

Copyright Statement

This copy of the thesis has been supplied on condition that anyone who consults it is understood to recognise that its copyright rests with its author and that no quotation from the thesis and no information derived from it may be published without the author's prior consent.

Simplifying Authoring of Adaptive Hypermedia Structures in an eLearning Context

by

Oliver Schneider

A thesis submitted to the University of Plymouth
in partial fulfilment for the degree of

Doctor of Philosophy

School of Computing and Mathematics
Faculty of Science and Technology

In collaboration with University of Applied Sciences Darmstadt

July 2014

Abstract

In an eLearning context, Adaptive Hypermedia Systems have been developed to improve learning success by increasing learner satisfaction, learning speed, and educational effectiveness. However, creating adaptive eLearning content and structures is still a time consuming and complicated task, in particular if individual lecturers are the intended authors. The way of thinking that is needed to create adaptive structures as well as the workflows is one that lecturers are unaccustomed to.

The aim of this research project is to develop a concept that helps authors create adaptive eLearning content and structures, which focuses on its applicability for lecturers as intended authors. The research is targeted at the sequencing of content, which is one of the main aspects of adaptive eLearning.

To achieve this aim the problem has been viewed from the author's side. First, in terms of complexity of thoughts and threads, explanations about content structures have been found in storytelling theory. It also provides insights into how authors work, how story worlds are created, story lines intertwined, and how they are all merged together into one content. This helps us understand how non technical authors create content that is understandable and interesting for recipients. Second, the linear structure of learning content has been investigated to extract all the information that can be used for sequencing purposes. This investigation led to an approach that combines existing models to ease the authoring process for adaptive learning content by relating linear content from different authors and therefore defining interdependencies that delinearise the content structure.

The technical feasibility of the authoring methods for adaptive learning content has been proven by the implementation of the essential parts in a research prototype and by authoring content from real life lectures with the prototype's editor. The content and its adaptive structure obtained by using the concept of this research have been tested with the prototype's player and monitor. Additionally, authoring aspects of the concept have been shown along with practical examples and workflows. Lastly, the interviewees who took part in expert interviews have agreed that the concept significantly reduces authoring complexity and potentially increases the amount of lecturers that are able to create adaptive content. The concept represents the common and traditional authoring process for linear content to a large extent. Compared to existing approaches the additional work needed is limited, and authors do not need to delve into adaptive structures or other authors' content structures and didactic approaches.

Contents

List of Figures	11
List of Tables	13
1 Introduction	23
1.1 Research Context: Atlantis University	24
1.1.1 Learner Preferences	26
1.1.2 Technological Platform to Support the Learning Process	27
1.2 Motivation: Proposal for a Supporting Concept	29
1.3 Aims and Objectives	30
1.4 Methodology	31
1.5 Thesis Structure	32
2 Authoring for Adaptive eLearning	35
2.1 Basic Concepts	35
2.1.1 Adaptive vs. Adaptable	36
2.1.2 Sequencing	36
2.2 Relevant eLearning Specifications	40
2.2.1 IMS Simple Sequencing	41
2.2.2 IMS Learning Design	43
2.3 Sequencing in eLearning	48
2.4 Adaptive Educational Hypermedia	49
2.5 Current State of Authoring Adaptive Educational Hypermedia	53
2.6 Appraisal	55
2.7 What's next	56
3 Adaptive eLearning Based on Authoring	57
3.1 Storytelling for Adaptive eLearning	58
3.1.1 Modern Storytelling Models	58
3.1.2 Storytelling Aspects of Interest for Adapting Linear Content Structures	62
3.1.3 Interactive Storytelling	64
3.2 The Concept: "Coherence"	66
3.2.1 Delinearise Content	67
3.2.2 Miscellaneous Concept Features	72
3.2.3 Sequencing Strategies	72
3.2.4 Summary	73

3.3	Implemented Concept	75
3.3.1	System Requirements	75
3.3.2	Components and Design	77
3.3.3	Learning Path Construction	92
3.4	Summary	96
3.5	What's next	97
4	Authoring Aspects	99
4.1	Consequences of Interactivity on Authorship	99
4.2	Structure Transfer	102
4.2.1	Adopting Basic Linear Structure	102
4.2.2	Structure Organisation	105
4.2.3	Fitting into an Environment	107
4.2.4	Weighting the Structure	111
4.3	Authoring Workflows	112
4.3.1	Adapting Existing Content	112
4.3.2	Adding Content	114
4.3.3	Adopting Learner Structures	115
4.3.4	eLearning 2.0 Aspects	115
4.4	Proposed Authoring Environment	117
4.4.1	Import	117
4.4.2	Relation Manager and Editor	118
4.4.3	Context Manager and Editor	120
4.4.4	Debugger	121
4.5	Summary	123
4.6	What's next	123
5	Prototypical Implementation of the Adaptive eLearning Concept	125
5.1	Application Specification	126
5.1.1	Actual State Analysis	126
5.1.2	Environment Analysis	127
5.1.3	Definition of Objectives	127
5.2	Scope of Services	129
5.3	Implementation	130
5.3.1	Programming Language and Framework	131
5.3.2	Code Organisation	131
5.3.3	Client Server Communication	137
5.3.4	Database	138
5.3.5	Data Models	139
5.3.6	Pathfinding	142
5.3.7	Adaptation	149
5.4	Graphical User Interface	150
5.4.1	Player	153
5.4.2	Editor	153
5.4.3	Monitor	158
5.5	System Requirements	158
5.5.1	Server	158

5.5.2	Client	160
5.6	Summary	160
5.7	What's next	161
6	Evaluation of the Concept by Research Interviews	163
6.1	Aim of Inquiry	163
6.2	Method: Expert Interviews	166
6.3	Methodological Aspects	171
6.4	Interview Guide	172
6.4.1	Interviewees' Background and Opinion	174
6.4.2	Introduction to the Concept and Hands On	178
6.4.3	Discussion about the Concept	178
6.5	Preparing the Prototype	180
6.5.1	Choosing the Content	182
6.5.2	Preparing the Content	183
6.5.3	Arranging the Coherence Prototype	185
6.6	Interviewees	193
6.7	Interview Situation	198
6.8	Analysis Process	200
6.8.1	Transcription	201
6.8.2	Typification	202
6.8.3	Code Matrix	206
6.9	Outcomes of the Interviews	208
6.9.1	Common Workflow for Creation of Learning Content	209
6.9.2	Lecture Preparation	212
6.9.3	Comprehension Problems Behaviour	212
6.9.4	Cooperative Content Creation	215
6.9.5	Experience in Adaptation	216
6.9.6	Estimation of Current Authoring Concepts	220
6.9.7	Introduction and Hands on	224
6.9.8	Authoring Content-Structures	226
6.9.9	Adaptivity	227
6.9.10	Support of Different Content-Structures	228
6.9.11	Applicability for Lecturing Purposes	228
6.9.12	Highlights	229
6.9.13	Proposed Improvements	238
6.9.14	Limitations	248
6.9.15	Scenario	256
6.10	Summary	258
6.10.1	Current Authoring Situation	260
6.10.2	Interviewees' Estimation of the Concept	261
6.10.3	Remarks on Using the Prototype for the Evaluation	262
6.10.4	Wrap Up and Further Notes	263
6.11	What's next	264

7	Conclusions and Outlook	265
7.1	Achievements of Research	265
7.2	Limitations of Research	267
7.3	Future Work	269
7.3.1	Concept	270
7.3.2	User Interface	272
7.3.3	Authoring	272
7.3.4	Integration	273
7.3.5	Miscellaneous	274
A	Publications	279
A.1	Conference Proceedings	279
A.2	Journals	279
A.3	Conferences	279
A.4	Conferences (Presentations)	281
B	Expert Interviews	283
B.1	Expert Interview Abstracts	283
B.1.1	Prof. Manfred Gaida	283
B.1.2	Dr. Stefan Göbel	285
B.1.3	Prof. Dr. Matthias L. Hemmje	287
B.1.4	Prof. Dr. Ido Aharon Iurgel	288
B.1.5	Prof. Dr. Detlef Krömker	290
B.1.6	Prof. Dr. Wolfgang Müller	292
B.1.7	Dr. Heiko Rölke	293
B.1.8	Prof. Dr. Ulrike Spierling	294
B.1.9	Dr. Ingo Stengel	297
B.2	Selected Transcripts	298
B.2.1	Transcript has been removed due to Personal Right restrictions	298
B.2.2	Dr. Heiko Rölke	298
C	Test Environment	317
C.1	Server	317
C.1.1	Ubuntu Linux	317
C.1.2	Web Server Apache 2	318
C.1.3	Database CouchDB	318
C.2	Client	318
C.3	Content	318
C.3.1	Example User	319
C.3.2	Coherence Lecture Test Content	323
C.4	Miscellaneous Preparations	357
D	Expert Interview Slide Set	359

E	Technical Details of the Coherence Model Components	367
E.1	Coherence	367
E.2	Condition	369
E.3	ContentSection	370
E.4	ContentType	371
E.5	ContextGroup	372
E.6	EmergencyExitType	373
E.7	NeedContext	375
E.8	ReleaseContext	376
E.9	Repeat	377
E.10	SetContext	378
F	Bibliography	381
G	Copies of Own Publications	401
G.1	Non-Linear Extended Blended Learning	402
G.2	Mobile Gaming Experience – Working on an Empirical Prototype . .	412
G.3	Learn Your Own Way: Decision Way through Narrative Approaches, Methods, and Paradigms for Learning Purposes	420
G.4	Inside Coherence: Concept for a Non-Linear eLearning Solution . . .	436
G.5	Find Your Own Path: Path Construction Strategy for Atlantis Uni- versity’s Coherence Service	448
G.6	Atlantis University: Learn Your Own Way	460
G.7	Simplified Creation and Presentation of Non-Linear Adaptive Content	478
G.8	Exploration of Learner Preferences and their Impact Within a Media Module	492

List of Figures

1	Example of the six learner-preferences	26
2	Collaborative Content Manipulation – CoCoMa	28
3	Spectrum of adaptation in computer systems	36
4	String of pearls	37
5	String of pearls variation	37
6	Branching	38
7	Complex branching	39
8	Simple Sequencing Standard Behaviour	42
9	Simple Sequencing Loop	44
10	Reload Learning Design Editor	46
11	LAMS Author Mode	47
12	Adaptive Techniques	50
13	Dexter Model	51
14	Adaptive Hypermedia Application Model	51
15	The five level AHS authoring model	52
16	Internal structure of linear content	63
17	StoryWorld Authoring Tool	65
18	Structure of sectioned linear content	68
19	Insertion of content sections that must be presented	70
20	Insertion of alternative content sections	71
21	Overview of the concept’s components	78
22	Coherence Concept Model	79
23	Content Sections	80
24	Content Types	82
25	Content type examples	83
26	Contexts	84
27	Context comparison modes	86
28	Best fitting content	87
29	Repeats	88
30	Content section information taken from source	104
31	Structure organisation	106
32	Content section 1 as a precondition for content section 7	108
33	Content sections that are preferred for users with a special context	111
34	New structure based on an existing one	114

35	Structure added to an existing one	115
36	Adopting Learner Structures	116
37	Coherence structure sorted by each author	119
38	Coherence structure sorted by author A	119
39	Coherence structure sorted by author C	120
40	Services needed for creation and presentation of adaptive content . .	129
41	Organisation of the Coherence code	132
42	Schematic player MVC class information flow diagram	134
43	Statechart diagram of player's init state	135
44	Statechart diagram of player's main state	136
45	Coherence Model	140
46	Coherence Runtime Model	141
47	Coherence Login	151
48	Register new user	152
49	Select Coherence	154
50	Coherence Player presents a content-section	155
51	Pathfinder pane to select the next step	156
52	Coherence Editor	157
53	Coherence Monitor	159
54	User-centred evaluation for personalised systems	170
55	Coherence Paper Prototype	184
56	Example Context	186
57	Example NeedContext	187
58	Example ContentSection	189
59	Example ContentType	190
60	Example Structure	191
61	Example Condition	192
62	Mapping Coherence to LAOS layers	273

List of Tables

1	The Functions of the Dramatis Personæ	60
2	Examples for context sources	85
3	Description for selected typical weight values	91
4	Some reasons to alter the original path	93
5	Code Matrix	208
6	Mapping Coherence to LAOS layers	274
7	Mandatory Coherence attributes	367
8	Mandatory Coherence children	368
9	Optional Coherence children	368
10	Mandatory Condition attributes	369
11	Mandatory Condition children	369
12	Optional Condition children	369
13	Mandatory ContentSection attributes	370
14	Optional ContentSection children	370
15	Mandatory ContentType attributes	371
16	Optional ContentType children	371
17	Mandatory ContextGroup attributes	372
18	Mandatory ContextGroup children	373
19	Mandatory EmergencyExitType attributes	373
20	Mandatory EmergencyExitType children	374
21	Optional EmergencyExitType children	374
22	Mandatory NeedContext attributes	376
23	Mandatory ReleaseContext attributes	377
24	Mandatory Repeat attributes	377
25	Mandatory Repeat children	378
26	Optional Repeat children	378
27	Mandatory SetContext attributes	379

Acronyms

- AEH** Adaptive Educational Hypermedia 31, 35, 49, 54, 56
- AEHS** Adaptive Educational Hypermedia System 30–32, 35, 49, 51, 53, 54, 64, 274
- AH** Adaptive Hypermedia 54
- AHAM** Adaptive Hypermedia Application Model 51
- AI** Artificial Intelligence 38, 287
- API** Application Programming Interface 83
- BSD** Berkeley Software Distribution 138
- CC** Common Cartridge 41
- CSS** Cascading Style Sheets 160
- ECTS** European Credit Transfer and Accumulation System 24, 53
- EML** Educational Modelling Language 43
- FQDN** Fully Qualified Domain Name 385
- GUI** Graphical User Interface 54, 133, 134, 149, 150, 153, 194, 195, 203, 234, 237, 245, 262, 295, 297
- HTML** Hypertext Markup Language 80, 102, 129–131, 160
- HTTP** Hypertext Transfer Protocol 137, 138
- ITS** Intelligent Tutoring System 49
- JSON** JavaScript Object Notation 131, 132, 137–139, 386
- LAOS** Layered WWW AHS Authoring Model and their corresponding Algebraic Operators 270, 274
- LBS** Location Based Service 275

LD Learning Design 43, 45, 46, 48

LDAP Lightweight Directory Access Protocol 41

LIS Learning Information Services 41, 273

LMS Learning Management System 28, 30, 48, 126, 127, 139, 160, 251, 252, 273

LODE Learning Object Discovery and Exchange 273

LOM Learning Object Metadata 41

LTI Learning Tools Interoperability 40, 127, 273

MD Learning Resource Meta-data 41

MVC Model View Controller 131, 133

ODP Open Document Presentation 117

ODT Open Document Text 117

OER Open Educational Resources 228, 252

PDF Portable Document Format 183, 248, 351

QTI Question and Test Interoperability 41

REST Representational State Transfer 131, 137, 139

RIA Rich Internet Application 130

ROA Resource Oriented Architecture 137

SCORM Sharable Content Object Reference Model 41, 43, 48

SOAP Simple Object Access Protocol 137

SVG Scalable Vector Graphics 102, 130, 160, 183

UoL Unit of Learning 45

URI Uniform Resource Identifier 137, 138, 150, 160

W3C World Wide Web Consortium 102, 130, 160, 183, 386

WWW World Wide Web 137

Acknowledgements

First of all, I would like to thank Anja Feix for her help, advice, understanding, support, and much more. Without her I would not have started this PhD research project, and without her I would not have finished it.

I also have to thank my family. Without them I could not have started this project, and without them I could not have finished it.

Also without the help of my first supervisor Prof. Dr. Udo Bleimann this work would have not been possible. He was always there in case of any problems or just for advice. He was also very motivational as he found the right solutions each time.

I would like thank my third supervisor Dr. Andy Phippen for his support. He always helped me wherever possible.

I would also like to acknowledge my former colleagues at Zentrum für Graphische Datenverarbeitung (ZGDV – Computer Graphics Centre), research department “Digital Storytelling”, as well as everybody at the Institut für Angewandte Informatik Darmstadt (aiDa – Applied Informatics Darmstadt), Zentrum für Advanced Learning, Medien und Simulation (igdv – Centre for Advanced Learning, Media, and Simulation), and, of course, all the students, supervisors, and researchers of the Atlantis University Project. Furthermore I thank my former colleagues of the research group on mobile gaming experiences and human-computer interaction “Gangs of Bremen” at Hochschule Bremen (Bremen University of Applied Sciences), namely Prof. Dr. Barbara Maria Grüter, for giving me advice and asking me the right questions, especially at the beginning of this project.

Of course, I would also like to thank all my friends who helped me proofread and brainstorm, hosted my office for several months, harboured me one year while I worked in the very north of Germany, helped me when coming up against hard times, or just had patience until the work was finished.

Further, I would like to thank Prof. Dr. Bettina Harriehausen-Mühlbauer for being my second supervisor.

Author's Declaration

At no time during the registration for the degree of Doctor of Philosophy has the author been registered for any other university award without prior agreement of the Graduate Committee.

This study was financed by myself, without any grant or support by any company or institution.

The postgraduate research project has been conducted and supervised under the agreement between the University of Plymouth and the Hochschule Darmstadt (h_da, University of Applied Sciences Darmstadt) concerning the establishment of the Darmstadt Node of CSCAN at Hochschule Darmstadt.

Relevant scientific seminars and conferences were regularly attended at which work was frequently presented, and several papers were prepared for publication.

