditionRule, postConditionRule, exitConditionRule, and ruleCondition(s) elements. As an example, the following picture shows the format of ruleCondition that will disable the associated item when condition is satisfied or completed.

Table 3.5 The adaptation rule format in IMS SS

```
<sequencing>
<sequencingRules>
<preConditionRule>
<ruleConditions conditionCombination = "any">
<ruleCondition condition = "completed"/>
<ruleCondition condition = "satisfied"/>
<ruleAction action = "disabled"/>
```

The lack of rules in IMS SS means they do not have pedagogical meanings. For example, if the sequencingRule described in Table3.5 is associated with an item, it is not clear as to exactly what condition must be completed or satisfied in order to disable the associated topic. In addition, teachers are not able to make their own vocabularies, for example, the terms'completed' or 'satisfied' are predefined for the attribute 'condition'. For some vocabularies, IMS SS does not provide enough explanation; for example, there is not enough information regarding an attribute called 'measureTreshold', as to what it represents exactly, except that it can keep a floating point number.

3.4. Summary

The use of learning standards is a solution for interoperability problems found in the use of transformation functions between two authoring tools that both define their own languages. There are a number of learning standards classified into learning object/content standards and learning design standards.Learning object refers to a set of learning materials that can be deconstructed into context independent fragments. From the learning object perspective, learning is viewed as a selection of suitable materials for learners, a delivery of a sequenced learning content from teachers to learners, and an assessment of learners' progress.

Learning Designs, on the other hand, are about more than simply delivery of structural content. Therefore, it is necessary to have standards for more than content packaging and delivery. A combination of learning object/content standards and learning design standards can be found in SCORM and IMS SS, IMS CP and IMS SS, and IMS CP or IMS LD. Based on an analysis on the pedagogical expressiveness perspectives of two learning design standards: IMS SS and IMS LD,it can be concluded that IMS LD is the better option. It provides elements that support various learning methods, such as individual and collective learning, individual and collaborative learning, general and adaptive learning, and blended learning. IMS LD allows teachers to express pedagogical intent, for example, in a set of learning activities that the learners will engage in.

Another analysis from the perspective of the requirements of adaptive learning authoring was carried out. It resulted in a conclusion that IMS LD provides elements for expressing the main components of adaptive learning systems: domain model, goal model, adaptation model, and learner model, while IMS SS does not. As a conclusion, this chapter has described the potential improvements for authoring adaptive learning resources with respect to the interoperability issue. In next chapter, CSCW methods will be discussed. It is aimed to give a description of another potential improvement to be carried out in order to solve collaboration problems.

Chapter 4 Computer-Supported Collaborative Work

CSCW has been successfully applied in various areas for authoring various objects. Some of them, such as Wikipedia (Kittur and Kraut, 2008) and semantic wikis (Lange, 2007; Lange and Kohlhase, 2007; Schaffert, 2006), enable large communities to contribute. Other examples of CSCW implementation can be found in authoring hypermedia documents (Haake, 1993), courseware (Dicheva et al., 2002; Ras et al., 2008), academic writing (Dimitrova et al., 2008), papers (Liccardi et al., 2007), and ontology (Noy and Tudorache, 2008; Tudorache et al., 2008). CSCW in particular enables social collaboration and evolves knowledge on a large scale. It offers numerous advantages over individual authoring. It reduces individual effort, provides different insights, and enhances the quality of output by enabling authors from different expertise to work together (Noël and Robert, 2004). It has been proven in previous research that multiple persons who collectively contribute their thoughts could surpass the achievements of someone who works individually (Dicheva et al., 2002; Haake, 1993; Posner and Baecker, 1992). However, collaborative work may potentially generate less positive output than individual work. This would be more likely to be the case when inappropriate communication and coordination mechanisms are applied (Kittur and Kraut, 2008; Kittur et al., 2009; Lowry et al., 2005).

Having several contributors working together on a collaborative work can be advantageous in the form of an emerging collective intelligence. There have been numerous studies on collaborative authoring approaches including traditional collaboration and online collaboration (Benbunan-Fich et al., 2003; Gutwin and Greenberg, 2002; Thagard, 1997). While traditional collaboration gets advantages from face-to-face meetings, online collaboration faces challenges on maintaining awareness where information resources are poor and interaction mechanisms are not common (Gutwin and Greenberg, 2002). Each author involved in online collaboration faces a challenge to make the work coherent with the other authors' work. In cases with independent tasks, such as collaborative proof-reading, communication is not very essential. On the other hand, in collaborative work with high-dependent tasks, such asthe collaborative authoring of papers, cohesive points of authors' views are important.

Communication and coordination methods applied in online authoring are different from those applied in traditional collaboration. In a traditional collaboration, careful planning of authoring is an important activity. It is supported by a direct communication in the form of face-to-face meetings. It is beneficial to the authors as it offers interactive and direct communication among the authors. In contrast, a careful plan is not considered necessary in an online collaboration where contributors have the freedom to do what they consider important. One observation on Wikibooks shows that authors use implicit planning tactics by creating links to other pages that do not yet exist (Kittur et al., 2009). This encourages other authors to create the missing page without discussion or brainstorming to define the consensus. This approach can be extended to cover the whole planning process.

4.1. Communication and Coordination

Collaborative authoring allowsa number of contributors to participate in the process. Research studies in the area of CSCW are concerned with the ways to enhance collaborative work. Posner and Baecker (Posner and Baecker, 1992), for example, defined the requirements of collaborative writing that address the importance of communication. Communication is needed to enable contributors to share their insights, based on their knowledge and skills, that can enhance the quality of products(Clearwater et al., 1991). However, although more contributorslead tomore advantages in authoring, this also may reduce productivity dueto the need for coordination. In addition, unlike in traditional collaborations where contributors are linked by professional ties, there may be no directinteraction among authors in an online environment.

There were argumentative contradictions regarding interaction. A study on the software industry said that coordination costs can be much higher than the benefits of added personnel; this is referred to as Brooks' law: "adding man power to a late software project makes it later" (Brooks, 1995). In contrast, research on open source suggests to "delegate everything you can, be open to the point of promiscuity" (Raymond, 2005). It is argued that involving many contributors will improve the quality of software more than just having a few developers working on it. Coordination can therefore strongly affect the quality of products.

To chose the appropriate type of coordination, the group size and the characteristics of the tasks must be considered. Kittur and Kraut (Kittur and Kraut, 2008) define two kinds of coordination: explicit coordination and implicit coordination. Explicit coordination is implemented in various approaches in computer-supported collaborative authoring tools. One example of features for explicit coordination is talk pagesin Wikipedia. Empirical studies on Wikipedia showed that coordination in Wikipedia is very important as 40% of Wikipedia activities includes communication/discussion, consensus building, conflict solving, and policy development (Kittur et al., 2007). These studies also proved that the quality of output was enhanced.

Until recently, there have been numerous research studies into how communication mechanisms affect the authoring process and output. It was found that the proper use of communication methods can improve the quality of artefacts (Kittur and Kraut, 2008). They tested the quality changes of 23,619 articles authored over a period of six months based on the initital quality, the number of editors, article age, and the coordination technique. They used Heckman regression to find correlations between such four variables and the effects on the articles' quality. Some conclusions produced from the research are:

1. There is a positive association between the number of editors working on anarticle during a six-month period and the article quality improvement during that period.
2. There are correlations between implicit coordination, early stages of authoring, and the quality of articles.
   - The advantages of implicit coordination are greater during the early phases of authoring, when the article is in its earliest versions. During these phases, outlining the article structure by a subset of authors will lead to greater increases in quality.
   - When the authoring work is carried out by the small subset of authors, the quality of articles will increase and is better than articles produced by group where the work is evenly divided amongst all authors.
3. There arecorrelations between explicit coordination, the number of authors, and the quality of articles.
   - The more communications made regarding the articles, the higher the quality of the finished articles.
   - Like implicit coordination, explicit coordination is more beneficial in the early stages of an article's lifecycle.
   - The benefits of communication decreaseas the number of authors increases.

From the studies, it can be concluded that coordination mechanisms are group size-specificand they vary depending on the number of contributors, the nature of the work (Kittur et al., 2009), and the independency of collaboration tasks (Kittur et al., 2009). Kittur and Kraut (Kittur and Kraut, 2008) highlight the relationship between coordination and quality in Wikipedia content and show that the use of appropriate coordination mechanisms is essential. Articles edited by many authors are generally better than those edited by fewer authors, but only when implicit coordination techniques are used.

Implicit coordination is implemented by structuring tasks according to a particular hierarchy, such as a managerial hierarchy or an organisational hierarchy (Lowry et al., 2005). Implicit coordination is commonly applied by collaborative authoring which has independent authoring tasks. It is possibly to apply role assignments with different authorities to the structure, such as when one author playsa role as a leader who structures tasks and directs authoring. On the other hand, it is possible that there are no role assignments and all authors have the same access to artefacts (Dourish and Bellotti, 1992; Kittur and Kraut, 2008; Kittur et al., 2009). An advantage of this approach is that it diminishes the coordination overhead that is found in explicit coordination. In addition, implicit coordination can be applied to small groups, as well as big groups.

In contrast, explicit coordination or direct communication between authors only improves articles written by a few editors, but actually diminishes quality when many editors are involved. This is confirmed by previous research (Stewart, 2006) that argues that larger teams generally perform better when they are engaged in low-coordination work than when engaged in tasks requiring a high degree of coordination. Explicit coordination, however, possibly leads collaborative work into a very low effective work. This happens when the number of authors involved in the authoring process exceeds the ideal number of contributors. Coordination will become very complicated and it will probably take much more time than the authors took to create the content. When this happens, conflicts potentially emerge, thus causing difficulty in gaining a consensus.

4.2. Workspace Awareness

Awareness refers to the authors' understanding of other authors' assignmentswhich provide them with contexts for future activities. Authors are required to have awareness when participating in collaborative authoring. Awareness is not only knowing about what has happened with in the collaborative work, but also understanding and responding to the changes made by other authors. Authors' workspace awareness is important in ensuring that the overall individual activities of authors are always relevant to authoring goals. As a consequence, it is important to provide awareness information in collaborative authoring whatever the domain. There are various ways such information can be provided, but what is important is whether it is generated or collected, directed to one/some authors or distributed to all authors, and whether it is presented in the same workspace as authored objects or is kept separate from the objects (Dourish and Bellotti, 1992).

Generally, there are several types of awareness in collaborative work for both asynchronous and synchronous collaborative authoring.

1. Self awareness. It refers to the information that authors maintain whether they or their work can be seen by other authors and whether they are able to see other authors and their contribution (Mitchell et al., 1995). It is also called personal awareness (Liccardi, 2010).
2. Informal awareness. It involves knowledge about who are recently working and what they are doing (Greenberg et al., 1996). It is also known as user presence awareness (Morán et al., 2001).
3. Social awareness. This is the information about other authors in conversational context, for example, whether other authors are paying attention to a particular problem or not. The information can be obtained through verbal interaction or non-verbal cues, for example, through contact eyes in video conferencing (Greenberg et al., 1996).
4. Group awareness. It refers to the information that user maintains about authoring process itself and about authors' roles and responsibilities in the group, their status and positions in particular issues (Greenberg et al., 1996)

There is another type of awareness which is called workspace awareness. It combines all of those types of awareness and addresses some information which is part of all of these kinds of awareness (Greenberg et al., 1996; Gutwin and Greenberg, 1996, 2002; Liccardi, 2010). Gutwin(Gutwin and Greenberg, 1996) argues that workspace awareness is related to authors' understanding of other authors' presence, activity levels, actions, intentions, changes, objects, extents, abilities, and expectations. Such data were applied in synchronous collaborative work which means that information is in real time with respect toauthors' present actions in authoring.

4.2.1. Effects of Awareness Support

Synchronous collaborative work allows people to work together at the same time and in a shared workspace. In a face-to-face setting, the workspace is a two dimensional areasuch as whiteboard or tabletop. In such a setting, a wide range of perceptual cues help collaborators to maintain awareness of other collaborators' interaction with the shared workspace. This awareness in the workspace is called workspace awareness and is used in collaborative work to coordinate activities, to simplify communication, and to provide guidance (Gutwin and Greenberg, 1998). Gutwin and Greenberg (1998) researched the qualitative evidence of the usability of awareness feature widgets and the quantitative effects of awareness support. The study proved that for tasks that use information about collaborators' location and activities, the workspace awareness information can reduce completion time, improve communication efficiency, and increase satisfaction.

Another study showed that ensuring collaborators stayed aware in authoring will improve the usability of the workgroup system (Gutwin and Greenberg, 2002). It identifies elements of workspace awareness in synchronous collaborative work that are related to present occurences:

1. Who; this is related to authors' presence, identities, and authorships.
2. What; this is related to authors' actions, intentions, and artefacts.
3. Where; this is related to authors' location, views, and gains.

All of this information can be gained from three kinds of resources including people's physical presence in the workspace, workspace artefacts, and conversations and gestures. The first resource can be found in face-to-face meetings or in a workgroup that provides a visual feature that enables an author to see other authors. Information provided by the second resource, for example, is the status of artefacts. The last resource is the most common one. An author can improve her awareness from conversation and gestures, either from her conversation with other authors or from simply overhearing other authors' conversations(Gutwin and Greenberg, 2002).

Workspace awareness is needed for the following five activities (Gutwin and Greenberg, 2002):

1. Management of coupling between working alone and working together.
2. Simplification of communication.
3. Coordination of actions so that they may be in right order, done at the right time and meet requirements.
4. Anticipation of other authors' actions.
5. Assistance that provides appropriate help to other authors if needed.

4.2.2. Workspace Space Awareness in Asynchronous Collaborative Authoring

Workspace awareness is an up-to-the-moment understanding of other collaborators' interaction with the shared workspace. It is an awareness of other people and what they have done in the workspace. As authoring is progressing in the workspace, workspace awareness must be maintained to keep it up-to-date.

Workspace awareness must not only be maintained in synchronous collaborative work, but also in asynchronous collaborative work. Research on workspace awareness in asynchronous collaborative authoring was carried out with the same motivation as in synchronous collaborative authoring (Dourish, 1997). Nevertheless, when the information of workspace awareness is applied to asynchronous collaborative authoring, the information is no longer about present occurrences, but about past interactions. Workspace awareness information in an asynchronous collaborative authoring is mainly about action history and artefact history (Tam and Greenberg, 2006). One approach to improve authors' workspace awareness in asynchronous collaborative work is by placing awareness information within a shared workspace. This approach would be effective if the workspace is the only shared space that provides awareness information.

Workspace awareness in asynchronous collaborative work is related to the history of occurrences (Gutwin and Greenberg, 2002), including:

1. Action history. This is related to how a change happened and what an author has been doing.
2. Artefact history. This regards information of how an artefact came to be in the current state.
3. Event history. This is related to when an event happened.
4. Presence history. This regards information of which authors accessed the workspace.
5. Location history. This is related to information of where an author has been.

Until recently, a number of communication features have been applied to various collaborative authoring tools for planning and enhancing awareness information. Some of these are communication features that gather information from the authors themselves.

1. Face-to-face meeting (Dourish and Bellotti, 1992). This feature is implemented in synchronous collaborative authoring tools.
2. Notes/Annotation (Dourish and Bellotti, 1992; Haake, 1993; Weng and Gennari, 2004). For example: Notes in Collaborative Protege (Noy and Tudorache, 2008; Tudorache et al., 2008), social annotation for authoring adaptive learning resources(Ghali et al., 2008), and CAWS (Liccardi et al., 2007).
3. Task scripts on a Process Structure approach (Lowry et al., 2005).
4. Talk pages, such as Wikipedia (Kittur and Kraut, 2008; Kittur et al., 2009; Kittur et al., 2007).
5. Structured messaging (Dourish and Bellotti, 1992).

On the other hand, to enhance awareness, some studies applied provenance information (Noël and Robert, 2004; Papadopoulou, 2009; Tam and Greenberg, 2006), such as in Collaborative Protégé (Noy and Tudorache, 2008).

4.3. Collaborative Authoring for Learning

There are a large number of studies on how to improve the authoring process. Research studies in the area of CSCW are concerned with how to enhance collaborative work.Some of the studies concerned factors that influence the performance of collaborative authoring. Posner and Baecker (Posner and Baecker, 1992), for example, declared that joint writing must manage four components including roles, activities, document control methods, and writing strategies. Other studies addressed the importance of coordination, communication, and conflict management (Dourish and Bellotti, 1992; Kittur et al., 2007; Kling, 1991; Viégas et al., 2004). In addition, some research studied coordination and communication methods and the importance of proper communication methods for collaborative authoring (Kittur et al., 2009; Lowry et al., 2005; Viegas et al., 2007). Another focus of research studies on CSCW is awareness support(Greenberg et al., 1996; Gutwin and Greenberg, 1996, 1998; Liccardi et al., 2008).

Former CSCW research studies have proven that most of the projects in academia, business, and industry were completed by groups of people who worked collaboratively (Posner and Baecker, 1992). In addition, authoring does not just refer to those technical tasks only carried out by administrators. Domain experts engage in online communities to contribute in authoring tasks, thus leading the authoring processto the development of a collective intelligence.

Earlier research studies have indicated that the more people involved in developing learning resources, the more meaningful the results that can be produced (Caplan, 2004; Hixon, 2008). There is some evidence from previousstudies that can be adopted in order to improve authoring for adaptive learning, such as the use of semantic technology and annotations (Dicheva et al., 2002; Ghali et al., 2008; Yuan et al., 2005). Considering that courseware development is a complex endeavour, as well as enhancing the quality of the authored objects, and keeping them continuously updated, people with various concerns should be encouraged to participate. A research study on authoring adaptive learning system resources (Brusilovsky et al., 2005), for example, involved developers' teams and teachers as authors. The former has a responsibility for establishing authoring environments, whereas the latter created the majority of the educational resources.

There have been a number of research studies on how the implementation of CSCW principles in an academic environment can improve collaborative authoring; for example, in developing hypermedia documents (Haake, 1993) and courseware (Dicheva et al., 2002). In terms of courseware development, collaborative authoring can offer an advantage in terms of time efficiency and the opportunity to keep learning resources continuously updated, thus keeping it relevant to students' needs(Allee, 2000; Hixon, 2008). It is combined with the fact that teachers develop learning resources and instructional designers design courses collaboratively. They take part in discussions, brainstorming sessions, coordination, and meetings to define a single vision in designing and conducting learning (Christensen and Osguthorpe, 2004; Kirschner et al., 2003). Asynchronous collaborative environments have been implemented in school and higher education to support teachers' knowledge building (Silverman and Clay, 2009), to support online text based discussion for collaborative projects and learning (Murphy, 2004; Taradi and Taradi, 2004).

Interaction influences teachers' decision making rather than the theories of instructional designs. On the other hand, a survey to academics, business, and industry professionals showed that most of them did their work cooperatively (Posner and Baecker, 1992). The quality of learning resources, however, is not merely influenced by how many authors contribute, but instead by how the collaboration is carried out. Gaining consensus (Kriplean et al., 2007) by considering all authors' insights and visions, imposing appropriate coordination techniques in collaborative work (Kittur and Kraut, 2008; Kittur et al., 2009), and providing features to improve authors' workspace awareness (Kittur et al., 2009; Liccardi et al., 2007) are the ways forward in collaboration that will produce meaningful results.

Collaborative work in creating adaptive learning resources has been studied in a research on social annotation that enables learning designers to rate and tag learning materials (Ghali et al., 2008). Both collaborative authoring and social annotation rely on cooperation. However, unlike collaborative authoring that updates learning resources, social annotation does not update the resources, but it does enable learning designers to update information on the resources in the forms of ratings and tags. The study proved that collaborative authoring should be carried out as a combination of a semantic web and social web that facilitates learning designers to created domain and pedagogical knowledge and a social web technique that enables learning designers to rate or tag resources.

4.4. Summary

In this chapter, methods and techniques in CSCW and their implementation in authoring documents were discussed. Based on the interaction of authors, collaborative work is classified into two types: synchronous with real-time interaction and asynchronous with non real-time interaction (Ellis et al., 1991). On the other hand, based on the locations where authors work, collaborative work is categorised into co-located (the same place) and remote (distant) collaborative work.

The effectiveness of CSCW tools is influenced by coordination and communication approaches. To choose an appropriate approach, the number of authors that contribute in the authoring and the independency of authoring tasks must be considered (Kittur et al., 2009). For a small group of authors with independent authoring tasks, a Process Structure method with implicit coordination, with or without role assignments, is the most appropriate approach.

In terms of collaborative authoring of learning designs, it is important to select the type of collaboration (whether synchronous or asynchronous), the size of groups, the type of communication and coordination (whether implicit or explicit), what awareness is supported, and what awareness features are needed. This research applies an asynchronous collaborative environment due to the emerging trend of the implementation of asynchronous collaborative environments in schools and higher education institutions (Section 4.3). Asynchronous collaborative environments are implemented for workgroups in which members do not need to work together at the same time; thus intensively direct communication is not essential. Regarding the reasons, an asynchronous collaborative environment is considered suitable for authoring learning designs.

The collaboration is for a small workgroup in which a limited number of authors contribute and which is not open to the general public as is the case with wikis, for instance. It is considered that many authors contributing in authoring a UoL will propose many preferences and suggestions for inclusion. This potentially raises conflicts to produce less meaningful output.

Notes and History are applied to support the workspace awareness of authors. This is based on former research studies where both features have been successfully applied in collaborative authoring on other types of objects (Section 4.2.2). This research focuses on workspace awareness rather than other types of awareness considering that workspace awareness combines all types of awareness (Section 4.2). In addition, Notes support limited communication for implicit coordination. Implicit coordination is proposed due to the similarity of the hierarchical structure of IMS LD and Process Structure methods, a type of implicit coordination.

Chapter 5 Analysis and Design of Collaborative Authoring Tools of IMS LD

Chapter 2 set out a comparison of of existing learning authoring tools from various perspectives. However, not one of the tools supports collaboration. Potential improvements come from former research on learning standards and CSCW designs as discussed in Chapters 3 and 4. Extending the discussion in those chapters,this chapter describes the design of the Collaborative ReCourse, the tool used in experiments. ReCourse was chosen to be extended due to the functions it offers. Our analysis of existing authoring tools found that ReCourse provides functions to create UoLs in IMS LD format for levels A, B, and C. It also provides functions for visualisation and for testing the validity of the UoL and linking to CopperCore, an IMS LD player. The main extension of ReCourse is the implementation of workspace awareness features: Notes and History.

5.1. The Authoring Scenario

A small group of four teachers wish to work together to create an instructional design of a Java programming course. Let us call them Alice, Bob, Claudia, and Daniel and they work in the same or different universities. They are socially or academically connected in a way whereby each author is known by at least one other author. They may face a location difference and may have different activities that make it difficult for them to work together at the same time. Hence, they will work mostly remotely and asynchronously.

With the Extended ReCourse, Daniel logs in and creates a new UoL and saves it as Java_programming. As the UoL creator, Daniel has the authority to add new authors. He can create new users comprising their usernames and email addresses. The passwords are self-generated. Once the other authors received the invitation emails, they can log in to the system and change their passwords. Daniel creates an overview of the UoL, pre-requisite courses, and learning objectives. In addition, Daniel defines a sequence of some or all plays. He leaves notes for other authors, for example, telling other authors what his vision is for the UoL or his motivation behind his actions. Before he logs out, he saves his work.

When Alice logs in, she finds the sequence of plays, pre-requisites, courses, learning objectives, and notes that Daniel has created and posted. From those, she is aware of Daniel's vision and his motivation. Furthermore, she gets an implicit guidancefrom Notes, probably with explicit guidance as well for the next actions that she should take. Alice revises and completes the sequence of plays, then creates some acts, leaves notes, and saves her work.

Several hours later, Claudia logs in. She finds the recent updates in History, recent notes in Notes, all notes from other authors in Note or objects' Notes, and notes posted by a certain author. After that, she makes a small revision to the sequence of plays and learning objectives and leaves notes in Notes. She then focuses on extending one or two plays by adding acts and learning/support activities. She leaves notes in activities' Notes and saves all of her work.

The next day, Bob logs in. He has found that Daniel, Alice, and Claudia have made some updates and that sequence of plays is quite mature and it suits the learning objectives and the pre-requisite courses. However, he finds that some plays and learning activities that a former author created are subjects that are to be taught as additional materials. Furthermore, he finds that the sequence does not accommodate the difference of learners, such as different profiles or performances. He thinks that when a learner fails in one play, the learner should get a chance to repeat the play with different activities, or acquire additional materials, such as case studies. Hence, Bob adds some properties for retaining learners' performances and creates some rules to anticipate special conditions of the learners. He leaves some notes and saves his work.

The next sessions will run much like the sessions describedabove. At the beginning, teachers will spend most of their time developing the learning flow (the sequence of plays and acts). After a few sessions, when all the teachers consider that the sequence has matured, they focus on the extension of the sequence by adding resources, activities, role-parts, environments, properties, and rules. Although in these sessions, changing the sequence is still allowed, refinement is considered to be more appropriate than revision.

This example scenario implements implicit coordination. It applies a Process Structure method that Daniel, who plays a role as a leader, used when he made a hierarchy of plays. The scenario does not implement an authoring task assignment; it means that all authors have the same access to the UoL.

5.2. Awareness Information Requirements

This section discusses the awareness information requirements of collaborative authoring tools for the authoring scenario presented in the previous section.

5.2.1. Workspace Awareness Information

As described in Section 4.2.2, in asynchronous collaborative authoring, workspace awareness is mainly about action history and artefact history. In other words, it focuses on the activities that updated artefacts. To enhance workspace awareness, learning designers must be supported with information about changes, objects, extents, abilities, actions, activity levels, intentions, and expectations. All of this information regards past interactions in authoring. Those two kinds of information can enhance learning designers' awareness in authoring learning design for adaptive learning:

1. Provenance information

   A kind of information that can improve the learning designer's awareness is provenance information, which records what the affected objects are, and the changes that have been made, by whom, and when.

2. Notes from learning designers

   In the context of collaborative authoring for adaptive learning resources, a note is typically a written opinion, feedback, or a short explanation posted by a learning designer. Since Notes are utilised during the instructional design development, Notes can be used by instructional designers for different purposes:

   - General comments. Learning designers can post notes to share information regarding the whole UoL and its attributes. It is useful as additional information cannot be covered in the attributes of UoL, such as an overview, pre-requisites, and learning objectives. In addition, learning designers can use Notes to explain a consideration that motivates their actions.
   - Comments about objects. Learning designers can post notes about objects, such as why an object is important or unimportant, what an object represents, when an object is used, and other aspects. In addition, learning designersmay give critiques about missing or existing objects made by other learning designers.

- Comments about actions. Learning designers may post comments to explain why they made an update, propose changes, share comments or critiques about other learning designers' actions, and so on.

Notes have been successfully implemented in previous research studies as presented in Chapter 4. It provides a facility for sharing information among learning designers. Notes, however, can be disruptive; for example, when learning designers write long comments which are unstructured and unorganised, thus making it difficult for other learning designers to find relevant comments. Hence, Notes must:

1. Have an ability to manage a large number of comments.
2. Be supplemented with functions to retrieve particular comments, such as recent notes or notes posted by a certain learning designer.
3. Be linked to artefacts. This will save learning designers' time by searching relevant comments relevant to particular objects.

5.2.2. Requirements

To maintain workspace awareness information, two features that are Notes and History are implemented:

R1. History

History is a feature to present provenance information about changes, the types of changes, the affected objects, and which learning designers made the changes.

R2. Notes

Notes (with a capital 'N') are sets of features for learning designers to insert comments. Considering that Notes are possibly used for various purposes and there are a large number of elements in a UoL, providing one Note for the whole unit of learning is not wise. Three kinds of Notes are designed that link to various artefacts:

R2.a. **Note**. Note (with a capital 'N') is a feature in which learning designers can share comments related to the UoL in general or to its overview, learning objectives, pre-requisite courses, and completing rules. In addition, Note can also be used to discuss or share issues in authoring, including problems that learning designers currently face in authoring, and motivation behind the concept structuring among others.

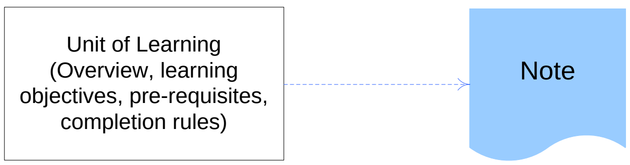


Figure 5.1 Note attached to a UoL

R2.b. **History's Note**. Sometimes learning designers need to explain the changes they have made to the UoL, such as why they deleted or updated plays, acts, or learning activities. History's Note aims to facilitate this kind of notes where learning designers can insert notes/comments on History's records.

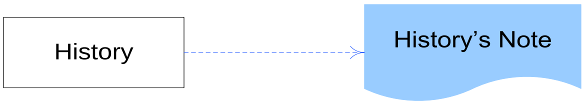


Figure 5.2 History's Note attached

R2.c. **Objects' Notes**. It often happens that learning designers need to leave or to find notes about particular objects. Managing specific notes about objects in the general Note makes it difficult for learning designers to findthe relevant information they need. For this kind of notes, objects' Notes are provided. They are attached to:

- Play and its underlying elements. One Note is provided for each play and all of its descendant elements including acts, learning/support activities, and activity groups. It can be accessed from the play and the underlying elements.

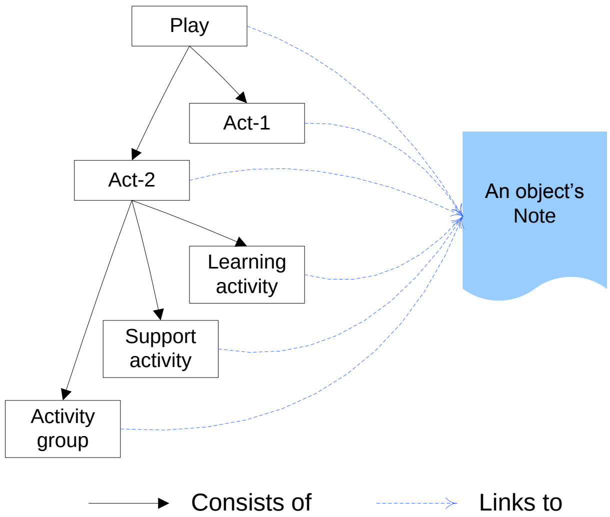


Figure 5.3 An object's Note that links to a play with its acts, learning/support activities, and activity groups

- Resource. One resource has one Note in which learning designers can write any comment about the resource.

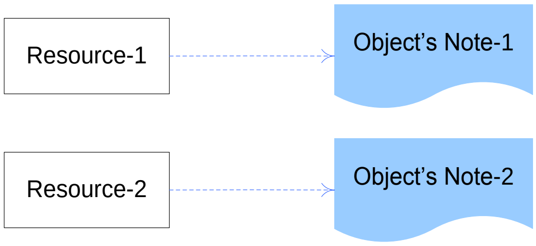


Figure 5.4 The one-to-one relationship between resources and objects' Notes

- Property. Same as resource, one property links to one Note. This is for instructional designers to write anything about the property.
- Condition(s). One condition/rule consists of one or several condition(s). One Note is provided for each condition with its underlying condition(s). Access to an object's Note from conditions or from any of its descendant conditions will refer to the same object's Note.

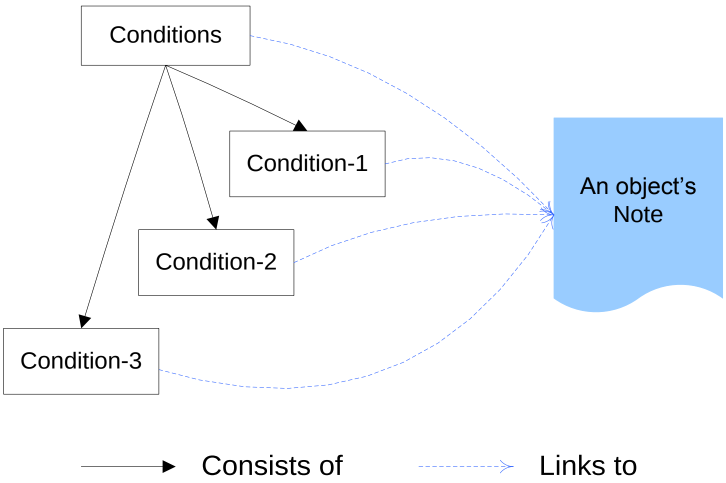


Figure 5.5 One object's Note links to one condition and its underlying condition(s)

5.2.3. The Authoring Approach

This approach does not propose a strict authoring phase as in previous research (Liccardi et al., 2007; Lowry, 2002). In the proposed approach, planningand drafting are implicit steps. Planning is the time taken when one or more learning designers create the UoL including defining objectives and building a sequence of plays. Afterwards, drafting is the time when most or all of the learning designers extend the sequence of plays. These are borderless phases that do not require authors to commit to the first phase before moving onto the second phase. The whole process will produce a UoL with Notes and History. The flow of authoring is modelled in the following activity diagram.

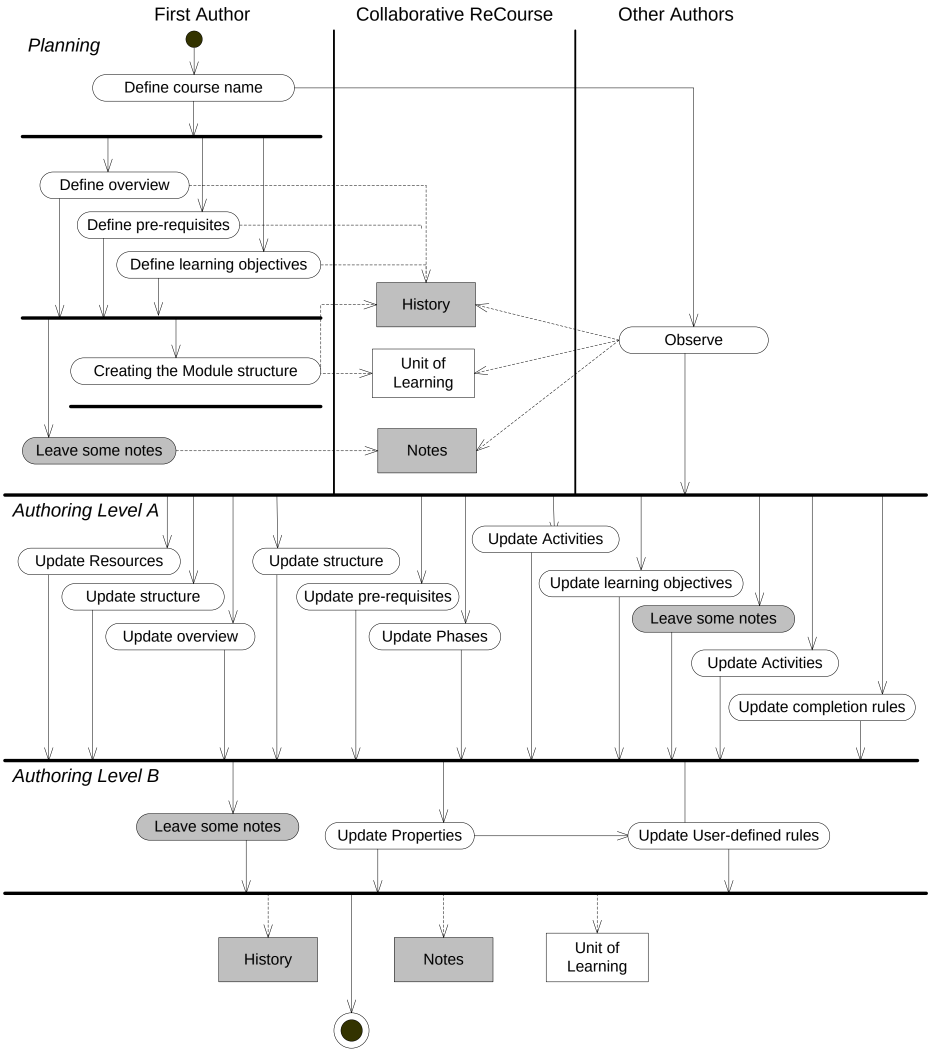


Figure 5.6 An activity diagram of the proposed authoring approach

5.3. ReCourse

ReCourse is an open-sourced authoring tool under a BSD (Berkeley Software Distribution)-type licence and written in Java, Eclipse, and Rich Client Platform (RCP) frameworks. It provides authoring functions for IMS LD levels A, B, and C.

5.3.1. Functionalities

In general, functions in ReCourse can be classified into seven main function groups.

1. **Function Group 1**: Create domain model: concepts and learning materials. Learning materials are represented in 'resource' elements that arepartsof IMS LD. Resource is an IMS CP's element that can be embedded in IMS LD, within learning activity, support activity, or learning object. A resource can comprise a text or link to files or pages. Included in learning materials are test materials in the form of IMS QTI.

2. **Function Group 2**: Create goal model.ReCourse provides functions to create goal models regarding pedagogical insights. Using these functions, authors can define a course name, learning objectives, pre-requisites, and overview. Furthermore, they can create:
   - Role. This is related to functions that persons play in learning.
   - Play and act. As ReCourse uses the terms 'module' (for 'play') and 'phase' (for 'act'), the same terms will be used in the context of ReCourse in the remaining chapters.
   - Learning activity, support activity, and activity group.
   - Completion (predefined) rules.
   - Learning environments.

   These functions include a function to define links between knowledge elements and learning materials. ReCourse provides functions to connect resources to learning activities, support activities, and learning objects.
3. **Function Group 3**: Create learner model. ReCourse provides functions to manage learner models that consist of learners' profiles represented in global-personal properties and learners' progress represented in local-personal properties.
4. **Function Group 4**: Define adaptation rules. ReCourse provides functions for authors to apply completion rules to the whole UoL to finish learning, as well as to modules and phases. In addition, ReCourse provides a function to create user-defined adaptation rules in the form of condition(s).
5. **Function Group 5**: Visualiser. This function visualises all elements. It helps authors to see the whole structure of the UoL and the relationships among elements. This function, however, does not enable updating or deletion.

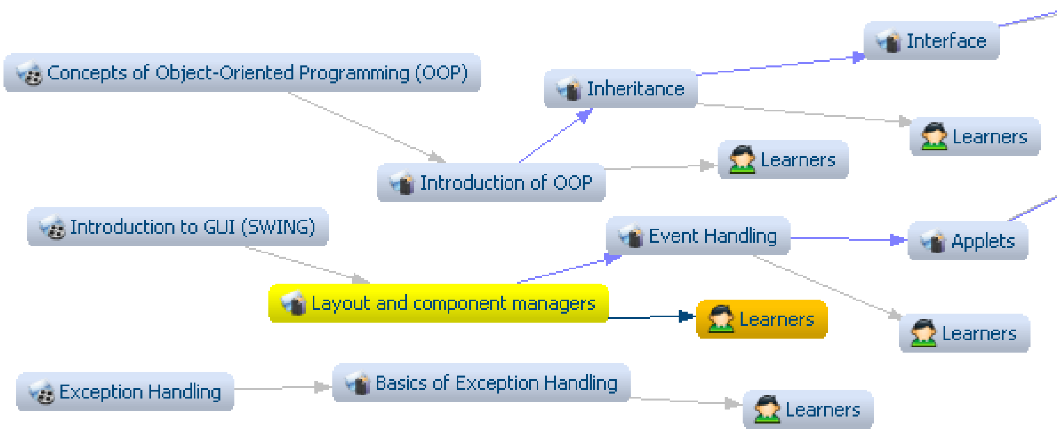


Figure 5.7 An example of a visualisation of some elements of the UoL

6. **Function Group 6**: Utilities. All functions classified in this group are related to the packaging of the tool, codes, and plugins. For example, functions to launch

the tool based on the provided operating system or functions to zip the source codes to be extended.

7. **Function Group 7**: Publishing to CopperCore. This function aims to publish the UoL in CopperCore. This function includes a checking function for the validity of the syntax of the UoL. It helps the user to produce a UoL that is logically and syntactically correct.

Figure 5.8 An example of errors appears when publishing the UoL to CopperCore

All those functions are contained in ReCourse modules. In total, there are 10 modules, of which LDAuthor is the main one.

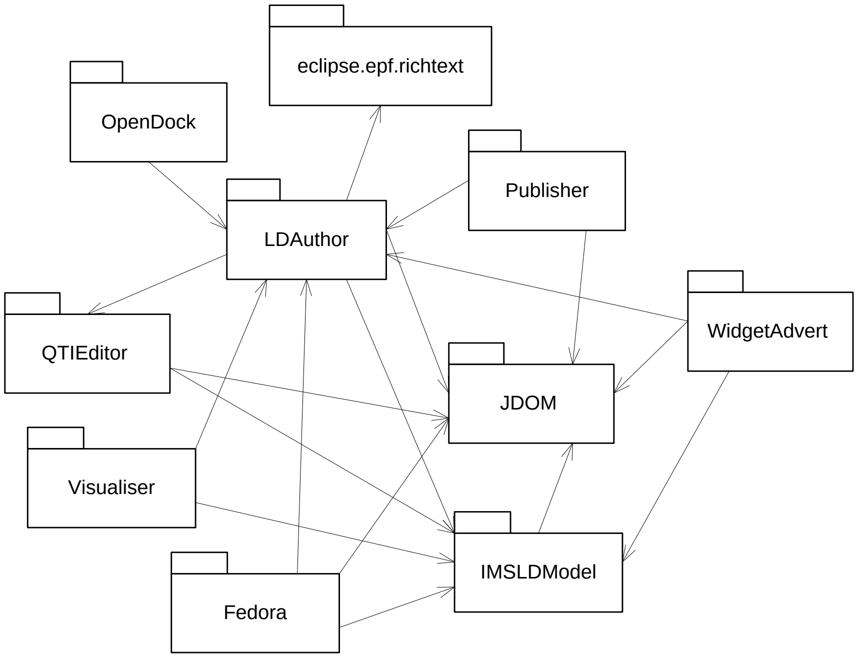


Figure 5.9 Dependencies among ReCourse's modules

1. org.tencompetence.jdom. This is a module that comprises functions for accessing, manipulating, and outputting XML based data on Java programs. The functions, for example, are used to save and load learning designs to or from imsmanifest.xml files.
2. wp6/org.eclipse.epf.richtext. This module consists of functions used to control access to rich texts. A function called addModifyListener, for example, is aimed to control updates in a rich text, such as the overview and learning objectives of a UoL.
3. wp6/org.tencompetence.imsldmodel. This module consists of classes to develop a UoL. A learning design is either generated when an author creates a new learning design or loads from an XML-based ims.manifest file to continue authoring.
4. wp6/org.tencompetence.ldauthor. This is the main module of ReCourse andthe biggest module with more than a hundred packages. It consists of all functions needed to access and manipulate a UoL.
5. wp6/org.tencompetence.ldauthor.fedora. This module declares classes that are important to establish open source Java programs.
6. wp6/org.tencompetence.ldauthor.opendock. This module provides functions for downloading or uploading UoL from or into Eclipse Java workspace.
7. wp6/org.tencompetence.ldpublisher. This module provides functions to manage connections to an IMS LD player called CopperCore and to publish the UoL produced in ReCourse.
8. wp6/org.tencompetence.ldvisualiser. This module provides functions to visualise a UoL. The visualisation uses Eclipse plugins: Zest for graph layout and Graphical Editing Framework (GEF) for a rich graphical editor.
9. wp6/org.tencompetence.qtieditor. This module provides packages and classes to manage the creation and manipulation of learning exams organised in IMS QTI (Question and Test Interoperability).
10. wp6/org.tencompetence.widgetadvert. This module provides classes that manage client-server connections needed for conference environment elements in UoL.

The dependencies among such modules can be found in Figure 5.9. The main module is LDAuthor which contains main classess. The dependencies among modules are presented in the following diagram.

5.3.2. The Static Model

In this section, screenshots of ReCourse are presented. In addition, the top level of the static model implemented in ReCourse is presented in Figure 5.10. Most of these classes are compiled in the module org.tencompetence.ldauthor.

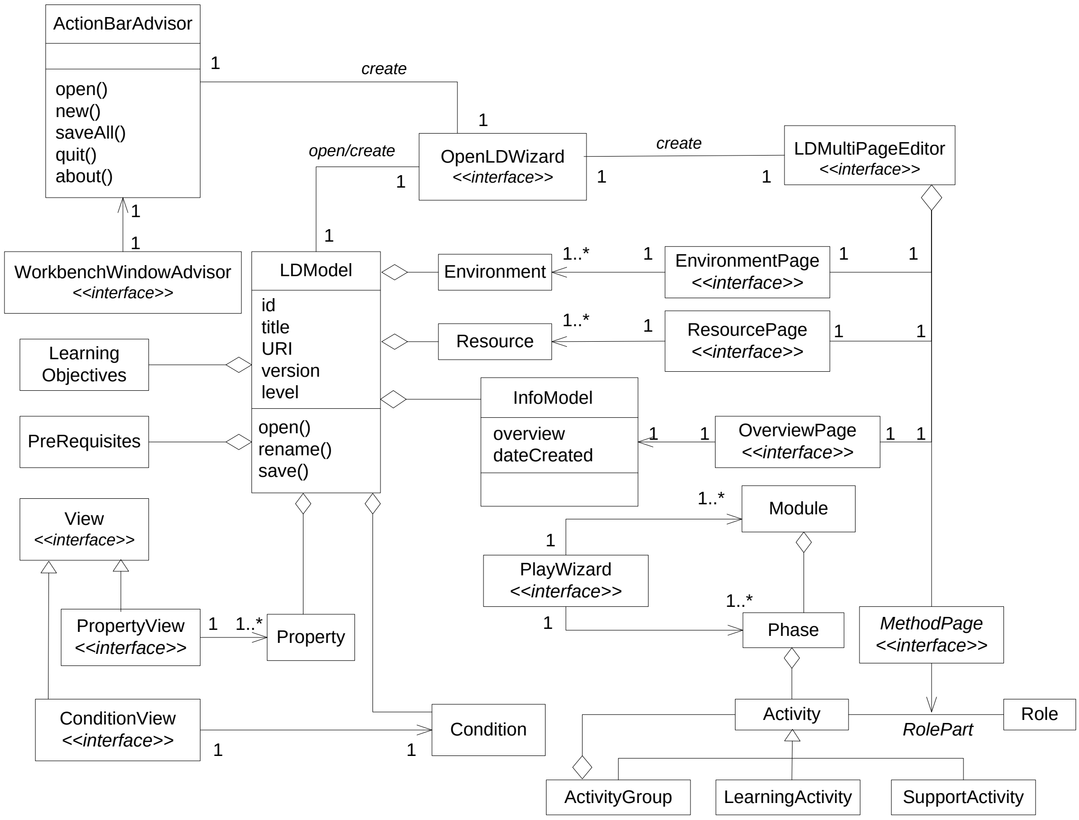
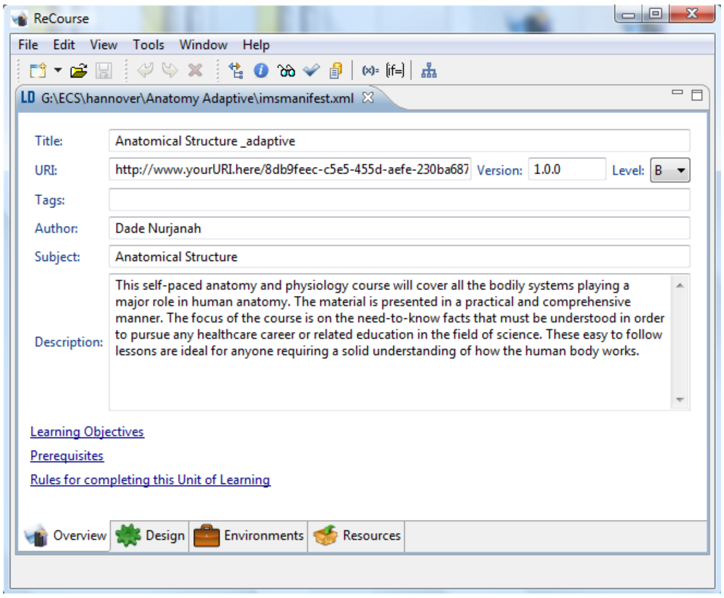


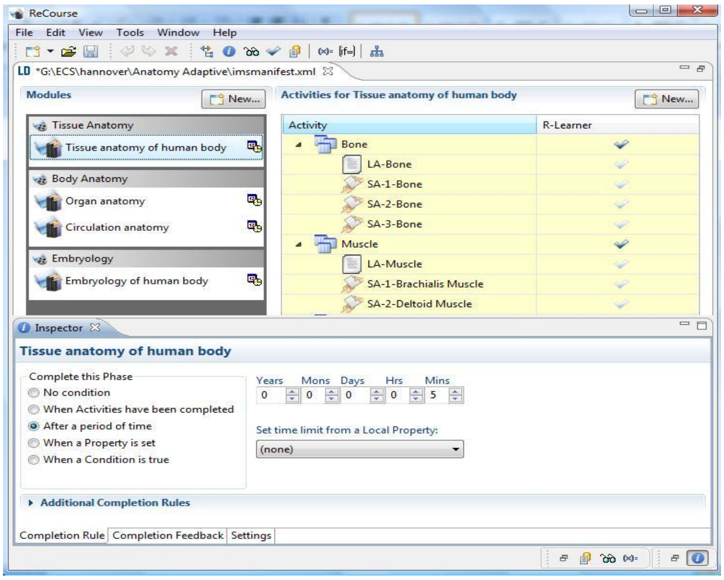
Figure 5.10 The static model of ReCourse

5.3.3. Interfaces

In this section, screenshots of ReCourse are presented. The overview of the course is displayed in Figure 5.11 (a). Teachers or learners can check out course overviews to find suitable courses. However, they may not find any information on the overview screen because ReCourse allows learning designers to leave it blank. Figure 5.11 (b) presents an authoring screen on which learning designers can see and update UoLs. The screen displays modules and phases on the top-left pane and activities (learning activities, support activities, and activity groups) on the top-right pane. Furthermore, it presents completion rules at the bottom of the screen.



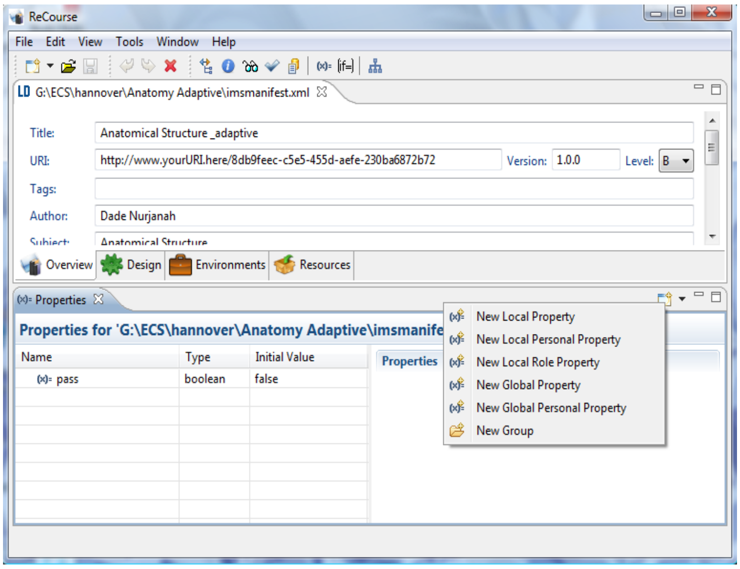
(a)



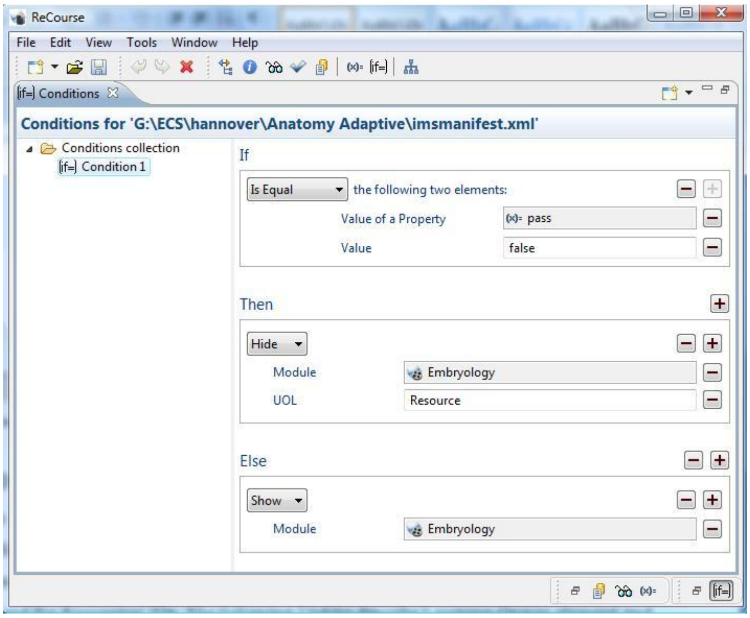
(b)

Figure 5.11 (a) The overview page in ReCourse (b) Modules, phases, activities, and completion rules

The screens for authoring adaptations are presented in Figure 5.12: for authoring learner model and other properties (Figure 5.12 (a)) and for authoring user-defined rules or conditions (Figure 5.12 (b)).



(a)



(b)

Figure 5.12 (a) The screen of authoring properties (b) The screen of user-defined rules

5.4. Collaborative ReCourse Prototype

This section discusses all new functions and the software architecture. New features are added to ReCourse consisting of user group management, History, Notes, and a feature for linking learning/support activities to external learning content. The architecture of Collaborative ReCourse is presented in Figure 5.13.

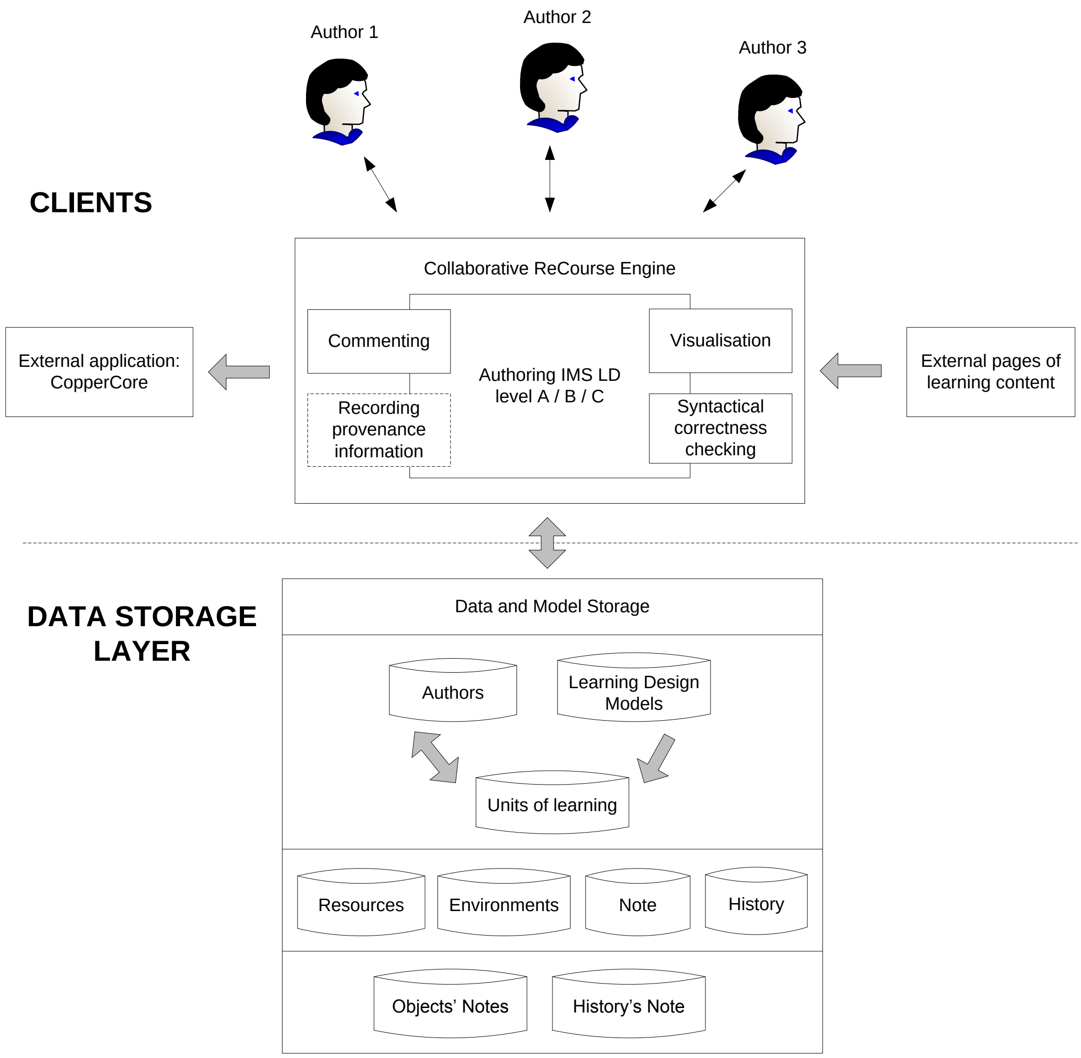


Figure 5.13 The architecture of Collaborative ReCourse

The architecture in Figure 5.13 is the ideal architecture of Collaborative ReCourse. The prototype that has been developed in this research is a stand-alone application that can run a simulation of asynchronous collaborative authoring of IMS LD levels A, B, and C. The client application runs from the same machine where the data are stored. In the future, the data storage should be placed in a server and clients should be able to run Collaborative ReCourse from remote machines.

5.4.1. Group management

In Collaborative ReCourse, one workgroup creates oneUoL. Authors are divided into two categories which are guest, who can read the UoL, and authors, who can read and modify the UoL. All authors in the group have the same authority in authoring as they are all free to modify the UoL. On the other hand, the first author has an authority to add new members into the group. The first author is identified as the coordinator, while the others are called members. These terms are only used to distinguish their authority regarding the addition of new members.

There are two files for managing author information: allauthors.xml that records all authors' information comprising username and password, and ldauthors.xml that records authors in one workgroup. For example, for an author who contributes in N workgroups, his data can be found in allauthors.xml file and in N files of ldauthors.xml. The data-type definitions for both files are presented in Table 5.1.

Table 5.1 The data-type definitions for author information

<table>
<tr><td>allauthors.xml</td><td>Maintains usernames and passwords of authors, valid for all UoLs.</td></tr>
<tr><td colspan="2"><authors>
    <!—zero or more <i>author</i> elements-->
    <author>
        <name/>
        <password/>
    </author>
</authors></td></tr>
<tr><td>ldauthors.xml</td><td>These data are valid for one UoL. This file maintains usernames, roles, and last-access dates and times.</td></tr>
<tr><td colspan="2"><authors coursename="">
    <!—zero or more <i>author</i> elements-->
    <author>
      <name/>
      <role/>
      <lastaccess/>
    </author>
</authors></td></tr>
</table>

5.4.2. History

One of the awareness features in Collaborative ReCourse is History which is likely to be activity log that maintains a history of users' actions. The history of users' actions is provided for several reasons. Firstly, it provides information about activities during the creation of the document (satisfying workspace awareness by providing information on what has been done by whom). Secondly, it provides a means of monitoring authors' actions from the beginning of the collaborative authoring activity in an academic environment. Once users click the History tab from the main form, they are forwarded to a list of updates that have been made. Updates are placed at the top of the list. Thirdly, it provides an effective means of providing an overview of what has been done to the document itself, identifying recent changes to the artefacts, and minimising duplication of the authors' efforts. Authors must be able to view the actions taken by other authors and gain a better understanding of the history of the document.

Every time an author performs an action within the system, the event will be added to History and it will be displayed as the top record. Unlike notes that can be posted into Note, objects' Notes, and History's Note, provenance information is recorded only in one History. However, authors can record comments about an action. All comments are maintained in the History's Note which is discussed in the next section. The purpose of this feature is to generate information about authors' actions and the interactions between authors and the system in order to provide workspace awareness and hence satisfy the requirements R1 as outlined in Section 5.2.2. A screenshot of History is presented in Figure 5.14.

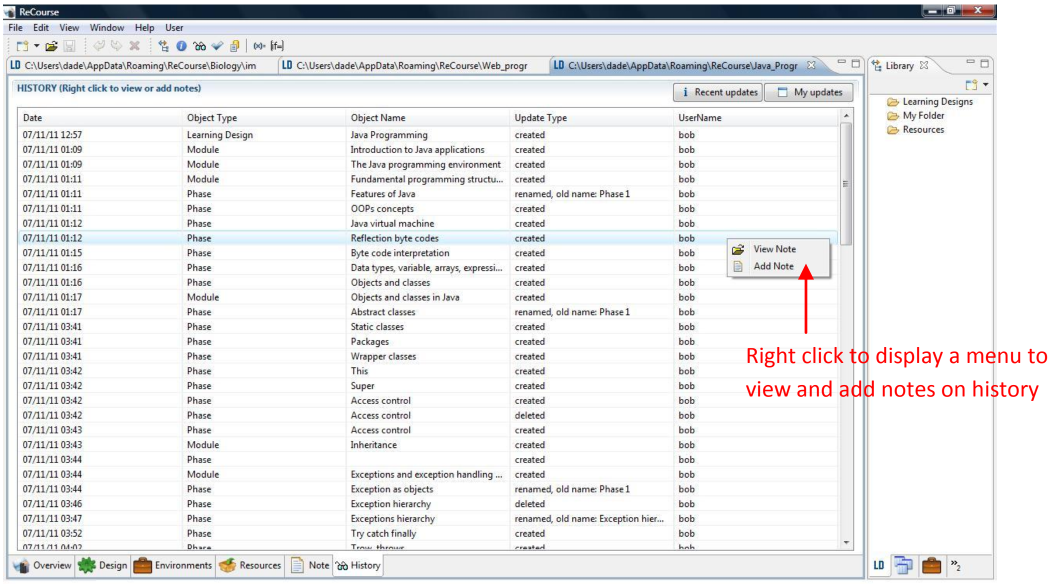


Figure 5.14 History and list of updates made by a certain author

Queries on History are provided in Collaborative ReCourse for authors to retrieve recent updates made by themselves or by other authors. The data-type definition of History is described in Table 5.2.

Table 5.2 The data-type definitions for History information

history.xml	This file records all updates made in authoring a UoL.

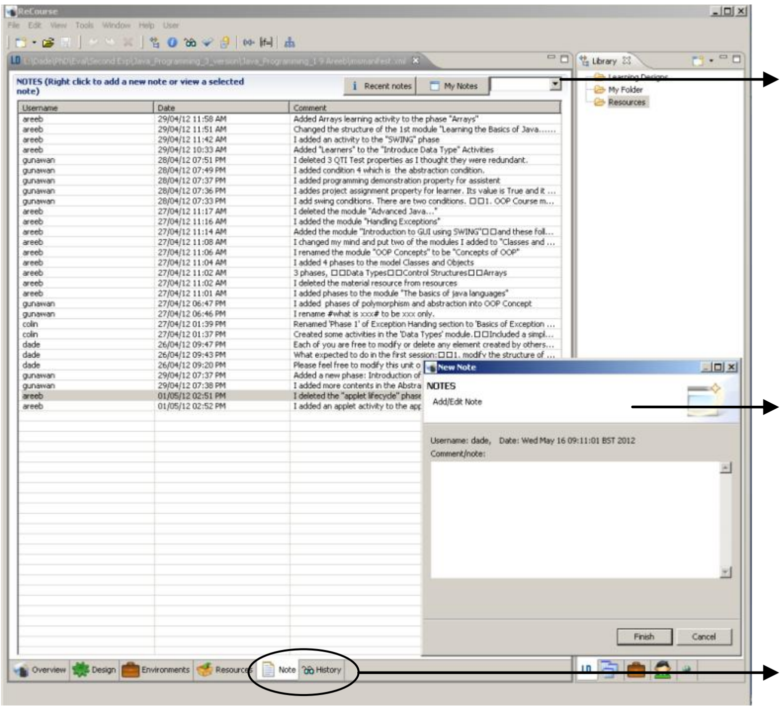
```
<histories coursename="" objecttype="">

    <!—zero or more history elements-->
    <history>
        <date/>
        <username/>
        <objecttype/>
        <objectname/>
        <updatetype/>
    </history>
</histories>
```

5.4.3. Notes

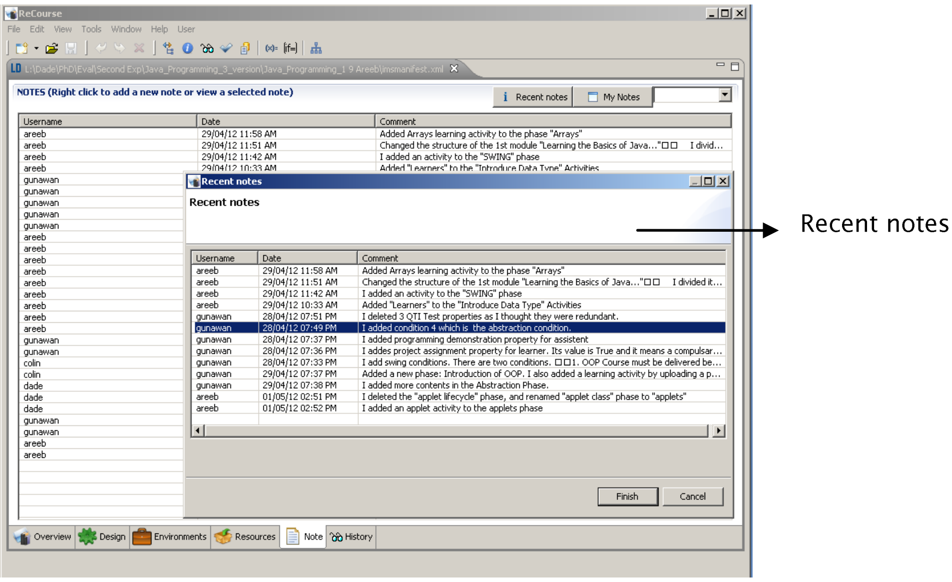
Providing support for commenting during development is crucial to the collaborative authoring process. Notes are therefore designed to satisfy the requirements outlined in Section 5.2.2. Authors need to be able to comment on the UoL, but this should not disrupt the process. In the Collaborative ReCourse, Notes are designed to serve different purposes during the UoL authoring process. Notes are designed tostore short comments from authors to avoid distracting the focuse of authors working on authoring tasks. Comments for authors are not classified based on the content of the comments to avoid authors getting confused about which category a comment should be posted in.

5.4.3.1. Note

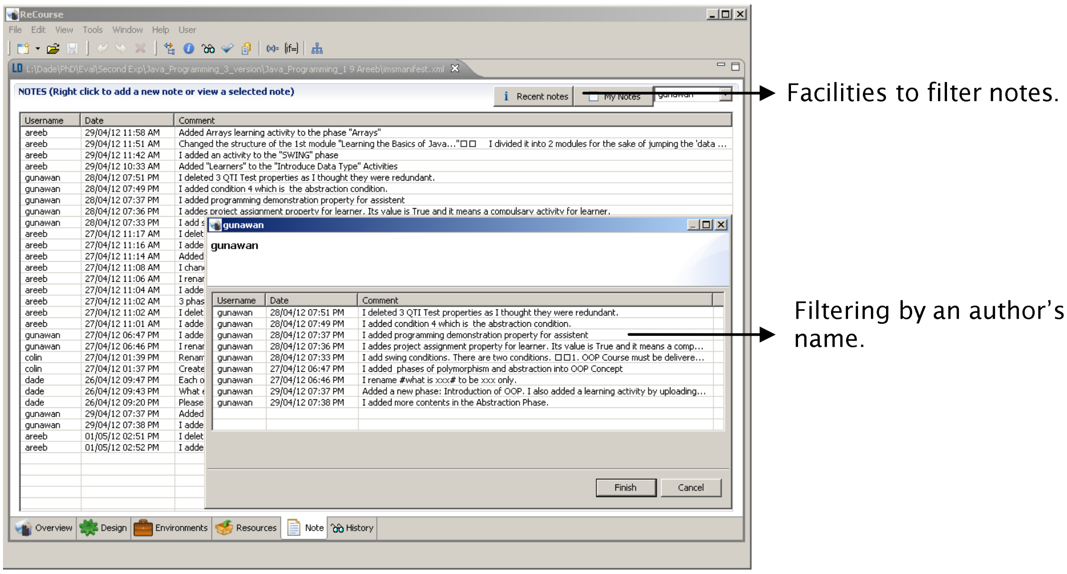
Authorsmay possess notes within the manuscript. Authors are required to express their point of view which can include opinions, suggestions, critiques, or arguments according to their personal knowledge. To make it easy for authors to find particular notes, notes are placed in Note, History's Note, and objects' Notes as discussed in Section 5.2. Authors can post notes into Note; this helps authors to post notes about the whole UoL or about actions made on the UoL. Some screen shots of Note are described in Figures 5.15.