Publications:

- Stengel, I., Schneider, O., Bleimann, U.: *Exploration of Learner Preferences and their Impact Within a Media Module*, in Bleimann, U., Dowland, P. S., Furnell, S.M., Schneider O. (Eds.): "Proceedings of the Eighth International Network Conference (INC 2010)", pp. 279–288, ISBN: 978-1-84102-259-8 (2010)
- Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen-Mühlbauer, B.: *Simplified Creation and Presentation of Non-linear Adaptive Content*, in M. Chang et al. (Eds.): "Learning by Playing. Game-based Education System Design and Development, Edutainment 2009, Banff, Canada, August 9–11, 2009. Proceedings", Lecture Notes in Computer Science, Volume 5670, pp. 239 – 250, Springer Verlag, Berlin Heidelberg, ISBN 978-3-642-03363-6, DOI 10.1007/978-3-642-03364-3_30 (2009)
- Schneider, O., Bleimann, U., and Stengel, I.: *Atlantis University: Learn Your Own Way*, Int. J. Mobile Learning and Organisation, Vol. 3, No. 2, pp. 184 – 201 (2009)
- Schneider, O., Bleimann, U., Phippen, A.D., Harriehausen, B.: *Find Your Own Path: Path Construction Strategy for Atlantis University's Coherence Service*, in Bleimann, U. et. al: Proceedings of the Fourth Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2008), Glyndŵr, UK, 6–7 November, p. 46–55, ISBN: 978-1-84102-196-6 (2008)

- Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen, B.: *Inside Coherence: Concept for a Non-Linear eLearning Solution*, Proceedings of the Seventh International Network Conference (INC2008), Plymouth, UK, 8–10 July, pp 223–233, ISBN: 978-1-84102-188-1 (2008)
- Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen, B.: *Learn Your Own Way: Decision Way through Narrative Approaches, Methods and Paradigms for Learning Purposes*, in Bleimann, U. et.al: Proceedings of the Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007), Plymouth, UK, 14–15 June, pp 99–114, ISBN: 978-1-84102-173-7 (2007)
- Grüter, B., Gröning, S., Milszus, W., Oks, M., and Schneider, O.: *Mobile Gaming Experience – Working on an Empirical Prototype*, NordiCHI’06 Workshop: User Experience – Towards a unified view. Oslo, Norway (2006)
- Schneider, O., Bleimann, U., Harriehausen, B., and Phippen, A.D.: *Non-Linear Extended Blended Learning*, Proceedings of the Sixth International Network Conference (INC2006), Plymouth, UK, 11–14 July, pp 377–384 (2006)

Presentations:

- Schneider, O., Bleimann, U.: *Adaptive Learning Using Storytelling Approaches*, Collaborative European Research Conference (CERC2012), Darmstadt, Germany (2012)
- Schneider, O.: *Einbindung externer Aktivitäten mit IMS-LTI (Learning Tools Interoperability)*, MoodleMoot 2012, Münster, Germany (2012)
- Schneider, O., Phippen, A.D., Bleimann, U., and Harriehausen-Mühlbauer, B.: *Coherence: The personal-individual way of learning*, in S. Wheeler (Ed.): “Digital Futures: Learning in a Connected World”, pp. 23, 6th Plymouth e-Learning Conference 2011, Plymouth, UK (2011)
- Schneider, O.: *Atlantis University Project: “Learn Your Own Way”*, Moodle 2010, Universität Duisburg-Essen, Germany (2010)
- Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen-Mühlbauer, B.: *Cooperative Creation of Non-Linear eLearning Content*, in S. Wheeler (Ed.): “Learning without Limits: Facing the Challenges”, pp. 59, 5th Plymouth e-Learning Conference 2010, Plymouth, UK (2010)
- Martens, T., Hatteh, A., Schulmeyer, M., and Schneider, O.: *Integrating Motivation in e-Learning*, 4th Plymouth e-Learning Conference 2009, Plymouth, UK (2009)
- Bleimann, U., Stengel, I., and Schneider, O.: *Atlantis University: The Future of Learning and Teaching*, 4th Plymouth e-Learning Conference 2009, Plymouth, UK (2009)
- Schneider, O.: *ODF for Blender in an eLearning Context*, Blender Conference, Amsterdam, Netherlands 24–26 October (2008)

Presentations and Conferences Attended:

- Collaborative European Research Conference (CERC2012), Darmstadt, Germany (2012)
- MoodleMoot 2012, Münster, Germany (2012)
- 6th Plymouth e-Learning Conference 2011, Plymouth, UK (2011)
- Eighth International Network Conference (INC 2010), Heidelberg, Germany (2010)
- Moodle 2010, Universität Duisburg-Essen, Germany (2010)
- 5th Plymouth e-Learning Conference 2010, Plymouth, UK (2010)
- MoodleMoot 2010, Berlin, Germany (2010)
- Edutainment 2009, Banff, Canada (2009)
- 4th Plymouth e-Learning Conference 2009, Plymouth, UK (2009)
- Fourth Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2008), Glyndŵr, UK (2008)
- Blender Conference, Amsterdam, Netherlands (2008)
- Seventh International Network Conference (INC2008), Plymouth, UK (2008)
- Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007), Plymouth, UK (2007)
- Sixth International Network Conference (INC2006), Plymouth, UK (2006)

Word count of main body of thesis: 60 424

Signed

Date Monday 28th July, 2014

Chapter 1

Introduction

People are different and therefore learn differently [22]. To support these differences, adaptive learning systems have been developed that adapt the presentation of learning content [86]. The objective is to improve learning success by increasing learner satisfaction, learning speed, and educational effectiveness. However, authoring adaptive content and structures is still an unsolved problem [20] that is addressed by the research project described in this thesis.

To set out the basis for the motivation for this research project, this chapter starts with the context of this research, the Atlantis University project. First, a brief overview is given about the project itself, followed by a deeper insight into the topics that are related to this research project: Learner preferences and the tool *Collaborative Content Manipulation*.

Based on the demand for creating, preparing, reusing, and presenting the content of a university network as described in the first section, the next section sets forth the motivation behind starting the research project presented in this thesis.

Section 1.3 *Aims and Objectives* highlights the research goals, followed by a section about the methodology for research and for system development. Lastly, section 1.5 *Thesis Structure* guides the reader through the thesis by outlining the information to be found in each chapter.

1.1 Research Context: Atlantis University

The research of this PhD project was part of the interdisciplinary project Atlantis University [107]. Atlantis University started in 2002 and was active until 2011. Ten universities and companies from the United Kingdom, Ireland, Poland, Hungary, Germany, and the United States of America collaborated in researching and developing new pedagogical concepts. The project focused on an innovative combination of different knowledge transfer forms called Extended Blended Learning [17], which in essence is a mix of project-based learning, eLearning, and face-to-face learning.

The internationalisation of Atlantis did not end with its international project-partners; it was international by all means possible and all the project partners worked together on the Atlantis approach. Of course, students were able to take courses at the partner universities and additionally there were international modules such as International Project Based Learning [16]. Some modules and lessons from the partner universities were combined which enabled partners (and lecturers) to focus on their strengths. Students gained internationally accredited and recognised qualifications through international cooperative, collaborative, and interdisciplinary learning.

To simplify the process of exchanging and merging learning content, the content and the organisation of the issues were standardised. The Bologna-process was a very important step for the project, but Atlantis University went beyond European Credit Transfer and Accumulation System (ECTS). The intention was to build a virtual university that provided all its partners with access to the content of Atlantis University. The modules were developed with the cooperation of the partners. The strongest partner, in each topic respectively, took the lead. Hence, the modules were developed once but could then be used many times at different locations.

Because Atlantis University brought together the content of many universities, large amounts of learning content were available. In particular, students of small universities or faculties were able to profit from this because they were able to

select from a large pool of content. Although this is an advantage, the factor of the agony of choice also had to be taken into consideration: In today's universities the students might know their lecturers from earlier modules and as such have the chance to estimate who can provide the best content for them. However, in Atlantis University many more modules and lecturers as well as languages and individual student preferences had to be taken into consideration. Therefore, Atlantis university needed a software which could filter the offered content to meet a suitable preselection.

Additionally, it was also desirable to combine not only complete modules, but also their structure and single learning units. In the vision of Atlantis University, when a lecturer wanted to assemble a new module he could consider the structure and application and then select already existing, suitable content from the Atlantis University's learning content database and adapt it to his needs. Another option would be using existing content, including its structure, as the basis for the lecturer's own learning content development. A large selection of content would allow for more possibilities of adaptation and personalisation and hence be beneficial to students.

A further aim of the Atlantis University project was to be involved in international cooperation and interdisciplinary learning and teaching within the scope of an internationally accredited study path [15]. Briefly outlined, in future the virtual university should offer online content, modules, and access to people affiliated with partner universities worldwide through a software portal. Using internationally equivalent content, examination rules, and degrees, a student should be able to take part in modules at one university but also to attend projects all over the world online. Atlantis University should serve as a mediator, offering communication interfaces and filters, enabling sorting and combining international content.

The above stated aims of the Atlantis University Project led to the research project that is reported in this thesis. A concept was to be designed that would allow the reuse of existent learning content according to offers tailored to the individual requirements of the students.

Before discussing the aim of this research project in more detail, the following sections present further details of the Atlantis University project that are relevant for the motivation of this PhD research project. These include a learner preferences model and parts of the technical environment of Atlantis University, and in particular the collaboration tool CoCoMa.

1.1.1 Learner Preferences

For further improvement of the learning process within Atlantis University, individual learning characteristics of learners and teachers were taken into consideration. The model developed by Röll merges seven preference determination models out of 70 existing models [23] and defines six different learner types [101]. A person does not just correspond to one learner-type, but his strong and weak developed learning preferences are distributed through all six preferences, see figure 1. Typically two preferences are high levelled, two are medium, and two are weak levelled [102].

The illustration shows exemplary strengths in the domains of perceiver and organiser. A person of this learner type learns especially well and with pleasure if he is led step-by-step through clearly structured learning content [23]. In addition, the

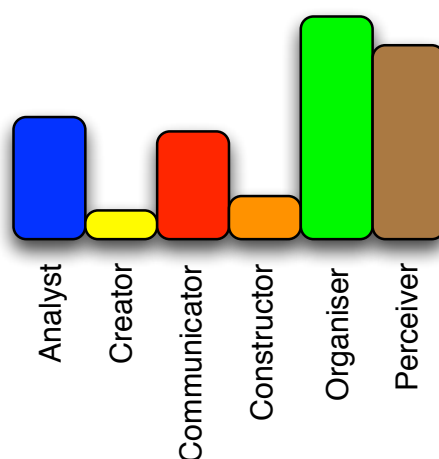


Figure 1: Example of the six learner-preferences: This shows how Röll's model consists of six types. In this example, the types, organiser and perceiver are strong, while analyst and communicator are medium, and constructor and creator are less well developed.

amplitude in the perceiver's field shows that the learner should have this content audio-visually presented to achieve optimum learning success [103]. Hence, the learning material prepared for this learner type is intended to stimulate his senses. These might be charts, animation, or videos, but also kinetic stimulation like touch or auditive talks and discussions. Constructors prefer experiments and are generally very pragmatically assessed. Engineers often represent this type. Communicators need group work, while analysts use a rather analytical approach and achieve the best learning results by using books [103]. Creators learn best if they deal with something completely new. They often lose interest if standard operations are involved in this process. Analysts are logical people who prefer facts and figures for learning.

The Atlantis University Project partners were interested in how these learner preferences could improve learning and teaching, for example seeing if different ways of teaching or different content about the same subject would be helpful to different learners. Also explored was how different content could be created effectively and if authors could create content that factors in the different needs of different learners [115]. Research was conducted to see if the wealth of information available in such a network of universities could be utilised to address different needs.

Atlantis University and this research project are not tied to the usage of this particular learner preference theory. Since the discussion about the right learner characterisation is not part of the scope of this thesis, the learner preferences model can be substituted by another model. However, the model has been used within this research project for application purposes in order to have a model to start with that can be used for adaptation.

1.1.2 Technological Platform to Support the Learning Process

The Atlantis University's portal integrated the project partners' international and interdisciplinary modules. On the one hand this was realised with well known online

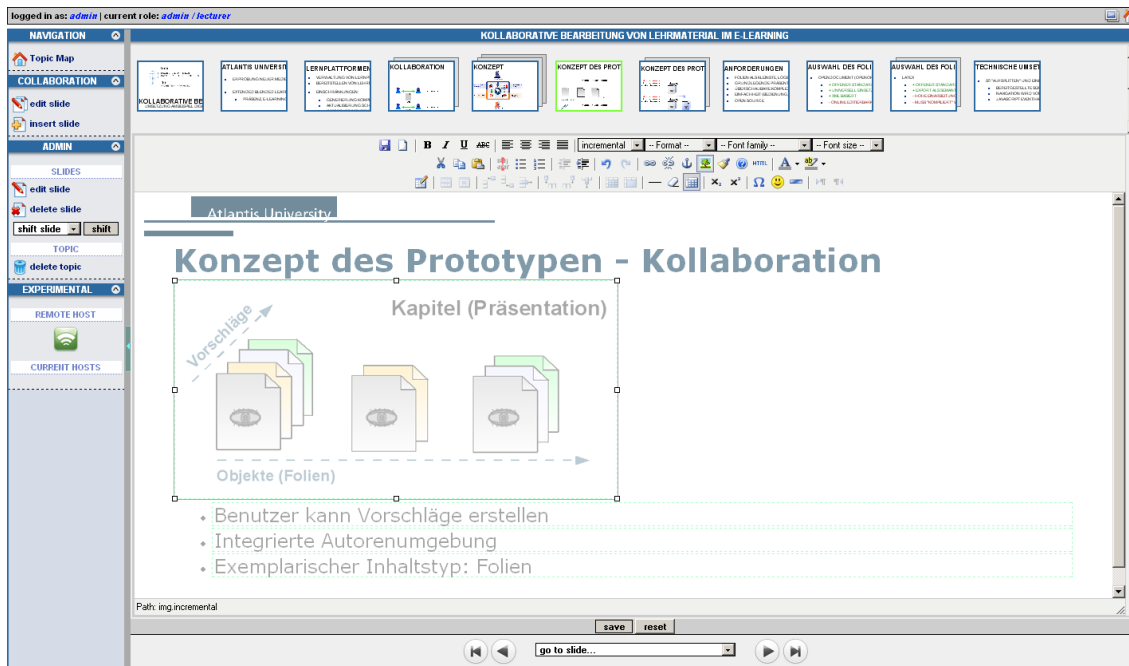


Figure 2: Collaborative Content Manipulation – CoCoMa: Here seen in editing mode. The left side contains overall controls like inserting or deleting slides and starting editing. The top lists all slides in a row, indicating alternatives as stacked on top of the primary slide. For example, the fifth slide has the most alternatives. The sixth slide is currently being edited in the biggest area of the CoCoMa window.

services, while on the other hand it was part of the project to research new services that support the learning process.

The portal was based on the Learning Management System (LMS) Moodle which focuses on cooperative working scenarios [128]. For Atlantis, the week-based course structure was used. The header of the Moodle course was used for the overall tasks, the week fields were filled with special time dependent tasks.

The international and collaborative interdisciplinary character of the project demanded applicable services. For collaboration on content between lecturers and their students of the different Atlantis partner universities, the Atlantis team developed the prototype *Collaborative Content Manipulation (CoCoMa)* [93]. CoCoMa is a mixture of an online presentation service and a Wiki with simple rights management. It imports slide sets that can be presented, but also edited by other lecturers or students (see figure 2). Should any changes occur the original author is informed and

can either replace the original slide or reject the new slide. This process not only simplified editing and the process of keeping the content updated, but also enabled collaborative learning by contribution. This was Atlantis University's approach towards eLearning 2.0 [14].

Soon the idea arose to not just dismiss or replace slides, but to keep appropriate edits as alternative versions to meet the needs of different learners. This raised some questions about handling the alternatives, for example: How could lecturers provide them easily? How could students find them easily? What about the structure of a slide set that contains edited versions? Could any kind of all over structure be used? These questions and the desire to answer them were the motivational factors behind starting this research project.

1.2 Motivation: Proposal for a Supporting Concept

Because of the networked universities within the Atlantis University Project, the collaborative contributions, ideas, and the research into learner preferences, this PhD research project was initiated to combine these subjects to create added value: Students should be able to use the content provided by the network, which is far greater than the learning content of individual universities, without getting lost in the content space. Röll's learner preferences could be incorporated as an added option to help students find the most suitable content. As proposed by eLearning 2.0, the students should be able to contribute content, their preferred structure, annotation-like comments, and ratings. The students should also be able to take individual learning paths, thus leaving the linear learning paths that are normally provided.

Therefore a concept was to be developed that could help both lecturers and students achieve this. The concept and the derived system should be usable in common environments. Hence it should be integrated in or at least work in conjunction

with LMSs. Therefore it needed to be web based and prepared to support common eLearning specifications. It should not only support the creation of new content structures but also reuse existing linear learning content, which is the wealth and advantage of such a university network. At first, the focus was not to be on students but rather on lecturers to enable them to create adaptive content, since this is the central issue. In order not to put lecturers off from authoring, the effort involved in learning how to create adaptive content and the corresponding structures as well as the work itself, which is needed to create an adaptive structure, should be doable.

As described with CoCoMa in the previous section, individuals – whether lecturers or students – edit the slides or any other kind of content. The outcomes are alternative versions of the same content that should be incorporated into the content structure. Thus although many parameters could be adapted, for example sorting, navigation, layout, and colour [70], the focus of this research is sequencing, because individual content sections should be included or the structures of different existing content should be merged.

1.3 Aims and Objectives

Based on the motivation described in the previous section, a concept should be developed in the context of the Atlantis University project that supports creation of adapted learning content, usable for web based LMSs. Therefore, the following question needs to be answered:

What concept of structuring content has the capability of simplifying the authoring of adapted eLearning content for non-technical users?

In respect to the state of the art in adaptive eLearning, besides the approaches of the eLearning area, Adaptive Educational Hypermedia Systems (AEHSs) are also of interest. They are seen as the research area for adaptive learning content and are mostly used for adaptive web-based systems [25]. The results should suggest a way

that an appropriate concept could be developed to fit the needs as described above. Hence, the following objectives need to be fulfilled by the research project:

1. Investigation of existing approaches in eLearning and AEHS with regard to authoring, focused on applicability for lecturers as the intended authors.
2. Design of an appropriate concept that is based on the results of the investigation. That includes directions of proposed workflows for targeted users.
3. Testing the technical feasibility of the concept by implementing a research prototype and realising the concept's essential parts.
4. Evaluation of the concept with an appropriate method.

1.4 Methodology

To get an overview about existing approaches, the related research literature was examined to highlight common features already existing in eLearning specifications and Adaptive Educational Hypermedia (AEH) focused on authoring. After seeing that authoring is still an obstacle for the wider usage of AEH, especially in terms of sequencing, a new concept was proposed that needed to be tested and evaluated.

As proof of the concept a prototype was realised that was used to test the main functionality. Due to the complexity of the common authoring approaches, the prototype was developed from scratch in order to tailor it to the proposed concept. Development started by implementing basic versions of all three software components player, editor, and monitor that provided a fully functional graphical user interface. Thus each step of the subsequent development could be tested, especially by monitoring each step of the concept's runtime behaviour with the monitor.

Lastly, the concept was evaluated quantitatively by conducting expert interviews. During the interviews the prototype helped the interviewees gain a better insight

into the concept's mode of operation and its implications for the authoring process, but also the anticipated effect on learning.

1.5 Thesis Structure

The second chapter that follows, discusses aspects and difficulties in authoring adaptive eLearning content. Therefore, appropriate eLearning specifications and AEHS approaches are investigated in respect to authoring. The chapter ends with a proposal for the research of a concept, which is usable for lecturers and enables the reuse of existing learning content.

Chapter 3 discusses how linear content is structured from the point of view of storytelling theory in respect to parameters that concern the creation of adaptive learning content structures. Based on the results, a concept is proposed that is expected to significantly reduce the complexity and effort needed for authoring these kinds of structures. It also discusses the consequences of the authorship: Generally, letting users manipulate content structures raises the question of whether they also become authors of the presented content which therefore may have an impact on the role of authors of adaptive learning content.

Intended authoring workflows are presented in chapter 4. It is based on the concept of the previous chapter and describes the transfer and enhancement of structures based on existing content. Additionally, the most important aspects of an authoring environment for the concept are proposed.

The prototype *Coherence* that was realised as proof of the concept is presented in chapter 5. After discussing the objectives of the prototype, the implementation is explained, including the client server concept, the code organisation, and the implemented pathfinding algorithms. It also gives the reader a better idea of the look and feel of the prototypical implementation of Coherence by presenting its graphical user interface.