(a)



(b)



(c)

Figure 5.15 (a) The main screen of Note (b) Recent notes (c) Notes filtered by an author's name

The aim of filtering is to remind authors of what comments they have posted and what notes other authors posted, and to make them aware what other authors have recently done and thought. Note interfaces are designed similarly to other existing ReCourse's screens in order to prevent authors from having to spend time learning and becoming familiar with new designs.

Table 5.3 Data-type definition of Note

note.xml	This file maintains notes posted by authors into Note.
<comments coursename=" " URI=""> <comment username="" date="dd/mm/yyhh:mm AM/PM"/> </comments>	

Table 5.4 A Java class declaration for a note with two functions to load/save the note from/into the XML-based Note file

```
publicclass Note {
   private String fUserName;
   public String fComment;
   public String fDate;
   DateFormatformatter = newSimpleDateFormat("dd/MM/yyhh:mm a");

publicvoidfromJDOM(Element element) {
   // load a note
       fComment =  element.getText();
       fUserName= element.getAttributeValue(LDModelFactory.
       NOTE_userName);
       fDate = element.getAttributeValue(LDModelFactory.NOTE_date);
   }

   public Element toJDOM() {
      // save a note
      Element authorComment = new Element(getTagName());
      if(StringUtils.isSet(getUserName())) {
         authorComment.setAttribute(LDModelFactory.NOTE_userName,
         getUserName());
      }
      if (StringUtils.isSet(fDate)) {
          authorComment.setAttribute(LDModelFactory.NOTE_date, fDate); }
      if (StringUtils.isSet(fComment)) {
          authorComment.addContent(fComment); }
      returnauthorComment;
   }
}
```

Table 5.5 A Java class declaration for the general Note with two functions to load/save all notes from/into the XML-based note file

```
publicclass Notes {
   privateILDModelfLDModel;
   private List<Note>fNotes = newArrayList<Note>();
   private String fCourseName, fURI;
   privateBooleanfDoNotify = true;

   public Notes(Notes notes) {
      setLDModel(notes.getLDModel());
      setCourseName(notes.getCourseName());
      setURI(notes.getURI()); }

publicvoidfromJDOM(Element element) {
   // build Note (a list of notes)
      fCourseName = element.getAttributeValue(LDModelFactory.
      NOTES_courseName);
      fURI = element.getAttributeValue(LDModelFactory.NOTES_URI);
      for(Object o : element.getChildren(LDModelFactory.NOTE_TAG))
         { Element child = (Element)o;
           Note note = new Note();
           note.fromJDOM(child);
           fNotes.add(note);}    }
```

```
   public Element toJDOM() {
// save Note (a list of notes)
      Element comments = new Element(getTagName());
      if (StringUtils.isSet(fCourseName)) {
       comments.setAttribute(LDModelFactory.NOTES_courseName,fCourseName);}
      if(StringUtils.isSet(fURI)) {
          comments.setAttribute(LDModelFactory.NOTES_URI, fURI);}
      if (fNotes!=null) {
          for(INoteModel note : fNotes) {
               Element comment= note.toJDOM();
               if (comment != null) {comments.addContent(comment);}}
      }
      return comments;
    }
}
```

5.4.3.2. Objects' Notes

When a UoL grows larger and larger, the recording of all notes in one storage (Note) will be detrimental to the objective of Notes which is to enhance authors' workspace awareness; authors will find it difficult to find notes for particular objects or actions. Object's Notes are designed to help authors to post notes about an object. An objects' Note is linked to a module with its underlying phases and activities, a resource, a property, and a condition (rule). A link to an object's Note and its screen are shown in Figure 5.16.

The application of objects' Notes is inspired by Talk Pages in Wikipedia as one Talk Page is automatically created when a wiki document is created. All authors understand that a Talk Page is a place where they can discuss the corresponding document. In IMS LD authoring, modules-phases-activity groups-learning/support activities are hierarchically structured. Considering that all underlying elements of a module are closely related, only one object's Note is created for the module and the underlying elements; the Note can be accessed through the module or through its underlying elements. This approach will avoid the existence of too many objects' Notes that could possibly lead to a condition where only a limited number of objects' Notes are used by authors.

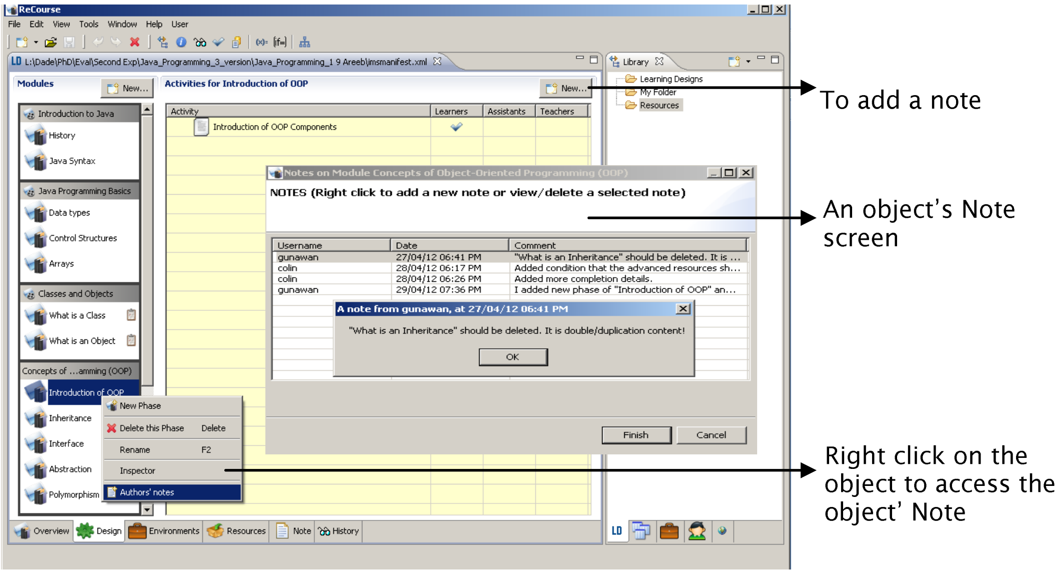


Figure 5.16 An object's Note for the phase'Introduction of OOP Components'

The data-type definition of objects' Notes are presented in Table 5.6. In addition, the Java class declaration is presented in Table 5.7.

Table 5.6 The data-type definition of objects' Notes

[objectName].xml	This file maintains notes posted by authors into an object's Note.
<comments objectname="" objecttype=""> <!—zero or more *comment* elements--> <comment username="" date="dd/mm/yyhh:mm AM/PM"/> </comments>	

Table 5.7 A Java class declaration for objects' Notes

```
publicclassNotesForObjects {
   privatePropertyChangeSupportfChangelisteners;
   privateILDModelfLDModel;
   private List<Note>fNotes;
   private String fObjectType, fObjectName, fCreated;
   private String fObjectFileName;
   private File fObjectFile;
   private booleanfDoNotify = true;

   publicNotesForObjects(String targetFolder,String type,String name){
        setObjectName(name);
        setObjectType(type);
        if (fNotes==null) { fNotes = newArrayList<Note>(); }
        fObjectFileName=fObjectName+".xml";  //$NON-NLS-1$
        fObjectFile = new File(targetFolder,fObjectFileName);
        if (fObjectFile.exists()) {loadNote(); }
   }
}
```

5.4.3.3. History's Note,

Another kind of Notes applied in Collaborative ReCourse is History's Note. Its aim is to help authors to insert comments about particular actions. In History's Note, a note posted by an author will be attached to an action; notes are grouped according to the actions they were posted for.

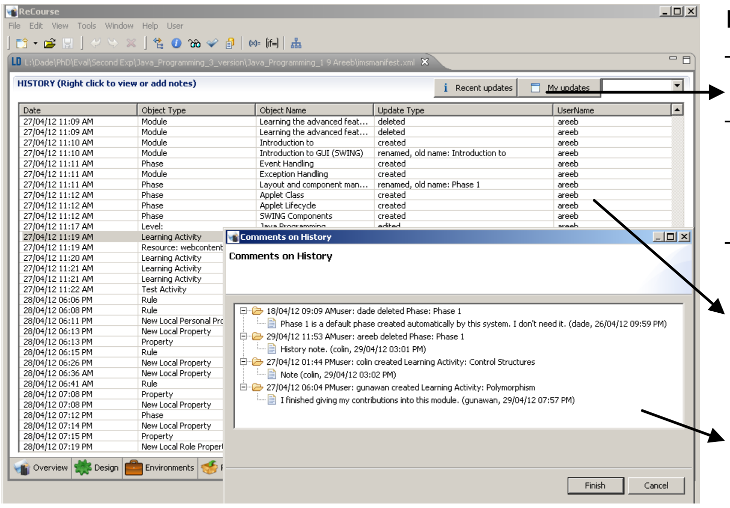


Figure 5.17 The History's Note

The History's Note is provided for several reasons. Firstly, it offers authors an effective means of providing a further explanation of what has been done such as the motivation and the advantages of their actions. Secondly, it provides a means to give authors an understanding of other authors' actions and to avoid contradictive actions that rollback artefacts to a previous status. Once the author has right clicked on the History form, they are forwarded a hierarchical list of notes on the history records.

Table 5.8 A Java class declaration of History's Note with a function to retrieve particular notes

```
publicclassNotesForHistory {
   private List<HistoryNote>fHistoryNotes=new
   ArrayList<HistoryNote>();
   private String fType;
   private String fName;

  publicHistoryNotefindFNote(HistoryElement selected){
                                  HistoryNotefoundNote=null;
     for (HistoryNotenote:fHistoryNotes) {
         if (equal((note.getHistory()),selected)) {
             foundNote=note; }
     }
     returnfoundNote;
   }
}
```

Table 5.9 Functions to build and save History's Note

```
publicvoidcreateHistoryNotes(){
    String targetFolders=fLDModel.getHistoryFile().getParent();
    fHistoryComments=newNotesForHistory();
    fHistoryNoteFile = new File(targetFolders+"\\note","historynote.xml");
    fHistoryFile = new File (targetFolders,"history.xml");
}

publicvoidloadComments() throwsIOException, JDOMException {
    if (fHistoryComments==null) { createHistoryNotes(); }
    if (fHistoryNoteFile.exists()) {
        fHistoryComments.fromJDOM(fHistoryNoteFile); }
}

publicvoidsaveComments() throwsIOException {
    if (fHistoryComments==null) { createHistoryNotes(); }
    fHistoryComments.toJDOM(fHistoryNoteFile, "history file",
    fLDModel.getTitle());
}
```

5.4.3.4. The Static Model

The static model of ReCourse has been presented in Figure 5.10. A number of classes are added consisting classes for updating, querying, and displaying Notes and History. Figure 5.18 captures the main new classes.

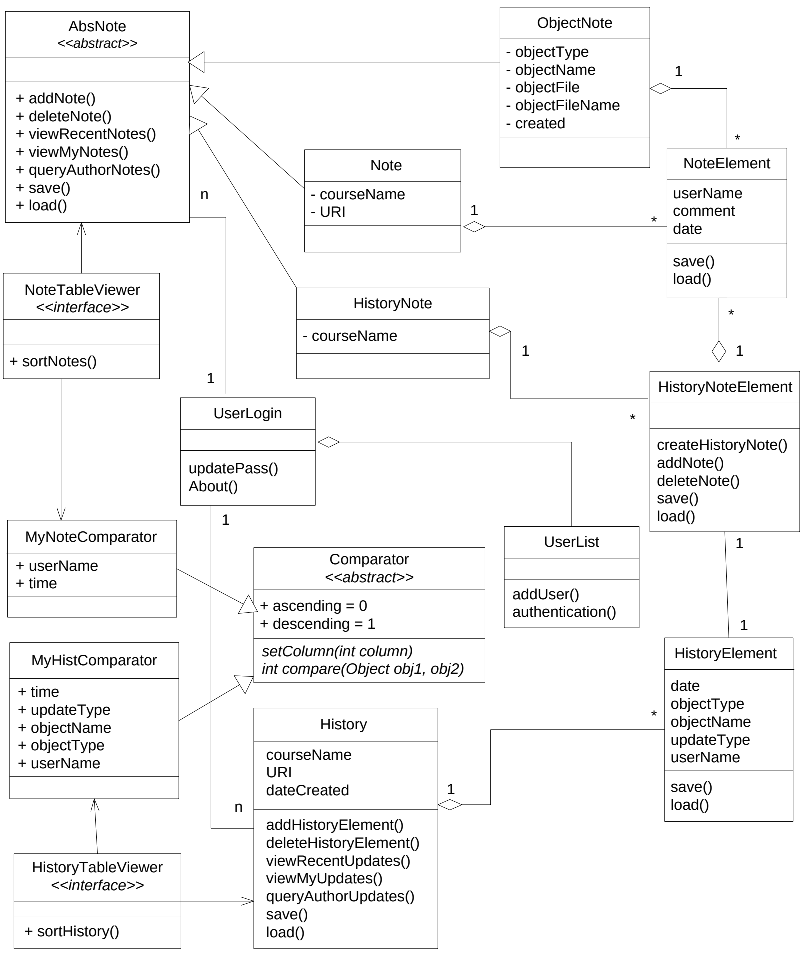


Figure 5.18 The static model of awareness features

All those classes are added in module LDAuthor, which is the main module in ReCourse. Table 5.10 presents a Java class declaration for UoL. This function is extended by calling functions to load Note, History, and History's Note. On the other hand, an object's Note will be loaded when the object is accessed.

Table 5.10 A Java class declaration of UoL with a function to perform a UoL

```
publicclassNewLDWizard{
    publicstatic String ID=LDAuthorPlugin.PLUGIN_ID+ ".NewLDWizard";
    privateNewLDWizardPagefMainPage;
    privateNewLDWizardPageLocationfLocationPage;
    privateNewLDWizardPageOverviewfOverviewPage;
    privateLDTemplateManagerfTemplateManager;
    @Override

    public booleanperformFinish() {
        Authentication authentication=new Authentication();
        // Get template
        ILDTemplate template = fMainPage.getSelectedTemplate();

        if(template == null) { returnfalse; }
        // Create Root folder
        File targetFolder = fLocationPage.getFolder();
        targetFolder.mkdirs();

        // Manifest, Note, History file
        File manifestFile=new File(targetFolder,"imsmanifest.xml");
        File noteFile = new File(targetFolder, "note.xml");
        File historyFile = new File(targetFolder, "history.xml");
        File authorFile = new File(targetFolder, "ldauthors.xml");
        OrganiserComposite.setAuthorFile(authorFile);

        if(template instanceofClonedLDTemplate) {
              File copiedLD = fLocationPage.getCopiedFolder();
              ((ClonedLDTemplate)template).setCopiedFolder(copiedLD);
        }
        // Then create it
        try {template.create(manifestFile,noteFile,historyFile);}
        catch(LDAuthorException ex) {
        MessageDialog.openError(getShell(),Messages.NewLDWizard_1,
        ex.getMessage());
        }

        // Add an Organiser Entry
        IOrganiserLDorganiserEntry = OrganiserModelFactory.
        createOrganiserLD(fLocationPage.getNameText(), manifestFile);

        // User authentication
        try {authentication.createUserFile(new
              File(fLocationPage.getFolder() +"\\ldauthors.xml"),
              fOverviewPage.getUOLTitle());
              LDAuthorActionBarAdvisor.setUserMenu();
        } catch (IOException e) { // TODO Auto-generated catch block
        e.printStackTrace(); }

        // Open the Editor
        EditorManager.openLDEditor(organiserEntry.getName(),
        organiserEntry.getFile());
        returntrue;
    }
}
```

5.5. An Additional Feature

In addition to all of the features mentioned above, the prototype also added a function for learning material reuse. This is not the focus of the research, but related to one problem in authoring: reuse and reusability. The tool enables authors to reuse existing learning content which is implemented in the form of a learning content gallery, from which authors can select appropriate content. Such features are aimed at decreasing authors' efforts when creating learning content and to enhance authors' workspace awareness of the availability of learning materials which are to be reused. Reuse is carried out in certain phase of a learning objects lifecycle as established in a previous study (Collis and Strijker, 2004).

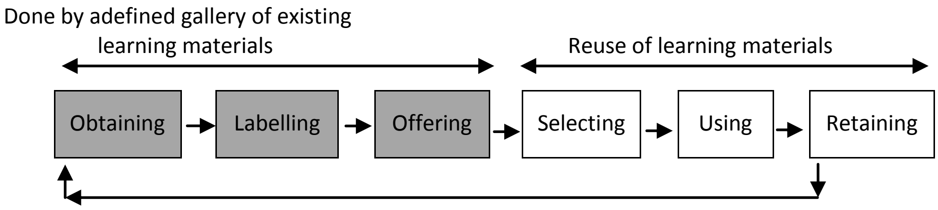


Figure 5.19 Reuse phase in a former learning object's lifecycle

The proposed authoring approach assumes that learning content for certain topics is available in open content management systems, open repositories, or wikis/semantic wikis. Reusing existing learning content will cut out three phase of the learning object lifecycle; obtaining, labelling, and offering, as presented in Figure 5.19. Reuse in this tool is implemented in 'selecting' and 'using'phases, whereas the 'retaining' phase tends to repurpose learning content by combining it with other content.

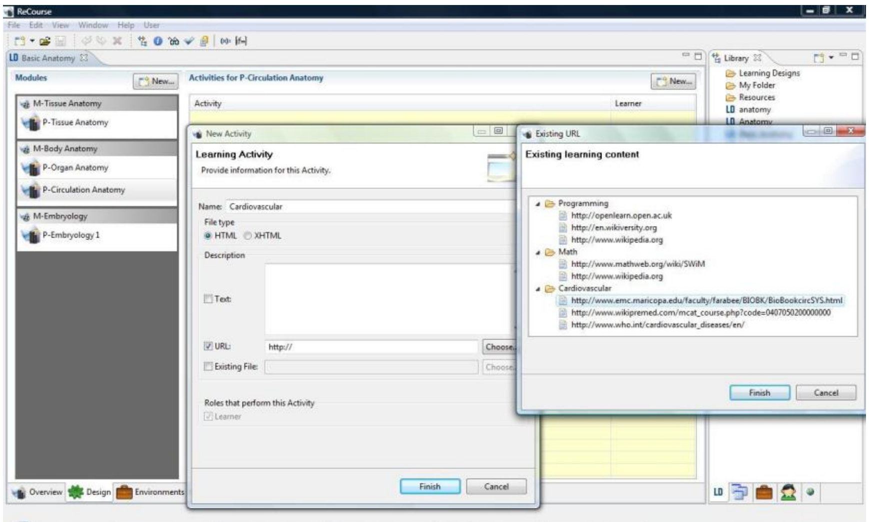


Figure 5.20 Gallery of existing learning materials

5.6. Summary

ReCourse provides functions for creating learning designs in IMS LD formats. Extending ReCourse by adding some features for collaboration is better than building a new authoring tool from scratch that would be time-consuming. The advantage of ReCourse is that it produces syntactically correct learning designs in IMS LD format levels A, B, or C. Another advantage is a connection to an IMS LD player, CopperCore, that can be able to help authors to create correct learning designs. In addition, ReCourse provides a visualisation function, so that authors can see the organisation of the learning design that is being authored.

The prototype of Collaborative ReCourse was designed for asynchronous collaboration. The workspace awareness information was collected from learning designers in the form of notes maintained in Note, History's Note, and objects' Notes, or automatically recorded in the form of provenance information in History. In addition, another feature to improve authoring is a gallery of existing materials from which learning designers can chose appropriate learning content. This feature, however, is not a focus of this research. This tool is used in experiments to test the hypothesis. Chapters 6 and 7 discuss the designs and the data analysis results of the experiments.

Chapter 6 Experiment 1: Workspace Awareness Study

Chapter 5 has described the analysis and design of the prototype of Collaborative ReCourse that is used in evaluation to test the hypotheses. The objectives of the evaluation are to investigate how learning designers develop learning designs, how Notes and History affect the workspace awareness of authors, and how Notes and History affect authors' work and the quality of authoring output.

This chapter discusses the design of the experiments that consist of a between-group quantitative inquiry with questionnaires and a qualitative inquiry through a combination of observation and interviews. The aim of the experiments was to study whether Notes and History could enhance learning designers' workspace awareness and whether they could positively affect the authoring process. Measurements were applied to learning designers' understanding of what has happened during authoring and to the quality of output. The experiment also investigated the way learning designers approach the development of learning designs collaboratively. This is related to the granularity of collaborative authoring. Table 6.1 shows the relationships among the experimental studies, research questions, and hypotheses.

The first experiment is a quantitative evaluation with questionnaires. The experiment received an Ethics Committee approval under reference number ES/11/12/001. The second experiment is a mixture of quantitative and qualitative evaluations that applied a workgroup observation and a questionnaire combined with a structured interview. This experiment received an Ethics Committee approval with a reference number 1457. This chapter presents the design and the statistical analysis results of the first evaluation.

Table 6.1 Relationships among the experimental studies, research questions, and hypotheses

Hypotheses	Research questions	Experimental study
Hypothesis 1: Learning designers who work with a collaborative authoring tool that provides Notes and History will have higher workspace awareness than those working with an authoring tool that does not provide Notes and History.	Sub-question 5: Do Notes and History improve workspace awareness of learning designers in authoring adaptive learning resources in IMS LD?	Experiment 1
Hypothesis 2: Measures of the soundness of the learning resources produced will be higher for learning designers working with an authoring tool which supports workspace awareness.	Sub-question 6: Do Notes and History improve the quality of learning designers' work that leads to the enhancement of the quality of adaptive learning resources in IMS LD?	Experiment 2
	Sub-question 4: at which level of granularity is the collaborative authoring of IMS LD carried out?	Experiment 2

6.1. The Experiment Design

This section describes the experimental methodology, materials, procedures, and the questionnaire designs. This evaluation tested Hypothesis 1.

6.1.1. Research Methods

Experiment 1 is a quantitative experimental study with a between-group method. In this experiment, participants were divided into two groups: Group 1 and Group 2. Participants in Group 1 worked with ReCourse, while participants in Group 2 worked with Collaborative ReCourse with Notes and History provided. The number of participants in Group 1 is equal to the number in Group 2. Participants were those who had teaching experience in the classroom or laboratory, such as lecturers, teaching assistants, or demonstrators. All participants have an educational background in techniques or engineering. They were either the teaching staff of Telkom Institute of Technology in Indonesia or PhD students at the University of Southampton in the UK.

Participants were recruited by personal emails which included general information about the experiments, a brief introduction to IMS LD, and information about the tools they would use in the experiments. The number of participants required for each experiment was estimated by G*Power software (Hendrix et al., 2008). The expected sample size is 21 for each group, obtained by using the given values of:

Tail(s) as 1

Effect size d as 0.8

Alpha error probability as 0.05

Power as 0.8

Test-family as T-test

Statistical-test as Means: differences between two independent means (two groups)

6.1.2. Experimental Materials

Two sets of documents were given to participants: an introduction document and a questionnaire. The introduction document was sent by email to participants to give them an understanding of the terms, definitions, formats, and tools used in the questionnaires. The document is organised according to the following structure:

- A brief introduction to IMS LD. This section briefly explains the objectives of IMS LD and definitions in IMS LD.
- Concepts underlying IMS LD. This section discusses the IMS LD's representation, format, and symbols with their meanings.
- A case study. This section describes how a subject is represented in a UoL in IMS LD format and how it is built using ReCourse. As an example, a UoL of 'Anatomy and Physiology' is presented. To give participants a better understanding, some screenshots captured in ReCourse are presented.
- Additional material: how a UoL in IMS LD format is delivered in an IMS LD player. The output of ReCourse is learning resources organised in a UoL in IMS LD format that is ready to be delivered to learners. This section describes a UoL delivery through an IMS LD player named CopperCore.
- Collaborative features of ReCourse. The questions are presented to participants in Group 2. It describes the prototype of Collaborative ReCourse. In this section participants can find the difference between ReCourse and Collaborative ReCourse.

The questionnaires consist of a number of questions classified into three main themes:

2. Participants' profiles. Questions classified in this theme aimed to test the difference between the profiles of participants in Group 1 and Group 2. If a difference was found, then the participants' profiles must be considered as a predicting variable in further evaluation.
3. The importance of particular information that is classified into two types including:
   a. Information about the UoL itself. Questions regarding this kind of information aimed to investigate what kind of information about courses teachers considered important. This study was to investigate participants' views on the availability of such information in ReCourse and Collaborative ReCourse.
   b. Information related to the development of UoL. Questions regarding this kind of information were motivated by the fact that information regarding a UoL is supposed to refer to and describe the development process. This study aimed to investigate whether teachers consider such information to be important or not. Furthermore, it studied the sufficiency of such information in ReCourse.
4. Learning designer's awareness. The effect of Notes and History is identified in two authoring cases: IMS LD level A, which defines non-adapting materials and IMS LD level B, which defines adapting materials. The aim of dividing separating the cases is to prove that Notes and History enhance learning designers' awareness in authoring non-adapting materials as well as authoring adapting materials. Themes, tasks, and the affected IMS LD layers of this experiment are shown in Figure 6.1.
5. The usefulness and the ease of collaborative features. This aimed to investigate the usability of Notes and History.

The complete materials can be found in Appendix A for an introduction file and Appendix B for the questionnaires.

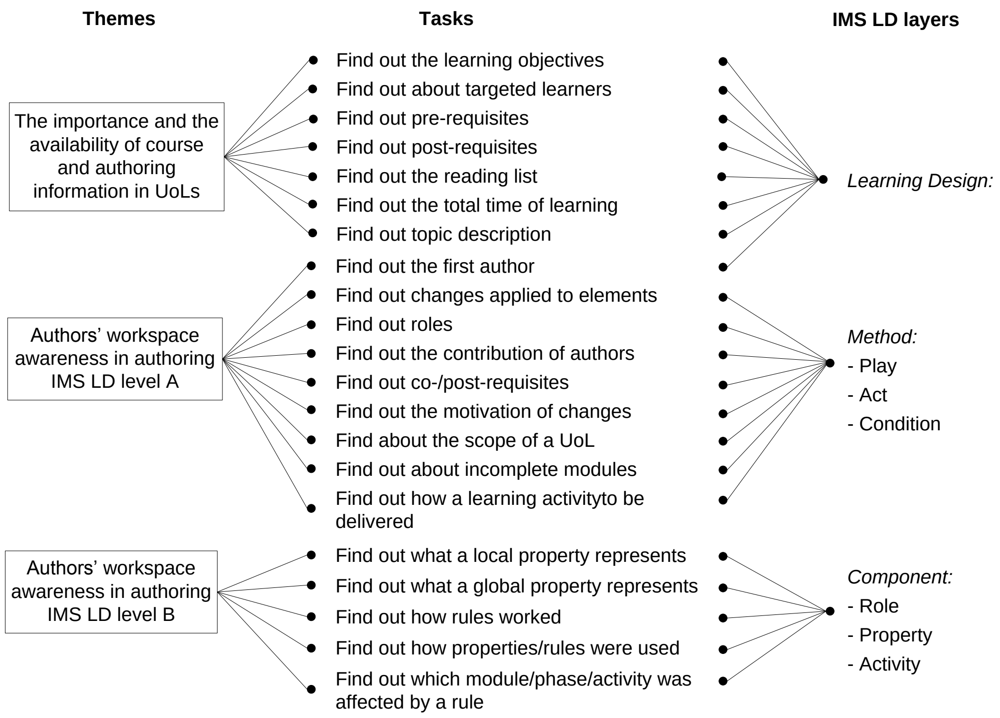


Figure 6.1 Themes, tasks, and affected IMS LD layers or elements in Experiment 1

Participants were required to follow the instruction on the questionnaires in order to perform authoring tasks using either ReCourse or Collaborative ReCourse which were installed on a desktop computer. Most of the questions used a 4-point Likert scale that did not allow participants to be neutral in any case. The aim behindthe absence of a neutral point in the questionnaires was to minimise desirability bias (Garland, 1991; Trochim, 2006).

Participants were required to undertake two kinds of tasks:

1. Observe UoLs
   Two UoLs, which were biology (California-University, 2009) and web programming (Tufts, 2011), contained only a few lessons were provided. These courses were chosen on the assumption that all participants would be familiar with them as they comprise basic topics on biology and web programming.
2. Update a UoL according to artificial authoring scenarios
   For these tasks, Java programming (Pollock, 2011) was implemented in a more completed UoL than the previous UoLs. Participants were required to made some updates on the UoL.

6.1.3. Experimental Procedures

Questionnaires 1 and 2 took place at different times. Participants in each group were not notified about the existence of the other group, which worked with a different tool and a different questionnaire. For each group, the experimental procedure consisted of the following steps:

1. Participants were welcomed and thanked for participating in the experiment.
2. Participants received an explanation of the experimental evaluation such as the objectives, procedures, and rules.
3. Participants in Group 1 received an explanation and brief training on IMS LD and ReCourse, whereas participants in Group 2 received training on IMS LD and Collaborative ReCourse.
4. Participants interacted with the system. Participants were given as much time as they required to complete what they were asked to do.
5. Participants were given consent information.
6. Participants were given a paper-based questionnaire and were asked to follow the instructions.
7. Participants were expected to spend no longer than 60 minutes on the questionnaire as set by the Ethics Committee of the University of Southampton that a questionnaire must be not exceed than 60 minutes. In addition, participants attended a 45-minute session on an introduction to IMS LD. The duration of the introductory session refers to a former study on the usability of IMS LD for teachers who have little or no previous IMS LD knowledge (Derntl et al., 2010; Derntl et al., 2012).

6.1.4. Questionnaire Designs

In this experiment, three UoLs were similarly implemented in both authoring tools: ReCourse and Collaborative ReCourse. The difference lies in the availability of Notes and History in Collaborative ReCourse. The UoLs were biology and web programming comprising a few elements, and Java programming which has more elements than the other two courses. The targeted information is classified into eight categories:

1. User Profiles
2. The importance of course information
3. The availablility of course information in a UoL
4. The importance of authoring information in a UoL
5. Users' workspace awareness in authoring IMS LD level A
6. Users' workspace awareness in authoring IMS LD level B
7. The value and ease of use of Notes and History
8. A gallery of existing materials (additional questions)

A mapping between questions and the targeted information is presented in Table 6.2. The table can be read by following the column headers and question numbers; for example, Information category 1 (user profiles) would be gained through questions 1a, 1b, and 2 from Group 1 and Group 2. In addition, information category 6 (users' workspace awareness in authoring IMS LD level B) would be gained through questions 19, 20, 21a, 21b, and 22 from Group 1, and through questions 21, 22, 23a, 23b, and 24 from Group 2. Similar ways can be applied to identify associations between information categories and question numbers from the table for both groups. The questionnaires can be found in Appendix B.

Table 6.2 A mapping between questions and the targeted information

Group 1's question numbers	**Question categories**								**Group 2's question numbers**	**Question categories**							
	1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
1a	■								1a	■							
1b	■								1b	■							
2	■								2	■							
3a		■							3a		■						
3b		■							3b		■						
3c		■							3c		■						
3d		■							3d		■						
3e		■							3e		■						
3f		■							3f		■						
3g		■							3g		■						
4					■				4					■			
5					■				5					■			
6					■				6					■			
7					■				7a				■				
8a				■					7b				■				
8b				■					7c				■				
8c				■					7d				■				
8d				■					7e				■				
8e				■					8					■			
9					■				9					■			
10					■				10					■			
11					■				11a			■					
12/13a			■						11b			■					
12/13b			■						11c			■					
12/13c			■						11d			■					
12/13d			■						11e			■					
12/13e			■						12							■	
14							■		13							■	
15					■				14							■	
16					■				15							■	
17					■				16					■			
18					■				17					■			
19						■			18					■			
20						■			19							■	

Group 1's question numbers	Question categories								Group 2's question numbers	Question categories							
	1	2	3	4	5	6	7	8		1	2	3	4	5	6	7	8
21a						■			20					■			
21b						■			21						■		
22						■			22						■		
23							■		23a						■		
24							■		23b						■		
25							■		24						■		
26							■		25							■	
27							■		26							■	
28								■	27							■	
29								■	28							■	
30								■	29								■
									30								■
									31								■
									32								■

The questionnaires were reviewed by two senior experts and one junior expert from related fields. The aim of this exercise was to ensure that targeted information can be gained through all the questions, and to avoid ambiguity of words in the questionnaires that can cause misunderstanding by participants. All reviewers have similarity profiles with participants that they have teaching experience as well as an educational background in engineering or technics. Because this experiment was carried out not only in the UK, but also in Indonesia in which the Indonesian language is the mother tongue, it was essential that at least one of the reviewers was fluent in both language.

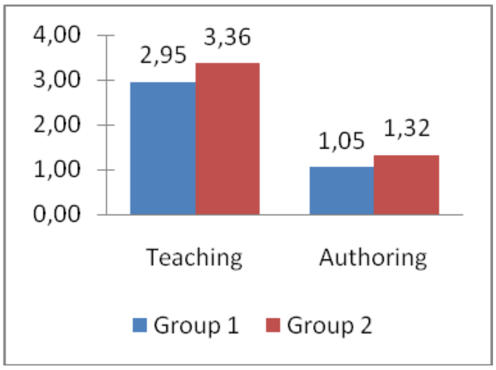
6.2. Data Analysis Results

This section discusses the statistical analysis results of the first experiment including participants' profiles, the importance of course and authoring information, authors' awareness of IMS LD level A and level B, and the influence and advantages of Notes and History.

6.2.1. Participants' Profiles

There were 44 respondents who participated in this evaluation for both questionnaires. Around 23% (10 participants) are PhD students at the University of Southampton, UK, who have worked as lecturers in their countries; the remaining participants are teaching staff at Telkom Institute of Technology in Indonesia. There were both male and female participants; of these, 36% (16 participants) were female (Nurjanah and Davis, 2012). All participants who were involved in this evaluation met the teaching experience requirement as shown in Figure 6.2. In general, participants in both groups have teaching experience, but limited working experience with IMS LD and IMS LD authoring tools.

Further information on the participants regarding their experience in working with learning authoring tools or IMS LD was also collected and is shown in Figure 6.2. On average, participants have some experience, even if limited, working in authoring. Furthermore, Figure 6.3 presents the composition of participants based on their knowledge of the three courses used in the questionnaires: biology, web programming, and Java programming.



	N	Mean	Std. Deviation
Teaching1	22	2,95	,722
Teaching2	22	3,36	,581
Authoring1	22	1,05	,213
Authoring2	22	1,32	,646

Figure 6.2 The mean scores of participants' experiences in teaching and working with IMS LD or IMS LD authoring tools

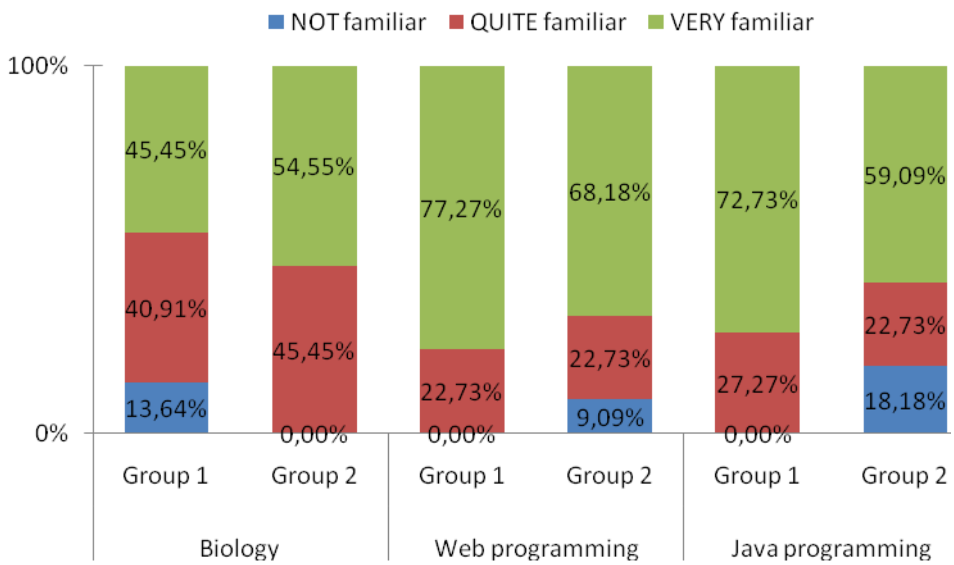


Figure 6.3 The composition of participants based on their knowledge of biology, web programming, and Java programming for Group 1 and Group 2

A MANOVA test was conducted in order to study whether participants' experiences of teaching and working with IMS LD or an IMS LD authoring tool, and their knowledge of biology, web programming, and Java programming, results in a significant difference between the profiles of Group 1 and Group 2. Hypothesis Ho for this test is that there is no significant difference between Group 1 and Group 2. With α=0.05, the test produces the following results (Table 6.3):

Table 6.3 The MANOVA test result

Effect		Value	F	Hypothesis df	Error df	Sig.
Group	Pillai's Trace	.244	2.449[a]	5.000	38.000	.051
	Wilks' Lambda	.756	2.449[a]	5.000	38.000	.051
	Hotelling's Trace	.322	2.449[a]	5.000	38.000	.051
	Roy's Largest Root	.322	2.449[a]	5.000	38.000	.051

The results show that all criteria comprising Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Rootproduced p=0.051, greater than α; hence Ho must be accepted. This means that there is no significant difference between the profiles of Group 1 and Group 2. Hence, participants' profiles should not be considered as a predicting variable in any case.

6.2.2. The Importance of Course and Authoring Information

A UoL is required to comprise the main content areas as shown in a syllabus (Altman, 1992). In the context of learning, this is information that learners should attain. On the other hand, in the context of collaborative authoring, this is the information that learning designers must create and share amongst themselves. The information includes:

1. Course Information. A UoL is required to give the following course information: course title, course number, and number of credit hours. In addition, it has to mention the pre-requisites needed as linkages to the previous courses and post-requisites in order to inform learners of why the course is important.
2. Course description and learning objectives. A course description is a text describing the general content of the course and which may also include information regarding instructional methods, grading, rules, and the like. Learning objectives inform uses of the desired learning outcomes of the course.
3. Readings and Materials. A UoL has to provide learners withdetailed information about the text books, supplementary readings, and other materials needed to complete the course.

In order to identify whether or not it is important for learning designers involved in collaborative authoring to be aware of what the group's vision is, participants were asked their vision regarding course information. This comprised the significance of the course information, such as learning objectives, targeted learners, pre- and post-requisite courses, reading lists, duration of learning, and the topic descriptions, hence, the results are presented in Figure 6.4.

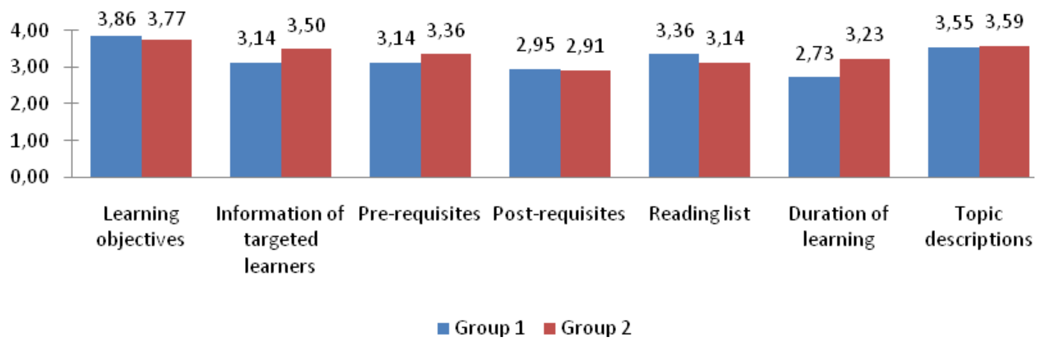


Figure 6.4 The mean scores regarding the importance of course information to be included in a UoL

Both groups considered these kinds of information to be important as indicated from the mean scores. Of those seven information items, learning objectives and pre-requisites are provided in ReCourse, but there is no information available for the remaining items. Nevertheless, there is a possibility that information on the remaining items can be found in the overviewof the course, in which learning designers can write anything in order to describe the course. After completing tasks on biology and web programming using either ReCourse or Collaborative ReCourse, participants were asked about the availability of the information. The results are presented in Figure 6.5.

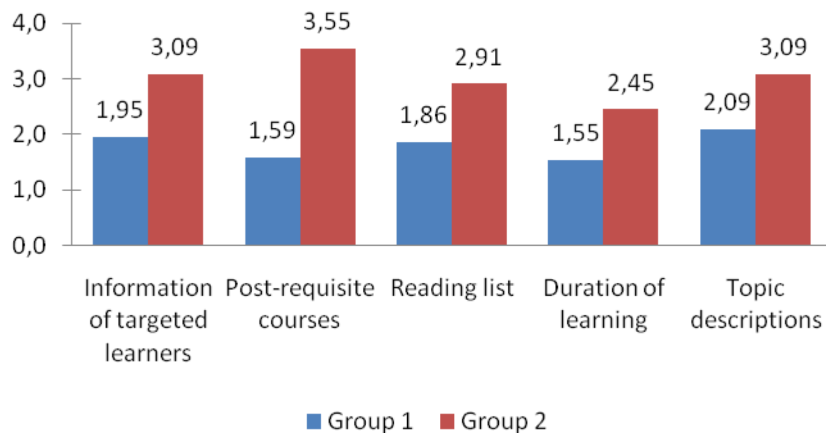


Figure 6.5 Participants' views on the availability of course information in ReCourse and Collaborative ReCourse

The graph shows that Group 2 obtained more information from Collaborative ReCourse than Group 1 did from ReCourse. However, to find out if the absence or presence of Notes and History made a significant difference to the availability of information in the UoL, a MANOVA test was carried out. Hypothesis Ho is that there is no significant difference between the availability of information in ReCourse and Collaborative ReCourse.

Table 6.4 MANOVA test results for the availability of course information

Effect		Value	F	Hypothesis df	Error df	Sig.
Group	Pillai's Trace	.626	12.731[a]	5.000	38.000	.000
	Wilks' Lambda	.374	12.731[a]	5.000	38.000	.000
	Hotelling's Trace	1.675	12.731[a]	5.000	38.000	.000
	Roy's Largest Root	1.675	12.731[a]	5.000	38.000	.000

The test produced p=0.00 ($p<0.05$) for all criteria: Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root, which means that Ho must be rejected. In other words, there is a significant difference between the availability of information in ReCourse and in Collaborative ReCourse; Notes and History give positive implications.

In addition to the course information, we argue that information regarding the authoring process itself is important for learning designers who work in collaborative authoring. Since there are a number of learning designers who contribute to the authoring, each one is required to be aware, not only ofthe course, but also of the authoring process itself. A learning designer, for example, needs to know with whom she works, or who created an artefact that she would like to reuse. For this case, some questions were distributed to participants to see if they agree with our argument regarding the importance of the authoring process information. Five examples of the authoring information were used: first author, the creation date, other authors in the group, the last update of the UoL, and the contribution of authors. The results are shown in Figure 6.6; it presents the means of participants' rating of the importance of authoring information. The response ratings ranged from 1 for not important to 4 for very important.

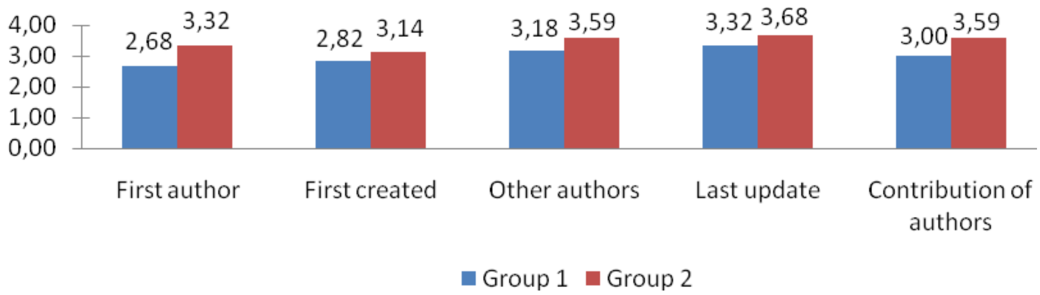


Figure 6.6 The rating averages of the importance of authoring process information

The question was posed to participants of both groups after they worked on biology which means that they all had experience working with UoLs and with Notes and History. Although Figure 6.6 shows that both groups consider Notes and History to be important, a MANOVA test was carried out. The Ho for this test is that there was not a significant difference between Group 1 and Group 2; both groups, which had or did not have working experience of Notes and History, agree that information about the authoring process was important. The test produced p=1.00 (p>0.05) for all criteria, Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largets Root, which means that there is not a significant difference between the insights of Group 1 and Group 2 regarding the importance of authoring information; both groups consider authoring information important enough to be included in a UoL.

Table 6.5 MANOVA test results for authoring information

Effect		Value	F	Hypothesis df	Error df	Sig.
Group	Pillai's Trace	.00	.00[a]	5.00	38.00	1.00
	Wilks' Lambda	1.00	.00[a]	5.00	38.00	1.00
	Hotelling's Trace	.00	.00[a]	5.00	38.00	1.00
	Roy's Largest Root	.00	.00[a]	5.00	38.00	1.00

6.2.3. Awareness of IMS LD level A

The study of the influence of Notes and History on learning designers' workspace awareness is divided into two categories: workspace awareness in authoring IMS LD level A that is related to general learning resources and IMS LD level B for adaptive learning resources. This section discusses the experiment results of the study on authors' awareness in authoring IMS LD level A. Both groups were required to observe the availability or unavailability of information regardingthe first author, changes applied to the IMS LD elements, roles, the contribution of learning designers, pre- and post-requisites, the motivation for changes, the scopes of the UoL, incomplete modules, the delivery of learning activities, and other authors who contribute.

In this theme, however, different approaches are applied to Group 1 and Group 2. Since such information is not explicitly maintained in ReCourse, participants in Group 1 are required to explore the UoLs, and then assessthe sufficiency of authoring information in ReCourse. The aim of this is to raise participants' awareness of the sufficiency/insufficiency of authoring information. Below are two examples of the questions.

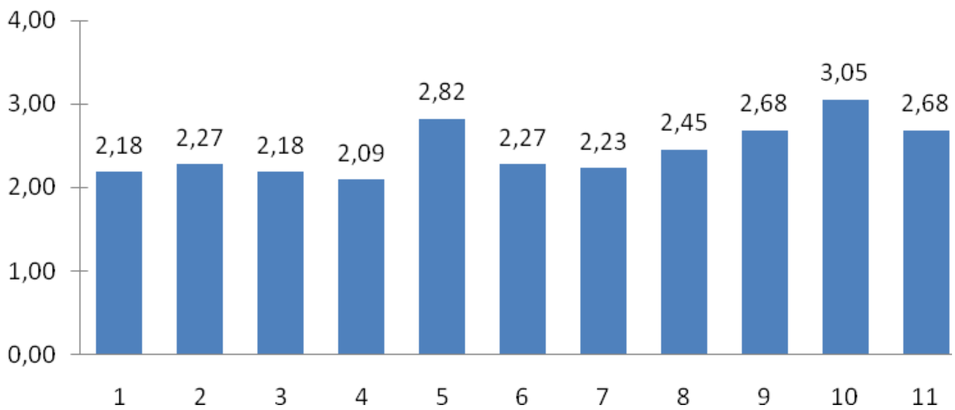
- Explore the unit of learning (UoL). Based on what you see in the UoL, how well can you guess who first created the UoL?
- Find the module 'Evolution, Taxonomy, and Microorganisms', and then take a look at the phase 'Darwin and Evolution'. Do you think the current information, if any, about the module and the phase is sufficient to understand them?

On the other hand, these kinds of information are provided in Collaborative ReCourse. Participants in Group 2 were asked to explore the UoLs, and then find specific information regarding authoring. There was no guidance offered to participants concerning where they could find the corresponding information needed to answer the questions. They were free to explore the UoL to find any relevant information that had been written by other learning designers in Note, History's Note, or objects' Notes, or perhaps in History. Correct or incorrect answers from participants indicate their level of awareness in authoring IMS LD. The questions are:

- Besides you, there are three other learning designers participating in creating this UoL. They are Alice, Bob, and Claudia. One of them has deleted a module. Who did it, which module was deleted, and for what reason(s)?
- There was a problem on the first version of this UoL in that it had too many topics. What is the solution for this problem?

A. Results from Group 1

Figure 6.7 presents the statistical analysis results regarding information sufficiency in ReCourse from Group 1. The study applied a 4-point Likert scale ranging from 1 for insufficient to 4 for very sufficient. The results indicate that in general, participants did not find sufficient information about the authoring process in ReCourse.



1: The first author
2: Changes to elements
3: Roles
4: Contribution of authors
5: Pre-requisites
6: Co/post-requisites
7: The motivation of changes
8: The UoL's scope
9: Incomplete modules
10: Learning activity delivery
11: Making understandable actions

Figure 6.7 Group 1's views of the information sufficiency in ReCourse

The data shown in Figure 6.7 are participants' responses to the questions related to biology and web programming, which are the less-complete UoLs and to Java programming, which is a more-complete UoL. The results indicated that participants were aware of the pre-requisites of the course. This is understandable since ReCourse maintains information about pre-requisites. On the other hand, the study produced unpredictable results on points 9 to 11, indicating that participants feel satisfied with the information on incomplete modules and learning activity delivery, and they believed that what they did could be understood by other authors.

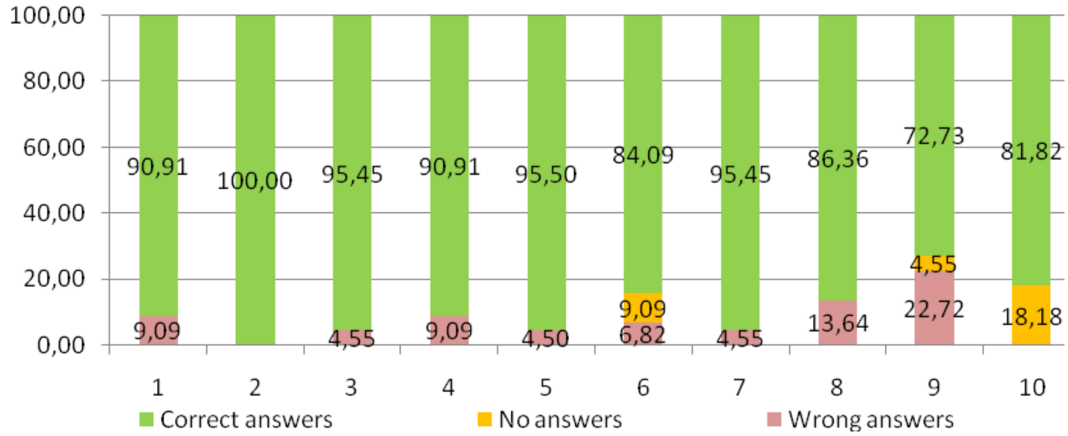
Since such information is not provided in ReCourse, it is hypothesised that there might be another variable, the completeness of the UoL, that influenced participants' opinions. To prove this hypothesis, a bivariate correlation test was applied. The test included all of those questions excluding the question about pre-requisites since it was obviously provided in ReCourse. The data are classified into two categories: less-complete UoLs (data 1 to 7) and more-complete UoLs (data 8 to 11). To select the right bivariate correlation test, a normality test was first conducted to test whether the data were parametric (normal distribution) or non-parametric (non-normal distribution). With a Kolmogorov-Smirnov test, the percentage of the participants' confidence in the sufficiency information in ReCourse, $D(220)=0.214$ with $p=0.000 < 0.05$, significantly proved that the data were non-parametric. Hence, the bivariate correlation test used Kendall's tau-b and Spearman's tests and the result is that:

> *There is a positive correlation, $r=0.224$ (Spearman's) and $t=0.208$ (Kendall's tau_b), between the completeness of the UoL and participants' opinions about the information sufficiency in ReCourse which is significant, $p=0.000< 0.01$ for both methods.*

The result indicates that there is a positive correlation between the completeness of learning resources and participants' confidence in the sufficiency of the information in ReCourse.

B. Results from Group 2

The frequencies of wrong, neutral, and correct answers from participants in Group 2 are presented in Figure 6.8.



1: The first author
2: Changes to elements
3: Roles
4: Contribution of authors
5: Post-requisites
6: Co -requisites
7: The motivation of changes
8: The UoL's scope
9: Incomplete modules
10: Learning activity delivery

Figure 6.8 Group 2 participants' awareness of the collaborative authoring of IMS LD level A

The data analysis results show that most participants in Group 2 could obtain each kind of authoring information. Since all those types of information were contained in Note, History, Objects' Notes, and History's Note, the experiment has provided evidence of the advantages of such features to support learning designers' awareness in authoring IMS LD level A.

6.2.4. Awareness of IMS LD level B

This section presents the results of a study on the influence of Notes and History on the workspace awareness of learning designers in the collaborative authoring of IMS LD level B. An adaptation model is one component of adaptive learning resources that is considered to be more difficult to understand than other resources. In this study, a comparison between Group 1 and Group 2 was drawn to see if Notes and History could help learning designers understand adaptation rules. All participants were required to find information in a UoL and they were free to explore the UoL. There was no guidance given to Group 2 participants as to where to find notes written by previous learning designers.

Afterwards, all participants were asked five questions related to the adaptation resources (rules and properties) of Java programming. The questions covered five cases including what a local property represents, how rules work, what a global property represents, how properties and rules are used, and what elements are affected by a certain rule. Each case employed simple rules and logic that learning designers could easily follow. Participants were required to read the rules and properties and find out which objects were affected by the particular properties or rules. This is an example of the questions:

Please find rules. You will find one rule: "Rule 1". What is the objective of the rule?

Unlike in the previous study, which was described in the previous section where participants in Group 1 and Group 2 received different questions, in this study all participants were required to find information in the UoL. Participants' answers indicated their awareness of the UoL and the authoring process. The questions used three nominal values to classify users' answers: wrong answers, no answers, and correct answers. A comparison between the number of correct answers given by Group 1 and Group 2 is described in Figure 6.9. In each case, Group 2, which worked with Notes and History, gave a higher percentage of correct answers than Group 1.

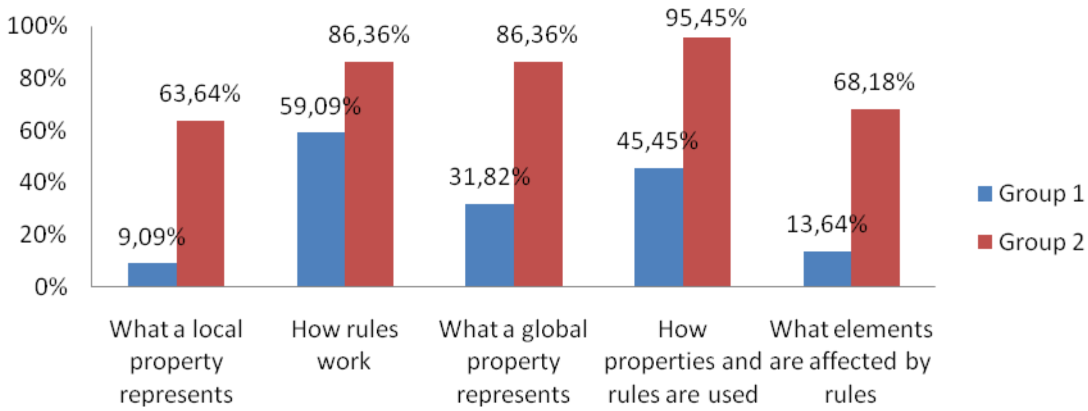


Figure 6.9 Users' awareness in collaborative authoring of IMS LD level B

A summary of participants' responses for all questions is described in Figure 6.10. As in the previous graph, this graph also shows the positive implication of Notes and History in enhancing learning designers' awareness. The workspace awareness of Group 2 is significantly higher than that of Group 1.

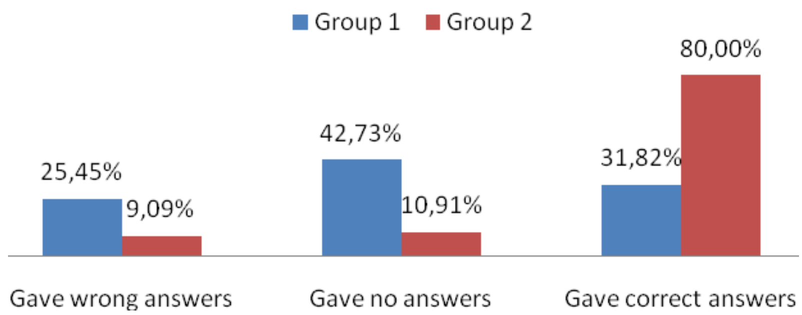


Figure 6.10 A comparison of users' understanding between Group 1 and Group 2 participants

As described in the first section, participants' profiles are similar and participants worked with similar UoLs of biology, web programming, and Java programming. The only difference between Group 1 and Group 2 in this case was that Group 2 had an advantage in terms of access to Notes and History. Therefore, it could be concluded that the presence/absence of Notes and History is the only affecting variable. To prove that there was a relationship between participants' answers and the presence/absence of Notes and History, a chi square test was carried out. A chi square test was chosen because the data are categorical. The test produced a value 52.126 with 2df and $p<0.001$ that indicated that there is a relationship between them.

6.2.5. A Summary: The Influence and the Advantages of Notes and History

Learning designers' awareness has been presented in Figures 6.8 and 6.9. In total, participants working with Collaborative ReCourse answered 15 questions related to what had happened during the authoring process and they were required to observe Notes, History, History's Note, and objects' Notes to answer the questions. As a summary, 85.45% gave correct answers; the standard deviation is 10.45%.

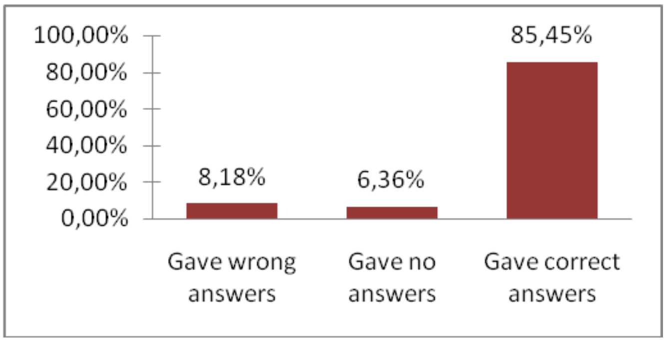


Figure 6.11 A composition of users' responses to the questionsregarding awareness measurement

The use of Notes and History in the early and later stages of authoring was also analysed. As mentioned in the previous chapter, these questionnaires used biology and web programming for the early stage of authoring and Java programming for the ensuing stage of authoring. The results are presented in Figure 6.12.

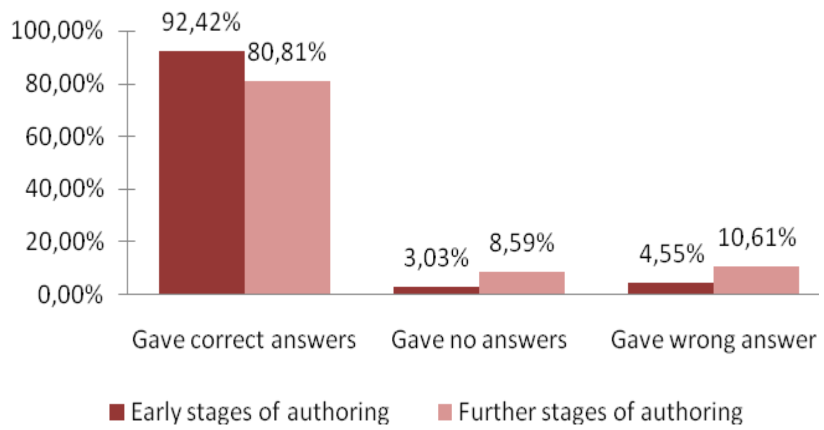


Figure 6.12 Participants' awareness in early and authoring stages

The graph in Figure 6.12 shows that participants demonstrated a high level of awareness in early as well as later stages of authoring. However, participants had better awareness when authoring at the early stages as the UoL was still relatively simple compared to the advanced stages in which the UoL becomes far more complex. A MANOVA test was carried out in order to find out the implications of the authoring stages. Ho for this study is that there is no difference between the two sets of data. The test produces the following data presented in Table 6.6, below:

Table 6.6 A MANOVA test of the influence of development stage on learning designers' awareness

Effect		Value	F	Hypothesis df	Error df	Sig.
Stages	Pillai's Trace	.352	1.990[a]	3.000	11.000	.174
	Wilks' Lambda	.648	1.990[a]	3.000	11.000	.174
	Hotelling's Trace	.543	1.990[a]	3.000	11.000	.174
	Roy's Largest Root	.543	1.990[a]	3.000	11.000	.174

Since all criteria - Pillai's Trace, Wilks Lambda, Hotelling's Trace, and Roy's Largest Root - have the same value, 0.174, which is greater than 0.05, Ho must be accepted. It can be concluded that the authoring stages do not influence the level of awareness of the learning designers.

In this study, the implications of the existence of Notes, History, objects' Notes, and History's Note on learning designers' awareness were investigated. Of the 15 questions on workspace awareness measurements, three questions were related to Notes, three questions were related to History, and two questions for History's Note, while the remaining ones were related to objects' Notes. There are more questions related to objects' Notes than the others because objects in UoLs are more varied including modules/phases/activities, properties, condition(s), and resources. The experiment results show that each of those features enhances participants' workspace awareness.

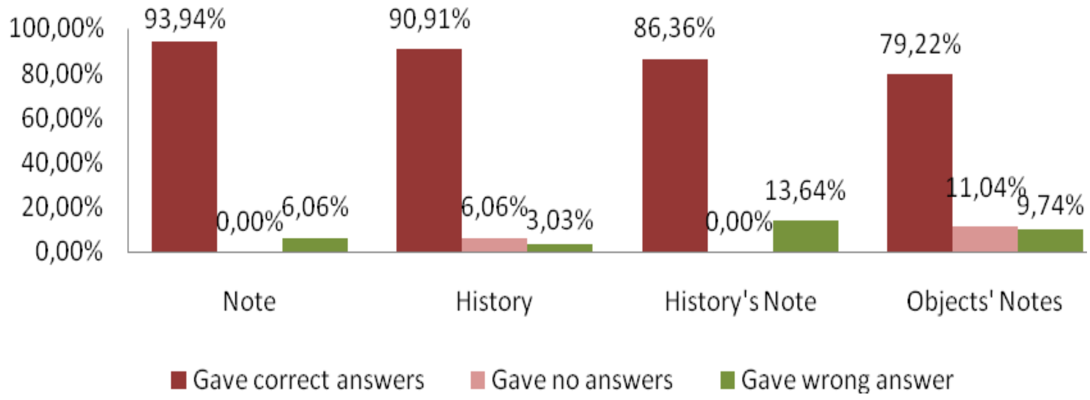


Figure 6.13 Learning designers' level of awareness based on the collaborative features used

To confirm our findings on the use of Notes and History, some questions about the usefulness of Note, History, objects' Notes, and History's Note and the ease with which information could be found in them were posed to Group 2. The study used a 4-point Likert scale with 4 for very useful/easy and 1 for useless/difficult. The results are described in Figure 6.14. The study also asked learning designers about the ease of adding notes in ReCourse. This produced 3.73 for the mean with a standard deviation of 0.456.

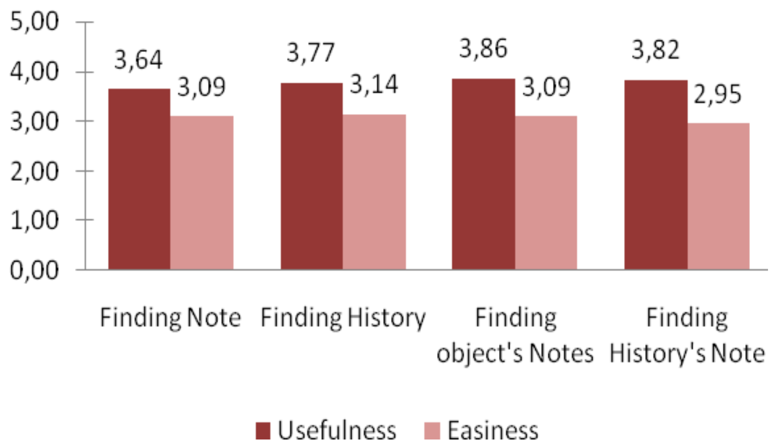


Figure 6.14 The usefulness and the ease of use of collaborative features

On the other hand, a low level of understanding was shown by participants in Group 1 which was supported by another finding that showed that they needed more information to be provided in ReCourse. The following table (Table 6.7) presents a study of the needs of Notes and History in ReCourse with Group 1 participants involved. The questions used a 4-point Likert scale with 4 for very important and 1 for not important. The data analysis results indicate that Notes in UoL, History, History's Note, and Notes on adaptation resources (rules) are important. Furthermore, the study shows that objects' Notes are essential for users to work efficiently and effectively.

Table 6.7 The needs of Notes and History in ReCourse

Notes/History	N	Mean	Std. Deviation
Notes on UoL	22	3.36	.727
History	22	3.00	.690
Notes on History	22	3.09	.921
Notes on rules	22	3.45	.671
Notes on objects for efficiency	22	3.41	.590
Notes on object for effectiveness	22	3.27	.827

6.3. Summary

In this chapter, the design and the results of Experiment 1 were discussed. The experiment involved two groups of participants, Group 1 and Group 2. Using a MANOVA statistical test, the participants' profiles are tested in order to expose the similarities and differences between the profiles of Group 1's and Group 2's according to their teaching experience and working experience with IMS LD or IMS LD authoring tools, and their knowledge on the courses used in the experiment: biology, web programming, and Java programming. The MANOVA test confirmed there is no significant difference between Group 1 and Group 2. Therefore, users' profiles were not considered an affecting variable in the experiment.

The experiment gathered participants' opinions about the importance of course information presented in a UoL. Several information items were used including learning objectives, the information of targeted learners, pre-requisites, post-requisites, reading lists, learning duration, and the topic descriptions. Both groups agreed that all of these information items are important enough to be presented in a UoL. As a consequence, the learning designers who are responsible for developing the UoL will be responsible for defining all of that information. ReCourse currently records learning objectives and the pre-requisites for each UoL, but it does not record the remaining information.

The next study aims to investigate whether Notes and History can function as media for authors to share and find information. Regarding the course information previously discussed and after participants had worked a little with ReCourse (Group 1) and Collaborative ReCourse (Group 2), Group 1 found that such course information is not sufficiently recorded in ReCourse. A significantly different opinion was drawn by Group 2, in that they found such information to be sufficient in Collaborative ReCourse. Since the difference in learning environments for Group 1 and Group 2 lies in the absence or the presence of Notes and History, and based on a MANOVA test, it can be concluded that Notes and History are the factors that make Group 1's and Group 2's findings different.

A further study on the importance of information was carried out. It aimed to gather participants' opinions as to whether or not it is important to share authoring process information among authors. As examples, information on the first author, creation date, all authors, last update, and the contribution of each author were used. Both groups agreed that such information is important enough to be shared among all authors.

In order to investigate the influence of Notes and History in enhancing authors' workspace awareness, the study addressed two concerns: authoring UoL level A and level B.

1. Authoring UoL level A. Different sets of questions were distributed to Group 1 and Group 2.
   - Questions to Group 1 asked more about learning designers' insights, opinions, or their confidence regarding the sufficiency of information in ReCourse. The experiment revealed that their insight is influenced by the completeness of the UoL. They felt more confident that they understood the others' visions, updates, or motivations when the UoL was more complete.
   - Questions for Group 2 tested learning designers understanding of what had happened during authoring the general learning elements. The study shows a very high awareness of authors regarding the first author, changes to elements, authors' roles, the contribution of authors, pre-requisites, co/post-requisites, the motivation behind updates, the UoL's scope, incomplete modules, and learning activity delivery.
2. Authoring UoL level B. The same set of questions was distributed to Group 1 and Group 2. These aimed to highlight the influence of Notes and History in enhancing authors' workspace awareness. The experiment revealed a vast difference in level of awareness between Group 1 and Group 2: Group 1 has low awareness, whereas Group 2 has high awareness. The chi square test has provided evidence that there is a causal relationship between the absence/presence of Notes and History and authors' awareness.