In chapter 6, the qualitative evaluation of the research by means of research interviews is described. It presents the preparations, including the test content, and discusses the analysis and the outcomes of the expert interviews.

Finally, chapter 7 summarises and concludes the results achieved. Additionally, it discusses the limitations of the research as well as possible directions for further work based on the results of this project.

Chapter 2

Authoring for Adaptive eLearning

Having set out the motivation for this PhD research project in the preceding chapter 1 *Introduction*, this chapter discusses authoring aspects of adaptive eLearning and AEH. Therefore it starts with an introduction to basic concepts of adaptive and interactive content. Thereafter, specifications of the eLearning area that include adaptive presentation by sequencing of eLearning content are presented because the motivation of this research is sourced by eLearning and its scopes of application. This is followed by an introduction to AEH that gives details about common concepts of this research area. Section 2.5 *Current State of Authoring Adaptive Educational Hypermedia* on page 53 presents the work currently undertaken that covers authoring adaptive content. Finally, section 2.6 *Appraisal* discusses aspects of the current authoring approaches and points out the research gap.

2.1 Basic Concepts

Before introducing to eLearning and AEHSs, basic concepts are presented, with a look, first, at the range of adaptation, before basic sequencing concepts are then introduced.

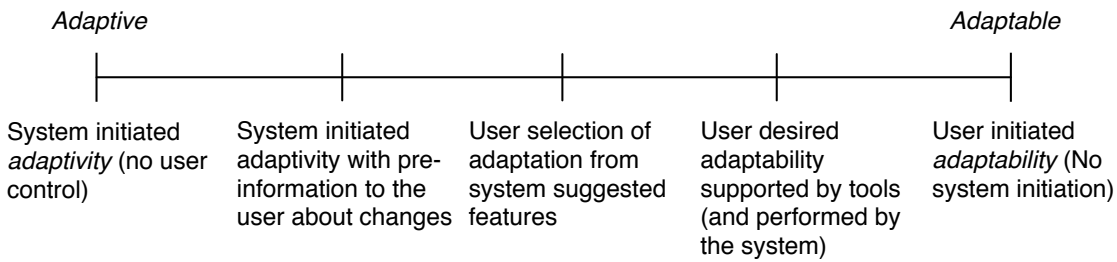


Figure 3: Spectrum of adaptation in computer systems [91]
Permission to reproduce this figure has been granted by Kinshuk

2.1.1 Adaptive vs. Adaptable

There are two main types of adaptation: *adaptive* and *adaptable* [91]. Also any mixtures between adaptive and adaptable are possible, see figure 3.

Adaptable systems allow the user to change certain system parameters to adapt its behaviour. These could simply be user interface features like font size, changing the position of blocks, for example moving the calendar, or adjusting the audio volume. It also includes explicit demands for additional learning content, for example by clicking on a “more information”, “examples”, or “exercises” button.

Adaptive systems adapt automatically based on the user’s interaction, for example browsers that change the colours of already visited links. In a learning context, already viewed learning content could be marked as the same. Adaptation may also be used to influence which content is presented and its order, which is called sequencing and is discussed in the following sections.

2.1.2 Sequencing

Sequencing is used to adapt the content structure, hence the order of presenting content parts and the decision, what is presented. The following sections present the underlying sequencing concepts and how they are used in this thesis. Therefore it starts with the concept that is closest to linear structures.

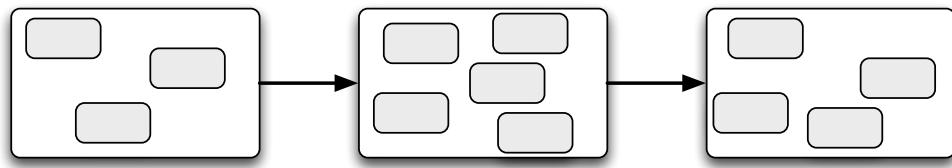


Figure 4: String of pearls: To proceed to the next step (white bricks), depending on the conditions one, some, or all substeps (grey bricks), need to be fulfilled.

String of Pearls

This structure is basically linear. It defines the order of predefined steps – pearls – with some freedom for the user. Before the user can proceed to the next step, he needs to fulfil one or more of the substeps of one pearl [79, p 62]. This structure does not need to be highly interactive, as the substep to be fulfilled can be, for example, having seen one content of the pearl.

The pearls can be sets which contain subsets of domain model concepts as used in an earlier version of InterBook [24], see figure 4. Or it may provide branches that immediately come back to the (linear) main branch. This is used to support the presentation of additional information, questions, etc., which is how it is used for example in LernBar [124], compare figure 5.

Because string of pearls is nearly linear, it is easy for authors. The structure is similar to a linear structure with additional information as used for example in textbooks that provide boxes with tips, exercises, etc. Hence existing content can be

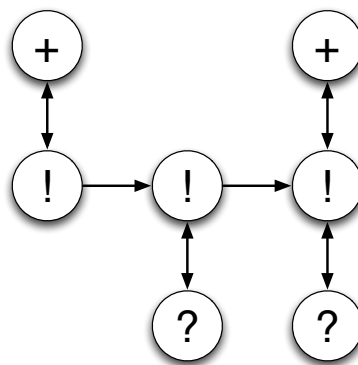


Figure 5: String of pearls variation: This more linear variation adds, for example, extra information (+) or questions (?) to the main path of content (!).

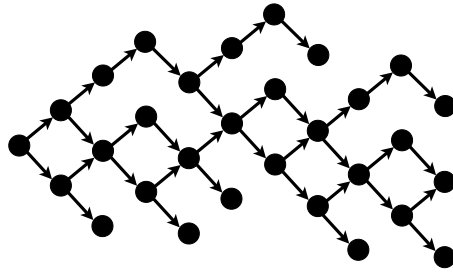


Figure 6: Branching: The path branches at decision points. While this figure only shows one or two paths going from a decision point, of course the number of alternative paths is not restricted and can be more than two.

adopted easily and the same is true for creating new content. However, extensive adaptive or interactive behaviour cannot be created with string of pearls, as it is limited to simpler structures.

Branching

This structure is characterised by dedicated decision points within the content where the path branches to two or more paths, see also figure 6. It is not required that the user notices branching like explicit branches in hypertext stories. Branches can be hidden, happen some time after a user action, or happen because of a number of actions.

The concept of branching is easy understandable. However, in case of creating non-trivial content, branching structures tend to become complex and are therefore difficult to handle, in particular for non-technical people (see figure 7). It is not only the huge number of content parts that is a reason for its complexity, but also that each branch of each position point needs to be formulated explicitly in the right context of the overall content.

Rule-Based Concepts

“Rule-based concepts” is used as a collective term that includes all the more complex concepts like preconditions and Artificial Intelligence (AI). The term itself is a bit misleading because string of pearls and branching may also be realised with rules.

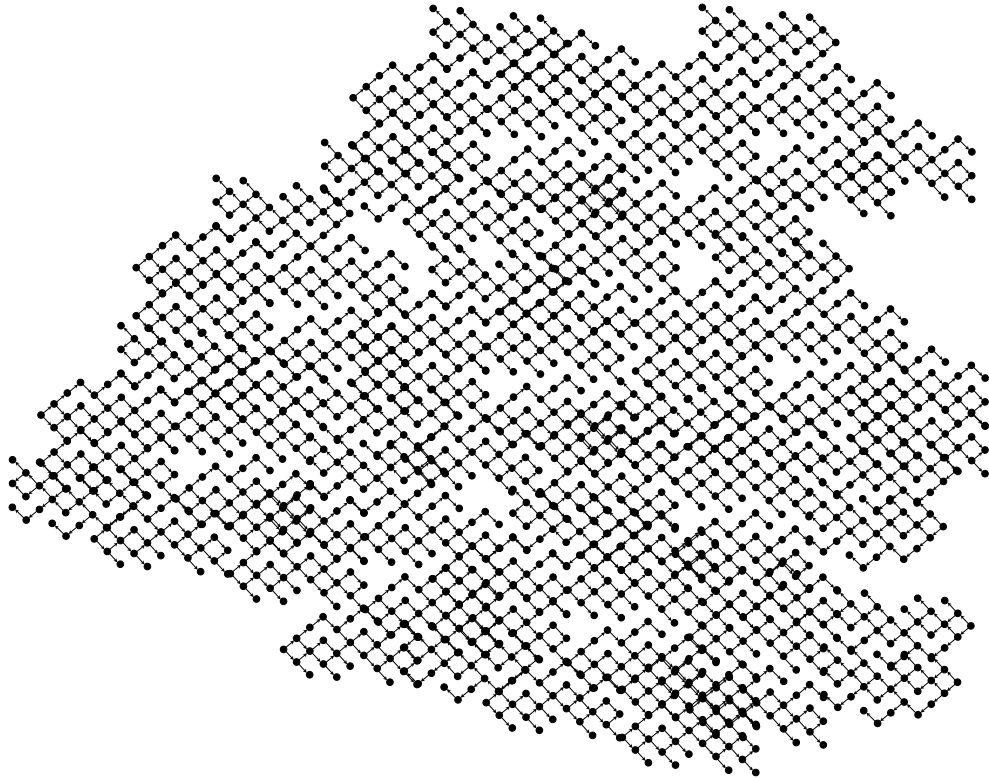


Figure 7: Complex branching: For non-trivial content, branching structures tend to become complex and therefore difficult to author.

However, because these two concepts can be also realised without rules, usually the term “rule-based concepts” does not include these concepts, as long as they only include simple logic.

This concept uses conditions that need to be fulfilled, rules that describe how the conditions should be fulfilled, and statements that describe what to do if the rules are fulfilled. The following pseudo code is a simple example:

```
if (passedXY and grade > 2.3 and !solvedExample)
{
    // Do something...
}
```

The code in curly brackets is only executed if the conditions within the round brackets are fulfilled. Thus the code is executed if the user has passed something beforehand, got a grade greater than 2.3, and did not solve an example. Because all

these conditions have to be fulfilled before they are asked for, often they are also called preconditions.

This simple code already shows some typical aspects of rule-based concepts, in particular in contrast to branching. While branching structures can be thought stepwise from the beginning to the end, rule based concepts are mainly backwards, because conditions have to be fulfilled *before* something can happen. Additionally, the branching concept requires the authors to specify and create (program) each single decision and each single step, rule based concepts only need the necessary rules that are required to distinguish between the possible different actions of a specific state.

2.2 Relevant eLearning Specifications

This section focuses on eLearning specifications that deal with adaptivity and interactivity. Most eLearning specifications focus on other typical eLearning applications like content, activity, user exchange, metadata for modules, etc. Some of them could be used in addition to the ones presented, for example for metadata or user modelling, but only the most important of these will be mentioned briefly within this section. A more detailed description of nearly all eLearning specifications from the point of view of adaptive hypermedia can be found in Hendrix' PhD Thesis [61].

Currently, the IMS Global Learning Consortium [66] is the main contributor for learning specifications. It has developed specifications for nearly every learning oriented purpose, but the consortium now focuses on the most important specifications needed for learning technology integration and content exchange. These are:

- Learning Tools Interoperability (LTI) [81]

Enables seamless integration of learning activities from other vendors into any supported Learning Management System. These activities could also be installed on other servers by any provider outside the campus.

- Learning Information Services (LIS) [109]
Defines the information needed to exchange learning related data, such as people, groups, memberships, courses, and outcomes. It also includes a service that could be seen as a learning directory service (like a Lightweight Directory Access Protocol (LDAP) server for learning purposes).
- Common Cartridge (CC) [68]
A specification for exchanging learning content.
- Question and Test Interoperability (QTI) [77]
A specification for describing questions and tests. Widely used in assessments.

Two more non IMS specifications are also widely used: Sharable Content Object Reference Model (SCORM) that is, like IMS-CC, a specification to exchange learning content and Learning Object Metadata (LOM) [62] that is still commonly used to describe learning object related metadata. Although these and other specifications may be used to describe parts of an adaptive or non-linear structure like LOM or IMS-Learning Resource Meta-data (MD) [10] for further description of the learning objects or IMS-QTI for integrated assessments, only those specifications that are about sequencing itself are of interest for this research project and therefore described in detail in the following sections.

2.2.1 IMS Simple Sequencing

IMS Simple Sequencing [89] is a specification to describe paths through a collection of learning activities. Thus it can be used to define the order in which the learning activities are presented, using conditions for selecting, delivering, and skipping resources. It is intended for:

- Multiple paths through one set of learning activities.
- Patterns of formative assessment.

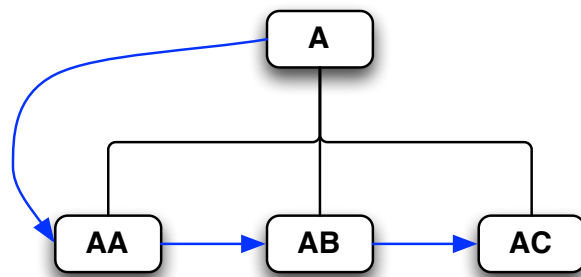


Figure 8: Simple Sequencing Standard Behaviour [89, p 11]: Child nodes of a parent node are presented one after the other.

Reprinted with Permission from IMS Global Learning Consortium (www.imsglobal.org) from IMS Simple Sequencing Best Practice and Implementation Guide Version 1.0 Final Specification, Copyright 2003, by IMS Global Learning Consortium Inc. All rights reserved.

- Summative assessments.
- Decision Trees.
- Adding Context Sensitive Network Services to Content.
- Step Through Tutorials.

It is called “Simple”, because it addresses not all, but an important segment of the entire problem space for learning content sequencing. Adaptation is only addressed in a limited way, and collaboration not at all.

The whole concept is based on learning activities that are arranged as an activity tree. Any leaf node may be associated with a content resource. An activity cluster is defined as a single node and all its immediate children. A cluster is the scope of rules and navigation control nodes that are associated to the parent node of a cluster and define the behaviour of sequencing its children.

The default mode allows the learner any sub-activity in a cluster, but a guided flow can also be defined. Unless otherwise specified with rules, a guided flow delivers all the children activities of a node, one after the other, see figure 8. This standard behaviour is called “forward flow”.

Sequencing itself happens in the sequencing loop (figure 9) that is started each time a learner moves to the next activity. It consists of six behaviours, each of them acting on its corresponding request. For example, the *Sequencing Behaviour* acts on any pending Sequencing Request and may result in a Delivery Request that in turn triggers the *Delivery Request Behaviour*.

Simple Sequencing is not at all “simple” to implement, which is perhaps why SCORM 2004 is the only known implementation of the specification [90].

2.2.2 IMS Learning Design

Learning Design (LD) [72] is intended to be a pedagogical meta language. As such it is the successor of Educational Modelling Language (EML) [71] that has been developed at the Open Universiteit Nederland.

LD has been “developed to describe an unlimited number of pedagogical approaches” [73, p v]. It is not only possible to describe the particular elements of a didactic situation, but the whole didactic situation itself. Therefore both the structural elements and the sequence of the learning activities are described. Sequencing does not need to be linear, but can be adapted to any context or can be parallel. It should also be usable in any scenario and therefore fit for eLearning, face-to-face learning, and blended learning. But it should also be suitable for adaptive learning, mobile learning, game based learning, and more. The aims can be described as follows:

- Description of actions for both learners and lecturers.
- Description of resources and services that are used during learning.
- Support for different pedagogical approaches.
- Support for single learners as well as learning groups.
- Support for eLearning and Blended Learning.

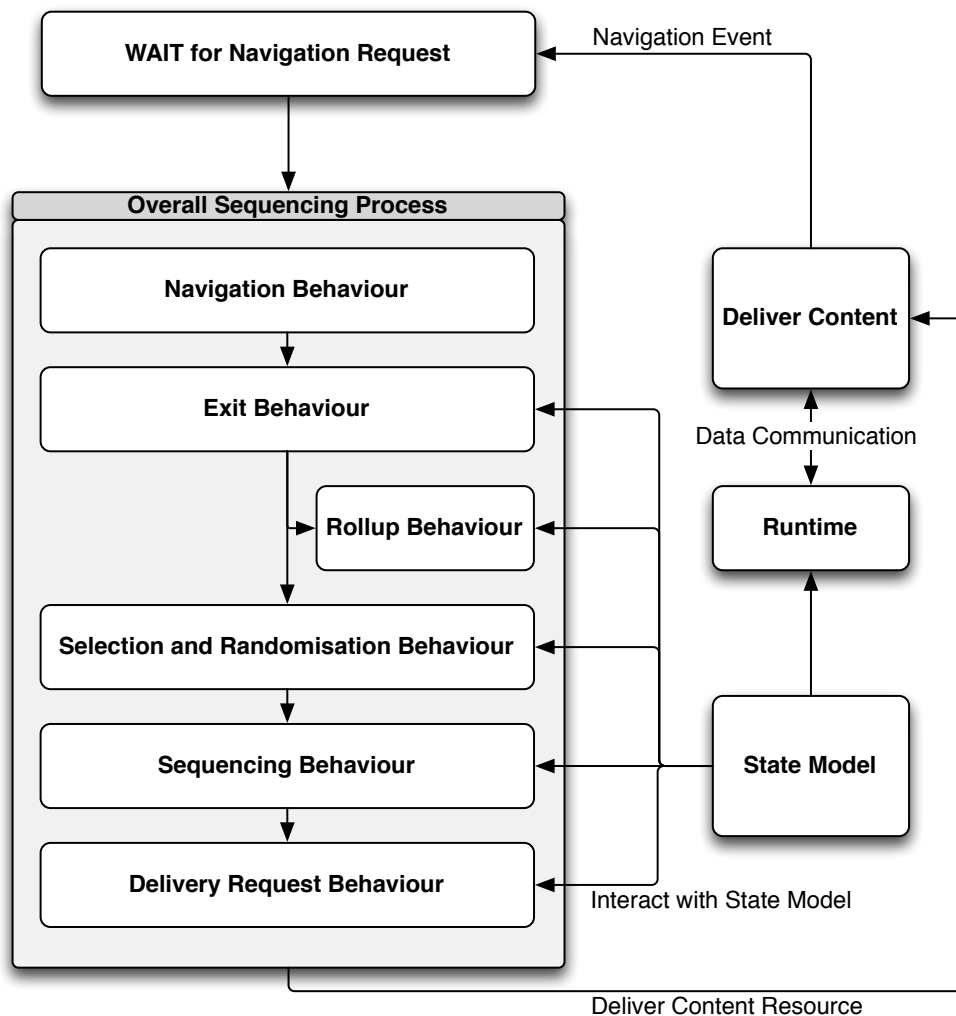


Figure 9: Simple Sequencing Loop [89, p 64]: It waits until the user requests new content (top brick). The six behaviours of the grey brick “overall sequencing process” influence the content that is chosen and presented (brick Deliver Content). Reprinted with Permission from IMS Global Learning Consortium (www.imsglobal.org) from IMS Simple Sequencing Best Practice and Implementation Guide Version 1.0 Final Specification, Copyright 2003, by IMS Global Learning Consortium Inc. All rights reserved.