The study also investigated the learning designers' awareness in the early stages of authoring biology and web programming and in the further stages of the authoring Java programming. The result shows that authoring stages do not influence learning designers' level of awareness; there is no evidence that authors will have either high or low workspace awareness in the early stages or in the later stages of authoring. The workspace awareness of authors is influenced by the existence of Notes including the general Note, History's Note, objects' Notes, and

History. In addition, authors found that all of these features are useful and are easy to use.

The experiment has presented an evidence for Hypothesis 1 regarding the positive influence of Notes and History in understanding what other learning designers have done. However, the evaluation did not investigate the implication of Notes and History on learning designers' future work leading to enhanced output quality. This would be proven, or otherwise, in the second evaluation. In the next chapter, the results of the second experiment are discussed. Unlike the first experiment, in which participants follow artificial scenarios, the participants of the second experiment were free to take any action in order to create a UoL of Java programming.

Chapter 7 Experiment 2: Asynchronous Workgroup Study

Chapter 5 discussed the methodology designs of the two experiments conducted in this research. The design and results of the first experiment have been presented in Chapter 6. This chapter presents the design and the data analysis result of the second experiment. This experiment applied categorisation to investigate the collaborative authoring approach that participants applied to IMS LD authoring, the quality of authoring output, accesses to Notes and History, and participants' responses to Notes and History. The data were categorised in various ways: per person, per group, or based particularly on access to Notes or History.

7.1. Experiment Design

This section describes the experimental methodology, materials, and procedures of Experiment 2. It is the second evaluation that was conducted in this research; the aim of which was to to answer sub-research question 4 about the granularity level of collaborative authoring with IMS LD and to test Hypothesis 2 regarding the effects of workspace awareness information on the quality of learning designs.

7.1.1. The Experimental Methodology

The second experiment involved 12 participants recruited by personal email invitations. They were all postgraduate students at the University of Southampton in the UK. They were divided evenly into four groups. Two groups worked with ReCourse, while the other two groups worked with Collaborative ReCourse. The primary goal of the second experiment is to investigate how learning designers carry out the collaborative authoring of learning designs and to measure the soundness of the learning designs produced by the collaborative authoring. This experiment applied qualitative inquiries in the forms of observation and structured interviews. Qualitative inquiry is the most appropriate method for research that aims to understand phenomena from participants' perspectives through observation, conversation, interview, review of documents, interaction and conversation, narrative analysis, journals, and photographs (Bowen, 2005; Marshall and Rossman, 2006). Unlike quantitative inquiry, which deductively derives postulates or tests hypotheses, qualitative inquiry is inductive, as researchers use data to generate concepts, methods, or approaches, in order to answer questions regarding particular phenomena.

There are some some key activities that must be carried out in qualitative inquiry (Bowen, 2005):

1. Participant selection (Bowen, 2005)

   In this experiment, purposeful sampling as opposed to random sampling was used. In qualitative inquiry, researchers have to carefully select participants, so that the observable facts in the study can be revealed by participants who have knowledge and experience within the area of study. Criteria used to determine participants in this experiment include:

   a. Gender. Since collaborative authoring of learning designs is not gender specific, male and female participants in a balanced composition are required be involved in this experiment.
   b. Experience. Participants are required to have teaching experience and Java knowledge.

   Potential participants were invited by private email invitations to participate in this experiment. There was not an open invitation which was distributed to the public. This was to ensure that the participants fulfilled the two criteria.

2. Data collection (Bowen, 2005; Marshall and Rossman, 2006)

   This experiment consisted of observation and structured interviews. The observation investigated collaborative authoring of IMS LD carried out by four groups of three learning designers. Each group was required to create a Java programming UoL in nine sessions; each participant worked in three separate sessions. The authoring was asynchronous as there were no participants from the same group working simultaneously. Two groups worked with ReCourse and the remaining groups worked with the Collaborative ReCourse prototype. Each session took 50 to 60 minutes, and participants were excluded from working in consecutive sessions.

This experiment applied experimental methodologies for gathering and analysing data. For data gathering, the following methods were used:

a. Participant observation (Zelditch, 1962)
   Observation was focused on the elements that learning designers updated in each session, the distribution of tasks in authoring all of the UoL's elements, the distribution of tasks in authoring adaptation, and the correctness of output.
b. Informant-interviewing (Zelditch, 1962)
   In addition to the observation, a mixture of questionnaires and interviews were also carried out. The targeted information includes participants' profiles, their insights regarding the efficiency of the authoring in their groups, the distribution of tasks among the group's members, and the barriers that might make learning designers reluctant to access Notes and History.
c. Enumeration and samples (Zelditch, 1962)
   This was only applied to the groups working with Collaborative ReCourse. The tool recorded the frequency of learning designers' access to Notes and History.

The experiment aims to answer sub-questions 4 and 6 (Section 1.3) through measurements of particular criteria as shown in Table 7.1.

Table 7.1 Evaluation criteria

Questions	Criterion Codes	Criterion Description
Sub-question 4 regarding the granularity level of the collaborative authoring of IMS LD	Criterion-1	The distribution of updates in authoring IMS LD level A (non-adapting materials)
	Criterion-2	The distribution of updates in authoring IMS LD level B (adapting materials)
	Criterion-3	The distribution of authoring tasks among participants in the group
	Criterion-4	The efficiency of authoring
	Criterion-5	The quality of authoring
	Criterion-6	Barriers to collaborative authoring
Sub-question 6 regarding the implications of Notes and History on the quality of learning designs	Criterion-7	The number of corrections required to fix the produced UoL
	Criterion-8	Access to Notes and History

3. Data analysis (Kearney, 2001; Marshall and Rossman, 2006)
   In general, data analysis bundles three main activities -description, analysis, and interpretation- which fall into seven phases, comprising: (a) organising the data; (b) immersion in the data; (c) generating categories and themes; (d) coding the

data; (e) offering interpretations; (f) searching for alternative understandings, and (g) writing the report (Marshall and Rossman, 2006). In analysing the data, researchers compare, aggregate, contrast, sort, and order data by reducing, condensing, categorising, and coding data in order to find patterns, links, and relationships (Savenye and Robinson, 2011). Although a large amount of raw data was collected, researchers must select cases to test a theory.

In this experiment, categorisation was applied to raw data collected in the observation phase regarding updates on units of learning (UoLs), look-up accesses in Notes and History, comments on Notes, and errors that authors made on the UoL.

7.1.2. Experimental Materials

There were three sets of materials distributed to participants:

1. An introductory file on IMS LD, ReCourse, and Collaborative ReCourse. This file was sent by email to participants to inform them of terms, definitions, and tools used in this experiment. It is the same file sent to participants in the first evaluation.
2. A UoLthat consists of several topics of Java programming (Pollock, 2011) and guidance for learning designers to work in groups. In the experiment, participants were required to contribute in a collaborative authoring for a Java programming course. Each group received a UoL that comprises the following information:

Course name:	Java programming
Pre-requisite:	Object-oriented Methods
Overview:	In this course, learners will learn new concepts and techniques through lectures and tutorials, and then exercise their programming skills through projects.
Course policy:	Assessment includes 30% from the exam, 60% from projects/assignments, and 10% from class participation.
Course objectives:	At the end of the course, students will be able:

a. to implement concepts in object-oriented methods including classes, objects, composition, inheritance, and polymorphism using Java;
b. to install and run the Java runtime environment;
c. to develop Java applications;
d. to build graphical user interface (GUI) applications using Swing and AWT;
e. to develop simple web applications using the J2EE framework.

The topics comprised in the UoL are:

a. Learning the basics of the Java language,
b. Classes and objects,
c. Object-oriented programming (OOP) concepts,
d. Learning the advanced features of the Java language.

3. A questionnaire combined with the structured interview. Participants were required to answer the questionnaire and attend the interview. The design of evaluation adapted a GQM approach to break down the evaluation objectives into questions, and a measurement metric.

The UoL also has three kinds of roles including teacher, assistant, and learners. Participants could make any update to the UoL, for example: modify the sequence, add/delete plays or other elements, extend plays by adding acts and activities, declare properties, and create adaptation rules, et cetera.This experiment would observe the authoring flow that learning designers have built, the distribution of tasks, authoring adaptation elements, access to Notes and History, and the quality of output. The complete materials can be found in Appendix A for an introduction file and Appendix C for the structured interview questions.

7.1.3. Experimental Procedures

The experiment involved four groups; Groups A and B were assigned to work with ReCourse, whereas Groups C and D worked with the prototype of Collaborative ReCourse. Each participant was required to work in three non-consecutive sessions. For each participant:

1. In the first session, the participant was introduced to IMS LD and either ReCourse or Collaborative ReCourse and asked to fill out a form giving their consent for participation in this study. For participants working with the Collaborative ReCourse, they would receive a username and password to access the authoring tool. The participant was able to freely update the UoL and save changes before logging out.
2. After the first session finished, the participant would receive an email that provided guidance for the second session.
3. In the second session, the participants could do the same tasks as they did in the first session and they were required to work on authoring adaptation tasks.
4. On completion of the second session finished, the participant would receive an email that provided guidance for the third session.
5. In the last session, the participant could do the same tasks as they did in the first and the second sessions. In addition, participants had to fill in a set of questions online regarding what they have done.

7.1.4. Design

This evaluation is aimed to acquire information regarding the granularity level of collaborative authoring of learning designs, the distribution of tasks, the quality of authoring output, access on Notes and History, and the efficiency of authoring. For each type of information, a table of goal-question-metric (GQM) is designed.

7.1.4.1. Participants' Profiles

Several questions would be distributed to all participants to gain information about their profiles, as described in Table 7.2. The information to be collected is about participants' experience in teaching and working on IMS LD or IMS LD authoring and their knowledge of Java programming.

Table 7.2 A GQM description for the evaluation of participants' profiles

Goal Purpose Issue Object/process	To confirm the profiles of participants
Viewpoint	All participants
Question	Do you have any teaching experience (as a lecturer/ teaching or lab-work assistant/ demonstrator)?
Metric	Average of teaching experience. Standard deviation of teaching experience.
Question	Do you have any experience in working with IMS LD or IMS LD authoring tools?
Metric	Average of working experience on IMS LD. Standard deviation of working experience on IMS LD.
Question	This questionnaire uses a UoL: Java programming. How much knowledge do you have of that course?
Metric	Average of participants' knowledge. Standard deviation of participants' knowledge.

7.1.4.2. The Granularity Level of Collaborative Authoring of Learning Designs

Regarding research question 4 about the granularity level of collaborative authoring of learning designs, one concern of this experiment is how to observe authoring flows carried out by participants. It observes the collaborative authoring approach in authoring IMS LD level A and learner designers' participation in authoring IMS LD level B. These are indicated by the types and the number of elements created or modified in each session.

A. The collaborative authoring approach in authoring IMS LD level A

Table 7.3 describes GQM to study the collaborative authoring approach in authoring IMS LD level A. It observes the number of plays, acts, activities, and properties produced in each authoring session.

Table 7.3 A GQM description for the collaborative authoring approach in authoring non-adapting materials.

Goal Purpose Issue Object/process	To investigate how learning designers collaboratively author UoL
Viewpoint	All participants
Question	How many plays did a group's memberscreate in each session?
Metric	The number of new plays.
Question	How many underlying actsdid a group's members create along with a play in each session?
Metric	The number of new acts.
Question	How many underlying activities did a group's members create along with a play in each session?
Metric	The number of new activities.
Question	How many plays did a group's members modify in each session?
Metric	The number of plays modified.
Question	How many plays did a group's members move in each session?
Metric	The number of plays moved.
Question	How many plays did a group's members delete in each session?
Metric	The number of plays deleted.
Question	How many acts did a group's memberscreate in each session?
Metric	The number of new acts.
Question	How many activities did a group's memberscreate along with an act in each session?
Metric	The number of new activities.
Question	How many acts did a group's members modify in each session?
Metric	The number of acts modified.
Question	How many acts did a group's members move in each session?
Metric	The number of acts moved.
Question	How many acts did a group's members delete in each session?
Metric	The number of acts deleted.
Question	How many activities did a group's members create in each session?
Metric	The number of activities created.
Question	How many activities did a group's members modify in each session?
Metric	The number of activities modified.

Question	How many activities did a group's member move in each session?
Metric	The number of activities moved
Question	How many activities did a group's members delete in each session?
Metric	The number of activities deleted.
Question	How many properties did a group's members create in each session?
Metric	The number of properties created.
Question	How many properties did a group's members modify in each session?
Metric	The number of properties modified.
Question	How many properties did a group's members move in each session?
Metric	The number of rules moved.
Question	How many rules did a group's members create in each session?
Metric	The number of rules created.
Question	How many rules did a group's members modify in each session?
Metric	The number of rules modified.
Question	How many rules did a group's members move in each session?
Metric	The number of rules moved.
Question	How many learning resources did a group's members createin each session?
Metric	The number of learning resources created.

B. Learner Designers' Participation in Authoring IMS LD level B

Table 7.4 describes GQM to study learner designers' participation in authoring IMS LD level B. It observes the number of properties, predefined rules, and user-defined rules produced in each authoring session.

Table 7.4 GQM for learning designers' participation in creating adapting materials

Goal	Purpose Issue Object/process	To investigate how learning designers create adaptation elements
	Viewpoint	All participants
Question		How many properties did each participant create?
Metric		The number of properties created.
Question		How many predefined rules did each participant create?
Metric		The number of predefined rules created.
Question		How many user-defined rules did each participant create?
Metric		The number of user-defined rulescreated.

7.1.4.3. The Distribution of Tasks

Another concern of this experiment with respect to research question 4 was about the distribution of authoring tasks. It aimed to observe the task distribution in an asynchronous collaborative authoring of learning designs with implicit coordination. To answer this, information about the number of actions that each participant made is required.

Table 7.5 A GQM description for evaluatingthe distribution of tasks

Goal Issue Object/process	Purpose	To investigate the distribution of authoring tasks
	Viewpoint	All participants
Question		How many actions did each participant create?
Metric		The number of actions made.

7.1.4.4. The Quality of Authoring Output

Authoring, collaboratively or individually, has to produce good quality output in a correct format. With IMS LD as language representation, authoring must produce a UoL that can be delivered in an IMS LD player, such as CopperCore in this experiment. To be successfully delivered in CopperCore, it may be needed to make improvements to incomplete parts that raise errors, thus causing the UoLto be undeliverable. An example of incompleteness is the absence of a resource in a learning activity or support activity. The quality of authoring output can be concluded from how much improvement is needed for the UoL to be successfully delivered in CopperCore.

Table 7.6 A GQM for the quality of output

Goal	Purpose Issue Object/process	To answer Research Question 4 How good is the authoring output?
	Viewpoint	All participants
Question		How many corrections are needed to gain a zero-error UoL?
Metric		The number of corrections.

7.1.4.5. Access on Notes and History

One of the objectives of this experiment is to investigate the effects of Notes, History, objects' Notes, and History's Note on the quality of learning designs produced in the authoring. To what extent such features affect the output quality is indicated by how many corrections are needed to gain a zero-error UoL and the frequency of participants' access to such features. Table 7.7 presents questions on the GQM approach for gathering information about access to Notes and History.

Table 7.7 A GQM description for the influence of Notes and History

Goal	Purpose Issue Object/process	To investigate the use of Notes and History
	Viewpoint	Participants who used Collaborative ReCourse
Question		How many times did participants check the Notes?
Metric		The number of access.
Question		How many times did participants check the History?
Metric		The number of access.
Question		How many times did participants check theobjects' Notes?
Metric		The number of access.
Question		How many times did participants check History's Note?
Metric		The number of access.
Question		How many notes did the participants make in Note?
Metric		The number of notes.
Question		How many notes did participants make in objects'Notes?
Metric		The number of notes
Question		How many notes did participants make in History's Note?
Metric		The number of notes.
	Viewpoint	All participants
Question		How many elements did participants produce?
Metric		The number of elements.

7.1.4.6. The Efficiency of Authoring

In addition to the observation, information is also gathered through an online structured interview combined with a questionnaire. Some questions were distributed to learning designersin order to ask them to undertake a self-assessment on the efficiency of their work and the barriers to using Notes and History. Table 7.8 presents questions delivered to participants regarding self-assessment.

Table 7.8 A GQM description for gathering learning designers' opinion

Goal	Purpose Issue Object/process	To gather learning designers' opinions about the efficiency of authoring in their group
	Viewpoint	Participants
Question		In your opinion, did you and your co-learning designers work efficiently? Please rate the efficiency of each learning designer's work.
Metric		The efficiency ratingaverage of learning designers' work.
Question		In your opinion, did you and your co-learning designers work evenly?
Metric		The rating average of the authoring task division.
Question		How was the distribution of tasks in each group?
Metric		The composition of task distribution.

7.2. The Observation Results

This section discuss participant selection, data collection, and data analysis results of the second experiment. The data analysis refers to the evaluation criteria in Table 7.1.

7.2.1. Participant Selection

In this experiment, 12 participants were selected, and they were divided evenly into four groups. The participants' profiles of working experience of IMS LD or IMS LD authoring tools are presented in Table 7.9. The experiment was carried out in nine sessions for each group. All groups worked on similar UoLs, Java programming. The authoring process was observed via the UoL produced by Groups A and B. For Groups C and D, the observation was carried out in the UoL they produced and also from Notes, History, and a log file that recorded authors' actions including accessing Notes, History, History's Note, and objects' Notes.

Table 7.9 Participants' profiles on working experience with IMS LD or IMS LD authoring tools

Groups	Tools	Learning designers	Experience
Group A	ReCourse	Learning designer 1	Little
		Learning designer 2	None
		Learning designer 3	Little
Group B	ReCourse	Learning designer 1	None
		Learning designer 2	Some
		Learning designer 3	None
Group C	Collaborative ReCourse (*Prototype*)	Learning designer 1	None
		Learning designer 2	None
		Learning designer 3	None
Group D	Collaborative ReCourse (*Prototype*)	Learning designer 1	None
		Learning designer 2	Some
		Learning designer 3	Some

7.2.2. Data Collection

The primary data collection method is a participant observation for which a UoL of four topics was provided to for completion by the participants. In the observation, the work done to the UoL was recorded from every session. These are the only data used to analyse which authoring tasks participants in Groups A and B accomplished, while for Groups C and D, updates made by the participants could be identified from History. The UoL is still used to confirm findings from History. Another sets of data collected from the observation comprised log files that recorded the look-up access for Notes and History by Groups C and D. An additional data collection method was a structured interview which aimed to confirm the findings from the observations.

7.2.3. Data Categorisation

Categorisation is applied to classify updatesthat are made in the nine sessions of observation. Firstly, updates are grouped into five groups based on the hierarchical organisation of IMS LD comprisingupdates on modules and the underlying elements, updates on phases and the underlying elements, updates on activities, updates on properties, and updates on rules.Updates are then categorised into 22 types as shown in the leftmost columns of Table 7.10 and Table 7.11.These tables summarise the number of updates by type by groups A and B working with ReCourse and by groups C and D working with Collaborative ReCourse. Detailed observation data comprising the updated elements, the updating authors, and the types of updates can be found in Appendix D.

Table 7.10 Categorisation of updates made by groups A and B working with ReCourse

Code	Actions	Sessions								
		1	2	3	4	5	6	7	8	9
1	add modules	12	3		4			1		
2	add modules+phases	25	8		1			1		
3	add modules+phases+activity	26	8		2			4		
4	modify modules									
5	move modules (all)		1		1	7				
6	delete modules (all)		1							
7	add phases	2		1	13		5	1		2
8	add phases+activities	2		1	11		4	2		5
9	modify phases							5		
10	move phases (all)		6			4	1	2	1	1
11	delete phases (all)				2					
12	add activities		7	5		4	2			
13	modify activities						3			
14	move activities									
15	delete activities		1							
16	add property		1	9		1	1	6	2	
17	modify property									
18	delete property									
19	add rules			8			5	4	1	
20	modify rules							2		
21	delete rules									
22	add resources	28	17	6	19	5	24			40

Table 7.11 Categorisation of updates made by Group C and D working with the Collaborative ReCourse prototype

Code	Actions	Sessions								
		1	2	3	4	5	6	7	8	9
1	add modules	9			2	1	1		1	
2	add modules+phases	15			4	3			1	
3	add modules+phases+activity	13			11	10			5	
4	modify modules									
5	move modules (all)									
6	delete modules (all)									
7	add phases	1	4	7			1		2	
8	add phases+activities		6	7			1		5	
9	modify phases			2						3
10	move phases (all)		1							
11	delete phases (all)					1			2	1
12	add activities	1	5	3			3	1	3	1
13	modify activities								3	
14	move activities						3			
15	delete activities									
16	add property				3	3	1	2	1	
17	modify property									
18	delete property									
19	add rules	6	1	1	8	3	8	1	2	
20	modify rules					1				
21	delete rules					1	2			
22	add resources	13	11	12		6	3	1	4	13

7.2.4. Data Analysis

Based on the evaluation criteria in Table 7.1, the data analysis results are discussed in two separate sections. The first section presents the granularity level of the collaborative authoring of IMS LD and the second section presents the implications of Notes and History for the quality of output.

7.2.4.1. The Granularity of the Collaborative Authoring of IMS LD

This section presents the experiment results regarding research question 4 on the level of granularity where an IMS LD authoring takes place. This experiment gathered information on which IMS LD level A elements were made in each session, how authoring tasks were distributed among learning designers, and how learning designers carried out the authoring of adaptation elements or IMS LD level B.The organisation of IMS LD, which is hierarchical, is similar to the Process Structure concept of coordination in collaborative authoring. The data analysis focused on finding a pattern for how learning designers develop a UoL. The analysis is applied to:

1. Authoring IMS LD level A that produces non-adapting elements, including modules/plays, phases/acts, activities (including learning activities, support activities, and activity groups), properties, and resources.
2. Authoring IMS LD level B that produces adapting elements including rules and properties.

Furthermore, the distribution of authoring tasks that were indicated by the contributions of each learning designer in the authoring process was analysed.

A. Authoring IMS LD level A

There are two ways in which learning designers carry out IMS LD authoring: by applying explicit or implicit coordination with or without a role assignment. This experiment applied implicit coordination without a role assignment which means that all learning designers have the same authority. This approach, however, still potentially creates a coordinator, which is an author who builds the top level of the UoL in the form of a sequence of modules that covers most required topics; other learning designers then extend the structure.

In the experiment, a log file was employed to record when authors accessed Note, History's Note, and objects' Notes. On the other hand, updates by authors were recorded in History. According to Tables 7.10 and 7.11, updates on IMS LD level A are those with codes 1 to 15 and code 22. Table 7.12 describes the frequency of each type of update. The summary can be found in Table 7.13 and Figure 7.1.

Table 7.12 The frequencies of participants' actions in authoring IMS LD level A

Code	Actions	1	2	3	4	5	6	7	8	9
1	add modules	21	3		6	1	1	1	1	
2	add modules+phases	40	8		5	3		1	1	
3	add modules+phases+activity	39	8		13	10		4	5	
4	modify modules									
5	move modules (all)		1		1	7				
6	delete modules (all)		1							
7	add phases	3	4	8	13		6	1	2	2
8	add phases+activities	2	6	8	11		5	2	5	5
9	modify phases			2				5		3
10	move phases (all)		7			4	1	2	1	1
11	delete phases (all)				2	1			2	1
12	add activities	1	12	8		4	5	1	3	1
13	modify activities						3		3	
14	move activities						3			
15	delete activities		1							
22	add resources	41	28	18	19	11	27	1	4	53

Table 7.13 The summary of participants' updates in authoring IMS LD level A

Types of Updates	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)	8 (%)	9 (%)
Updates of modules and phases (in blue)	59.80	12.75	0.00	11.76	10.78	0.98	1.96	1.96	0.00
Updates of phases and activities (in red)	22.68	12.89	9.28	20.10	7.73	6.19	7.22	7.73	6.19
Updates of activities (in green)	2.22	28.89	17.78	0.00	8.89	24.44	2.22	13.33	2.22
Updates of resources (in purple)	20.30	13.86	8.91	9.41	5.45	13.37	0.50	1.98	26.24

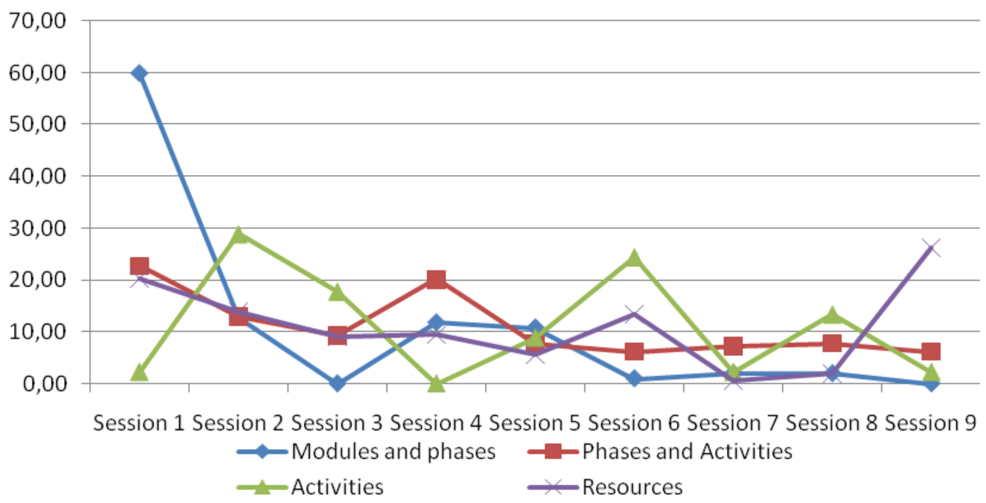


Figure 7.1 The summary of participants' updates in authoring IMS LD level A

The graph shows the updates for:

1. Modules and phases. The blue line shows updates on modules and its underlying phases built at the same time. It draws the data numbers 1 to 6, excluding number 3, in Table 7.12.
2. Phases and activities. The red line denotes updates on phases and its underlying activities built at the same time. It draws the data numbers 3 and 7 to 11 in Table 7.12.
3. Activities. The green line comprises updates on activities. It draws the data number 12 to 15 in Table 7.12.
4. Resources. The purple line comprises updates on activities. It draws the data number 16 in Table 7.12.

According to the data, 59.80% of the updates on modules and their underlying phases were carried out in the first session. These then drastically decreased in the following sessions. On the other hand, the number of updates on phases and their underlying activities, activities, and resources fluctuated across all sessions. Another finding revealed by the experiment is that from 21 modules created by all groups, only three modules were created by one single participant; the remaining modules were created by contributions from more than one participant. These data have proven that collaborative authoring is applicable not only on the top level of UoL, but also to the lower level of UoL. Participants can work collaboratively on all IMS LD level A elements.

B. Authoring Rules and Properties

This section presents the contributions of participants in authoring IMS LD level B that produces adaptation elements including the properties, user-defined rules, and predefined (completion) rules applied to modules, phases, and the overall UoL itself. This experiment observed what updates the participants made. Updates on IMS LD level B comprise updates on properties, updates on user-defined rules, and updates on predefined (completion) rules for each of the participants. According to Table 7.10 and 7.11, updates on IMS LD level B are those with codes 16 to 21. Table 7.14 describes the frequency of each type of update.

Table 7.14 A summary of participants' actions on authoring adaptation resources

Groups	**Participants**	**Adaptation Elements**		
		Properties	**PredefinedRules**	**User-defined Rules**
Group A	Participant 1	Add two properties.		Add one condition.
	Participant 2		Add completion rules to15phases of three modules.	
	Participant 3	Add six properties.	Add completion rules to seven phases of one module. Add two completion rules on phases. Edit a completion rule.	
Group B	Participant 1	Add nine properties.		Add seven conditions.
	Participant 2		Add a completion rule to a phase.	
	Participant 3	Add two properties.		
Group C	Participant 1	Add one property.	Add four completion rules.	Add one condition.
	Participant 2	Add three properties	Add four completion rules.	Add four conditions.
	Participant 3	Add two properties.		Add two conditions.
Group D	Participant 1	Add one property.	Add one completion rule to a phase. Add four completion rules tomodules.	Add two conditions.
	Participant 2		Add four completion rules.	Add seven conditions.
	Participant 3	Edit two Properties.	Add one completion rule to anactivity.	Edit one condition. Add one condition.

All participants contributed to authoring properties and rules. However, participants created their own properties or rules; they almost never edited existing properties or rules that had been created by other participants. From 95 actions regarding properties, predefined rules, and user-defined rules, only three of participants edited the existing rules; the remaining actions were the creation of new properties or rules. However, the data show that Groups C and D undertook better collaborative work in authoring IMS LD level B since almost all of the authors in the groups contributed to those three kinds of authoring actions.

7.2.4.2. The Distribution of Tasks

Another concern of the second experiment is the distribution of tasks among authors. It regards the contribution of each author in the collaborative authoring. The experiment gathered information as to what updates each participant has made to the authoring. The task distribution of each group is described in Table 7.15 and Figure 7.2.

Table 7.15 Participants' contributions

Group	The Distribution of Authoring Tasks		
	Participant 1	Participant 2	Participant 3
Group A	39	125	55
Group B	114	25	19
Group C	52	28	39
Group D	55	38	38

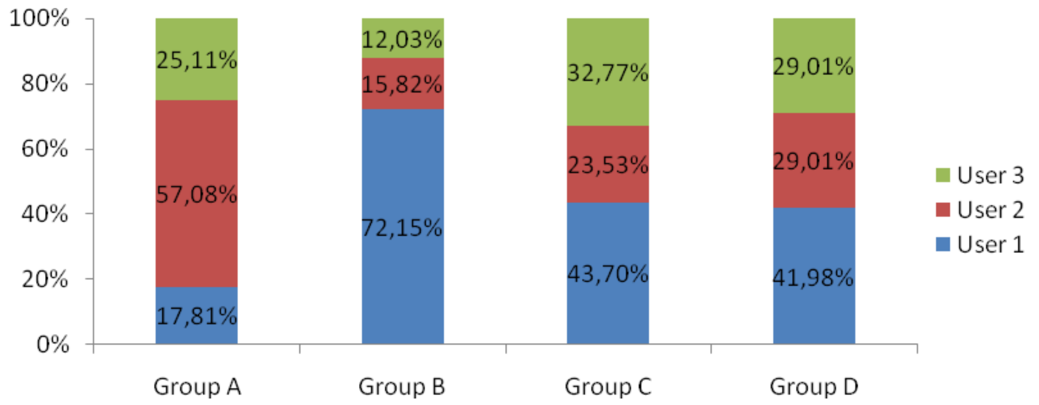


Figure 7.2 Participants' contribution to each group

The data show that in each group there was a participant who gave the highest contribution. This is acceptable since the experiment only observed the first nine sessions of the entire authoring process. In addition, an implicit coordination method, a Process Structure method, was applied, and although it did not apply a role assignment, it might create a coordinator. The existence of a coordinator is identified from the highest contributing authors, particularly in the first several sessions. Data collected from the experiment as shown in Table 7.15 and Figure 7.2 have confirmed the previous studies. Nevertheless, a different phenomenon emerged in the groups working with ReCourse to that which emerged in the other group working with the prototype of Collaborative ReCourse. In Group A and Group B, the coordinator made very large contributions which accounted for more than 50%. On the other hand, in Groups C and D, participants' contributions are not overly different as the highest contribution is less than 50%. There is no convention as to how much work the coordinator should carry out, but it can be concluded that a group of authors working with Collaborative ReCourse shows a more balanced participation of authors in the collaborative authoring of learning designs than those working with ReCourse.

7.2.4.3. The Implications of Notes and History to Authoring Output

The quality of the authoring process can be identified from the output. There are various ways to assess the quality of an authoring output; one of these is an assessment by experts on Java programming. In this experiment, the first criterion of the quality of the authoring output is that it must be able to be delivered via an IMS LD player, CopperCore. Hence, the quality of output is identified by how many corrections were needed to fix the UoL in order to be played in CopperCore. The fewer the corrections, the better quality the UoL must be. The observation shows that all UoLs produced by all of the groups could not be delivered through CopperCore. As most of the participants were using ReCourse for the first time, some parts of the UoLs were incomplete; thus not all of the UoLs could be delivered in CopperCore.

Corrections must then be applied in order to fix the produced UoL to be able to play it in CopperCore. The corrections applied to a UoL are categorised into the seven categories listed below.

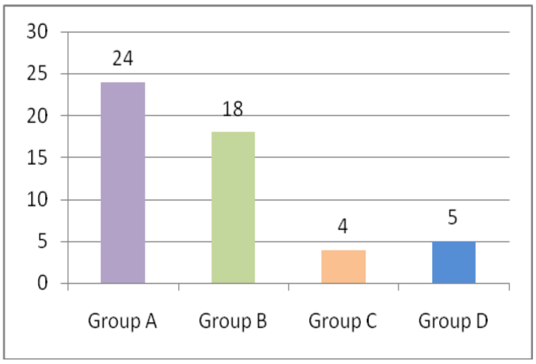
1. Add learning activities to phases. This improvement was applied to all phases that did not have learning or support activities.
2. Change activity groups to learning activities. This improvement must be made to every activity group that does not have any learning activity or support activity.
3. Delete property groups. A property group is a set of properties which contains at least one property. Each property group that did not contain a property was deleted.
4. Delete user-defined rules. Some rules had to be deleted because they did not have any conditions or actions attached to them.
5. Correct user-defined rules. This improvement is applied to incomplete rules that, with small corrections, could work properly. An example case is the absence of an action in the 'ELSE' block of an IF-THEN-ELSE rule; for this example, the 'ELSE' block is deleted.
6. Delete incomplete predefined (completion) rules. Some completion rules were deleted since they did not affect modules/phases/activities, for example, condition-based completion rules that comprised blank conditions.

7. Correct incomplete predefined (completion) rules. This kind of improvement is applied to incomplete predefined rules that can be fixed with small changes. An example case can be found in a rule that combines a string property with an integer value.