IMS LD distinguishes between three implementation levels:

- Level A is the main level that supports basic functionality that consists only of the LD core objects: roles, activities, any resources, and structure elements such as method, play, act, and role-part. Activities are performed by learners and teachers in a linear order or without any restrictions, using resources and services.
- Level B adds properties and conditions. Properties store information about learners, roles, and the state of LD itself. Conditions influence the learning flow according to specific circumstances or properties.
- Level C adds notifications that may trigger actions in response to events in a learning process.

A LD Unit of Learning (UoL) can be compared to a written lesson plan that includes any resources and actions that might be needed during teaching. The conceptual structure of LD is constructed like a theatre play: *Activity* is the central and main part and describes the *tasks* the *role* has to perform and the available *environments*. The *play* consists of *actors* (*roles*) and *parts* (*role-parts*). A sequence *consists* of parts that are ordered one after another. As default, the following act begins as soon as the previous one is finished. This can be changed by the designer. The specification describes two types of roles: Staff and Learner. Commonly the learners do the learning activities and staff provides feedback and monitors the progress with support activities. More specialised roles can be created using sub-roles.

Non-linearity can be provided in two ways: Either simple sequencing is utilised, or the LD possibilities of level B are used as follows: Any play's method may contain conditions that define the run of the play – and therefore influence the sequence. For example, after finishing an activity a role may choose the next one on its own and conditions check and set properties to hide or show different content to the role.

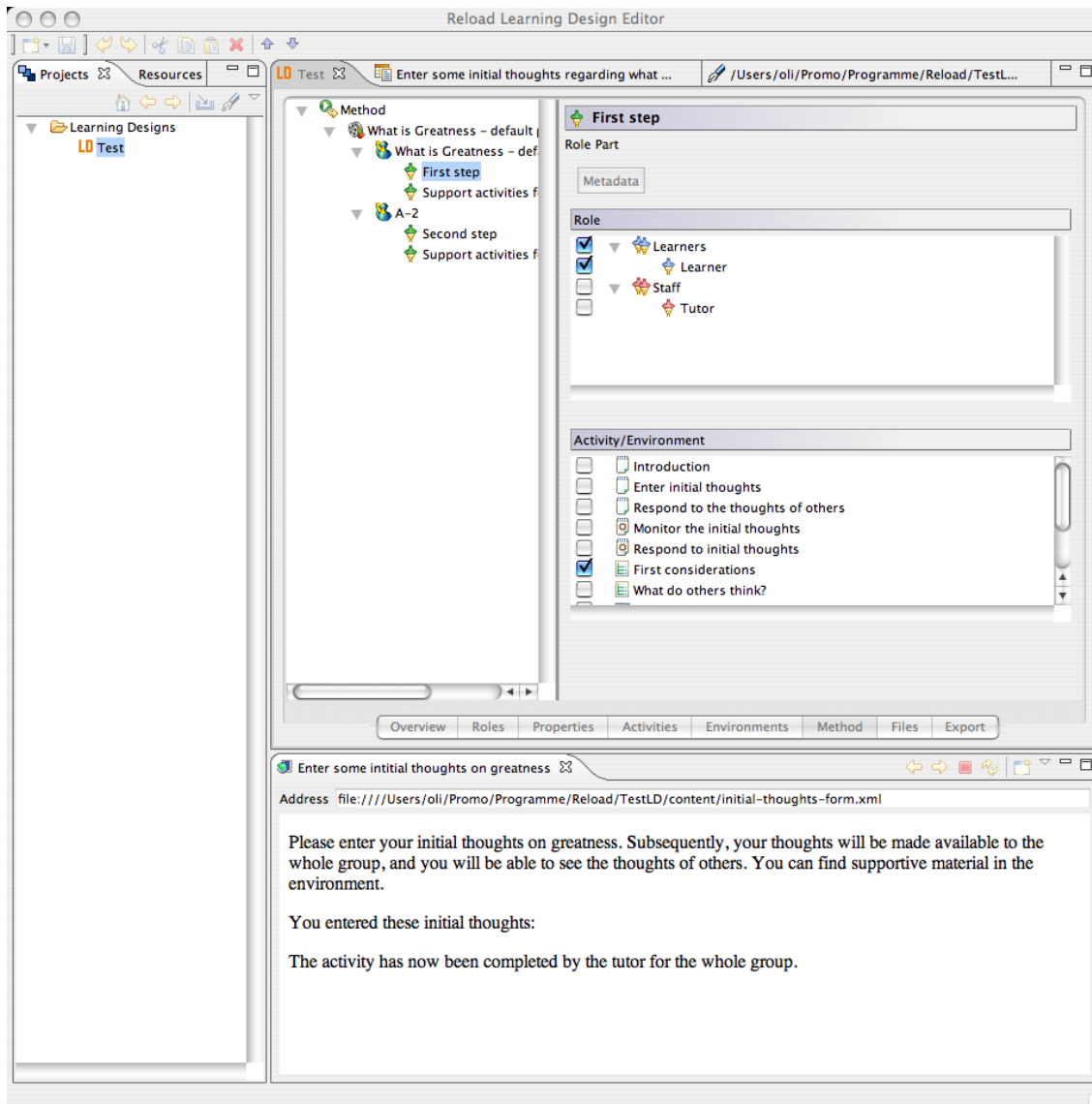


Figure 10: Reload Learning Design Editor

Various tools have been developed to author or edit LD, but only two of them have been successful: Reload Learning Design Editor and LAMS.

The Reload Learning Design Editor [98] (see figure 10) is the reference editor for the LD specification and one of the few LD editors that supports all three levels A, B, and C. On the other hand, it is not intended for endusers, as it basically just presents the internal structure of LD. Additionally, it does not support any kind of content creation – hence the learning content itself has to be created with other tools and then imported into this editor. Development stopped in 2006.

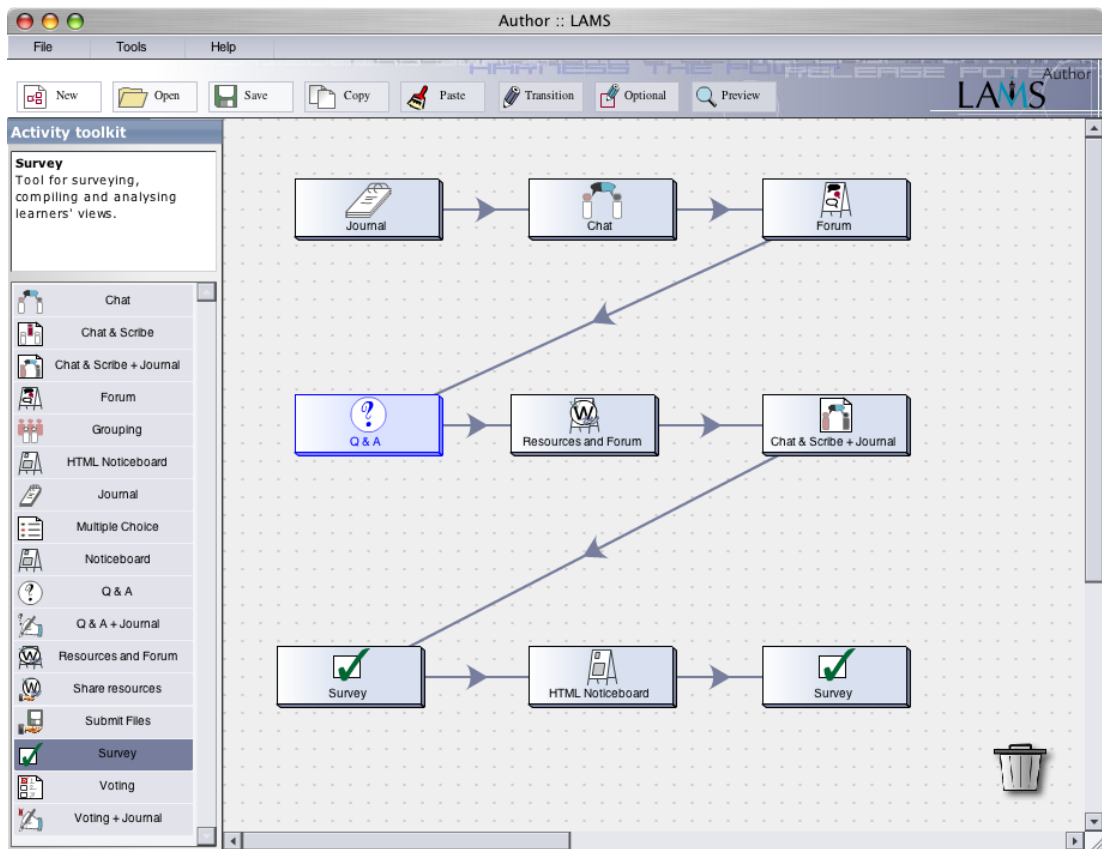


Figure 11: LAMS Author Mode

The Learning Activity Management System LAMS [76] is still maintained and provides a user interface that is manageable by non-technical endusers (see figure 11). The downside regarding LD is that it is not a real LD tool but only is inspired by this specification, and the version 1.x series stuck to linear sequences. Beginning with version 2.x, LAMS provided LD Level A export, and internally non-linear sequences. LAMS is still being developed and supported [75].

2.3 Sequencing in eLearning

Although some eLearning projects tried different sequencing approaches, for example Chameleon [43], ACE [110], and LernBar [124], however, by 2007 still none of the approaches had been adopted by eLearning systems, and therefore none of them is used widely [60]. Even eLearning specifications do not integrate adaptive learning anymore because lecturers could do sequencing better. For example, while SCORM 2004 integrated IMS Simple Sequencing, the comparable specification IMS Content Cartridge – its version 1.0 Final Specification was published four years later on 1st October 2008 – did not use any adaptation.

Currently, the established LMSs are to some extent taking on adaptation and adaptivity. Looking at, for example, Moodle, of course it could be stated that already earlier versions provided adaptation: The personal page “MyMoodle” lists all the learner’s modules (Moodle calls them “courses”). Additionally, module participants can be assigned to teams, so that each team may be assigned its separate activities. This does not mean that different teams are presented different activities as they are all the same. But the teams have separated access and they may not see or edit the other teams’ activities, depending on the module settings. However, this is not adaptive in terms of personalised learning systems because it is static and does not change due to any kind of rules or be influenced by the learner’s behaviour and activities.

Moodle 2.0 took one step in the direction of adaptive learning by introducing “conditional activities” [84]. It restricts access to activities in respect to grades, completion of other activities, date, time, and more. It can be used to disallow working through special activities until some preconditions are met, but it can be also used to provide adaptive learning paths. Usage is very low level, especially in the case of the latter it is very complicated, because preconditions have to be defined for every single step of each path. As this is a very new feature of Moodle, it remains to be seen if educators will accept it.

2.4 Adaptive Educational Hypermedia

The presentation of learning content can be personalised by adapting it to a learner’s needs. This is the domain of the research field AEHs [86], which is based on hypermedia, adaptive systems, and Intelligent Tutoring System (ITS) [24]. Because it is normally used in a web context, models and algorithms are often simpler compared to ITS [37].

Many parameters can be adapted, for example colour, layout, language, sorting, and more, see figure 12 [70]. This research focuses on sequencing of content, which in figure 12 is called “Adaptive Navigation Techniques”.

Regarding the underlying models, first single purpose systems had been developed for AEHS that used hard coded models and content. Using another content or pushing it into a different domain was difficult or impossible, because the concepts and the models had been too specialised.

The second generation is based on reference models. The best known is the Dexter model [57] that consists of three layers: The run-time layer, the storage layer, and the within-component layer, see figure 13. Basically the storage layer describes the hypermedia itself, hence a network of nodes and links. It is worth noting that nodes are called *components* within the Dexter model because the specification group

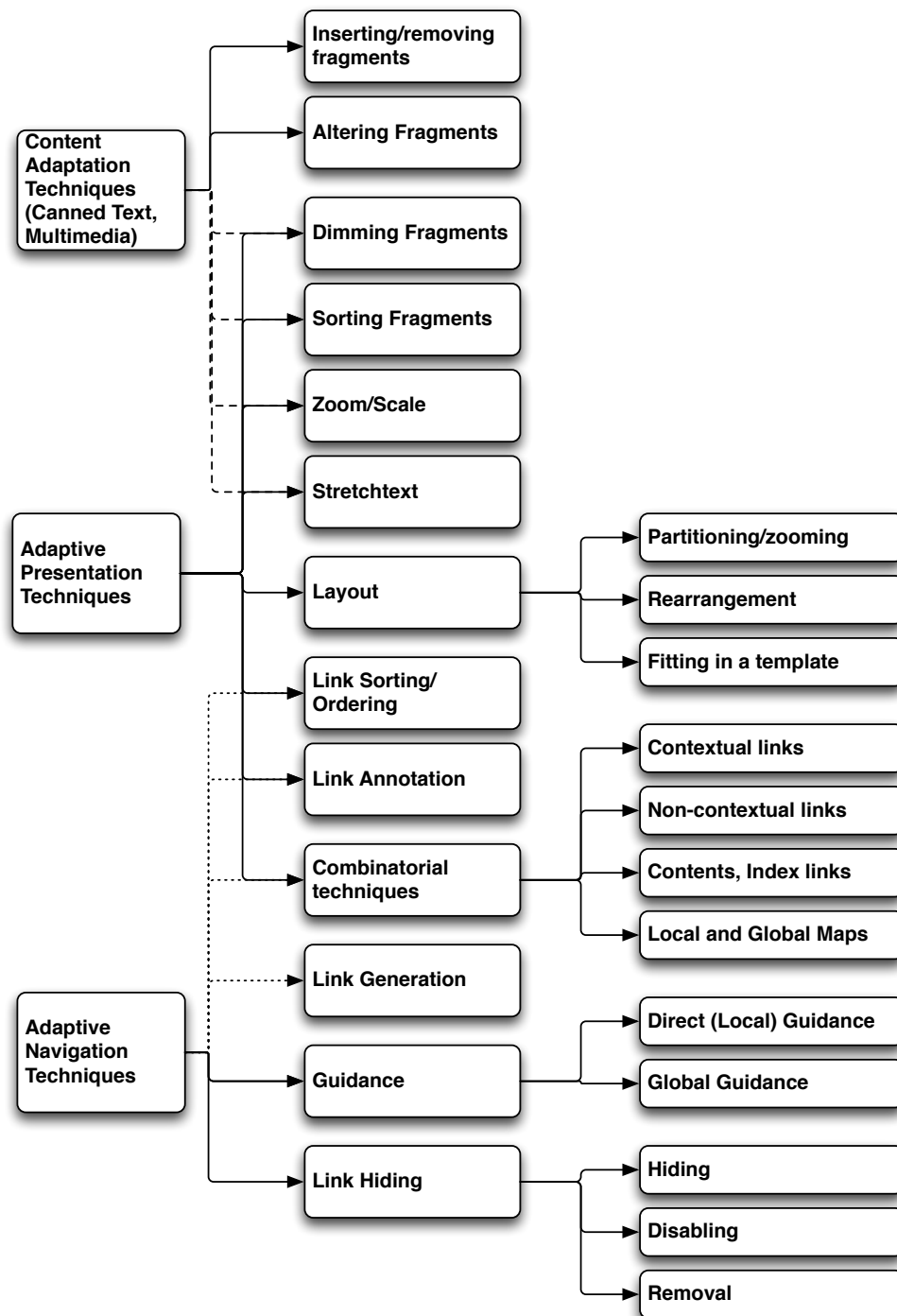


Figure 12: Adaptive Techniques [70]

Permission to reproduce this figure has been granted by Taylor & Francis Group.

Figure has been removed
due to Copyright restrictions.

Figure 13: Dexter Model [57]

had too many divergent interpretations about a node. The run-time layer presents the hypermedia and handles user interactions and dynamics. It is connected through the presentation specifications to the storage layer. The within-component layer is not specified because this would be pointless as there are too many possible nodes like text, pictures, films, and more.

In 1999, the Dexter model had been extended to the Adaptive Hypermedia Application Model (AHAM) [19] that supersedes the storage layer with three models: The teaching model, the domain model, and the user model, see figure 14. AHAM consists of five models – separating the entire model into five layers or sub-models is the current status: “A typical architecture of the state of the art of AEHS is fully decoupled and consists of five complementary models: i) The domain model which

Figure has been removed
due to Copyright restrictions.

Figure 14: Adaptive Hypermedia Application Model [19]

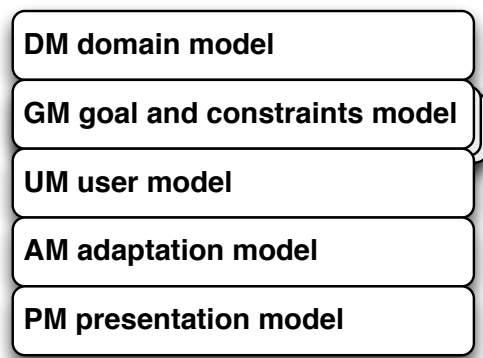


Figure 15: The five level AHS authoring model [37]

specifies what is to be adapted ii) The user and context models which indicate what parameters the content can be adapted and iii) the instructional and adaptation models which express the pedagogical approach the learning process should be based on, as well as the forms of adaptation to be performed.” [86]

Looking from the authoring side gives a similar picture: It started with three layers: The conceptual layer, the lesson layer, and the student adaptation and presentation layer [36]. This was soon revised to five layers: domain model, goal (and constraints) model, user model, adaptation model, and presentation model [37], see figure 15.

This layering is done to separate the content itself from various abstraction layers. Thus the presentation can be adapted following a mixture of different strategies, each of them defined in its own layer. This increases reusability because in order to adapt the content presentation to another context potentially not the content itself but only the strategies of the according layers need to be defined.

However, from an authoring point of view this seems problematic for two reasons: First, thinking in layers seems to be challenging for authors who are unfamiliar with creating adaptive content structures: “when creating a course authors do not mentally distinguish between topic relations and pedagogical relations” [20]. Second, creating generic content units that may be moved to different positions within a path seems unfamiliar for non technical authors: “authors often start out by thinking in

terms of a sequence or learning path instead of leaving as much navigational freedom as possible in their course and only using prerequisites where really needed” [20]. These aspects do not seem to have been addressed so far.

2.5 Current State of Authoring Adaptive Educational Hypermedia

In addition to the problem that authoring adaptive content is an unfamiliar and difficult process, it is also labour-intensive and therefore too expensive [97]. According to De Bra et al., transferring existing content for 1 ECTS module (representing 25 to 30 hours of study time) into an adaptive online module needs at least one person working 6 months full time [20]. One reason is the poor usability because of the prototypical implementation so far [26], but also the architectural design fails to meet the overall needs of Web-enhanced learning [82], so it is regarded with scepticism whether educators are “willing to invest the significant time and effort required to initially integrate an AEHS into their teaching plans and to ensure that the learning offerings provided meet the curriculum.” [86]

Currently efforts are being made to combine the best of AEHSs and courseware re-use systems. Projects like APeLS, KnowledgeTree [26], and the EU project GRAPPLE (Generic Responsive Adaptive Personalized Learning Environment) [53] extend the idea of reusing content that can be searched by authors – as seen for example in ARIADNE [47] and MTS [51] – with adaptivity of AEHSs. These could solve the problem of creating content that could be also used for adaptive learning systems. However, none of these kinds of systems have been accepted by educators so far, hence there is no reusable content in courseware re-use systems. But even if they already had been used widely, adaptivity itself is the problem. For example, Paul de Bra et al. summarise for GRAPPLE: “The real bottleneck in large scale adoption of adaptive learning is still the authoring of the adaptation.” [20] Thus, a

number of research projects have been started in the last years to improve authoring for AEHS.

In his PhD thesis, Hendrix has researched on many aspects of improving authoring for AEH [61]. He sees a lack of appropriate authoring workflows and systems: “The authoring process, however, is time consuming and cumbersome.” [61, p XIX]. He has tried automatism to decrease the authors’ work, for example by using the metadata of files from a semantic desktop. He also improved reusability of an adaptation language called LAG by adding a meta level that enables developing reusable meta strategies. Additionally, he has investigated the possibilities of graphical authoring by developing the tool Concept Adaptation Model (CAM). However, this tool had some usability difficulties: “While technically experienced authors can successfully create Domain Models, they struggle with creating the adaptation using the more concept Concept Relationship Types. Also authors are having issues with creating the overall course in the Concept Adaptation Model.” [61, p 202]

Foss pursued Hendrix’ work [48] and “looked at how visualization can help users with the adaptation process” [48, p293]. Among others he described workflows that import linear content that use as much information provided by the source material as possible and add metadata for adaptation either manually or automatically. However, he describes only the technical authoring process without mentioning if the outcome is usable for sequencing.

Scotton focuses on the delivery of Adaptive Hypermedia (AH) to make adaptive hypermedia more generally usable [108]. Like Hendrix, he works on various aspects like improving the adaptation language and improving the Graphical User Interfaces (GUIs) in a technical way. While graphical tools and help are essential for most authors to even become able to create adaptive structures, usage of code seems to be problematic for non-technical authors: “Evaluations have demonstrated that authors require tool support with a graphical user interface that includes a strategy library or repository to use, change and apply strategies without necessarily having to write

programming code.” [108, p 239]

The findings and outcomes of these PhD projects are very valuable and simplify authoring a lot by addressing the main issues of the existing tools and workflows. It can thus be seen as essential fundamental work that mostly solves drawbacks in a technical way, for example by increasing the ability of reusing materials and concepts. However, the evaluations only test very specific parts of the authoring process, mostly by comparison with a direct ancestor version of a tool that has been improved. The concepts and workflows themselves are not questioned, though they are very generic.

2.6 Appraisal

Obviously, one of the main problems of all these adaptive approaches is the effort needed to create adaptive structures and the difficulty of the authoring process. This is acceptable for research projects and applications that address teams of experts. But as soon as adaptivity needs to be manageable by single lecturers, approaches are needed that will be more author friendly.

A concept that is based on linear content and takes into account its particular characteristics seems to be promising: It would avoid the problems of the unfamiliar workflow noticed by De Bra et al. [20] (authors do not distinguish between different kind of relations and authors often think in terms of a sequence) because most lecturers are used to creating content in a linear way, tailored to their individual style. In many cases content about the same subject has already been prepared by different lecturers, in particular in university networks like Atlantis University. Reusing this content in an adaptive manner to support the students’ learning process could decrease the authoring effort significantly.

As mentioned above, reusing existing material by importing linear content has already been addressed by some research. However, the composing process of such

material is not mentioned. Even if not looked at from the sequencing perspective, linear content cannot be adapted without preparation. For example, according to Foss, the import process should separate different media types, like text, figures, films, etc. [48]. But it is not mentioned which effect removing any parts of the original content might have, and how these effects could be treated. For example, it is very likely not possible to adapt to people who prefer figures just by not showing the texts. It would also be difficult to hide the figures without changing the text, because all these parts are interrelated in linear content. Even if figures are not explicitly mentioned in the text, most probably the text needs to be adapted as soon as it is presented without figures, because they are referenced implicitly. Very likely the author would have written the text differently if he wanted to create content without (or with other) figures. Thus authoring adaptive learning content that is based on linear content needs to be addressed specifically.

2.7 What's next

Having shown that one obstacle for the wider usage of AEH is the authoring process that could be addressed by reusing existing linear content and adopting its creation workflow, the following chapter looks in more detail at linear structures and develops a novel concept based on the typical characteristics of linear content.

Chapter 3

Adaptive eLearning Based on Authoring

Chapter 2 *Authoring for Adaptive eLearning* discussed the common concepts of adaptive learning concepts. It also showed that current authoring approaches are only manageable by teams of specialists that are experts in different domains: The domain of the topic to be lectured on, but also experts for the adaptive content itself, and pedagogic specialists. Additionally, the workload is enormous.

The creation of adaptive eLearning content doesn't meet established authoring workflows and most of the already existing content cannot be reused. The method of adaptive eLearning content creation does not seem to be the normal way of thinking for most authors, and all these drawbacks have thwarted lecturers from authoring adaptive eLearning materials.

This chapter looks from the opposite side at the problem. It addresses the outcomes presented in the previous chapter by first giving one possible explanation for the lecturers' problems with authoring: Human ways of story-like thinking for more complex topics. Based on this, this chapter then discusses approaches of another interactive discipline: Interactive Storytelling. Based on the outcomes of the previous chapter and the insights into storytelling as well as Interactive Storytelling,

a new concept is developed that is based on the workflows, which are common for linear content authors, but leads to adaptive eLearning content. This is followed by a description of the requirements needed for an adaptive system that meets the demands of the concept.

3.1 Storytelling for Adaptive eLearning

For adaptive eLearning adaptable content is essential – and that is a real problem. To be able to move sections of the content to another position of the presentation path, adaptable content must have as few preconditions as possible. The more a section is related to other sections, the less it can be moved without breaking these relations. Additionally, all existing preconditions have to be described explicitly – not occasionally through several layers. On the one hand it is very hard to describe all existing dependencies of a content fraction (because of all their interlocking immediate elements [11], see following paragraph), on the other hand content without dependencies is soulless. Additionally, humans do not think in independent content fractions [20]).

Looking at research on storytelling can explain these characteristics. For a basic understanding, the story models that have been the basis for the concept first need to be presented.

3.1.1 Modern Storytelling Models

The following sections subsume aspects of storytelling theory that have influenced this research. Although, they are all about linear content, they are helpful for the initial step of understanding some of the difficulties in adapting content. Second, they can be seen as theoretical aspects of the already existing learning content from a storytelling point of view.

The Propp Model

The Russian formalist Wladimir Jakowlewitsch Propp established a model for the structural analysis of Russian fairy tales [96]. He concluded that all Russian fairy tales show the same structure irrespective of the mode of content. A story is divided into individual *functions* that act on the course of the story irrespective of the concrete action that happens within a function and the person that carries it out.

Propp calls them morphological functions. The functions' impact on the course of the story are unalterable, however, the content itself may differ. Their figure is changeable and therefore "morphological". These functions are constant basic units of the story. Their quantity is limited and they are always in the same order. However, not all functions have to be used for a concrete story [54].

Propp introduced a system for the notation of this structure for fairy tales and assigned a symbol to each function. The following table lists all the functions:

Symbol	Description
Ɔ	absentation
g	interdiction
d	violation
e	reconnaissance
z	delivery
h	trickery
J	complicity
A	villainy/lack
B	mediation
C	beginning counteraction
↑	departure
D	first function of the donor (testing or interrogation)
E	the hero's reaction
F	provision or receipt of a magical agent

Symbol	Description
G	spatial transference between two kingdoms, guidance
H	struggle
J	branding, marking (of the hero)
I	victory
K	initial villainy or lack liquidated (a pair with A)
↓	return
Pr	pursuit, chase
Rs	rescue (of the hero from pursuit)
O	unrecognized arrival
L	unfounded claims
M	difficult task
N	solution
Q	recognition
Ex	exposure
T	transfiguration
U	punishment
W	wedding

Table 1: The Functions of the Dramatis Personæ [96]

Basically he distinguishes between two categories of stories: On the one hand defeating an enemy in a fight (1), on the other hand, solving a difficult assignment (2). The structures of both categories appear as follows:

$$ABC\uparrow DEFG\ H\ JI\ K\downarrow PrRs^\circ LQExTUW^* \quad (1)$$

$$ABC\uparrow DEFG^\circ\ LMJ\ NK\downarrow PrRs^\circ\ ExTUW^* \quad (2)$$

Some functions may be left out; however, there are some dependencies. For example, the misfortune A must be made good in K. A fight against the enemy H leads necessarily

to the victory I, a difficult assignment M to their coping N and the pursuit of the hero Pr to his rescue Rs [54, p 64]. This can be noted as follows:

A → K

H → I

M → N

Pr → Rs

At first Propp's model was only intended to formally describe Russian fairy tales and Russian formalism is certainly an extreme approach to disposing of all aesthetic aspects of a story. However, this approach is not new – Aristotle had already divided the tragic play into the three elements of prologue, episode, and exodos [9, p 9].

Because of defining so many functions and its very precise formulation, Propp's model seems to be very restrictive. However, it also fits or can be adapted to modern stories. For example, Lesinskas has analysed Star Wars (1977) using Propp's functions [78]. This model has also been used for various interactive projects, in particular for Interactive Storytelling projects. For example, Braun and Grasbon have realised a StoryEngine that is based on the Propp model [55].

Barthes' Model

Barthes proposes to study narratives on different levels of description [11]. He describes three levels of instances: functions, actions, and narration.

narration (top level)

 narrative communication

 narrative situation

actions (middle level)

functions (bottom level)

functions (relate to the same level)

cardinal functions (nuclei) (important for the narrative)

catalysers (complementary)

indices (relate across levels)

indices (relate to character, feeling, atmosphere, philosophy)

informants (identifies, locates in space and time)

Functions is the smallest unit of narrative, something that may not even have a meaning on its own but which acquires meaning in combination with other units, on the same level or on a higher level. Functions can in some cases be shorter than a sentence or even parts of a word. It should be noted that although they are given the same name, however, Barthes' functions do not need to be the same as Propp's functions.

Actions is the level of characters. Characters in the narrative are classified according to their participation in actions. Actions are often two sided. For instance *Giving* has a Donor and a Receiver. Examples of actions are desire, communication, and struggle.

The narration level includes narrative communication between author, narrator, recipient, and narrative situation as a set of protocols according to which the narrative is consumed. This includes different styles of representation, the point of view, and codalities.

3.1.2 Storytelling Aspects of Interest for Adapting Linear Content Structures

It is important to realise that parts of a narrative cannot be changed without influencing the rest. A narrative does not consist of independent units, instead they are all related: "Narrative thus appears as a succession of tightly interlocking

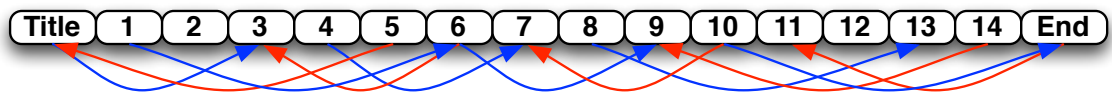


Figure 16: Internal structure of linear content: The row of bricks symbolises the linear content, the red and blue coloured arrows indicate pre and post conditions, respectively.

mediate and immediate elements” [11] and “the meaning does not lie ‘at the end’ of the narrative, but straddles it” [11]. It is also nearly impossible to describe all interdependencies because “Stories are complex structures that must meet many hard-to-specify requirements.” [32, p 14] Additionally, regarding Propp, moving one part to another position changes its function and hence it has another purpose [96].

Thus, looking inside the structure of linear content, it can be seen that its structure is very complex, see figure 16. It not only consists of concatenated content units, but also has a lot of pre and post conditions. Some of them are set explicitly, such as “hero has taken key” or “student has solved exercise A”. However, many of these conditions are set for the better flow of the content because it *feels* right and therefore cannot be described. This structure results in *the* order the content is presented in. Changing the content would very likely also change the structure. Sometimes changing one word entails a reordering process. This is a common content creation process: During content creation, the structure is changed until it fits [30, 46]. This is why even presentation software like Keynote or Impress provides screens to simplify the reorganisation of content. It is also a common design process, especially for Information Design (that is used to organise eLearning content [126]), because design expresses content: “In order to satisfy the information needs of the intended receivers information design comprises analysis, planning, presentation and understanding of a message – its content, language, and form” [92]. These observations can be summarised as follows:

- It can be expected that in many cases automatically generated or sequenced content is only second best compared to pre-authored content.

- Changing any content section, even a word, may cause a butterfly effect: It may happen that big portions of the content have to be changed because of one word. Due to the implicit conditions this can be problematic for the adaptation system, the author, or both.
- Because adaptive sequencing means changing the order and merging content from different contexts, it should only be done if necessary and in a clustered way to avoid breaking the interrelations of the content.

As a consequence for content presentation it can be stated that different appearances of the different content is not bad, because it visualises the change of the explanation context. Hence, visual changes can be an important hint to the recipient to get a better orientation in the content space.

These insights make String of Pearls [79] a very interesting candidate for authoring, although it is very limited – content and structures are authored and used just like lecturers teach: Preparation and presentation of linear content, but in the case of questions they adapt by branching to another explanation and afterwards fall back to the original discourse.

Summarising all these aspects, it can be concluded that all authoring friendly approaches should be based on linear structured content. How delinearisation could be done is discussed in section 3.2 *The Concept: “Coherence”* on page 66. However, before this it is necessary to look at Interactive Storytelling to give an overview of the authoring situation in this research field.

3.1.3 Interactive Storytelling

Investigations into Interactive Storytelling have been motivated by the assumption that this research discipline could suit “normal” authors. However, the situation is comparable to AEHS: Research is ongoing in this topic, but results do not so far seem to be usable for endusers.

Typically, concept creators and engine programmers think that authors of interactive content should program [116]. Thus, mostly only the architecture of such systems have been evaluated, and sometimes the effects on player’s experience, but almost no evaluations have been carried out regarding the authoring aspects [28].

One of the best-known projects is Crawford’s Erasmatron which is one of the first projects that could be implemented. However, the problem is the complexity of the production of a story for the system, so that no author has been able to implement a story [31].

Because of this Crawford started to develop Storytron, which was published in March 2009 [35]. It provided the development tool SWAT (StoryWorld Authoring Tool) for authors, see figure 17. However, again “the central mistake was too much complexity” [33]. Currently, Crawford is in a brainstorming process regarding what

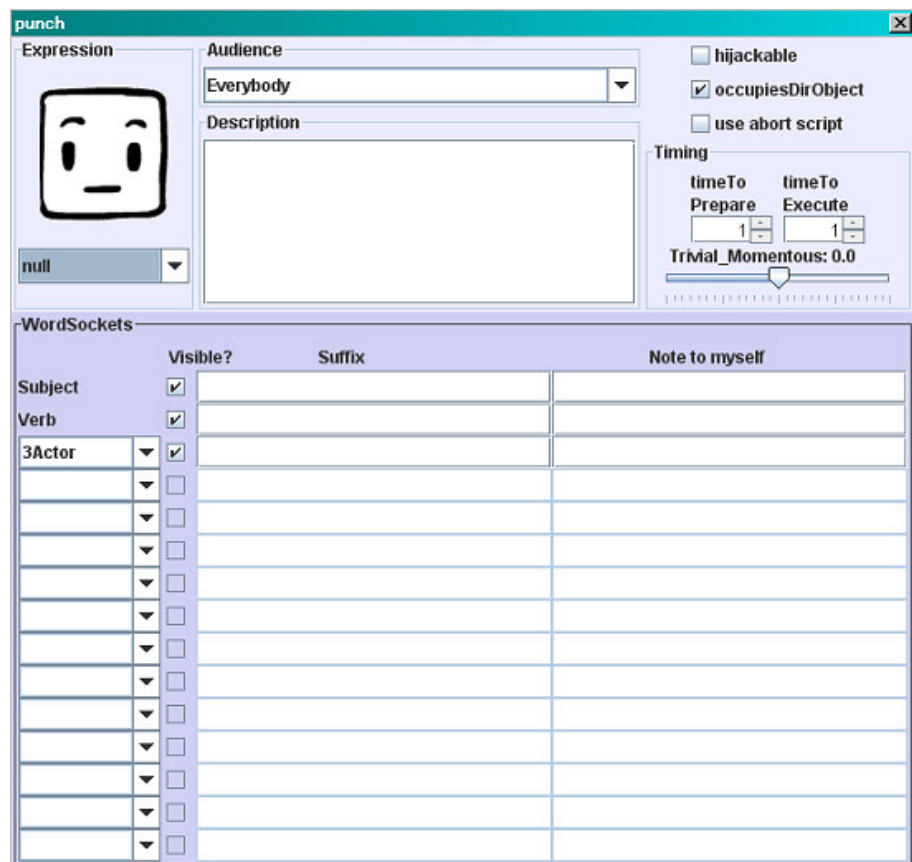


Figure 17: StoryWorld Authoring Tool [34]

Permission to reproduce this figure has been granted by Chris Crawford.

to cut out to decrease the complexity of the system.

This kind of authoring gap [113] was one of the main research objectives [112] of the EU funded project IRIS (Integrating Research in Interactive Storytelling) [67]. Within this project the participating organisations developed engines, tools, and authoring environments. They searched for ways to simplify authoring. The results for the latter were in the form of authoring models and descriptions for authors of how they could manage the technology. Theoretical background on this research can be found in Spierling's PhD Thesis '*Implicit Creation*' – *Non-Programmer Conceptual Models for Authoring in Interactive Digital Storytelling* [111]. On the one hand, this research is a huge step forward, but on the other hand authors still have to learn lots of tools and concepts before they can start creating content. Additionally, these tools require experts, untrained individuals such as lecturers have problems in using them.

As a result, the authoring concept for lecturers as authors still needs to be developed. This concept should avoid any programming, but should follow the authors' way of creating linear content.

3.2 The Concept: “Coherence”

Based on the results of the investigation discussed in chapter 2 *Authoring for Adaptive eLearning* on page 35, it seems unpromising to take one of the existing approaches and try to make it useable for lecturers. Hence, this research tries to start from scratch and develops a new concept from the ground up, influenced by and incorporating the storytelling aspects discussed above.

It can easily be seen that seamless adaptation using pre-authored linear content would demand on the one hand both micro and macro adaptation. As described above, changing one word may result in the need to change the overall structure and vice versa. On the other hand, seamlessly adapting the content itself would demand

from the system to have knowledge of the content, the language, the authors’ styles, and more. This would go beyond cutting edge research of, for example, text mining and text interpretation, but also of automatic interpretation of figures, films, and animations. All this is out of the scope of this research project. Another option would be letting authors do this job by creating all the content sections that provide the changes required for a fluent presentation, but this would raise two further problems: This would again mean lots of work for interdisciplinary teams of specialists, and it seems nearly impossible to pre-author all possibilities or relevant combinations. Thus, a simpler solution is sought.