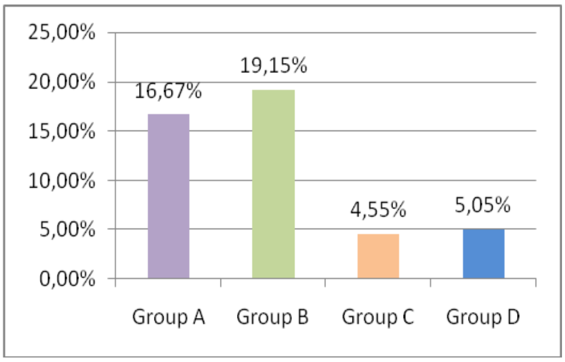
In addition to such errors, a kind of logical error was found in the form of rules which inserted the same actions in both the THEN and ELSE blocks. Because this error does not prohibit the UoL delivery in CopperCore, an improvement on this kind of error is unnecessary. A summary of improvements done to all groups' output is presented in the following table. Table 7.16 describes the number of improvements for each type of correction and Figure 7.3 summarises the total number of corrections made to each group's output.

Table 7.16 Improvements applied to UoLs

#	Improvements	Group A	Group B	Group C	Group D
1.	Add learning activities to phases	3			
2.	Change activity groups to learning activities	1	3		
3.	Delete property groups	2	7		
4.	Delete user-defined rules: incomplete conditions/actions	2	4		
5.	Correct user-defined rules	1	1		
6.	Delete incomplete predefined (completion) rules	2		2	1
7.	Correct incomplete predefined (completion) rules	13	3	2	4
8.	Logical errors on rules				



(a)



(b)

Figure 7.3 (a) A comparison of the number of corrections applied to the authoring output (b) The percentages of corrections compared to the number of updates the groups made

The table and figure both confirm that the number of corrections made to UoLs produced by groups C and D is less than those applied to the other groups' output.

This indicates that groups working with Collaborative ReCourse produce higher quality output than those working with ReCourse.

7.2.4.4. Access of Notes and History

In the previous section, it has been shown that groups working with Collaborative ReCourse produced higher quality output than the groups working with ReCourse. In order to investigate whether Notes and History positively affect the quality of participants' authoring of learning designs, the experiment observed the usability of all kinds of Notes. That is indicated by the frequency of participants accessing Notes or History and leaving comments in Note, objects' Notes, and History's Note.

First, the data analysis focuses on what each participant did regarding Notes and History. The data are then categorised into 'look-up' and 'leave a note' actions for each kind of note: Note, objects' Notes, and History's Note and for each participant. These are described in Table 7.18 with a summary in Figure 7.4.

Table 7.17 The frequency of participants looking up and leaving notes

Participants	Note		Objects' Notes		History's Note		Total
	*	**	*	**	*	**	
C-1st participant	27	15	21	5	2	1	71
C-2nd participant	24	2	33	15	4	1	79
C-3rd participant	20	9	21	7	11	1	69
D-1st participant	19	2	48	35	4	0	108
D-2nd participant	21	3	16	2	2	1	45
D-3rd participant	36	12	5	0	3	3	59

* looked up ** left a note

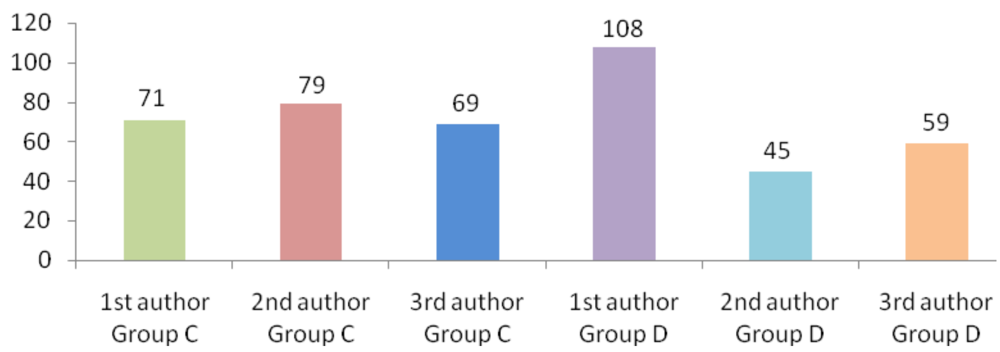


Figure 7.4 The number of accesses by participants of the three kinds of Notes

Table 7.18 and Figure 7.4 demonstrate that each participant used the Notes and History features to find what other authors had done. The other focus of this observation is which feature was the most accessed by each group. Hence, the data are categorised into two categories: ‘look-up’ access and ‘leave notes’ access for each kind of feature: Note, objects’ Note, History’s Note, and History, and for each group. The data are shown in Figures 7.5 and 7.6.

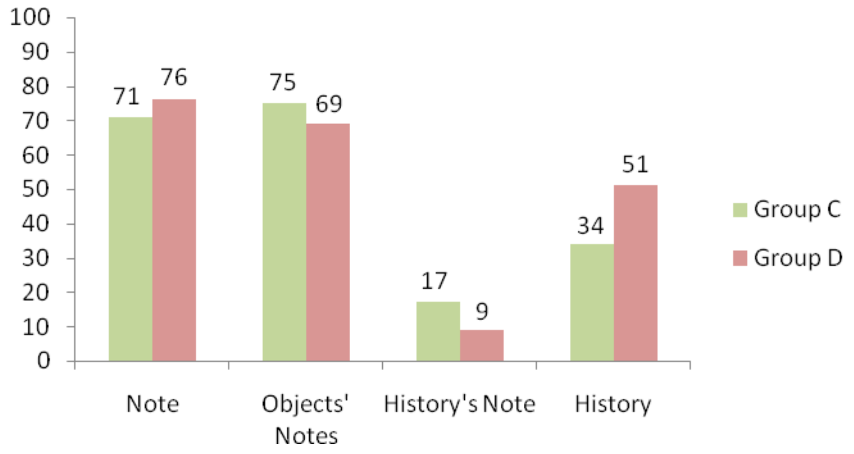


Figure 7.5 The frequency of groups looking up Notes (Note, objects’ Notes, and History’s Note) and History

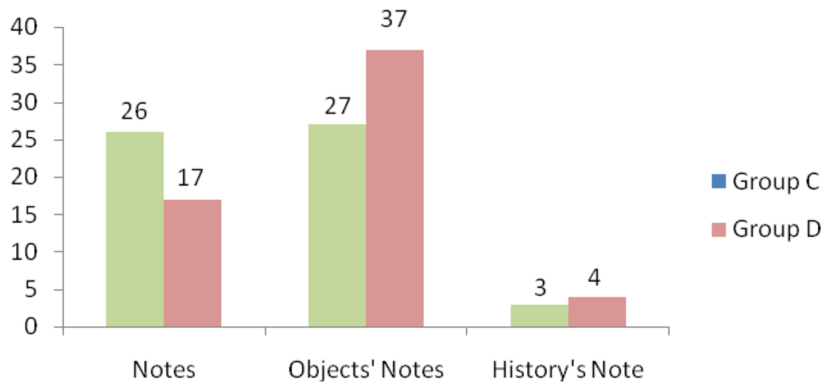


Figure 7.6 The number of notes left in Note, objects’ Notes, and History’s Note

Figures 7.5 and 7.6 show the same patterns in both groups as both groups preferred Note or objects’ Notes, rather than History’s Note, to find out what has happened during authoring or to leave comments. In addition, Figure 7.6 revealed that participants considered Notes to be more important than History.

7.2.4.5. Data from Written Interviews

In addition to the observations, structured interviews were conducted during the last session of the experiments. Some questions were distributed in order to gain authors’ views of the authoring they have have undertaken. First, all of the participants were asked about the changes they had made on the top level of the UoL, which was the sequence of modules. This is an open ended question that offers multiple choices and one blank option in which participants can freely answer without being comprised by other options. The result shows that around 58% of participants modified the order of the module sequence, which is the same number of participants who added one or more modules. Furthermore, around 92% of participants extended existing modules and 67% added modules in order to complete the structures.

Afterwards, the participants who worked with Collaborative ReCourse were asked about their reluctance to use Note, History, objects' Notes, and History's Note. According to their answers, there were two main reasons for this. First, they thought that it was not necessary to leave detailed notes for changes they had made. They considered comments only to be necessary when they had made changes which might be unclear to other participants, or to perhaps identify areas where additional improvements could be made. Second, participants reported that they did not always have time to leave notes.

All participants, however, were aware of the availability of the objects' Notes which link to resources, properties, rules, and modules (including their phases and activities). They looked up objects' Notes to find comments related to specific objects and to see their own contributions before adding new elements. They considered objects' Notes to be important as they can explain how to relate the objects.

Participants also gave a favourable response regarding History, which they found to be advantageous. They consider History to be important since the information in History complements the information in Notes. However, most of them did not think History's Note was very important and they did not use often this feature for different reasons. Some participants simply were not aware the existence of History's Note. The remaining participants consider History's Note to be redundant when compared to Note; hence they prefer to just use Note and objects' Notes. On the other hand, not having enough time to put notes into History's Note was cited as another reason.

The last two questions distributed to participants were:

- Please rate how good your collaborative work is. Give the highest rating if all authors gave good contributions.
- Please rate how efficient the collaborative work is in your group.

These used a 5-point Likert scale with 1 for the least positive appreciation and 5 for the highest positive appreciation. Groups A and B gave ratings of 2.67 and 2.67 for those questions, while groups C and D gave 4.33 and 4.

7.3. Summary

In this chapter, the results of Experiment 2 were discussed. The experiment involved four groups of three participants each that had similar profiles as they are all PhD students or researchers who have teaching experience either in the UK or in their country of origin. The observation applied in this study has given direct insights into the collaborative process and produced an overview of how the collaborative authoring of an IMS LD is carried out. Furthermore, the structured interviews have exposed possible reasons reluctance to use Note, History, objects' Notes, and History's Note and have provided valuable feedback from participants about the collaborative work they experienced.

The observations have confirmed that the implicit coordination method applied, Process Structure, without role assignment, is suitable for collaborative authoring of learning designs in IMS LD format. It is supported by evidence that in all the groups, collaborative authoring was carried out not only at the top level of IMS LD, which consists of modules and phases, but also at the lower level of IMS LD, which consists of learning activities, support activities, activity groups, properties, predefined rules, and user-defined rules. Learning designers can collaboratively work on authoring adapting learning resources as well as on non-adapting learning resources. The evidence that one participant in each group worked much more than the others has reconfirmed findings from previous studies regarding the emergence of a coordinator, who is the one who worked the most in the early stages.

The first experiment discussed in Chapter 6 has shown that Notes and History give positive implications for the level of participants' workspace awareness in collaborative authoring of learning designs, for creating both general learning elements and adaptive learning elements. In this experiment, another advantage of Notes and History has been shown as such features can provide participants information or insights which lead them to work more efficiently. This is confirmed by the experiment results showing that the groups working with the prototype of Collaborative ReCourse presented better collaborative work than those working with ReCourse. They produced higher quality output that was identified by how many corrections had to be applied to the UoL to be delivered via CopperCore, with the fewer the corrections needed, the better. In addition, they present better contributions of all group members.

Another finding from the observations is that participants use Note, objects' Notes, or History more than History's Note. This was confirmed through the structured interviews which established that participants tended to ignore History's Note as they believed it to be redundant compared with Note. Most of them felt it was more convenient to work with Note, objects' Notes, and History. They agreed that Note, objects' Notes, and History are necessary in the collaborative authoring of a learning design. In contrast, they considered History's Note not that necessary.

Finally, in the last part of the structured interviews, participants were asked to rate the collaborative work carried out by their own groups regarding the contribution of all authors in the collaboration and the efficiency of the collaborative work. As a result, participants working with Notes and History gave better ratings than those working without Notes and History. The experiment has provided evidence for Hypothesis 2 regarding the implications of Notes and History for the quality of learning designs.In the next chapter, conclusions from both experiments are discussed, along with the limitations of the study. Areas for future work are also outlined.

Chapter 8 Conclusions

This thesis has explored the subject of collaborative authoring systems for adaptive learning resources. It proposes a collaborative authoring approach that applies IMS LD for representing adaptive learning resources. The proposed approach provides features, Notes, and History, which support workspace awareness, and potentially solves common problems that occur within existing learning authoring tools. The motivation behind this research was twofold; firstly, existing learning authoring tools have common problems with the interoperability of output and the absence of collaborative work support, thus impairing their effectiveness. Secondly, there are CSCW methods that can be applied to enhance the authoring of adaptive learning resources.

This chapter concludes the thesis. It summarises the conclusions that have been drawn from all of the studies and experiments. The objectives of the research will be examined to evaluate how successfully they have been achieved, andfinally, suggestions for future research will be presented.

8.1. Summary of Findings

This research began by exploring the problems in the provision of learning resources of AEH systems. The huge volume of learning resources, the wide range of topics that must be included, and the various types of knowledge and materials make it difficult for a single learning designer to develop it single handily. Collaborative authoring is not new in learning design. It has traditionally been practiced by learning designers along with communication practices in the forms of brainstorming, discussions, or face-to-face meetings. Challenges emerge when collaboration is carried out in computer-supported environments. This is in regards to how teachers interact when authoring adaptive learning resources and whether they are aware of what others have done during the authoring process.

This question leads to several sub-questions. The first sub-question concerns what existing authoring tools for learning are, and what their advantages and disadvantages are. To answer this question, previous research on AEH systems and authoring systems for learning were explored. The results of the study were discussed in Chapter 2. In this chapter, firstly, a comparison of the knowledge base structures of general hypermedia and AEH systems was made. The distinction relies on the existence of a knowledge space in an AEH system which is not found in general hypermedia systems, thus making authoring processes for AEH systems much more complex than those of general hypermedia systems. Secondly, an in-depth examination of existing learning authoring tools provided insights into what kinds of problems could be faced by current authoring approaches including usability, interoperability, efficiency, and collaboration. This research focuses on collaboration and interoperability problems.

The second sub-question concerns which learning standards are considered to be able to solve interoperability problems. The analysis of existing authoring tools has shown that using learning standards would be better than employing transformation functions that often caused a loss of information during transformation. Chapter 3, therefore, analysed learning standards which were preceded by learning theories to give users an understanding of the learning methods comprised in learning standards. Comparisons between learning designs and learning objects and then between IMS LD and IMS SS were drawn. These comparisons led to the conclusions that learning designs are more appropriate for learning than learning objects and that IMS LD is the most suitable learning standard for adaptive learning.

The third sub-question concerns which CSCW approaches, communication methods, and features that have been successfully applied in other areas and are considered appropriate for collaborative authoring of adaptive learning resources. Hence, previous research on CSCW approaches was studied and discussed in Chapter 4. This chapter discussed workspace awareness and communication methods, and it showed that the identified problems could be framed in terms of awareness and communication issues.

Derived from the identified problems and findings gained from the analysis of previous research, two hypotheses were defined. In addition, a prototype of an authoring tool for asynchronous collaborative work was built. It extended ReCourse, an authoring tool of IMS LD with new features: Notes (Note, objects' Notes, and History's Note) and History. The user interface design of Collaborative ReCourse is the same as ReCourse.

The first hypothesis regards Sub-question 5 which concerns the implication of Notes and Historyto improve workspace awareness in authoring learning designs inthe IMS LD format. An experiment was conducted in order to prove the hypothesis. This was a between-group quantitative study in which participants were divided into two groups; one group who worked with ReCourse, the other who used Collaborative ReCourse. The experiment provides evidence that learning designers who worked with Collaborative ReCourse, which provides Notes and History, have higher workspace awareness than those working with ReCourse, which does not provide Notes and History (**Conclusion 1**).

The second hypothesis assumes that the soundness of the learning resources produced by learning designers working with Collaborative ReCourse would be higher than those produced by learning designers working with ReCourse. The hypothesis was defined for Sub-question 6 and concerns the implications of Notes and History on the quality of output. This was proven through the second experiment which was a qualitative inquiry in the forms of observation and structured interviews. In the experiment, participants had to work toward real goals over a much longer time frame. They were divided into four groups: two groups worked with ReCourse, and the two other groups with Collaborative ReCourse. Based on the number of corrections needed to fix the produced UoL, the evaluation provides evidence that UoLs produced from collaborative authoring with Collaborative ReCourse are better than those produced by groups working with ReCourse; this indicates that Notes and History positively affect the quality of outputs (**Conclusion 2**).

The second experiment also observed the granularity level of the collaborative authoring of IMS LD and tested whether an implicit coordination method is appropriate for the collaborative authoring of an IMS LD. It regards Sub-question 4. The data analysis showed that authors worked collaboratively in creating and structuring plays and the underlying elements (acts and learning/support activities), and also on all other elements (properties, conditions, and resources). They also worked collaboratively to create non-adapting, as well as adapting, artefacts in the forms of IMS LD level A and level B. According to the experiment results, it can be concluded that collaborative authoring of learning designs in IMS LD can be used to create all kinds of IMS LD elements. In the context of AEH systems, it is possible to carry out collaborative authoring to create not only the hyperspace, but also the knowledge space of AEH systems. Learning designers can collaboratively work not only on the authoring of domain models, but also on authoring pedagogical models, adaptation models, and learner models (**Conclusion 3**).

The composition of the authors' contributions in the groups working with Collaborative ReCourse is better than the other groups working with ReCourse. All groups, on the other hand, present a phenomenon as a coordinator emerges in each group; this is the one author who gives the highest contribution in the early sessions of the collaborative authoring. This fact was supported by the authors' self-assessments through structured interviews. It provides evidence that authors working with Collaborative ReCourse rate the work efficiency and task distribution in their groups higher than those working with ReCourse. Hence, it can be concluded that implicit coordination with Notes for communication is appropriate for the collaborative authoring of learning designs in IMS LD (**Conclusion 4**).

8.2. Limitations of the Present Study

According to this study, there are limitations that need to be addressed. Each limitation is described as follows:

1. Authoring approach
   The proposed collaborative authoring approach is designed for asynchronous collaborative authoring and as such does not support synchronous collaborative authoring. In an asynchronous collaboration, learning designers will not encounter problems regarding finding appropriate times to work together simultaneously. However, this does not offer the advantages that synchronous collaborative work offers. For example, in synchronous collaborative work, learning designers can brainstorm and do not need to wait for responses in order to begin their work.
2. Communication method
   This study hypothesised that implicit coordination and without role assignment is appropriate for collaborative authoring of learning designs in IMS LD format. The second experiment through observations has proven that learning designers could work well with Collaborative ReCourse which implements the proposed approach. The quality of learning designers' work is reflected in the quality of output and the contributions of learning designers. The experiment, however, has a limitation as it was not compared to any other method, for example: what if learning designers were introduced to explicit coordination with role assignments? which approach would they prefer? This research did not make comparisons between such approaches because of the unavailability of tools that could be applied to the other approach.
3. Participants selection
   All participants in both experiments were learning designers in technology or engineering courses. Most of them have computer science background, and therefore should be familiar with using computers and software. The proposed collaborative authoring approach was not tested on learning designers in other courses, such as social sciences or humanities. The difference in participants' profiles may result in different outcomes of the experiments.

4. Measurements for qualitative inquiry

   There are two kinds of evaluation that can be applied to the observation results: objective and subjective evaluations. In the context of learning design authoring, a subjective evaluation might be accomplished through expert reviews that learning designers could be invited to review and to compare the results from each group. Evaluation criteria, for example, can refer to the 12 criteria of the Penn State quality assurance e-learning design standards (Ragan, 2009), including navigation, student orientation, syllabus, instructor response and availability, course resource requirements, technical support, accessibility requirements, learning objectives, learning activities and assessment, copyright requirements, course functionality, and student input for course improvements. This research, however, did not conduct a subjective evaluation considering the output from each group is not quite mature because it was produced from the first nine sessions. Hence, this research used an objective measurement based on the number of corrections applied to fix the UoLs.

5. Application

   At this stage, the Collaborative ReCourse was implemented as a prototype that did not particularly address usability and accessibility. The original ReCourse is a stand-alone authoring tool with easy-to-use interfaces, but it does not provide any help or guidance to the users. It was built with Eclipse and Rich Client Platform (RCP). A transformation of the tool into a real web based or a client-server based authoring tool requiresanother plugin, Rich Ajax Platform (RAP), to replace RCP. The problem emerges when the current version of RAP is not compatible with other plugins used in the original ReCourse. Hence, with the limited usability and accessibility, users may have felt uncomfortable when interacting with the system.

6. Reusing learning materials

   As explained in Section 2.1, authoring for AEH systems or adaptive learning systems is more complex than that of general hypermedia systems. The existence of the knowledge space has made the authoring cycle more complicated. The authoring cycle, however, can be simplified by diminishing one step of authoring regarding learning content. Learning designers should not spend most of their efforts on creating learning content. In this research, an early feature called learning content gallery, which links IMS LD elements to existing learning content, has been created. However, it needs more work to make it useful for learning designers.

8.3. Future work

Some limitations are acknowledged in Section 8.2. A future work plan is then introduced to address the direction of research regarding those drawbacks.

1. Authoring approach

   Future work can include the implementation of a synchronous collaborative approach for creating adaptive learning resources in IMS LD. Afterwards, a comparison of synchronous and asynchronous collaboration can be carried out in order to find the most suitable collaboration type for authoring learning designs.

2. Communication method

   There is another kind of approach that can be applied to the authoring of learning designs. Considering a learning design has hierarchically structured elements, this research applied a Process Structure method with implicit coordination that has been successfully applied to collaborative authoring by both small and large groups. However, considering the authoring of learning designs is commonly conducted by small groups of learning designers, it is possible to apply explicit coordination in which learning designers need to gain a consensus before taking an action. Explicit coordination works well only in small groups of authors. For this method, notes or annotations are not enough for learning designers to communicate; a communication feature that enables learning designers to have true discussions is needed. In the future, conducting a research on this kind of approach will present which approach is the most appropriate for collaborative authoring of learning designs.

3. Application

   In this research the proposed authoring approach was implemented as a prototype. A future work can focus on transforming the prototype into a collaborative authoring tool which provides guidances that is useful for learning designers who might not have working experience in IMS LD and collaborative authoring.

4. Reusing learning materials

   From a few questions asked to the participants about the gallery of learning content, it was indicated that the learning content gallery had provided some important resources which could be reuse. The gallery, however, must be improved by providing more relevant links to existing learning content. In addition, the study showed that participants agreed that a combination of keywords and URLs is sufficient to retrieve suitable learning materials from the gallery. Participants confirmed that it is easy to reuse the learning content from the gallery. Future work can focus on this topic in order to manage links needed to open learning content repositories and recommend relevant learning content to learning designers.

8.4. Concluding Remarks

This research proposed a collaborative authoring approach for adaptive learning resources. The idea behind the proposed collaborative authoring approach is the desire to reduce the problems of the interoperability and collaborative support found in current existing authoring tools for learning. To gain the reusability and interoperability of output, the proposed approach uses IMS LD to represent adaptive learning resources. Among the various learning standards, learning designs offer more advantages than other learning standards. IMS LD is more suitable for adaptive learning than IMS SS regarding pedagogical expressiveness, adaptation support, and the suitability with the authoring process of AEH systems.

This research investigated how learning designers work in collaborative authoring of IMS LD, how two collaborative features, including Notes and History improve learning designers' workspace awareness of what has happened in authoring, and how such features lead to better output of authoring. The experiment results confirmed that a Process Structure method with implicit coordination method and without role assignment is a suitable approach to the collaborative authoring of learning designs. The experiments also showed that collaboration can be carried out for authoring adapting as well as non-adapting learning resources. The evaluation also presented the findings that with Notes and History, learning designers improves their workspace awareness regarding what has been done in the authoring. In addition, they work more efficiently which is indicated by better output. The development of a collaborative authoring approach of adaptive learning resources intends to allow researchers to conduct further studies on various related concerns.

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Appendix A

An Introduction File for Experiments 1 and 2

An Introduction to IMS Learning Design, ReCourse, and Collaborative ReCourse

This document aims to introduce participants to IMS Learning Design (IMS LD), ReCourse, and Collaborative ReCourse authoring tools. The paper is organised as follows:

- Section 1: A quick introduction to IMS LD. This section briefly explains the objectives and the general structure of IMS LD.
- Section 2: Concepts underlying IMS LD. This section discusses the XML based structure and format of IMS LD.
- Section 3: A case study. This section describes how a subject is represented in IMS LD format and built in ReCourse. It presents a Unit of Learning (UoL) for 'Anatomy and Physiology' course as an example, which is produced by ReCourse. To make this section more understandable, some screenshots captured from ReCourse are presented.
- Section 4: Additional material: how a UoL in IMS LD format is delivered in IMS LD player. In the previous section participants have been introduced to ReCourse to produce a UoL in IMS LD. Since ReCourse does not have any function to deliver a UoL to learners, another kind of tool called the IMS LD player is needed. This section describes how a UoL is delivered to learners by an IMS LD Player, CopperCore. Some screenshots captured from CopperCore are presented in this section.
- Section 5: An extended ReCouse: Collaborative ReCourse. This section describes a prototype of the extended ReCourse -called Collaborative ReCourse- that enables teachers to work collaboratively. This section sets out the differences between ReCourse and Collaborative ReCourse.

1. A brief general introduction to IMS LD

IMS LD is a technical specification which is expressed in XML and it represents a wide range of learning activities to support the exchange of learning materials between different systems. IMS LD enables people to organise learning activities and to add control of properties and conditions, so that complex branching workflows can be generated based on learners' needs. A Unit of Learning is a set of learning activities designed by a teacher or course author and expressed in IMS LD.

It can be a single lesson, or a whole course. A Unit of Learning (UoL) is a collection of:

- Learning objectives
- Learning resources, such as web links, text documents, images, etc.
- Services which learners and teachers can use, such as chatting, messaging, voting, etc.
- Roles to be taken by the participants in the UoL, which is typically “learner” and “teacher”, but it could also include technical support, different groups of learners, etc.
- Instructions for learners, telling them what they need to do, for example: “Read this text and discuss it with the other members of your group in the forum”

A Unit of Learning can be very simple (for example: "everybody look at this web page and discuss it on this forum") or very complex, or it can define a complex workflow with alternative routes and activities depending on the learners’ activities.

2. The concepts underlying IMS LD

The structure of IMS LD is presented below:

STRUCTURE	DESCRIPTION
learning-design title learning-objectives prerequisites components	*learning-design* represents a course, a module, or a lesson which addresses some learning objectives.
roles learner* staff*	*roles* represents actors participating in learning.
activities learning-activity* environment-ref* activity-description support-activity* environment-ref* activity-description	
activity-structures* environment-ref* environments environment*	*environment* is a context in which all learning activities take place. It can be a resource pack containing documents and links to services that can help learners to carry out learning activities.
method play*	*play* defines the flow of learning activities. It is like a complete piece of learning, for example a lesson; a UoL must have at least one play. A *Play* must have at least one *Act* which is like a sub-lesson, a session or phase within a lesson.

act* role-parts* metadata	Complete lessons: a combination of activities, roles, and enviroments.

* means the element probably has some/many instances

3. A Case Study

3.1 Description

This section presents an example of the implementation of IMS LD for some topics of Anatomy-Physiology course which refers to http://www.universalclass.com/i/course/anatomy-and-physiology.htm. The topics implemented in this case comprise three modules and each of them has at least one lesson (phase). Each phase is delivered in one or more learning activities or support activities and it involves one or more learners or teachers. In this example, there are three roles including new learners, remedial learners, and teachers.

Type of learning: individual learning

Roles: learner

Course name: Anatomy

Pre requisite: Introduction to Human biology.

Description:

This self-paced anatomy and physiology course will cover all the bodily systems playing a major role in human anatomy. The material is presented in a practical and comprehensive manner. The focus of the course is on the need-to-know facts that must be understood in order to pursue any healthcare career or related education in the field of science. These easy to follow lessons are ideal for anyone requiring a solid understanding of how the human body works.

Objectives:

By successfully completing this course, students will be able to:

- describe the chemistry basics involved in Anatomy and Physiology.
- describe the function of cells.
- identify different types of tissues and their functions.
- describe and identify specific parts and key terms of the Body Anatomy.
- describe embryology.

Module 1: Tissue Anatomy

Lesson:

- Tissue anatomy of the human body

Activity groups: Bone, Muscle, Nerve.

Module 2: Body Anatomy

Lessons

- Organ anatomy

    Activity groups: Brain, Lymph system.

- Circulation anatomy

    Activity groups: Artery, Vein.

Module 3: Embryology

Lessons

- Embryology of human body

    Activity groups: Embryo genesis.

3.2 The screenshots using ReCourse

The screenshots of the UoL produced by ReCourse are presented in the following figures.

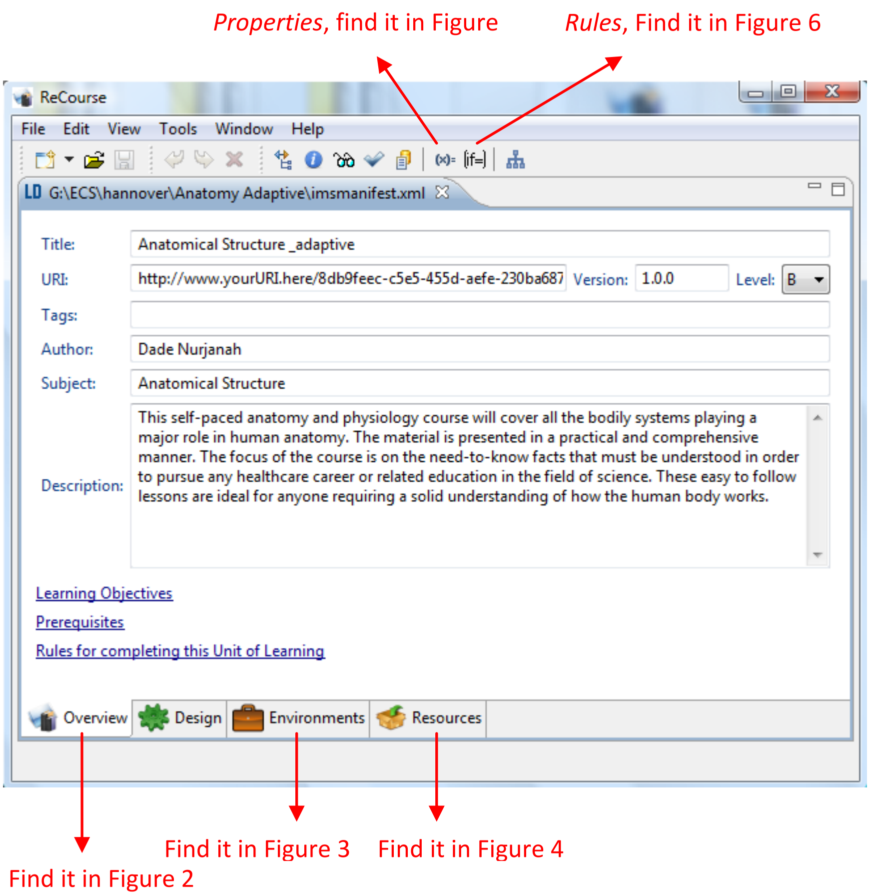


Figure 1. The Overview page in ReCourse

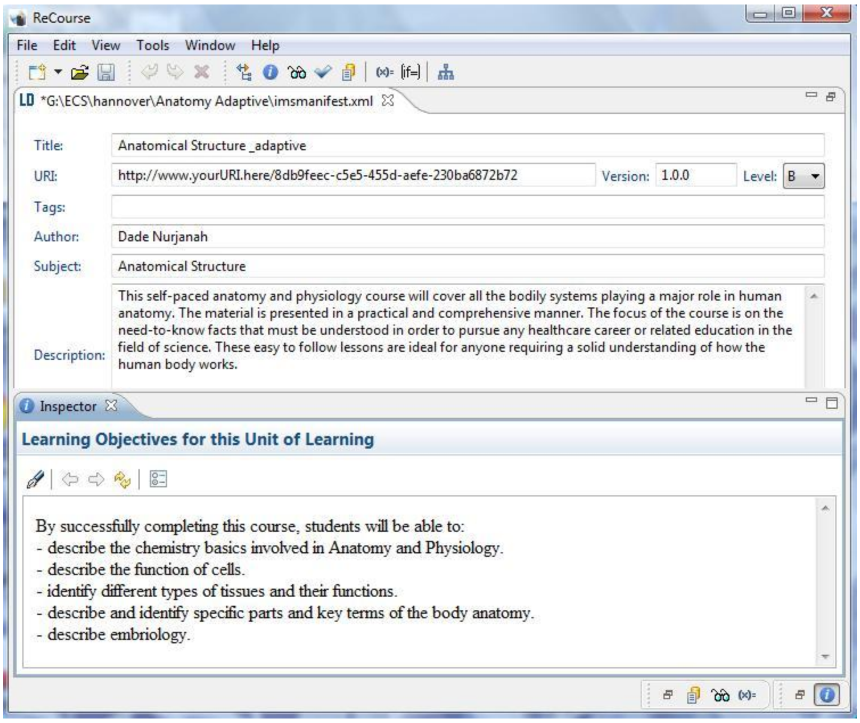


Figure 2. The title, description, and learning objectives of the UoL

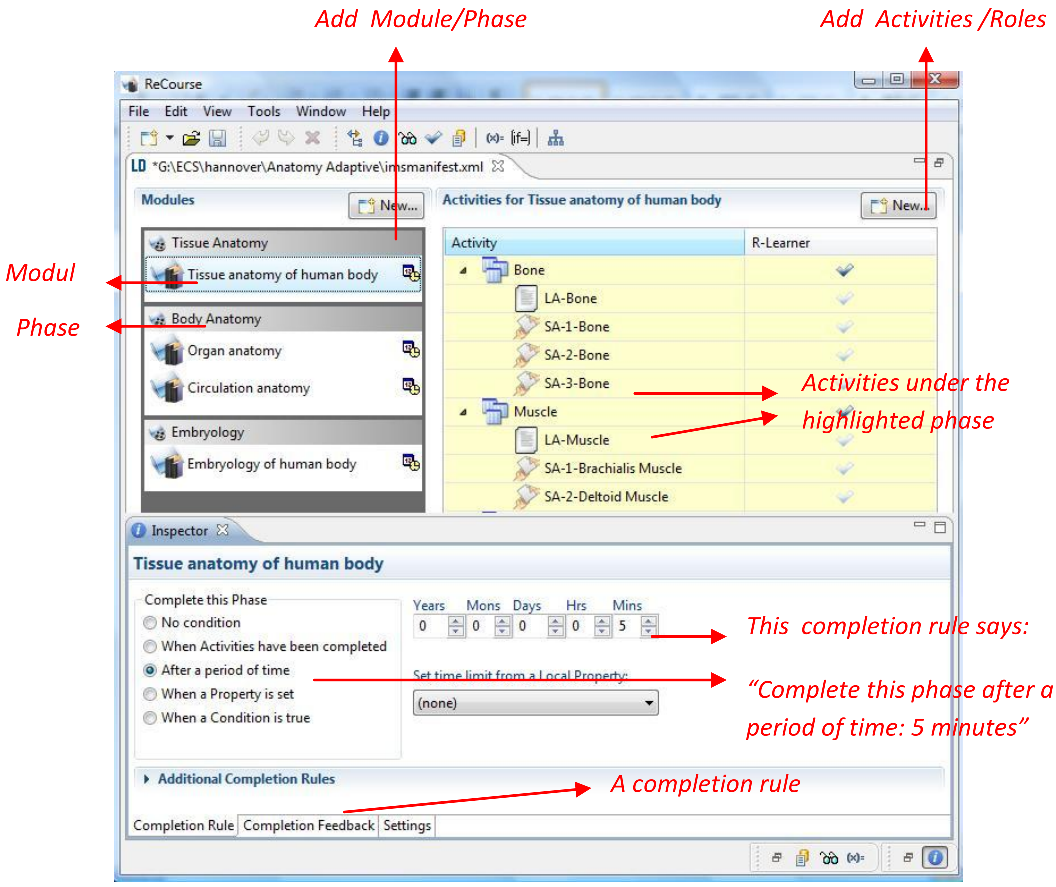


Figure 3. The structure of UoL, the detail of phase 'Tissue anatomy of human body' and its completion rule