Hence, this research focuses on sequencing. The source material that should be macro adapted by sequencing is linear learning content, either pre-authored for already held classes, or specially made or customised for a system based on this concept. Although different kinds of workflows for creating content could also be discussed, like [30, 46, 121], but also like [13, 87, 118] and others, it has been seen as unnecessary, because the linear content itself should be used as the starting point however it has been created.

Therefore, the concept is developed by first looking at what authoring artefacts already exist or can be expected to exist. Then it is seen how this can be first decomposed and afterwards recomposed again, also mentioning concept features that are common for such systems. These steps have been undertaken excluding any presumption of expected ways of interaction with the enduser, namely the learners. The concept should develop free from such constraints, pushing the responsibility towards the view of a complete system, such as is described in section 3.3 *Implemented Concept* on page 75.

3.2.1 Delinearise Content

Within a linear structure more information than only a sequence of units, which has a lot of relations, is hidden. First of all, the structure has a goal, which is the

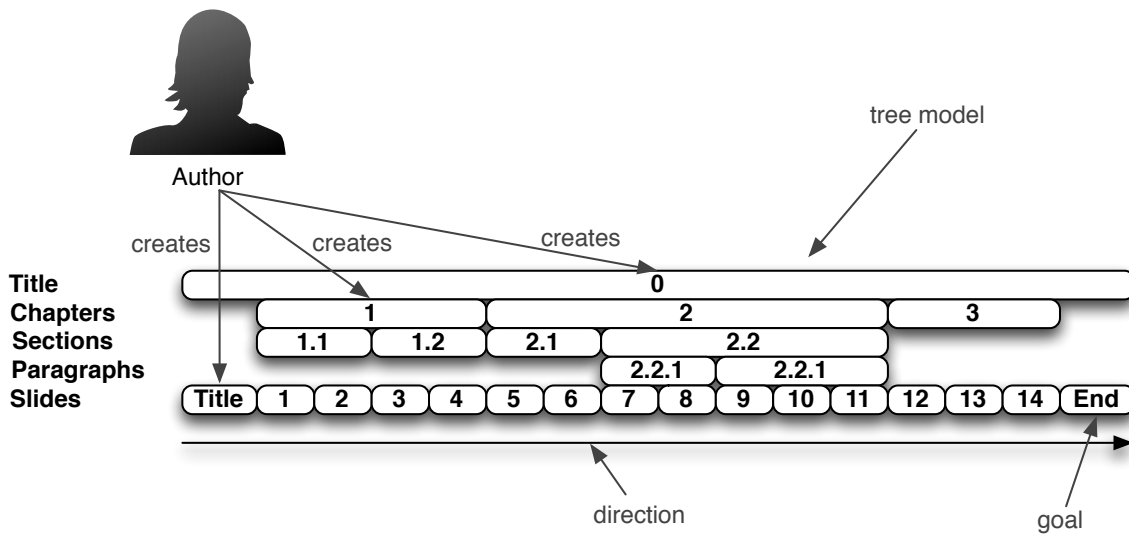


Figure 18: Structure of sectioned linear content: The linear content itself consists of slides, begins with the title slide and goes linearly to the end, which normally corresponds with the goal of learning content in terms of having gone through all the content and also understood it all. The horizontal arrow under the content shows its direction. On top of the content the tree structure is illustrated with bricks, which show the numbers of the chapters, sections, etc. Also shown is how the author of this content has created both content and structure.

end of the sequence. The direction is also clear: constantly moving forward from the beginning to the end. Additionally, content is usually structured in chapters, sections, and paragraphs, hence presenting a tree-based model. It is also important to recognise that the author (or team of authors) have created the whole content including its structure: The author’s point of view is part of each piece of content and its structure. This includes his personal characteristics and view of the domain, didactic approaches, and more. All levels of a multi layer model are merged into each piece of content and structured with different and changing weights. Figure 18 provides an overview.

To this extent, all the information can be extracted automatically from existing content. When new content is created, the author can set this structure information without changing his workflow and without any additional effort. The result so far complies with the standard flow behaviour of IMS Simple Sequencing (compare figure 8 on page 42).

However, additional content must be added in order to delinearise this kind of structure. Since this research project originated as part of the Atlantis University Project, which, among other things, was a network of universities that had multiple lecturers teaching the same subject. In most instances the lecturers created their own content. Naturally, different lecturers explain and present information differently. This difference can be obvious or only slightly so. However, the content is distinct in that they vary in the way of explanation, wording, structure, assessments, didactic methodology, figures, and more. Such different content and structures can be merged by annotating related fractions (for example slides), sections, chapters, etc. across the different linear content defining interrelationships. Consequently, in this research semantic relations are used and called *content types*, typifying similar sections of content.

Branching to another author’s content also implies changing to his context in terms of his way of teaching and presenting. It is like changing the room to take lessons of another lecturer, comparable to a traditional higher education setting, where a student can, based on the attendance of previous modules, choose an lecturer whose teaching methodologies or way of teaching and explaining works best for that particular student. Thus, just jumping around will provide additional content, but might also confuse the learner, because the flow of the content sequence is broken. This cannot be prevented entirely, but further utilisation of the existing structure lessens the negative impact of switching the context, because the result is closer to the originally authored content including its structure, and the following characteristics (which have already been discussed in section 3.1.2 *Storytelling Aspects of Interest for Adapting Linear Content Structures* on page 62) are harmed as little as possible:

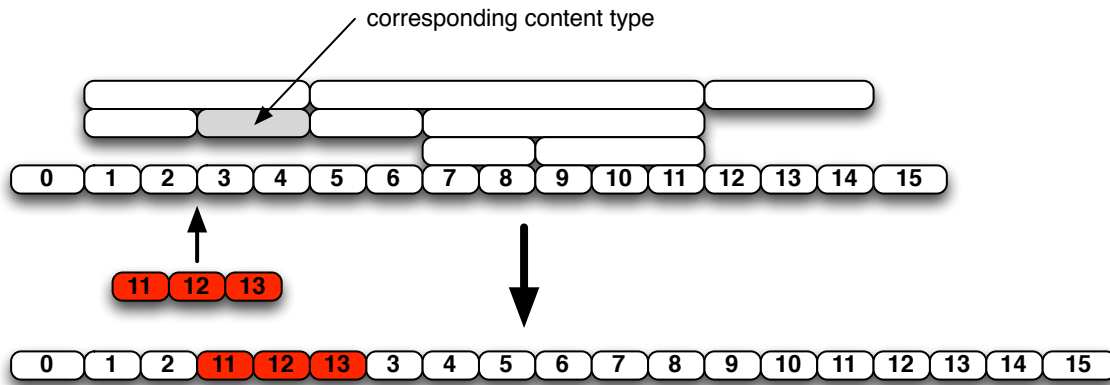


Figure 19: Insertion of content sections that must be presented: The empty bricks are content types and repeats representing the content structure. The numbered white coloured bricks are one author’s content sections, altogether building his linear content, illustrated by the upper line of numbered white bricks. The red bricks are another author’s content sections that have been marked as must be shown. They are inserted at the beginning of the group of content sections belonging to the same content type, resulting in the path illustrated at the bottom of the figure.

- Succession of tightly interlocking mediate and immediate elements [11].
- Complex structures that must meet many hard-to-specify requirements [32, p 14].
- Moving a part to another position changes its purpose [96].

Having discussed aspects of decomposing linear content, now aspects for recomposing are described. As was done for decomposing the content, care is taken to change the source content’s structures as little as possible.

The key for recomposing content paths can be found in the sections (and chapters and paragraphs, etc.) of the tree structure: They describe a group of content sections. These content sections belong together more than content sections outside of the group. Thus, the margins of these groups are the preferred locations where the linear sequence can be branched.

To produce as few changes as possible, inserted content should be joined author wise. Content that *must* be presented should be inserted at the beginning of the corresponding group. Thus, the sequencing system has a good chance of being able

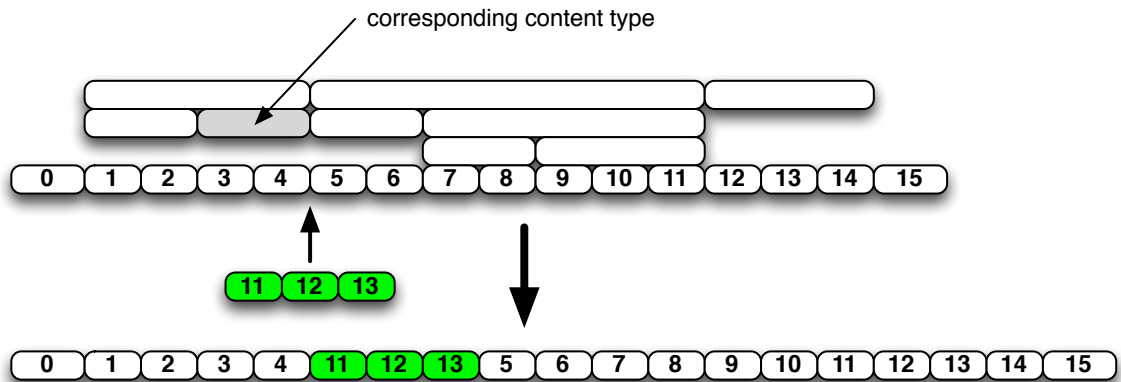


Figure 20: Insertion of alternative content sections: As in figure 19, the empty bricks are content types and repeats representing the content structure. The numbered white coloured bricks are one author’s content sections, altogether building his linear content and illustrated by the upper line of numbered white bricks. The green bricks are another author’s alternative content sections. They are inserted at the end of the group of content sections belonging to the same content type, resulting in the path illustrated at the bottom of the figure.

to react to any negative impact these insertions might have, see figure 19. However, content that is inserted as an alternative should be inserted at the end of a group (see figure 20), so that the system can react to user behaviour. For example if the user needs longer than expected, the previously inserted alternative content might be changed or dismissed.

In the case of inserting another author’s content fractions, the other author’s context must also be taken into consideration. As a consequence, the content that is necessary for understanding the current content sections should also be part of the inserted group before the actual section that it is branched to. However, this does not mean that all the prior content needs to be shown. Instead only those parts are needed that have not yet been explained by the author of the path that is being branched from. Hence, only content sections that are not related to previously presented sections will be taken into account.

3.2.2 Miscellaneous Concept Features

All other features that are needed for an entire adaptive concept are summarised in this section, because they have no unique characteristics, but still are essential for a working system. They are not focus of this research and therefore will not be investigated in depth.

Content sections are the leaves of the content tree structure. They are (and include) references to the actual content. Content sections can only appear once in a path. To enable a user to repeat a content section, a history or something similar should be provided.

Contexts are like one-dimensional variables. They can be set, deleted, and demanded. The latter is used for comparisons to allow adaptation and preconditions. Contexts are organised in a tree structure. They can be attached to any content element and user.

The *user model* is just a context structure. Hence, usage is identical to contexts as described above.

The tree-based content structure is represented by a *repeat-tree*. Conditions can be used as gatekeepers that decide upon the repetition of a content group. In that case, emergency exits should prevent it from running out of fitting content. To avoid repetition of the same content, only content types can be repeated, but content sections can only be shown once.

Weights define the importance of any content element and context. They can be set to any value between *must* and *must not*.

More details on usage of these features can be found in section 3.3.2 *Components and Design* on page 77.

3.2.3 Sequencing Strategies

Basically, two different sequencing strategies have been identified: *Change and stay* and *change and fall back*.

The first strategy prioritises the requirement of changing the path as little as possible. Thus, after the path has transitioned, this strategy tries to build the rest of the path with this author’s content only. This strategy behaves comparably to a concept in-between branching and rule based logic. A positive aspect is a kind of self healing effect: If the adaptation algorithm did not begin with the best fitting sequence to start with, changing the path has been motivated by the student and he is satisfied with the new path, it is very likely that it fits to him. Conceivably, the user context could be adapted if such a behaviour has been recognised by the system, or he might be asked if the changes should be saved in his profile.

The second strategy prioritises the author of the path the sequence has started with. In case the path has changed, the strategy would try to come back to the original author’s path as soon as possible. This behaviour is comparable to String of Pearls. If the sequence starts with the lecturer that is teaching the current student’s module, this strategy will ensure that the student is presented with all the requisite content that is needed for this module from the “right” author. Only in case of comprehension problems would short digressions be taken to present the student with alternative explanations.

Of course, many more strategies are also possible, but many of them would be pointless, for example showing all available content or randomly chosen sections. All useful strategies are expected in between the two presented above.

3.2.4 Summary

Most lecturers have already created learning content that they use to teach their students. If they have reused their content for later modules, most of them have tweaked it for each usage, incorporating their experiences of the material: Optimising the parts the students did not understand, adapting parts to new developments and findings, etc.

It is a difficult task, even for experts, to create non-linear and adaptive content and it usually takes a team of specialists to create it. However, the aim of this research is to find a concept that supports lecturers without a background in adaptive or interactive structures. Thus, the commonly accepted concepts and process have been rethought.

The result is the opposite of currently widely used content creation processes for adaptive and interactive content: Instead of first planning and implementing the structure before any content is created, existing linear content is used and delinearised step by step. Therefore, different authors' content is added and correlated. It is decomposed by its content structure, and composed by altering the original path as little as possible. Adaptation is done lazily, only when needed or requested. This approach has the following benefits:

- Existing content can be reused as is.
- Each lecturer (author) can teach and therefore create content and its structure as he prefers.
- Different content structures and therefore ways of teaching are supported.
- While creating the content there is no need to think in terms of adaptive or interactive structures. Lecturers can think of their content in their preferred way – linearly.
- When relating different authors' content during the authoring process, only the corresponding content pieces need to be found. There is no need to realise, accept, or merge the other structures, like didactic, domain, etc.

Now that a rough concept has been defined, the aspects needed for an implementation are examined in the following sections. A real prototypical implementation is discussed in chapter 5 *Prototypical Implementation of the Adaptive eLearning Concept* on page 125.

3.3 Implemented Concept

A rough concept has been developed in the previous sections. The following sections describe the requirements of an adaptive system, which is based on the approaches discussed above. Although these requirements describe the functionality, which an adaptive player software should provide, the underlying aim of the research is a concept applicable for non-technical users. The authoring process itself is outlined in the following chapter.

3.3.1 System Requirements

The main requirement of the system is to present adaptive content in a coherent way, independently of any special content [106]. To facilitate the authoring process it has to support different structures. Further details can be found in the following sections.

Coherence, Conclusiveness, and Completeness

Important requirements for the application are content coherence, conclusiveness, and completeness. Of course, the system cannot ensure these requirements on its own; it needs help for this. This help is either authored explicitly, or hidden in the linear content structures.

The system must be able to provide coherence and conclusiveness, so that module-content is not lined up pointlessly or contradictorily. For example a student should not be led to start a practical for object-oriented programming before he can learn the corresponding content.

Additionally, the system should do its best to ensure completeness, to lead to a successful end. For example, students should feel assured that they were presented with all relevant information, from the lecturers point of view, needed to pass examinations.

Independence of Content

The concept and the system should not assume any pedagogical strategies, content, or structures, because these aspects should be part of the content as specified by the authors. They should not be limited by the system. This signifies that it is not only independent from the media type, but the system should be usable for each kind of learning content and learning styles. For example, it should not make a difference whether the content is a video or a set of slides, until the author explicitly defines that they should be treated differently.

Due to technical restrictions, this requirement will very likely not be completely fulfilled in the early stage of development. For example, user interactions will be restricted to the implemented ones instead of giving the full range of possibilities.

User Adaptation

Two types of adaption to the user are possible: Micro and macro adaptation. Because this concept is based on pre authored linear content that is not changed during presentation, but influences the flow of presenting the content, it realises macro adaptation. In the eLearning context this is also called *sequencing*.

Adaptation needs to be influenced implicitly and explicitly. For example, the user's performance, his already chosen content, and his learner preferences [23], should influence path creation. Furthermore, content sequences could be repeated with different learning styles due to failed assessments. But it should also be possible for the user to have the final say about the next step.

Due to the usage of macro adaptation, the user's interactions only can have an influence at discrete instants of time between two steps. Of course, interactions may be done at any time, but the paths are only built in between two steps, so any manipulation that may affect this process can be only interpreted during creation.

The presented content may be interactive on its own. Thus, it may react to user interactions directly. However, this is the content's responsibility. Any interactions

that should be passed to the pathfinder need to be collected by changing the context variables accordingly.

There is one exception: The user action to go to the next step is possible at any time. The system will always react to this interaction by stopping the current step and starting the pathfinder.

Support of Different Structures

The same topic can be explained in different ways. Because the adaptation of this concept is based on changing to the right position of another author's content, different structures have to be supported. The concept achieves this demand by using the linear representations of structures.

3.3.2 Components and Design

To fulfil the demands described in the preceding section, a design has been chosen that integrates the following common concepts:

- *String of Pearls* in its basic form are used for the initial import of the author's content, because it is the most simple authoring structure for non-linear content.
- *Semantic relations* provide the needed adaptation. They relate the different linear content and therefore set the possible branching points, where the pathfinder may breakout of the linear structure to build a fitting path.
- *Fuzzy preconditions* optionally refine the content interdependencies.

The structure and therefore its root element has been named "Coherence". For a schematic overview of the components see figure 21, figure 22 gives a more detailed technical view. They are described in detail in the following sections.

For illustration purposes demo content data of the prototype is used for examples, including Röll's learner preference model introduced in section 1.1.1 *Learner Preferences* on page 26.

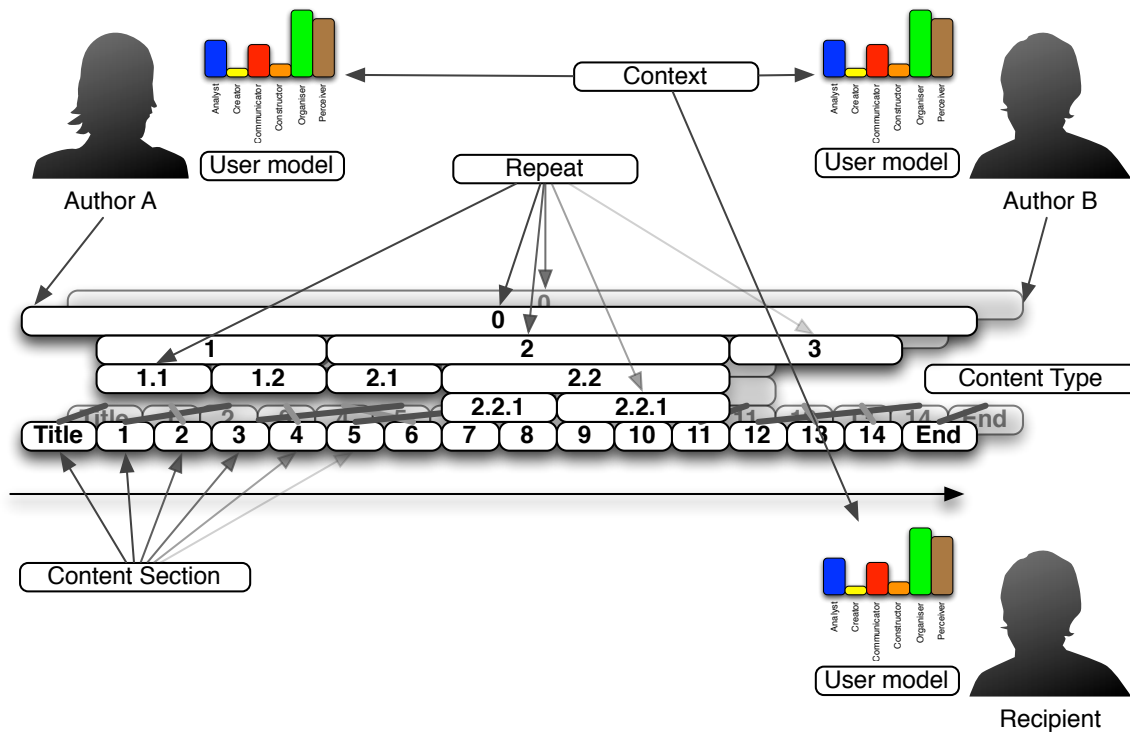


Figure 21: Overview of the concept's components: This shows the content of two authors. Content sections are the smallest parts of the authors' content. Related content sections of different authors are linked with content types. The repeats define the content structure. In the figure, contexts are shown for persons defining the user models, but they can be also used for content sections, content types, and repeats.

Content Sections

Content sections are the leaves of the content tree structure and represent parts of content within the model, see figure 23. In most cases these are learning units, but they are not restricted to that.

The most important parameter is the uniform resource locator to the content itself. This could be a Hypertext Markup Language (HTML) page as used in the prototype, but also any other document or application as long as its behaviour is defined in the runtime environment.

The position parameter sets the position of a content section within one author's linear content. This implies the order of all the content sections.

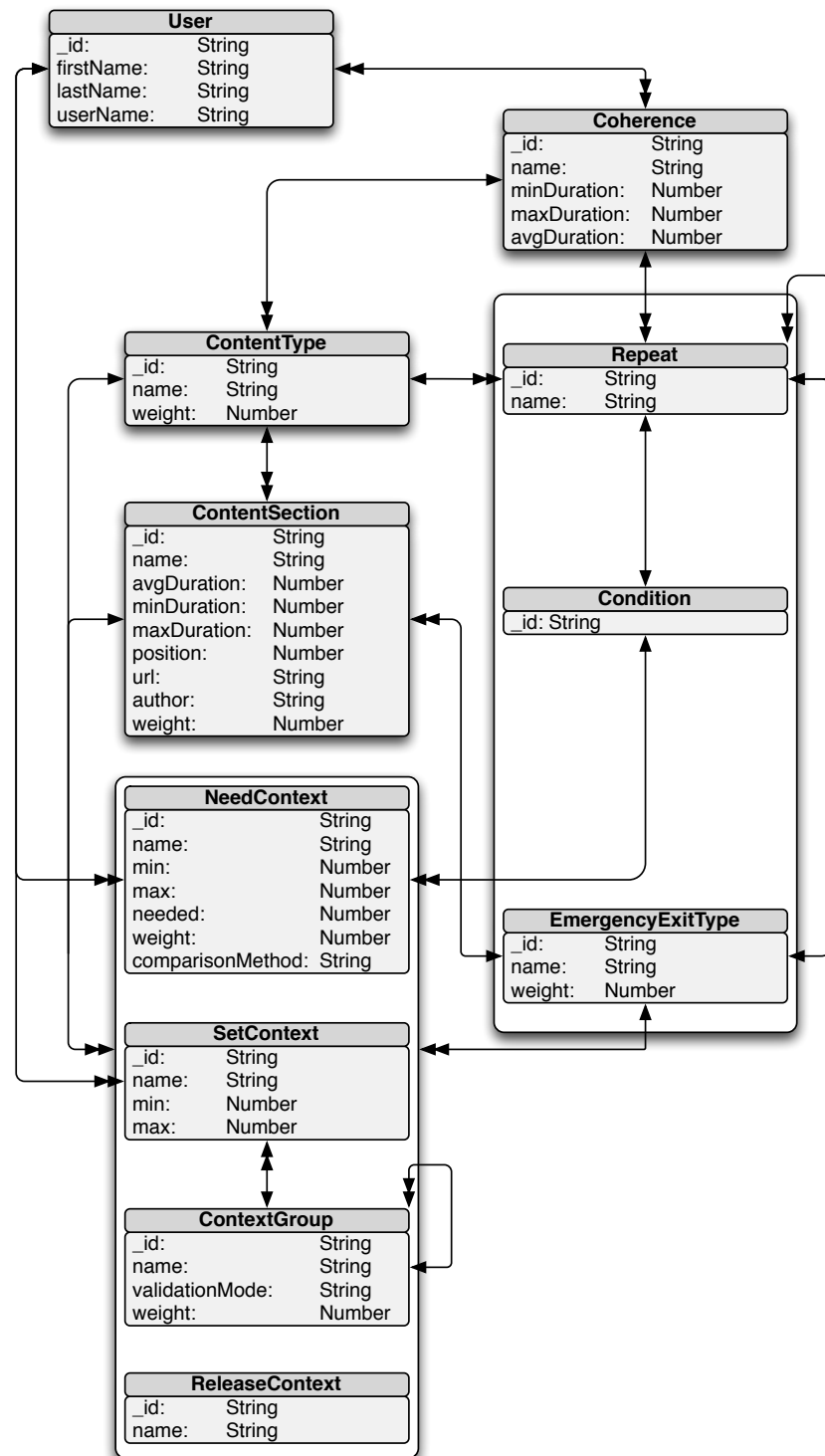


Figure 22: Coherence Concept Model: For details please refer to the following sections in the text.

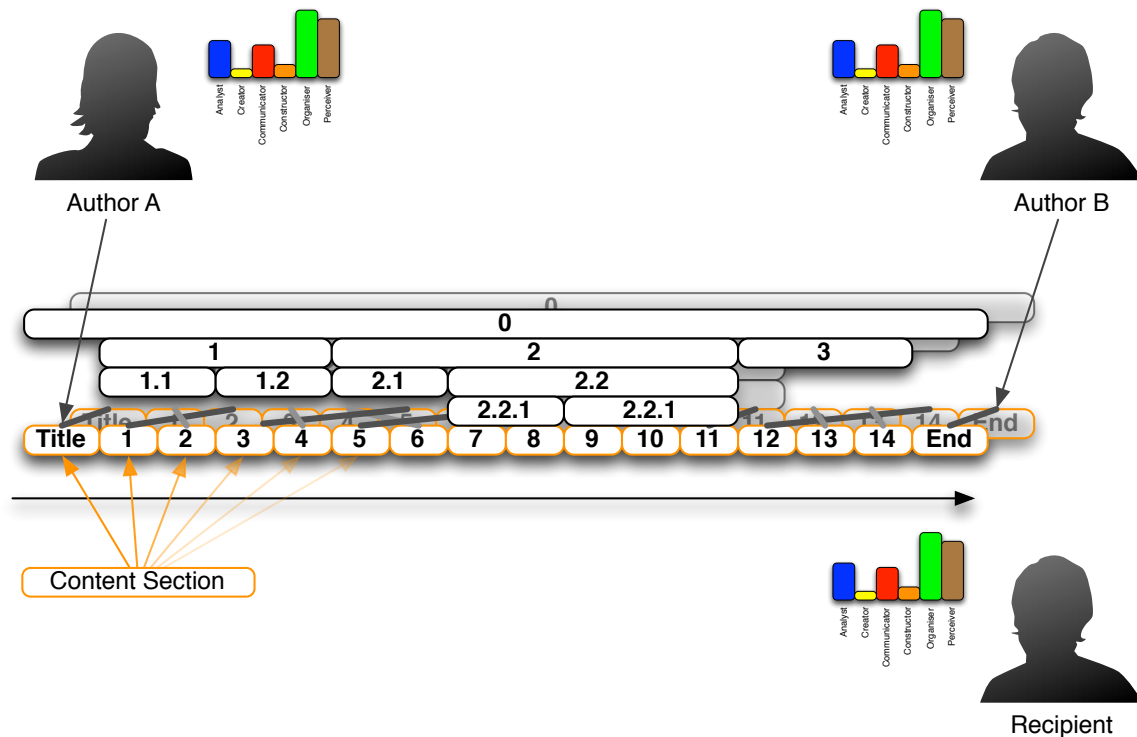


Figure 23: Content Sections: They are marked orange in this illustration. The figure shows two linear content paths from two different authors.

Content sections are bound to the author who created them, stored in their author parameters. All the author’s contexts are used as part of the comparison for adaptive pathfinding.

The following listing is an example of a content section. Parameters that have been not already discussed can be found in section 3.3.2 *Semi Global Attributes* on page 90.

```
{ "type": "ContentSection",
  "name": "Objektorientiertes Design",
  "url":  "/Coherence/OD/Hahn-eLectures/OD_1.html",
  "avgDuration": 40,
  "minDuration": 30,
  "maxDuration": 50,
  "position": 121,
  "weight": 0.5,
```

```
"author": "hahn"  
}
```

Some characteristic features of the scenes of stories are transferable to this context. A scene can be compared to a learning content section or a learning unit. For example, the subjects Addition and Subtraction could correspond to a scene within a mathematics-story. Scenes are small parts of the story, but are coherent and are self-contained, so the scene's unity is guaranteed [46]. The temporal unity should arise from the organisation of the subjects in scenes, so that a subject can be completed within a session (for example lesson) and is not interrupted by other subjects.

In this respect the local unity is interesting because the concept of this research project intentionally jumps between the linear structures. A content section should only refer to a subject within one structure and one didactical context. Even if an addition is explained within an eLecture content section followed by a slide explaining the same topic, they are still different content sections.

While not directly applicable to the concept of the story, all the content sections of this concept should act like dramatic scenes, and should propel the content either by itself or by user interaction [46]. For this purpose every content section should be able to find out at least whether it was finished successfully or not. This can be done by using explicit user input, for example with thumbs up and down icons as implemented in the prototype (see section 5.4.1: *Player* on page 153), or using the results of any user interaction, for example an assessment.

Content Types

Content elements from different authors that are about the same topic are connected via semantic relations. Because the functions relate content elements and therefore typify them, they are called *content types*. They are marked orange in figure 24.

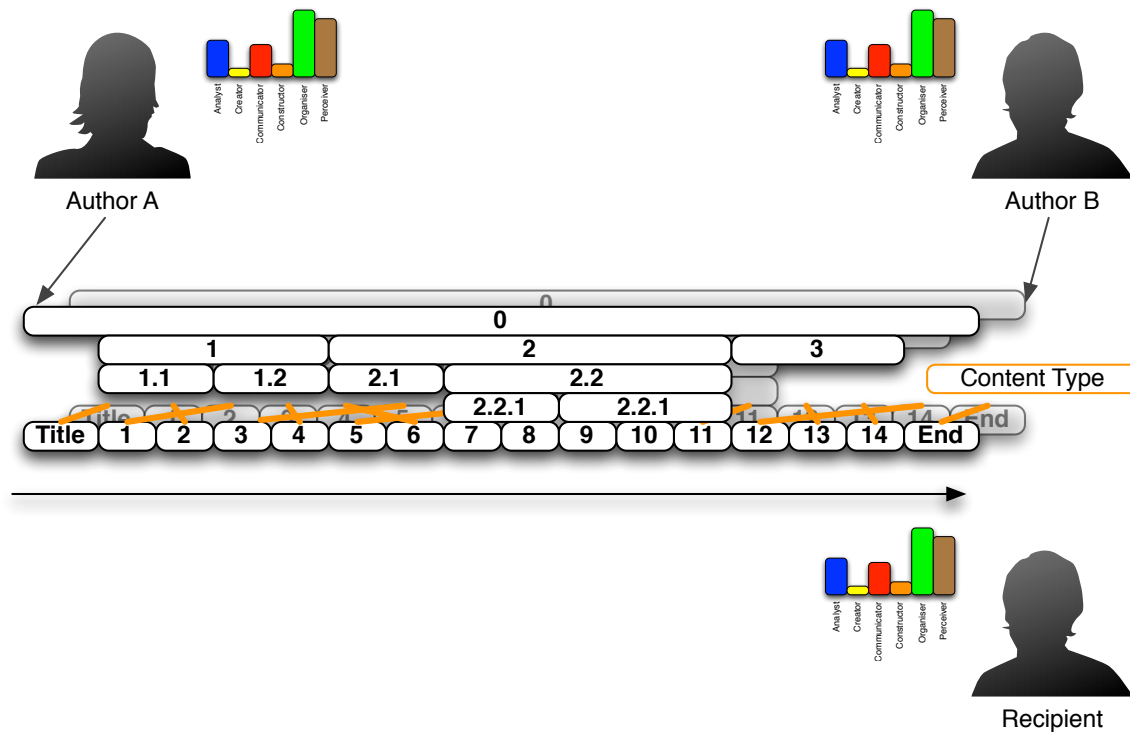


Figure 24: Content Types: They are marked orange in this illustration. The figure shows how the two authors' content sections are related with content types.

The following listing is an example of a content type. Discussion of the *weight* parameter can be found in section 3.3.2 *Semi Global Attributes* on page 90.

```
{ "type": "ContentType",
  "name": "Titel Objektorientiertes Design",
  "weight": 1,
  "treeItemChildren": [...] // e.g. ContentSections
}
```

Figure 25 illustrates some content type examples that relate content types, and a possible resulting path. Author *A* provides content sections for all content types, while author *B* has only three content sections, content type *End* has only author *A*'s content section. Hence, it is not a real relation but a prepared relation, because it does not relate to any content section. The example path for author *B* shows that missing content sections can be added from another author to get a conclusive and complete path. This can be forced by an author by weighting the content section

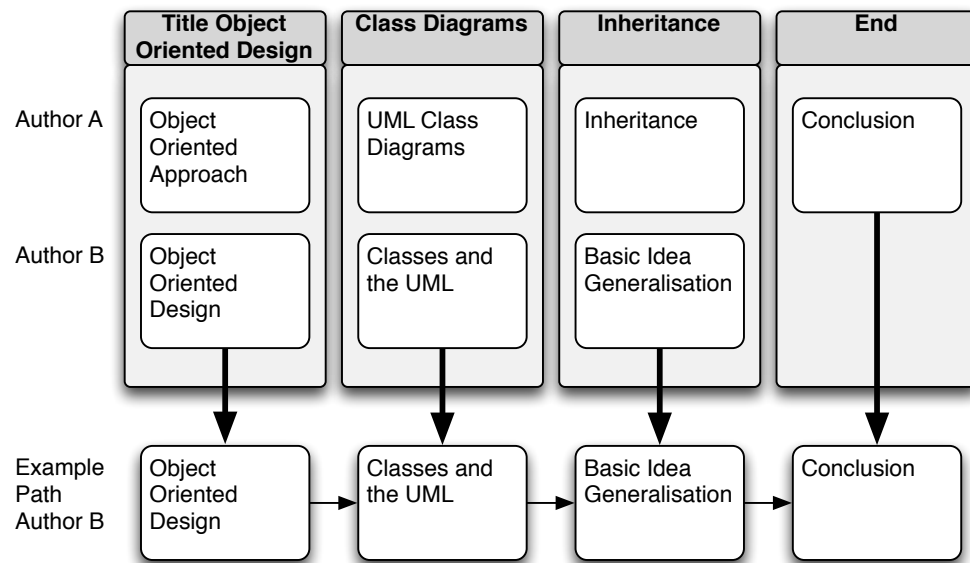


Figure 25: Content type examples: It illustrates some content type examples that relate content types, and a possible resulting path. Author *A* provides content sections for all content types, while author *B* has only three content sections, content type *End* has only author *A*'s content section. The example path for author *B* shows that missing content sections can be added from another author to get a conclusive and complete path. Of course, this should be used carefully so that the result is not confusing or incoherent.

with 1 as shown in the listing. Of course, this should be used carefully so that the result is not confusing or incoherent.

Contexts

Contexts provide coherences and dependencies between the content sections. They serve as variables for the communication between content sections, module content, and system. Figure 26 illustrates that contexts can be used nearly everywhere. They can be used to define user models, for repeat conditions, and to typify content sections and content types. In this research project, Röll's learner preference model has been used as an example.

Contexts can be set, needed, and released. Context values can be set and changed by the Coherence structure itself (content section and content type), by presets (currently realised with the runtime model, see section 5.3.5 *Data Models* on page

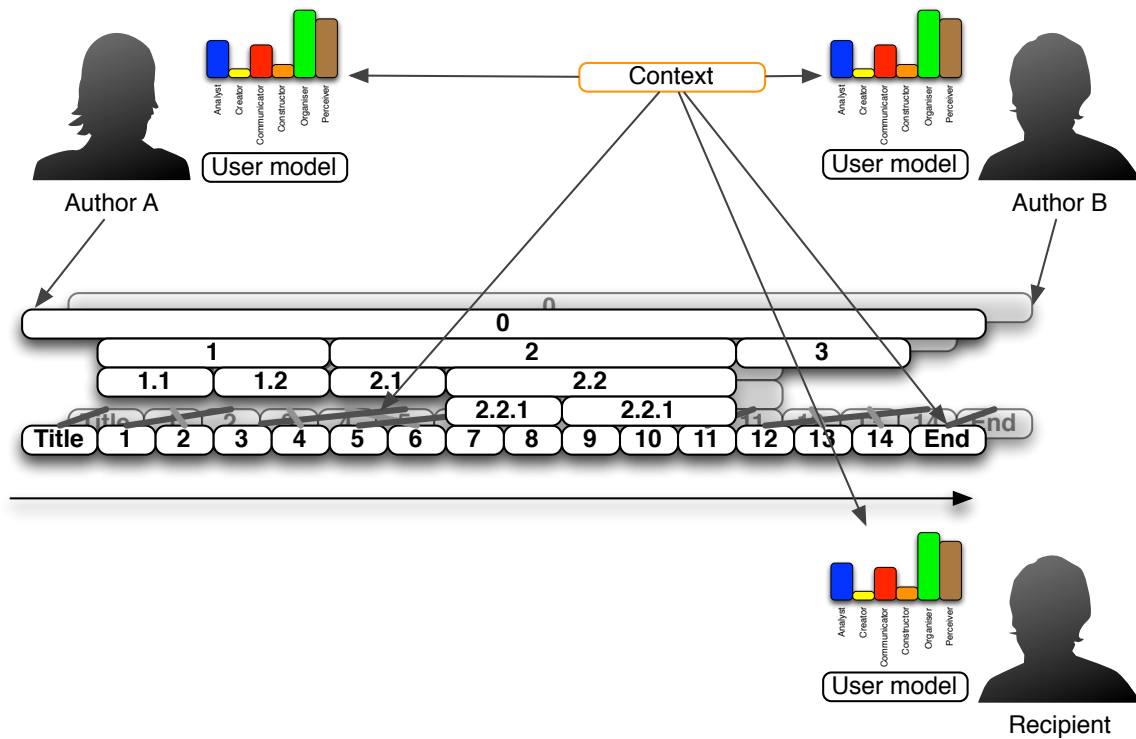


Figure 26: Contexts: They are hidden in this illustration. The figure shows that contexts are used to create user models, typify content sections and content types, and to define repeat conditions.