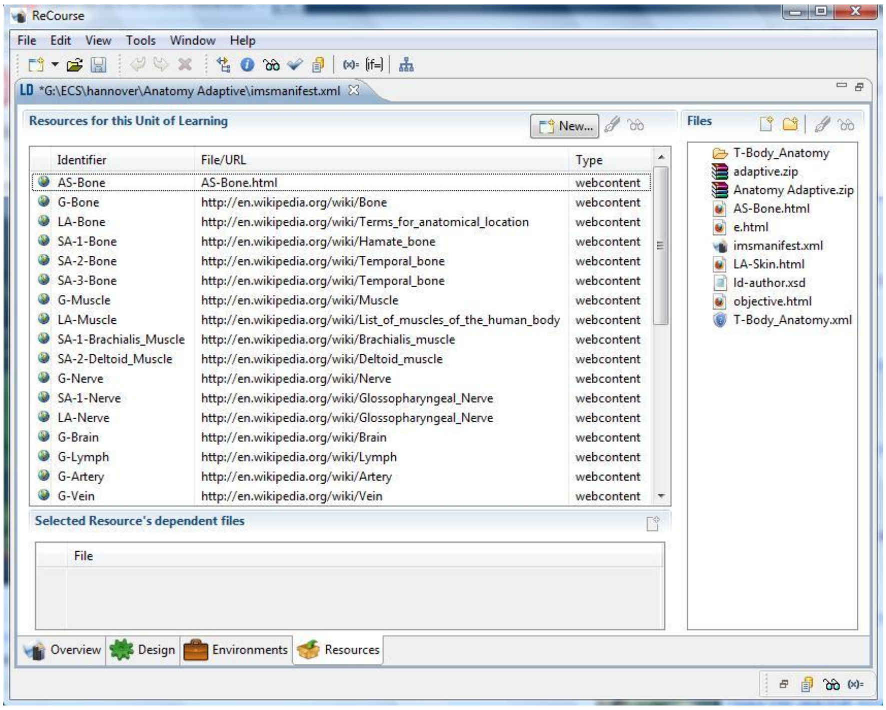


Figure 4. The resource page of the UoL

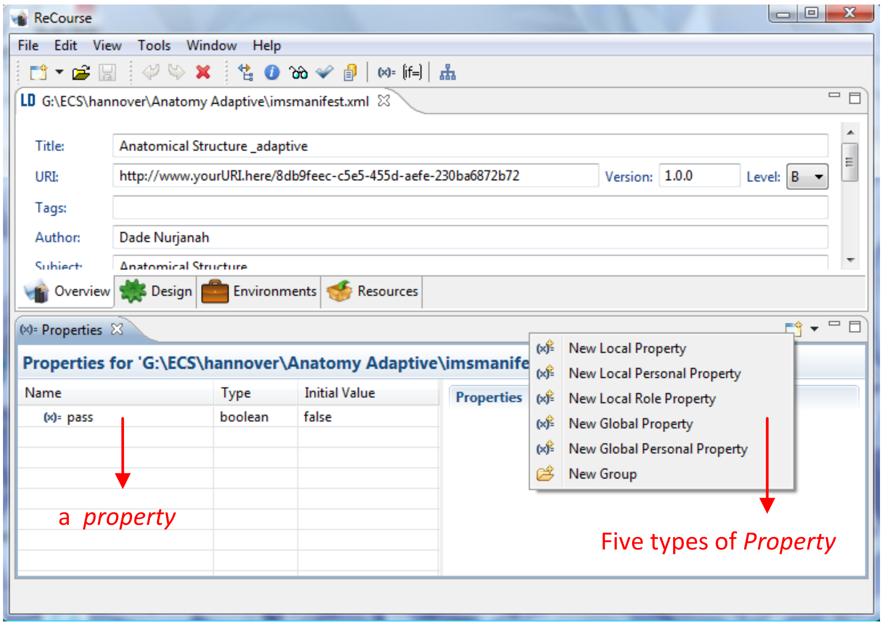


Figure 5. Page for updating *Properties*

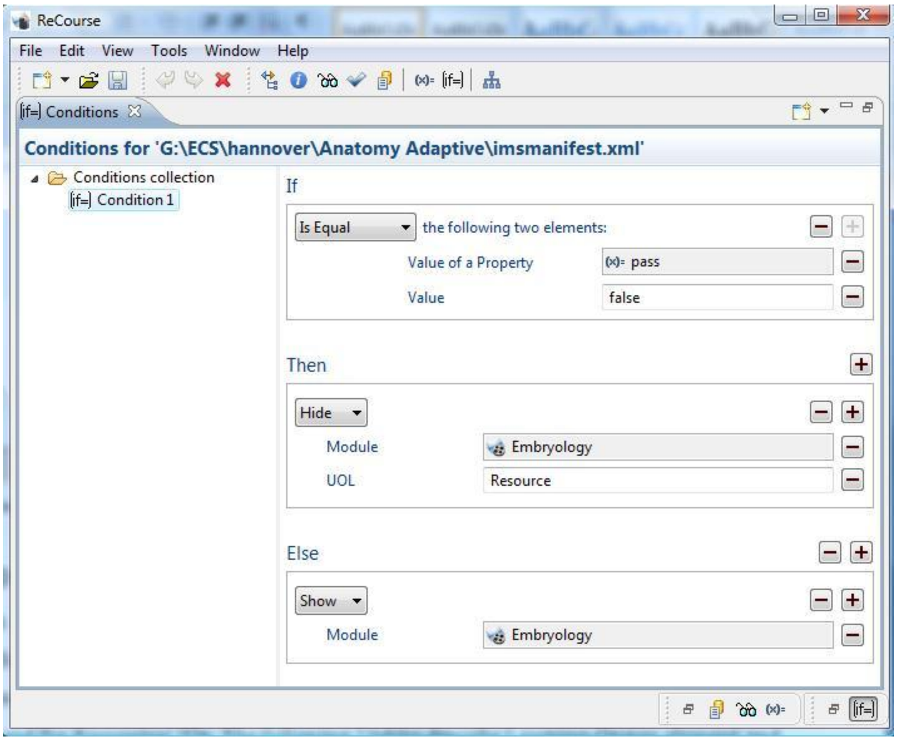


Figure 6. An adaptation rule: module Embryology will be shown if property 'pass' is true. Property 'pass' is set true when module Body Anatomy has been completed (see Figure 7)

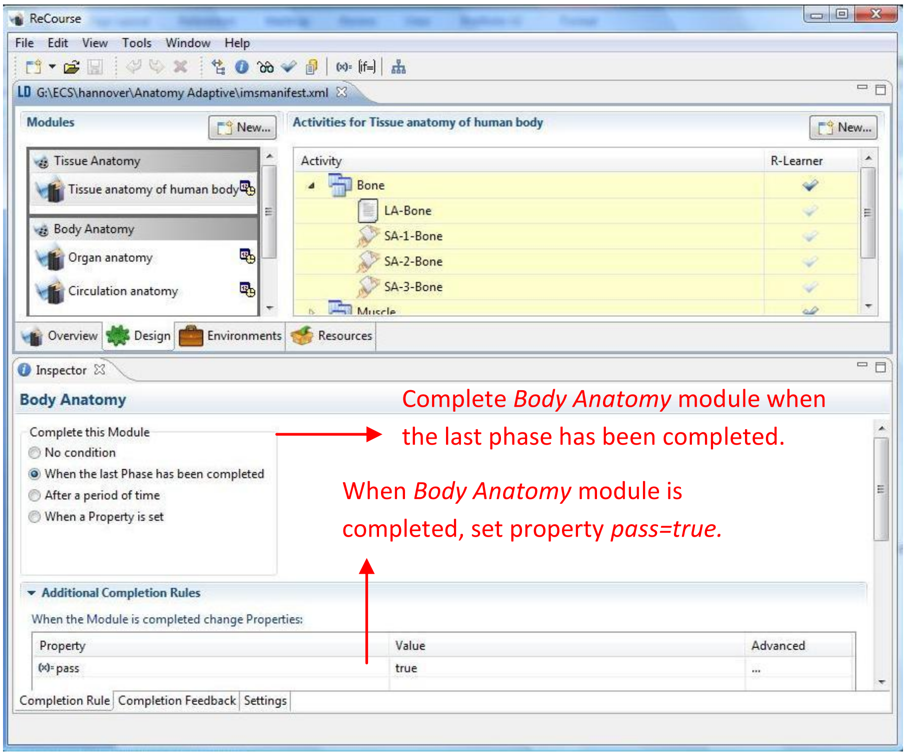
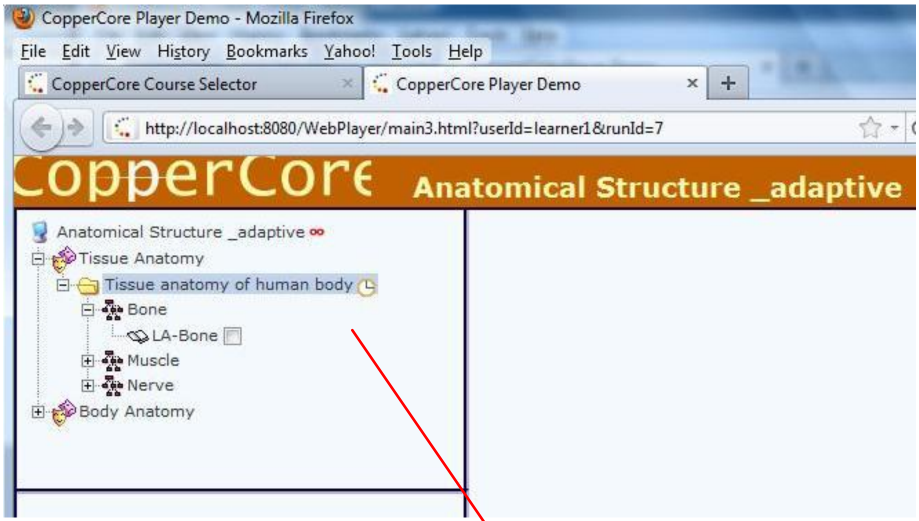


Figure 7. A completion rule for the Body Anatomy module

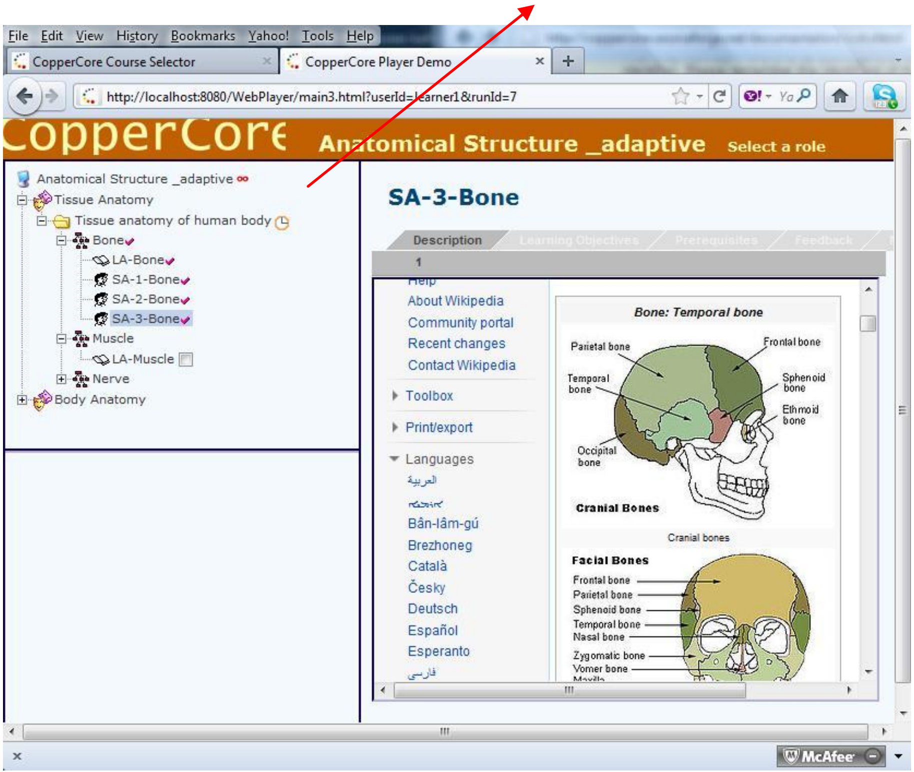
4. Additional material: how IMS LD is delivered in an IMS LD player

This section is aimed to give an understanding on how a UoL is delivered in IMS LD players. In this case, we used CopperCore.



(a)

See the first module Tissue Anatomy. In phase "Tissue anatomy of human body", only one activity: LA-Bone is shown. An activity will be visibleto a learner when he has finished learning the previous one.



(b)

Figure 8. Two examples of how a UoL is delivered in CopperCore

Figure 9. Only Module 1 and Module 2 (Body Anatomy) are displayed. The third module (Embryology) will be shown once the learner finished learning the second module.

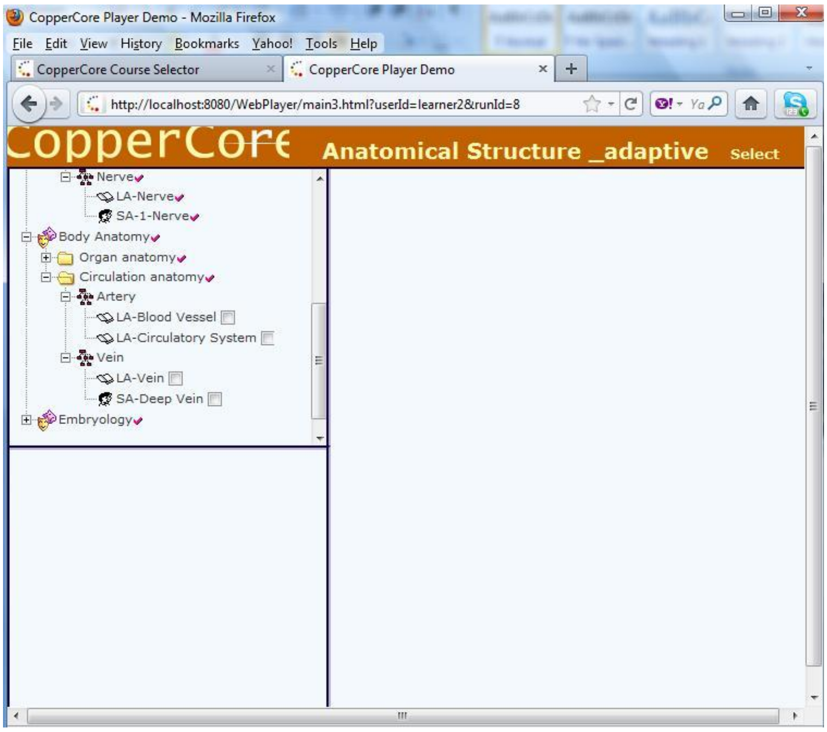


Figure 10. The third module:Embryology is shown. The second module of Body Anatomy has finished because the time for completion has finished, someactivities have not been finished yet (see the un-thicked activities under phase “Circulation Anatomy”)

5. An Extension of ReCourse: Collaborative Features

There are two collaborative features in the Collaborative ReCourse: *Note* and *History*. *Note* is a feature that allows authors to leave comments. *History* is a feature that records changes made in the unit of learning.

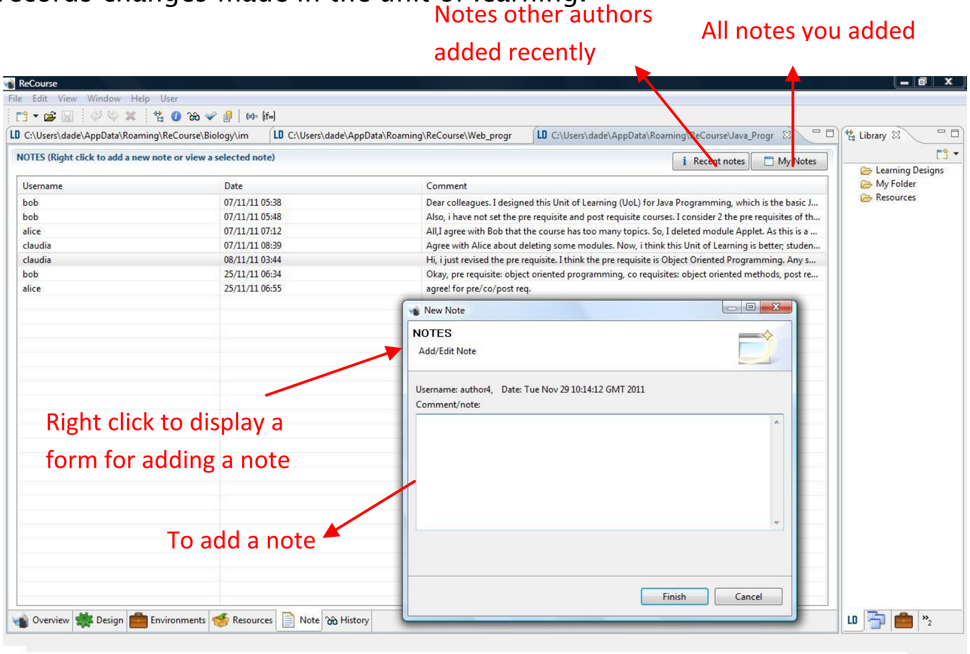


Figure 11. The *Note* screen

Figure 11 shows the screen of *Note* for the whole unit of learning. *Note* is also applied on *History*, in that authors can write notes for every single record of *History*. Figure 12 shows the screen of *History* and guidance on how to access notes on it.

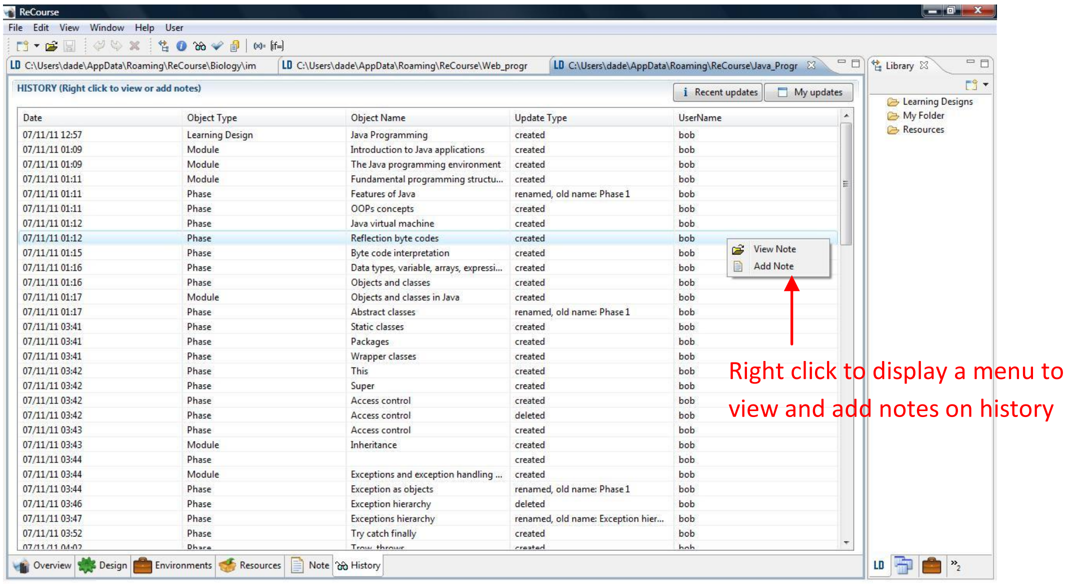


Figure 12. The *History* screen

In addition, *Note* is also applied on modules/phases, resources, properties, and rules. Figure 13 shows how to access *Note* of an object.

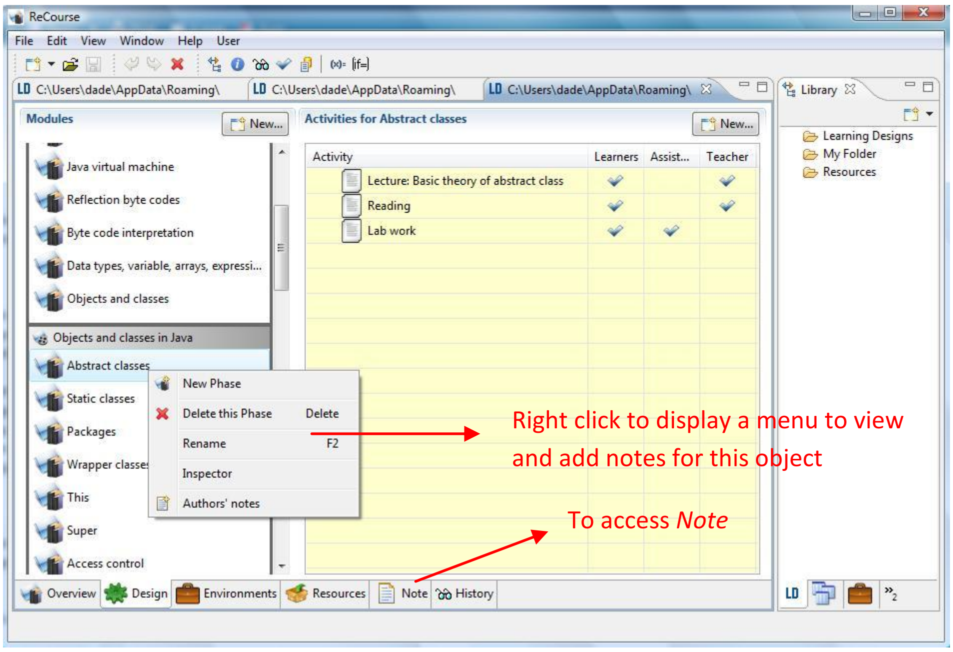


Figure 13. Access to *Note* of an object

Another new feature of Collaborative ReCourse is a gallery of existing learning materials:

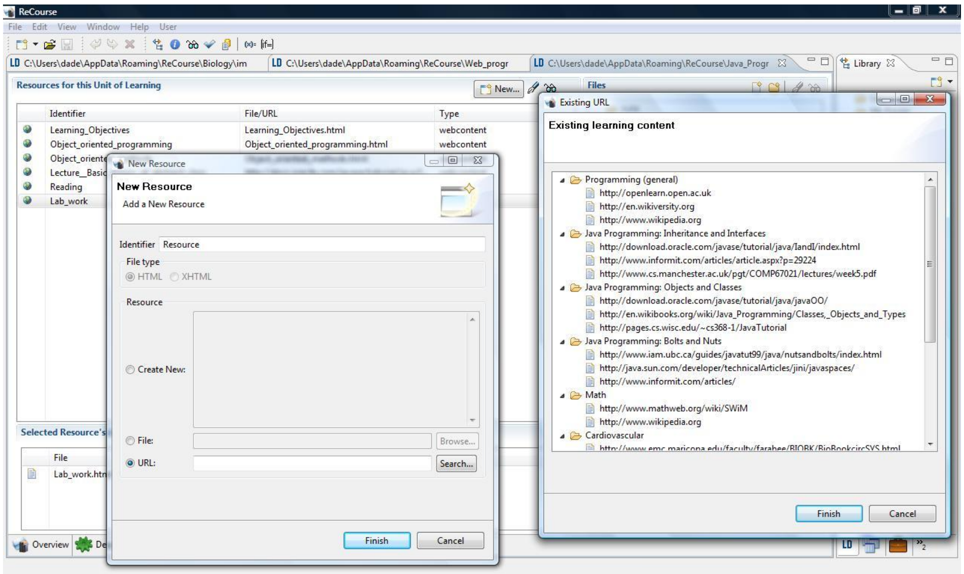


Figure 14. A gallery of existing learning materials

As a conclusion, ReCourse that you will use in this experiment is purely authoring tool. It does not have any function to deliver learning materials to students

Appendix B

Experiment 1

B1. Information Page and Consent Form

QUESTIONNAIRE: THE STUDY OF THE NEEDS AND THE USABILITY OF COLLABORATIVE FEATURES IN AUTHORING LEARNING DESIGNS

TOOL: RECOURSE

RESEARCHER: DADE NURJANAH

Thank you for agreeing to take part in this study of the usability of collaborative features in authoring learning designs. This forms part of my PhD thesis which focuses on the development of a collaborative authoring model for adaptive learning resources. Your participation in this study is voluntary and you may withdraw at any time without consequence; however, we would appreciate it if you could answer the following questions to help us research this topic.

The participants of this questionnaire are postgraduate students or those who have teaching experience. The collected data will be kept confidential and for research purposes only. Results from this questionnaire will be used to inform the usability of collaborative features in authoring learning designs.

The questionnaire is paper-based and it should take 45-60 (max) minutes of your time.

This study has been granted full Ethics approval from the ECS School, University of Southampton. The reference number is ES/11/12/001.

CONSENT FORM

Study title: The study of the needs and the usability of collaborative features in authoring learning designs

Researcher name: Dade Nurjanah

Ethics reference: ES/11/12/001

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet and have had the opportunity to ask questions about the study ☐

I agree to take part in this research project and agree that my data can be used for the purpose of this study ☐

I understand my participation is voluntary and I may withdraw at any time without consequence ☐

Signature of participant ……………………………………………………………..

Name of Researcher (print name): Dade Nurjanah

Signature of researcher ……………………………………………………………..

Date ………………………………………………………………………………………

B2. Group 1 ReCourse Questionnaire

Select one option for each question

PART 1: Background information

1. This question is about your background:
   a. Do you have any teaching experience (as lecturer/ teaching assistant/ lab-work assistants/ demonstrators)?

a lot	some	little	none
◯	◯	◯	◯

   b. Do you have any experience in working with IMS Learning Design (IMS LD) or IMS LD authoring tools?

a lot	some	little	none
◯	◯	◯	◯

This questionnaire uses Unit(s) of Learning (UoL): Introduction to biology, web programming, and Java programming.

2. Are you familiar with the following subjects

	yes	know a little	no
Introduction to biology?	◯	◯	◯
web programming?	◯	◯	◯
Java programming?	◯	◯	◯

Part 2: The absence of *Note* and *History* for planning authoring learning design

3. When you read a syllabus, is the following information important for you?

	very important	quite important	not very important	not important at all
a. Learning objectives	◯	◯	◯	◯
b. Prior knowledge of expected learners	◯	◯	◯	◯
c. Pre-requisite courses	◯	◯	◯	◯
d. Post-requisite courses	◯	◯	◯	◯
e. Course reading list	◯	◯	◯	◯
f. Overall learning time	◯	◯	◯	◯
g. Descriptions of topics	◯	◯	◯	◯

Select one option for each question

Open Unit of Learning Introduction to biology. In tab *Overview* you can find the learning objectives, pre requisites, and description of the course.

4. Explore the Unit of Learning (UoL). Based on what you see in the UoL, how well can you guess who first created the UoL?

very well	well	bad	very bad
◯	◯	◯	◯

5. Look for the module "Evolution, Taxonomy, and Microorganisms", and then take a look phase "Darwin and Evolution". Do you think the current information, if any, about the module and the phase is sufficient to understand them?

strongly sufficient	quite sufficient	not very sufficient	not sufficient at all
◯	◯	◯	◯

6. Find out *roles* in this UoL; one of them is *assistant*. Do you think the current information, if any, on the roles is sufficient to understand why the UoL needs 2 assistants?

strongly sufficient	quite sufficient	not very sufficient	not sufficient at all
◯	◯	◯	◯

7. This UoL was developed by more than one author; a few authors have revised the original UoL by adding or deleting some elements. Based on what you see in the UoL, how well can you guess which elements were added most recently, which elements that have been deleted, and why?

very well	well	bad	very bad
◯	◯	◯	◯

8. When you read a UoL, is the following information important for you?

	very important	quite important	not very important	not important at all
a. Who first created the UoL	◯	◯	◯	◯
b. When the UoL was first created	◯	◯	◯	◯
c. Who contributed	◯	◯	◯	◯
d. When the last update was	◯	◯	◯	◯
e. Who created which part	◯	◯	◯	◯

Select one option for each question

Now, open UoL web programming.

9. Based on what you see in the UoL, how sufficient is the information (if any) about the pre requisites of this UoL?

strongly sufficient	quite sufficient	not very sufficient	not sufficient at all
◯	◯	◯	◯

10. Based on what you see in the UoL, how sufficient is the information about the co-requisites and post-requisites of this UoL?

strongly sufficient	quite sufficient	not very sufficient	not sufficient at all
◯	◯	◯	◯

11. Find the module "Java Script Libraries". That is the only Java topic in this UoL. Does the UoL provide sufficient information on why the topic is there or why there is no other Java topic?

strongly sufficient	quite sufficient	not very sufficient	not sufficient at all
◯	◯	◯	◯

Give your answers for questions number 12-14 **based on your experience playing with UoL web programming and Introduction to biology.**

12. You have played with two UoLs. How sufficient is the following information in ReCourse?

	very important	quite important	not very important	not important at all
Information about targeted learners	◯	◯	◯	◯
Post requisite courses	◯	◯	◯	◯
Suggested reading list	◯	◯	◯	◯
Overall learning time	◯	◯	◯	◯
Descriptions of some (all) topics	◯	◯	◯	◯

13. Related to question 12, is the information that you found sufficient to understand a UoL?

strongly sufficient	quite sufficient	not very sufficient	not sufficient at all
◯	◯	◯	◯

14. Do you agree that it will be useful if more information about a UoL is provided?

strongly agree ◯ agree ◯ disagree ◯ strongly disagree ◯

Select one option for each question

Part 3: The absence of *History, object's Note,* and *History's Note*

Open UoL Java programming. Questions 15 to 22 are related to UoL Java programming.

15. Explore the UoL. Based on what you see in the UoL, is there sufficient information regarding the UoL (such as its scope, sequence, etc.) ?

strongly sufficient ◯ quite sufficient ◯ not very sufficient ◯ not sufficient at all ◯

16. Find the module 'Inheritance'. Based on what you see in the UoL, is there sufficient information about sub-topics that are missing or what sub topics should be added into the topic?

strongly sufficient ◯ quite sufficient ◯ not very sufficient ◯ not sufficient at all ◯

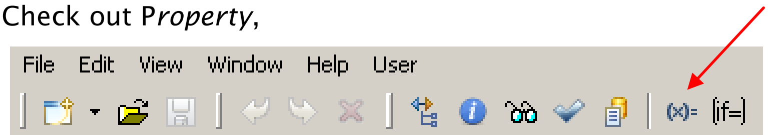
17. Create a module 'Interfaces and inner classes'. Do you agree that other people can understand what the module is about, how its scope, and what sub-modules (phases) are to be added?

strongly agree ◯ agree ◯ disagree ◯ strongly disagre ◯

18. Find the module 'Objects and classes in Java' and phase 'Abstract classes'. You will see that the phase has 3 learning/support activities. How well can you guess which activity that will be conducted in group?

very well ◯ quite well ◯ quite bad ◯ very bad ◯

19. Check out *Property*,

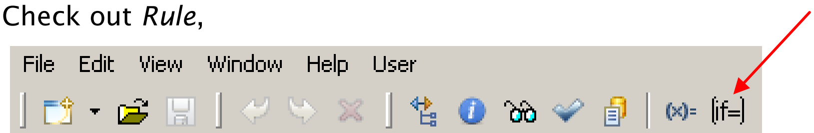


You will find a property named 'LocPers1', what is the property for?

- ◯ Grade required to pass this course
- ◯ Mark a learner achieved on last phase
- ◯ Average of marks a learner gained so far
- ◯ I don't know

Select one option for each question

20. Check out *Rule*,



You will find a rule named 'Rule 1'. What is the objective of the rule?

- ◯ To give additional modules to learners who need them
- ◯ To give additional learning activities to learners who need them
- ◯ To hide the next module if learners fail on the current module
- ◯ I don't know

21. Find the properties. You will find a property named 'Time'.

a. What is the property for?

- ◯ Maximum time for learning a module
- ◯ Maximum time for learning a phase
- ◯ Maximum time for doing an activity
- ◯ I don't know

b. In which module is property 'Time' used?

- ◯ Fundamental programming structures of Java
- ◯ Objects and classes in Java
- ◯ Inheritance
- ◯ I don't know

22. Find the module"Inheritance". The completion of the module involves 3 properties.Which one of the following statements is wrong?

- ◯ The three properties are Pass, Grade, and Mark.
- ◯ Pass is a boolean property that will be set 'true' if Mark=50
- ◯ Grade does influence only learners
- ◯ I don't know

Part 4: Summary for *properties* and *rules*

23. In your opinion, is information about *properties* and *rules* important?

very important	quite important	not very important	not important at all
◯	◯	◯	◯

Select one option for each question

24. In your opinion, to work efficiently (*do right*) in authoring involving some authors,do you think that *Notes* on objects(module/phase/resource/etc.) from other authors are important?

very important	quite important	not very important	not important at all
◯	◯	◯	◯

25. To work effectively (*do faster*) when reusing other authors' work,do you think that *Notes* on objects (module/phase/resource/etc.) from former authors are important?

very important	quite important	not very important	not important at all
◯	◯	◯	◯

26. In your opinion, when reuse other authors' UoL (Unit of Learning), do you think that *History* which maintains information about what authors have done to which objects is important?

very important	quite important	not very important	not important at all
◯	◯	◯	◯

27. Related to question 26, do you think that authors' *Notes* on *History* important for you to understand why an author did something (add/edit/delete) to an object (UoL's element)?

very important quite important not very important not important
at all

◯ ◯ ◯ ◯

Part 5: Reusing existing learning materials

Click tab *Resources*. Create a new resource of *Polymorphism.* Click URL to reuse existing online materials*.*

28. When you would like to reuse existing online learning materials, do *keywords* and *URL* of the materials provide enough information to find suitable materials?

strongly agree ◯ agree ◯ disagree ◯ strongly disagree ◯

Select one option for each question

Questions 29 and 30 are related to the following list.

topics
topic name="Programming (general)"
http://openlearn.open.ac.uk
http://en.wikiversity.org
http://www.wikipedia.org
topic name="Java programming: Inheritance and Interfaces"
http://download.oracle.com/javase/tutorial/java/IandI/index.html
http://www.informit.com/articles/article.aspx?p=29224</url>
http://www.cs.manchester.ac.uk/pgt/COMP67021/lectures/week5.pdf
http://ocw.csail.mit.edu/f/10
topic name="Java programming: Objects and Classes"
http://download.oracle.com/javase/tutorial/java/javaOO/
http://en.wikibooks.org/wiki/Java_Programming/Classes,_Objects_and_Types
http://pages.cs.wisc.edu/~cs368-1/JavaTutorial
topic name="Java programming: Bolts and Nuts"
http://www.iam.ubc.ca/guides/javatut99/java/nutsandbolts/index.html
http://java.sun.com/developer/technicalArticles/jini/javaspaces/
http://www.informit.com/articles/
topic name="Math"
http://www.mathweb.org/wiki/SWiM
http://www.wikipedia.org

29. Check out the list. Do you agree that a number of URLs in the list are useful?

strongly agree ◯ quite agree ◯ quite disagree ◯ strongly disagree ◯

30. Check out the list. Do you find some URLs you have never heard about in the list?

many ◯ some ◯ a few ◯ none ◯

B3. Group 2 Collaborative ReCourse Questionnaire

Select one option for each question

PART 1: Background information

1. This question is about your background:
   a. Do you have any teaching experience (as lecturer/ teaching assistant/ lab-work assistants/ demonstrators)?

a lot	some	little	none
◯	◯	◯	◯

   b. Do you have any experience in working with IMS Learning Design (IMS LD) or IMS LD authoring tools?

a lot	some	little	none
◯	◯	◯	◯

This questionnaire uses Unit(s) of Learning (UoL): Introduction to biology, web programming, and Java programming.

2. Are you familiar with the following subjects

	yes	know a little	no
Introductory to biology?	◯	◯	◯
web programming?	◯	◯	◯
Java programming?	◯	◯	◯

Part 2: *Note* and *History* for planning authoring learning design

3. When you read a syllabus, is following information important for you to understand it?

	very important	quite important	not very important	not important at all
a. Learning objectives	◯	◯	◯	◯
b. Prior knowledge of Expected learners	◯	◯	◯	◯
c. Pre requisite courses	◯	◯	◯	◯
d. Post requisite courses	◯	◯	◯	◯
e. Course reading list	◯	◯	◯	◯
f. Total learning time	◯	◯	◯	◯
g. Descriptions of topics	◯	◯	◯	◯

Select one option for each question

Open Unit of Learning Introduction to biology. In the tab *Overview* you can find the learning objectives, pre requisites, and description of the course. Click the tab *Note* to see authors' notes or click *History* to find out what have been done so far.

Questions 4 to 7 are related to UoL Introduction to biology.

4. Who firstly created the UoL?

   ◯ Alice ◯ Bob ◯ Claudia ◯ I don't know

5. Which elements did Claudia create?

   ◯ Phase Darwin and Evolution
   ◯ Phase Fungi and Plant Evolution
   ◯ Phase Ecology and Conservation
   ◯ I don't know

6. What did Bob do?

   ◯ Added module 'Fungi and Plant Evolution'
   ◯ Added phase 'Plant Reproduction, Development and Control'
   ◯ Change the name of a module: from 'Ecology' to 'Environmental Biology'
   ◯ I don't know

7. When you read the UoL which has been created, is the following information important for you?

	very important	quite important	not very important	not important at all
a. Who first created the UoL	◯	◯	◯	◯
b. When the UoL was first created	◯	◯	◯	◯
c. Who contributed	◯	◯	◯	◯
d. When the last update was	◯	◯	◯	◯
e. Who created which part	◯	◯	◯	◯

Select one option for each question

Now, open UoL web programming. Questions 8-10 are related to UoL web programming.

8. What roles willbe involved in web programming?
   - ◯ Learners and two teachers.
   - ◯ Learners, a teacher, and a teacher assistant.
   - ◯ New learners, remedial learners, a teacher, and a teacher assistant.
   - ◯ I don't know

9. What course is proposed to become a post requisite course?
   - ◯ Internet Foundations, Technologies, and Development.
   - ◯ Principles of Interactive and Dynamic Media.
   - ◯ Java Programming.
   - ◯ An Introduction to Computer Science.
   - ◯ Advanced web programming, Development, and Database Integration.
   - ◯ I don't know

10. Alice, Bob, and Claudia participated in the creation of this UoL. One of them deleted a module. Who did it, which module, and why?
    - ◯ Bob, Server-Side Programming with PHP (continued), because it has been covered in another module.
    - ◯ Claudia, Overview Java, because the topic should have been learned in the pre requisite course: Fundamental Java.
    - ◯ Alice, Java script library, because it is not needed.
    - ◯ I don't know

Select one option for each question

Give your answers for questions number 11-14 based on your experience playing with UoL web programming and Introduction to biology.

11. You have played with two UoL. How sufficient is the following information in *Notes* and *History?*

	strongly sufficient	quite sufficient	not very sufficient	not sufficient at all
Information about targeted learners				
Post requisite courses				
Suggested reading list				
Total learning time				
Descriptions of some (all) topics				

12. How useful is *Note?*

very useful   quite useful   not very useful   not useful at all

13. How easy to find that information in *Note?*

very easy   quite easy   quite difficult   not useful at all

14. How useful is *History?*

very useful   quite useful   not very useful   not useful at all

15. How easy to find that information in *History?*

very easy   quite easy   quite difficult   very difficult

Select one option for each question

Part 3: ***Object's Note,*** **and** ***History's Note***

Open UoL Java programming. Questions 16-28 are related to UoL Java programming.

Access *History* and right-click on it. You will see *History's Note* from authors.

16. One topic discussed is about pre-/co-/post- requisites. As a result, which is the co-requisite course?
    - ◯ Object-oriented methods
    - ◯ Object-oriented programming
    - ◯ Advanced Java programming for e-commerce
    - ◯ I don't know

17. There was a problem on the first version of the UoL in that it has too many topics. What is the solution for this problem?
    - ◯ Delete the last three modules
    - ◯ Delete some phases of some modules
    - ◯ No changes, but the learning objectives were revised to fit the UoL
    - ◯ I don't know

18. Please find the module 'Inheritance', and right-click on it to access its Note. What is discussed in the Note?
    - ◯ Missing modules
    - ◯ Module deletion
    - ◯ Merging modules
    - ◯ I don't know

19. Create a module 'Interfaces and inner classes', and then add a note on the new module. How easy is adding a note?

very easy	quite easy	quite difficult	very difficult
◯	◯	◯	◯

Select one option for each question

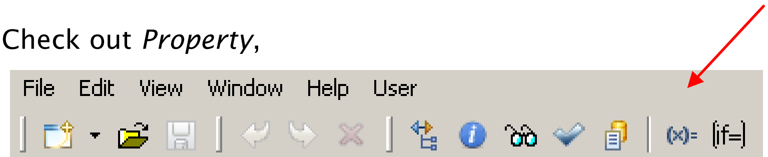
20. Please find

    module 'Objects and classes in Java', phase 'Abstract classes'

You will see that the phase has three learning/support activities. Right click on the phase or on each activity to see *Notes*. Which activity that will be conducted in groups?

- ◯ Reading
- ◯ Lecture
- ◯ Lab work
- ◯ I don't know

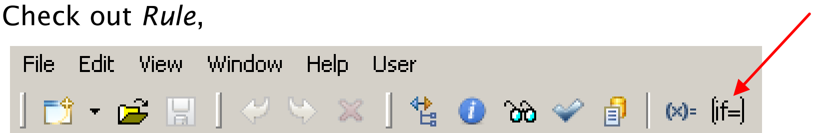
21. Check out *Property*,



You will find a property named 'LocPers1'. What is the property for?

- ◯ Passing grade to pass this course
- ◯ Mark a learner achieved on last phase
- ◯ Average of marks a learner gained so far
- ◯ I don't know

22. Check out *Rule*,



You will find one rule. What is the objective of the rule?

- ◯ To give additional modules to learners who need them
- ◯ To give additional learning activities to learners who need it
- ◯ To hide the next module if learners fail on the current module
- ◯ I don't know

Select one option for each question

23. Check out *Property*. You will find a property named 'Time'.

a. What is the property for?

- ◯ Maximum time for learning a module
- ◯ Maximum time for learning a phase
- ◯ Maximum time for doing an activity
- ◯ I don't know

b. In which module is property ‘Time’ used?

- ◯ Fundamental programming structures of Java
- ◯ Objects and classes in Java
- ◯ Inheritance
- ◯ I don’t know

24. Look for the module“Inheritance”. The completion of the module involves 3 properties.Which one of the following statements is wrong?

- ◯ The three properties are Pass, Grade, and Mark.
- ◯ Pass is a boolean property that will be set ‘true’ if Mark=50
- ◯ Grade only influences only learners
- ◯ I don’t know

25. How useful are *Notes* on objects (such as on modules, phases, resources, or learning activities)?

very useful	quite useful	not very useful	not useful at all
◯	◯	◯	◯

26. How easy is it to find information in *objects’ Notes?*

very easy	easy	difficult	very difficult
◯	◯	◯	◯

27. How useful is History’s Note*?*

very useful	quite useful	not very useful	not useful at all
◯	◯	◯	◯

28. How easy is it to find information in *History’s Note?*

very easy	quite easy	quite difficult	very difficult
◯	◯	◯	◯

Select one option for each question

Part 4: Reusing existing learning materials

29. When you would like to reuse existing online learning materials, do *keywords* and *URL* of the materials provide enough information to find suitable materials?

strongly agree	agree	disagree	strongly disagree
◯	◯	◯	◯

Click the tab *Resources*. Create a new resource of *Polymorphism*; choose a material from the gallery of existing materials by clicking *URL.*

30. Do you agree that a number of URLs in the gallery are useful?

strongly agree	agree	disagree	strongly disagree
◯	◯	◯	◯

31. Do you agree that you do not know about a number of URLs in the gallery?

strongly agree	agree	disagree	strongly disagree
◯	◯	◯	◯

32. How easy is the reuse of existing materials in this authoring tool?

very easy	quite easy	quite difficult	very difficult
◯	◯	◯	◯

Appendix C

Experiment 2: Structured Interview and the Results

STUDY TITLE: WORKGROUP EVALUATION OF THECOLLABORATIVE AUTHORING APPROACH FOR LEARNING DESIGNS

RESEARCHER: DADE NURJANAH

ETHICS NUMBER: 1457

Thank you for agreeing to take part in this workgroup evaluation of the collaborative authoring approach for learning designs. This is part of my PhD thesis which focuses on the development of a collaborative authoring model for adaptive learning resources. The aim of my research is to improve the authoring process by applying collaborative authoring features and a learning standard called IMS learning Design (IMS LD), and reusing existing learning content. I extended a standalone IMS LD authoring tool, ReCourse, to be a collaborative authoring tool that is designed for a small group of teachers to work asynchronously to create UoLs in IMS LD format. To evaluate whether my proposed approach is helpful for users or not, I need to conduct a workgroup evaluation.

The participants of this evaluation are those who have teaching experience.Your participation in this study is voluntary and you may withdraw at any time without consequence; however, we would appreciate it if you could finish the evaluation to help us research this topic. For each participant who completes the evaluation, we provide a £20 Amazon voucher.

No risks are involved in this evaluation. You are required to work in three sessions over one to two weeks and each session will take no more than 30 to 45 minutes of your time. In session 1 and session 2 you are required to work in a group to collaboratively author a unit of learning in IMS LD format. Afterwards, in session 3 you are required to answer a mixed questionnaire and structured-interview that are distributed in a paper.

The collected data will be kept confidential and for research purposes only. Results from this evaluation will be used to inform the usability of collaborative features in authoring learning designs.

CONSENT FORM

Study title: Workgroup evaluation of the collaborative authoring approach for learning designs

Researcher name: Dade Nurjanah

Study reference: Workgroup evaluation of the collaborative authoring approach for learning designs

Ethics reference: 1457

Please initial the box(es) if you agree with the statement(s):

I have read and understood the information sheet (insert date /version no. of participant information sheet) and have had the opportunity to ask questions about the study. ☐

I agree to take part in this research project and agree that my data can be used for the purpose of this study ☐

I understand my participation is voluntary and I may withdraw at any time without my legal rights being affected ☐

I am happy to be contacted regarding other unspecified research projects. I therefore consent to the University retaining my personal details on a database, kept separately from the research data detailed above. The 'validity' of my consent is conditional upon the University complying with the Data Protection Act and I understand that I can request my details be removed from this database at any time. ☐

Data Protection

I understand that information collected about me during my participation in this study will be stored on a password protected computer and that this information will only be used for the purpose of this study. All files containing any personal data will be made anonymous.

Name of participant ....

Signature of participant ....

Date ....

TOOL: RECOURSE

QUESTIONNAIRE / STRUCTURED INTERVIEW

Please answer the following questions. For multiple choices,
◯ **means you are required to choose only one option.**
☐ **means you are allowed to choose more than one option.**

PART 1: Participants' profiles

1. Do you have any teaching experience (as lecturer/ teaching assistant/ lab-work assistants/ demonstrators)?

a lot	some	little	none
◯	◯	◯	◯

2. Do you have any experience in working with IMS Learning Design (IMS LD) or IMS LD authoring tools?

a lot	some	little	none
◯	◯	◯	◯

3. This questionnaire uses a Unit of Learning (UoL): Java programming. What do you consider your level of knowledge of this course is?

	a lot	some	little	none
Java programming	◯	◯	◯	◯

PART 2:*Note* and *History*

4. What is your role in the authoring?

Author 1	Author 2	Author 3
◯	◯	◯

5. If you worked as Author 1, please give your answer for the following questions.
   - ◯ I constructed the whole sequence of modules with phases in some/most of them.
   - ◯ I made the whole sequence of modules without phases.
   - ◯ I made some modules with/without phases.
   - ◯ I made a complete module with its phases and let other authors to complete the outline.
   - ◯ None of the above. I did:

   ____

   ____

6. If you worked as Author 2 or 3, please give your answer for the following questions. As the second/third author, how much you worked on outlining the UoL?

   ☐ I modified existing modules or revised the sequence of modules.
   ☐ I extended existing modules (added phases or activities).
   ☐ I added new modules to complete the outline.
   ☐ Added one/few modules and let other authors to complete the outline.
   ☐ None of the above. I did:

   ____
   ____

7. Did you modify/delete *modules* created by other authors?

   Yes ◯ No ◯

   If so, please explain your reason(s) for doing this?

   ____
   ____

8. Did you modify/delete *phases* created by other authors?

   Yes ◯ No ◯

   If so, please explain your reason(s) for doing this?

   ____
   ____

9. Did you modify/delete *learning activities* created by other authors?

   ◯ Yes No ◯

   If so, please explain your reason(s) for doing this?

   ____
   ____

10. Did you modify/delete *support activities* created by other authors?

   ◯ Yes No ◯

   If so, please explain your reason(s) for doing this?

   ____
   ____

11. Did you modify/delete *resources* created by other authors?

◯ Yes ◯ No

Please explain your reason(s) for doing this?

____

____

12. Did you create *adaptation rules* and apply them to modules/phases/activities that had been created by other authors?

◯ Yes No ◯

13. Did you modify/delete *adaptation rules* created by other authors?

◯ Yes No ◯

If so, please explain your reason(s) for doing this?

____

____

14. Did you use *properties* created by other authors?

◯ Yes No ◯

15. Please rate how good/bad you considered the division of authoring tasks in your group was. Give the highest rating if the contribution of all authors is quite similar.

1 (lowest)	2	3	4	5 (highest)
◯	◯	◯	◯	◯

16. Please rate how efficient (produced right output) you consider the collaborative authoring in your group is.

1 (lowest)	2	3	4	5 (highest)
◯	◯	◯	◯	◯

PART 3: Reuse

17. On average, how much time (minutes/second) did you spend on creating a learning resource? ________ minutes, _________ seconds.

TOOL: COLLABORATIVE RECOURSE

QUESTIONNAIRE / STRUCTURED INTERVIEW

Please answer the following questions. For multiple choices,
◯ means you are required to choose only one option.
☐ means you are allowed to choose more than one option.

PART 1: Participants' profiles

1. Do you have any teaching experience (as lecturer/ teaching assistant/ lab-work assistants/ demonstrators)?

a lot	some	little	none
◯	◯	◯	◯

2. Do you have any experience in working with IMS Learning Design (IMS LD) or IMS LD authoring tools?

a lot	some	little	none
◯	◯	◯	◯

3. This questionnaire uses a Unit of Learning (UoL): Java programming. How much is the extent of your knowledge of that course?

	a lot	some	little	none
Java programming	◯	◯	◯	◯

PART 2: Notes and History

4. Your group will get a UoL that has a sequence of four modules. What changes did you make to the existing sequence of modules?
   - ☐ I modified the order of those modules. (go to the next page)
   - ☐ I extended the sequence by adding one/some modules. (go to the next page)
   - ☐ I extended the sequence by adding phases or activities to one/some modules. (go to the next page)
   - ☐ I added some new modules to make the sequence complete. (go to the next page)
   - ☐ None of the above. (go to Question 2, below). I did:

     ____

     ____

5. Note is a feature for authors to leave commentsabout what they have done or about elements they updated. From Note, authors can get information about the authoring process. Did you sometimes feel reluctant to use this feature? If so, please explain why.

____

____

6. History records changes made to Unit of Learning. It provides information about what updates have been made, to which objects, and by whom. Did you sometimes feel reluctant to use this feature? If so, please explain why.

____

____

7. Objects' Notes are Notes linked to objects: resources, properties, rules, and modules (including its phases and activities). Did you sometimes feel reluctant to use this feature? If so, please explain why.

____

____

8. History's Note is a Note linked to History. Did you sometimes feel reluctant to use this feature? If so, please explain why.

____

____

9. Did you create resources? If so, how much time (minutes, seconds) on average, did you spend on creating a learning resource?

____

____

10. Please rate how good/bad you consider the division of authoring tasks in your group was. Give the highest rating if the contribution of all authors is quite similar.

1 (lowest)	2	3	4	5 (highest)
◯	◯	◯	◯	◯

11. Please rate how efficient (produced right output) is the collaborative authoring in your group is.

1 (lowest)	2	3	4	5 (highest)
◯	◯	◯	◯	◯

Appendix D

Experiment 2: Data Collected from the Observation

This paper presents raw data collected from the observation. Updates applied to UoL are categorised 22 types and coded as follows.

Table D.1 Update Categories

Codes	Actions
1	add modules
2	add modules+phases
3	add modules+phases+activity
4	modify modules
5	move modules (all)
6	delete modules (all)
7	add phases
8	add phases+activities
9	modify phases
10	move phases (all)
11	delete phases (all)
12	add activities
13	modify activities
14	move activities
15	delete activities
16	add property
17	modify property
18	delete property
19	add rules
20	modify rules
21	delete rules
22	add resources

D.2 Authoring Tasks Done by Group A working with ReCourse

				Participants:	**P1**	**P2**	**P1**	**P2**	**P3**	**P2**	**P3**	**P1**	**P3**
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
			QTI			16							
			QTI						16				
			MinimumMark								16		
			Marks Final test								16		
			time/attendance								16		
			marks lab work								16		
			learners full mark								16		
			marks for coursework								16		
				blank rule							19		
			MaximumMark									16	
			Experts									16	
				Condition 2								19	
Learning the basics of Java					1	6							
	Java language overview				2								
		Overview			3								
		Java Principle			3								
		java version			3								
How to use this course material									5				
	Learning plan												
		Tips for learning a programming language											
		How to use this course											

				Participants:	**P1**	**P2**	**P1**	**P2**	**P3**	**P2**	**P3**	**P1**	**P3**
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	Course plan												7
		Week 1 until week n											8
		Test 1											8
		Test 2											8
		Final											8
Setting up Java									5				
	Setting up Eclipse												
				Completing rule by time (zero)						16			
		Setting up java SDK											
		Compiling and running Hello World											
Introduction to Java						1							
	What is Java												7
		What is Java											8
	Java Learning Tips					2							
		Java Learning Tips				3							
	Why java is important					2							
		The importance of java				3							
	A brief comparison Java and other language					2							
		Java vs C and C++				3							
		A comparison of Java and .NET platform					12						
	What is Java						7						
		What is Java					8						

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	OOP							7					
		Object Oriented Programming						8					
	Java Learning Tips												10
		Java Learning Tips											
How to use this course material								1					
	Learning plan							2					
		Tips for learning a programming language						3					
		How to use this course						3					
Setting up Java						1							
	Setting up Eclipse					2							
		Setting up java SDK				3							
		Compiling n running Hello World				3							
OOP Concepts								5					
				Each phase will be completed when property Time is set (till phase Exercise)							19		
	What is objects? Objects							7			9		
		Objects Introduction to Objects						8		13			
	What is class? Classes							7			9		
		Classes Introduction to classes						8		13			

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	What is inheritance? Inheritance							7			9		
		Introduction to Inheritance								12			
		Inheritance						8					
	What is interfaces? Interfaces							7			9		
		Introduction to Interfaces								12			
		Interfaces						8					
	What is packages? Packages							7			9		
		Packages Introduction to Packages						8		13			
	Exercises							7					
		Exercises							12				
	Test 1										8		
Language basics								1					
				Each phase will be completed when property Time is set						19			
	Variables							7					
		Basics about variables							12				
	String and Numbers									7			
		String								8			
		Numbers								8			
	operators							7					
		Basics about operators							12				

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	expressions, statement, blocks							7					
		Expressions, statement, blocks							12				
	control flow statements							7					
		Control flow statements						8					
	Exercises									8			
Classes n objects					1								
				each phase will be completed when property Time is set						19			
				only phase Classes							20		
	Classes				7								
		Classes			8								
	Objects				7			11					
		Objects			18								
	Exercises									7			
	Exercises									7			
	Test 2										7		
OOP Concepts					1								
	OOP				2			11					
		OO Programming			3								
Learning the adv features					1								

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
				Each phase will be completed when property Time is set						19			
				Except exercise							20		
	Class libraries				2								
		Swing			3								
		AWT					12						
	Generics									7			
		Generics								8			
	Examples on using Classes									7			
	Exercises										8		
Resources						1							
				Each phase will be completed when property Time is set						19			
	Recommended text books					2							
		Text books				3							
	Recommended websites								10				
		Java official doc n tutorial webs											
		Java Tutorials on W3School											
	Example codes									10			
		Java example codes											
	Java References								10				
		Java script objects											

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		Java script n HTML DOM ref											
	Example codes								10				
		Java example codes											
	Official Java tutorial from Oracle								10				
		Java official tutorial											
	Java online test							7					
		BetterProgammer.com						8					
		IndiaBix.com						8					
		Javacamp.org						8					
	Recommended websites					2							
		Java official doc n tutorial webs				3							
		Java Tutorials on W3School					12						
	Example codes					2							
		Java example codes				3							
	Java References					2							
		Java script objects					12						
		Java script n HTML DOM ref					12						
	Official Java tutorial from Oracle							7					
		Java official tutorial						8					
Completing this course											1		

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	Course work										2		
				Completion rule: time							19		
	Lab work										3		
	Test 1										3		
	Test 2										3		
	Final test										3		
				Apply rule (zero)							19		

Table D.3 Authoring Tasks Done by Group B working with ReCourse

				Participants:	P1	P2	P1	P3	P3	P2	P3	P2	P1
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
			Java JDK installation					16					
			Java configuration					16					
			Modul 1				16						
			Modul 9				16						
			Modul 2				16						
			Modul 3				16						
			Modul 7				16						
			Modul 8				16						
			Modul 4				16						
			Modul 5				16						
			Modul 6				16						
				Modul 1 - (then = else)			19						

				Participants:	P1	P2	P1	P3	P3	P2	P3	P2	P1
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
				Modul 2			19						
				Modul 3 - (then = else)			19						
				Modul 4			19						
				Modul 5			19						
				Modul 6			19						
				Modul 7			19						
Learning the basics of Java lang					1								
	Overview of java				2								
				Completion rule: activities			19			19			
		course outline				12							
		reading the history of java lang -			3	15							
		java tutorial			3								
		getting started -				12							
	Setting up java environment				2								
		install the Java JDK -			3								
		configure the Java environment -			3								
	Writing simple Java appl				2								
		writing a very simple Java appl -			3								
		compiling the program -				12							
		running the application -				12							
	Java 2 libraries				2								

				Participants:	P1	P2	P1	P3	P3	P2	P3	P2	P1
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		understand the directory of java compiler structure -			3								
	Java primitives				2								
		declaring and assigning values to variables -			3								
classes and objects						5							
	Class methods and attributes												
		the java OOP tutorial -				12							
		project group 1 -				12							
	Static class methods and attributes					10							
	instance class methods and attributes					10							
Java control structures					1								
	Java packages				2								
		reading: java tutorial *			3								
	ControL structures: using if, if else				2								
		writing a simple code with IF and nested IF			3								
		writing a simple code with for, while, and do.			3								
		QTI: Programming assignment about IF, nested IF, while and to-				12							
	Java methods: creating a method				2								

				Participants:	P1	P2	P1	P3	P3	P2	P3	P2	P1
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		java tutorial *			3								
	Arrays n strings in Java				2								
		QTI programming Homework 1 -			3								
classes and objects					1								
	Class methods and attributes				2								
	static class methods and attributes				2								
	Instance class methods and attributes				2								
OOP Concepts					1								
	Class inheritance					10							
		writing some example codes about class inheritance -											
	Encapsulation					10						10	
		writing an example code about encapsulation -											
	Polymorphisme					10					10		
		writing some codes about polymorphism -											
	Java interface mechanism					10					10		
		writing some codes about Java interface mechanism -											
	Encapsulation				2								
		writing an example code about encapsulation -			3								

				Participants:	P1	P2	P1	P3	P3	P2	P3	P2	P1
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	Class inheritance				2								
		writing some example codes about class inheritance -			3								
	Polymorphisme				2								
		writing some codes about polymorphism -			3								
	java interface mechanism				2								
		writing some codes about Java interface mechanism -			3								
	Object oriented odesign				2								
		QTI: Programming assignment -			3								
Learning the advanced features of Java lang					1								
IDE					1								
Collection framework					1								
GUI Programming					1								
	Graphics and Java				2								
		Reading material -			3								
	GUI Components				2								
		Writing some codes -			3								
	2D classes				2								
		Writing some codes -			3								
	Java inner classes				2								

				Participants:	P1	P2	P1	P3	P3	P2	P3	P2	P1
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		Group assignment -			3								
Threading					1								
GUI Programming									5				
	Graphics and Java												
		Reading material -											
	GUI Components												
		Writing some codes -											
	2D classes												
		Writing some codes -											
	Java inner classes												
		Group assignment -											
IDE									5				
Threading									5				
Collection framework									5				
Learning the advanced features of Java lang									5				

Table D.4 Authoring Tasks Done by Group C working with Collaborative ReCourse

				Participants:	**P1**	**P2**	**P3**	**P2**	**P3**	**P1**	**P2**	**P3**	**P1**
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
			time					16					
			start of course					16					
			exception test acore					16					
				condition 1				19					
				condition 2				19					
				condition 3				19					
				condition 4				19					
			programming demonstration						16				
			project assignments						16				
				Swing condition: condition 1					19				
				Swing condition: condition 2					19				
			Student has programming background							16			
				Conditions based on the programming background of the student: Condition 1, Condition 2.						19			
Learning the basics of Java language					1								
	History						7						
		The history of Java prog language (text)					8						
		Java Programming Evolution								12			

				Participants:	P1	P2	P3	P2	P3	P1	P2	P3	P1
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	Java syntax									7			
		Java cheat sheet								8			
	Data types				2								
		Introduce data types (text)				12							
		QTI Short test on data types				12							
	Control structures				2								
		Control structures (text)				12							
		Help session on control structure -				12							
	Arrays				2								
				Completion rule: condition	19					21			
Java programming basics										1			
	Data types									14			
		Introduce data types (text)											
		QTI Short test on data types											
	Control structures									14			
		Control structures (text)										13	
		Help session on control structure -										13	
	Arrays									14			
		Arrays								12			

				Participants:	P1	P2	P3	P2	P3	P1	P2	P3	P1
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		Other collection									12	13	
Classes and objects					1								
	What is a class					10							
				completion rule: activities	19								
		What is a class											
		QTI T/F about classes and objects											
	What is an object				2								
				completion rule: activities	19								
		What is an object			3								
	What is a class				2								
				completion rule: activities	19								
		What is a class			3								
		QTI T/F about classes and objects -			3								
concepts of OOP					1								
	Introduction of OOP											7	
		Introduction of OOP components										8	
	What is inheritance Inheritance				2		9						
				completion rule: activities	19								
		What is inheritance -			12								

				Participants:	P1	P2	P3	P2	P3	P1	P2	P3	P1
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	What is interface interface				2		9						
				completion rule: activities	19								
		What is interface			3								
		Interface advance -					12						
		QTI T_F about abstraction					12						
	Abstraction						7						
		Abstraction -					8						
				completion rule: activities				19					
	Polymorphism						7						
		Polymorphism -					8						
				completion rule: activities				19					
	Test						7		11				
		Test -					8						
				completion rule: activities				19	21				
introduction to GUI (SWING)					1								
	Layout and component managers				2								
		Java Swing tutorial				12							
	Event handling				2								
		Event handling -					12						
	Applet class Applets				2								9

Module	Phase	LA/SA/AG	Properties	Rules	1	2	3	4	5	6	7	8	9
				Participants:	**P1**	**P2**	**P3**	**P2**	**P3**	**P1**	**P2**	**P3**	**P1**
		Applets											12
	Applet lifecycle				7								11
	SWING components				2								
		Java Swing								12			
Exception handling					1								
	Basics of exception handling					7							
				completion rule: activities		19							
		Exceptions tutorial				8							
		QTI exception test				8							

Table D.5 Authoring Tasks Done by Group D with Collaborative ReCourse

Module	Phase	LA/SA/AG	Properties	Rules	1	2	3	4	5	6	7	8	9
				Participants:	**P1**	**P2**	**P1**	**P2**	**P3**	**P2**	**P3**	**P1**	**P3**
				Rule 1: condition 2			19						
				Rule 1: condition 3				19	20	21			
			TimeForCompare								16		
			TimeForTest								16		
			JDBC time									16	
				Rule: conditions collection						19			
				condition 1						19			
				condition 2						19			
				condition 3						19			

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
				condition 4						19			
				condition 5						19			
Pre requisite				condition 6						19			
				condition 7							19		
				condition 8								19	
Learning the basicsof java language					1								
	Getting started				2								
		Getting started			3								
		Java installation -			3								
Classes and objects					1								
	Objects and classes				2								
		What are objects and classes			3								
		Declaring classes			3								
			What is abstract class						16				
				Completing rule: condition					19				
		Creating objects			3								
		QTI: assignment to Create classes and declaring objects -			3								
	Abstract class					7							
		What is abstract class				8							
	Interface					7							
		What is interface?				8							

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		what is the difference between abstract class n interfaces -				8							
	Methods and instances				2								
		Defining methods			3								
		Calling methods -			3								
	Data types				2								
		Declaring variables -			3								
object oriented programming concepts					1								
	Inheritance						7						
		Inheritance -					8						
	Abstraction						7						
		Abstraction -					8						
	Polymorphism						7						
		Polymorphism -					8						
learning the advanced features of Java lang					1								
	Java IDE					7							
		Eclipse				8							
Language basics								1					
	Variables							2					
		Primitive data types -						3					

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		Arrays -						3					
		Expressions -						3					
	Operators							2					
		Assignment and arithmetic operators -						3					
		Equality, conditional, and relational operators -						3					
		Bit shift operator -						3					
	Control flow							2					
		for statement -						3					
		if then else statement						3					
		while -do while statement -						3					
		swithc statement -						3					
		assignment to create program using operators and control stat						3					
Advanced Programming								1					
	Numbers and string class							2					
		Number class and formatting -										12	
		Advanced arithmetic -										12	
		Introtuction to string class										12	
		String manipulation and comparison										11	

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
	GUI and graphics											7	
		Introduction to AWT programming										8	
		applet component -										8	
		swing component and programming -										8	
		QTI write a program to use applet and swing component -										8	
java applets and application									1				
	Introduction overview of the difference								2				9
		Define the meaning of java applet and java ppl							3				
		State the characteristics of applets and application							3				
		Differentiate the major benefits of applets and application							3				
	Design and development								2				
		Design the user interface for java applets							3				
		Develop the basic programming of java applets							3				
		Execute and test the java applet							3				

				Participants:	P1	P2	P1	P2	P3	P2	P3	P1	P3
Module	**Phase**	**LA/SA/AG**	**Properties**	**Rules**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
		Design the user interface for java applets							3				
		Develop the basic programming for java application							3				
		Execute and text the java application							3				
	Comparative study								2				
				Rule: condition								19	
		Compare the major different features of applets and appl							3				
		Comparing test of applet										12	
Database connectivity												1	
	JDBC architecture JDBC Connection											2	9
		intro to JDBC connection										3	
		establishing database connection and working with connection										3	
		creating and executing SQL statement										3	
		working with query result set										3	
		QTI: assignment to show use of JDBC										3	