139), the presented content, and external sensors. The two first context sources can be used right away, the latter two would need an Application Programming Interface (API) that is currently neither designed nor implemented. Examples for context sources are given in the following table 2:

Context	Source	Type
device	sensor (e.g. firmware)	dynamic
location	sensor (e.g. GPS)	dynamic
language	preset	static
country	preset	static
university	preset	static
learnerPreferences	preset	static
assessment	content	dynamic
moreInformation	content	dynamic

Context	Source	Type
algorithmPresented	structure	static
chapterDone	structure	static

Table 2: Examples for context sources

In contrast to normal computer languages every context has two values stretching a value range. For example, a context `acceptedAge` could be set with the minimum value *18* and the maximum value *30*:

```
{ "type": "SetContext",
  "max": 30,
  "min": 18,
  "name": "acceptedAge"
}
```

The content-sections needing these contexts likewise define a value range that is compared to the set range:

```
{ "type": "NeedContext",
  "max": 18,
  "min": 45,
  "name": "acceptedAge",
  "weight": 0.5,
  "needed": 1,
  "comparisonMethod": "overlapping"
}
```

The comparison delivers a standardised return value between *0* and *1* that is multiplied by a weighting value that is likewise defined in the context query. This value's range is defined between *-1* and *1* and serves to evaluate the result of the corresponding query. Hence, this enables ratings that are fluently between “must

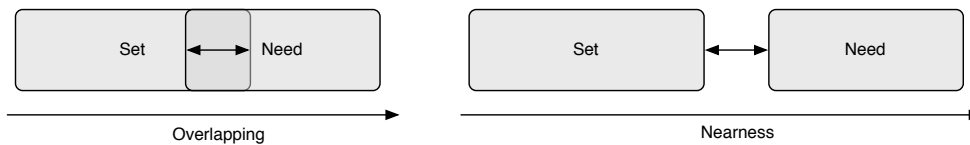


Figure 27: Context comparison modes: Overlapping measures how much the set context range and need context range overlap. Nearness looks for the distance between a set and a needed context.

not” (-1) through “should not” and “should” until “must” (1). The limit values -1 and 1 signify compelling requirements for including and excluding specific content.

Contexts can be organised in groups that may be further nested in sub-groups. Thus, a context tree can be developed. Several contexts can be checked in an interrelated manner by calling a context-group. For instance it could be checked whether a student has passed all modules that are necessary for a specific lecture, or two location contexts can be combined to get 2D coordinates and check if the student is at the right place for presenting a location dependent content section in favour of a general one.

Currently the concept provides two different query-modes, see Figure 27. The overlapping algorithm investigates how much the set context and the needed area overlap. The result is the ratio between the whole area and the overlapping area. Hence, using overlapping the result is more than 0 as soon as the set context overlaps with the needed one. 1 is returned only if both value ranges are identical. For example, a student could state that he likes to be presented with learning content-sections that are designed for students aged between 20 and 30 years. If this context is defined to 18 – 30, the comparison result is a value near to 1. Hence, based on that context, this content will very likely be shown.

However, if the learner-preferences should be checked, the second query mode is used. In this case the nearness between the set and the requested values is tested. 1 is returned if the values touch. With increasing distance the value becomes smaller and smaller and approaches 0. With the **needed** parameter the demand for a context can be adjusted. The value range is between -1 and 1 , where 1 indicates that the

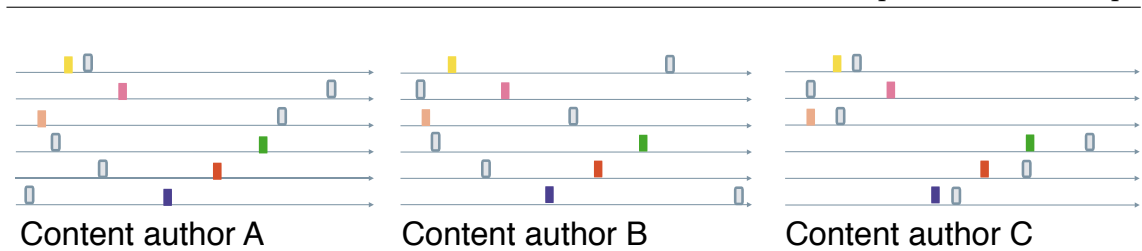


Figure 28: Best fitting content: The figure illustrates a subject prepared by three authors. The authors' learner preferences are illustrated by the grey bricks. A learner who wants to learn the subject has learner preferences, illustrated by the coloured bricks. Author C's preferences are closest to the learner's preferences. Thus his content is seen as the best fitting one. This is based on the assumption that lecturers teach best the way they also would understand best. Hence, students who would learn similarly would understand the lecturer's explanations best. This assumption gives a good starting point for adaptation, but is not science-based.

context must be set, and -1 that the context must not be set. Thus, setting a 1 simulates binary behaviour. A 0 indicates that the structure does not care if the context is set or not – but if it is there, its values will be compared with those needed.

A complete example that demonstrates the usage of Röll's learner preference model as user model can be found in section C.3.1 *Example User* on page 319. The **contexts** are set automatically to the content that has been authored by this user. If the user has the role of a learner, all his **needContexts** are used to rate how good a content does fit. Therefore it compares all own contexts with the set contexts of the current content. Because the comparison method **nearness** has been chosen, it is looked for the content that has the nearest context values – averaged over all context values in respect to their weights.

Figure 28 illustrates the comparison: A subject has been provided by three authors: Author A, author B, and author C. Their learner preferences have been tested and annotated to their content, illustrated by the grey bricks. The learner's learner preferences are shown by the coloured bricks. It can be seen easily that the distances between the learner's bricks and a author's bricks are smallest for author C on the far right side. Hence, author C's content fits best to the learner's preferences.

It needs to be noted that this comparison is based on the assumption that learner preferences correspond to teaching preferences. That means that a lecturer could

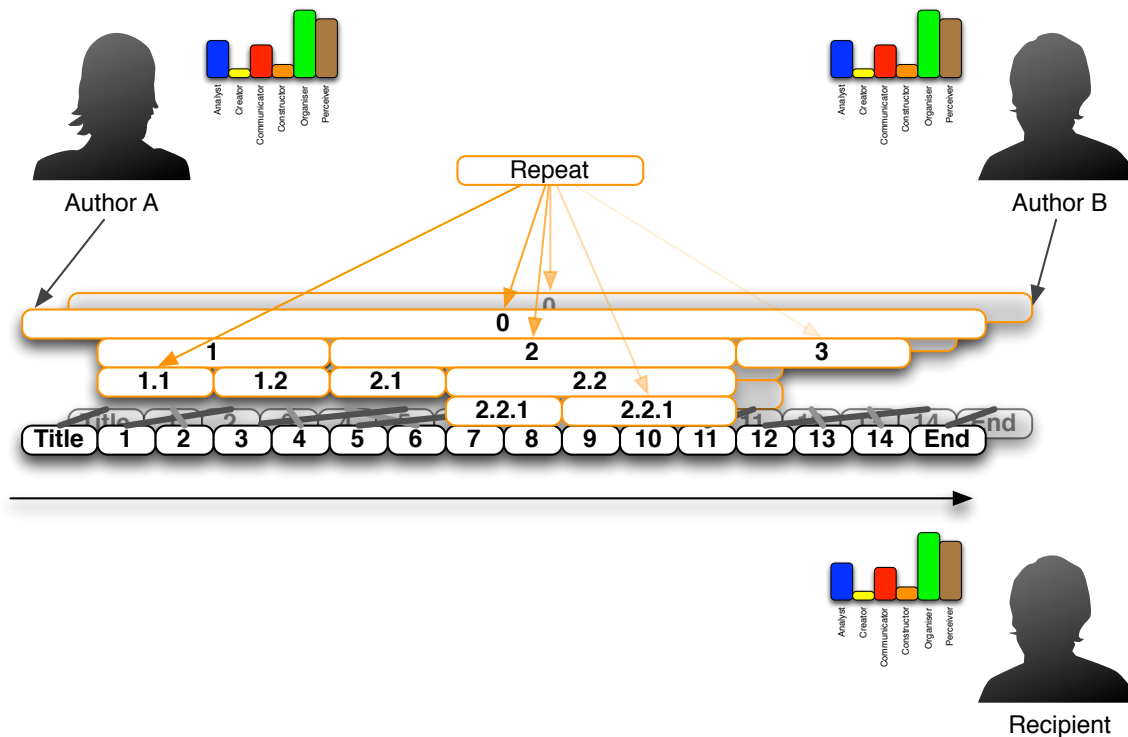


Figure 29: Repeats: They are marked orange in this illustration. Repeats indicate that underlying content types can be repeated. They are also used to organise the content, giving it a tree structure.

better teach those students who have the same or similar learner preferences, because he would teach the way he understands best. This assumption is not science-based at all but is just an assumption providing a starting point for adaptation.

Repeats

On the one hand, repeats are used as they are named: They indicate repeatable parts of the content. On the other hand, repeats are used to organise the content, comparable to chapters, sections, and paragraphs. To realise more complex structures, repeats can be nested. For an overview see figure 29.

Repeats are needed to enable the presentation of alternatives. They are the basis to insert content of other authors at some places as described in section 3.2.1 *Delinearise Content* on page 67. Because content sections are only presented once,

identical content is not repeated. Content types are repeated, resulting in the presentation of alternatives.

Repeats loop through their enclosed content-types, until one of the following three exit conditions is fulfilled:

- Within the repeat a context has been set that is used as exit condition. This is comparable with a *while*-loop that runs until a variable has been set to *true*.
- The content types within the repeat have no more content-sections that can be appended to a suitable path. This can happen either because all available content-sections have been already presented, or because every remaining content-section cannot be presented due to the lack of fulfilled preconditions. If the repeat exits because of this condition, it looks for the best fitting content section within the `EmergencyExitType` and presents it.
- Presenting any further content would make the total duration too long, so the coherence-model could not be presented completely. Also in this case an exit content type must be determined.

The following example would present content sections of its children content types, until the context `Inheritance` is set to 1, or no content sections are available anymore or no time is left. It insists on setting the context to 1, because its `needed` attribute is also set to 1, indicating that it must be set. This kind of usage is similar to the common way of using a precondition.

```
{ "type": "Repeat",
  "treeItemChildren":
  [ { // ContentTypes
    },
    { "type": "Condition",
      "treeItemChildren":
      [ { "type": "NeedContext",
```

```
    "max":      1,
    "min":      1,
    "name":     "Inheritance",
    "weight":   1,
    "needed":   1,
    "comparisonMethod": "overlapp"
  } ]
} ]
}
```

Although this description suggests that repeating content types is a very common task of the concept, it is important that needed contexts are always fulfilled as long as their `needed` attribute is less than 1 and more than -1. All values between these limiting values indicate that the content type should or could be repeated.

Because the pre authored linear structure is the preferred way through the content space, repeats may appear like a futile element of the concept. But in most cases repeats are used to determine if a sequence of content types could be repeated if the user tells the system that he is not satisfied with the content he got presented. Repeating does not mean that he gets the identical material presented again, which would be senseless in the case of comprehension problems. Only content types are repeatable and content sections are only presented once. As a result an alternative is presented and the same subject is presented differently.

Additionally, the repeat blocks show the pathfinder the margins of related and therefore coherent parts of the content. These margins are the preferred points to leave the linear structure for presenting alternative point of views.

Semi Global Attributes

Other than the special attributes that are part of the elements discussed above, there are two attributes used virtually throughout the concept: Weight and duration. They

are called global not because of their scope but because they are used by almost every Coherence model element.

The weight defines the importance of an element with a range from -1 to 1, expressing a value between “must not” and “must”. Some values and their interpretation are listed in the following table 3:

Value	Description
-1	must not
-0.5	should not
0	do not care
0.5	should
1	must

Table 3: Description for selected typical weight values

For example, the weight of a content type rates the importance of the presentation of at least one of its content sections. Only the limit values force or deny a presentation. If the weight of a context type is smaller than 1 (for example 0.99), paths lacking this content type would be also possible. However, a rating algorithm would value these paths rather badly because the necessity of 0.99 is still very high.

The duration attributes ensure that the content is presented within the given time frame. The concept uses two kinds of the duration attributes: The **Coherence** element uses these attributes for the overall duration range of the presentation. The content sections’ duration attributes are the expected duration of this part of content. During runtime the real duration is compared with the expected duration and content sections are added or deleted from the path, respecting their importance and their matching. Hence, the most important parts are always presented, ensuring at minimum a basic understanding of the topic.

Duration as a parameter for path constructing has been introduced, because learning time is always restricted by time limits like lessons or semesters. While this seems obvious it has some problems:

- Restricting learning time makes no sense in most self driven learning situations: Normally learners want to have the time they need if they learn by themselves (or in groups).
- Measuring the learning time is very difficult. The duration between starting a section and requesting the next one is very likely not the real learning time. Maybe the learner has answered an eMail, went to the kitchen to get a coffee or something similar.

Basically in the realisation of this concept it is used to measure the completeness of the content presented so far. For future research, alternatives should be investigated that provide more freedom of time management for the students.

3.3.3 Learning Path Construction

If the lecturers have done an adequate job their linear content should be coherent, conclusive, and complete. Hence, if one author's complete content is presented these requirements are fulfilled. As long as a student is satisfied with the content as presented, there is no need to traverse and find alternative fitting content. The student would expect that a given path is left untouched if there is no reason to behave differently. Additionally, it is dangerous to break the highly complex structure of linear content into pieces and should be avoided as far as possible to not irritate the learner.

Thus the pathfinding strategy is conservative – it tries to leave the linear structure as it is as far as it can in order to present the originally authored path through the content space. Therefore, as a first guess, the pathfinder uses optimistic assumptions as follows: The learner is assumed to

- accept each suggested step,
- fulfil all content sections,
- not leave the path by choosing another one, and
- stay within the given timeframe.

However, in any case where the expected parameters are not met, the path is adapted to the environment that is parameterised with contexts. Table 4 summarises reasons to alter the original linear structure:

Impact	Implication
content section rejected	alternative content section
content sections omitted	shorter
another path chosen	prefer another author's path
duration too long	omit content sections
duration too short	add content sections
context changed	rating changed, maybe context not fulfilled
context not fulfilled	alternative path

Table 4: Some reasons to alter the original path

It should be remarked that any impacts listed in the table above might also change the contexts and therefore may have a stronger influence on the path creation than the listed implications might indicate. It should also be realised that changing the path rating does not change the created paths themselves, but may push another path into the position of the most preferred path. This changes the path implicitly, because the suggested path has changed. If this is seen in the context of the already presented content sections, this behaviour is put on a level with forking from the initial path.

Even in the case of adapting the path, there is an attempt to change the linear structure as little as possible. The pathfinder uses the information that is hidden in

the repeats: They normally reflect the same structure as the linear source and just uses nested repeats instead of chapters, sections, and so forth. Hence, the repeats describe coherent sequences of content sections. The repeats' margins are also the margins of these sequences and therefore the preferred positions to branch off.

The following sections give more details on the pathfinding algorithms that create the content sequence. It starts with general determining factors that all the specialised pathfinders have to take into consideration. These specialised pathfinders can be found right after those general factors. Each of them subserve one aspect of the whole pathfinding process. The last section describes the preparations before the paths are presented to the user.

Determining Factors

To avoid repetitions, content sections can be part of the path once at the most. Each content section that has already been presented is stored in a history that enables the learner to rollback. Also content types with at least one fulfilled content section are removed from the path, except of content sections that must be presented and if a content section is needed to fulfil a needed context.

Find Content Sections That Must be Presented

Within a content, structure might be content sections that must be presented. These are either content sections that are weighted with 1, or at least one content section of content types weighted with 1. To create valid paths, all these content sections must be found and incorporated into the paths on the right position, if they are not already included or have already been presented.

Including new content sections may disturb the flow of the original linear structure, because they have not been planned to be integrated. Hence, they should be included as inconspicuously as possible. Good inserting positions are any margins: The beginning or the end of the content or of any repeats. In this case, the content

sections to be added are not possible alternatives, but they must be presented. Therefore they should be presented as early as possible, to have a good chance of reacting to any bad impact these insertions might have. Hence, all found content sections that are related should be clustered and added group wise at the beginning of the corresponding sequence. This corresponding sequence is a child of the same repeat or any parent repeat as the subsequently to be added content sections.

Create Paths Based on Authors

This is the linear part of the path creation. Beginning with the user's position, all content sections of content types that have no fulfilled content sections are sorted corresponding to their linear source. Normally, this is each author's linear content without the already presented parts. The valid paths are sorted and presented to the learner. All invalid paths are handled by the following steps.

Adjust Path duration

If the path's duration does not fit into the Coherence's time limits, the path's length is adjusted. Too long paths are shortened by deleting the worst rated content sections until the duration is less than the maximum. If the path is too short, best rated content sections are added until the duration is more than the minimum. They are inserted like content sections that must be presented, except that they should be inserted at the end of content sequences, because they are alternatives to the linear content.

Solve Impossible Paths

Because of the optimistic path creation strategy, impossible paths might occur. Impossible paths have one or more needed contexts that are not fulfilled. They can be solved with content sections that set (and therefore resolve) the needed contexts.

The best rated of those should be chosen, the following steps are chosen according to the sequencing strategy used:

In case of *change and stay*, the path should be recreated beginning with the first of them, to keep the structure as linear as possible. It might be needed to repeat this process until all impossible sections are solved.

If *change and fall back* is used, only the chosen content sections and all additionally required ones should be added to the path. Behind those, the path should be completed with the original selected lecturer's content, to diverge as little as possible from his content that might be needed to, for example, pass the exams or use the laboratory equipment.

Rate and Sort Paths

To make valuable suggestions to the learner, the paths are sorted regarding their suitability to the history and the current context. The algorithm itself is not the focus of this work, but has been realised for testing and evaluating purposes. As a first possibility, all the parameters that have to be taken into account are averaged using the arithmetic mean. Further details can be found in section 5.3.6 *Pathfinder* on page 142.

3.4 Summary

Based on the research question and the difficulties of authoring as described in the previous chapter, initially a reason was looked for to explain why authors refuse to accept adaptive concepts and tools, and why they reject thinking in layers and exchangeable content sections as observed by De Bra et al. [20]. Storytelling has given a possible explanation, as it describes the complexity of linear content and that good content is characterised by deep interconnections between the sections of the content through several layers. Additionally, moving a part of the content to

another location of the whole content would change its purpose. It seems that it is easier for people to think in these kind of structures.

These insights have lead to a new concept for authoring of adaptive content that is based on the linear structures authors are used to. In contrast to common approaches, it uses only two mandatory layers and one optional layer: One layer that adopts one content structure as is, creating a tree structure from its chapters, sections, etc. The second layer relates content of different authors that is about the same subject by linking similar content sections. The optional layer can be used for refinement by setting weights and conditions. These layers can be completely separated during the authoring process. First, the linear content can be created that includes the content structure. Second, it can be related to another content, creating the second layer. Consequently, this also means that already existing linear content can be used for this approach.

This is followed by a description of how the content can be decomposed and recomposed. Then the components of a system realising the concept are outlined.

The main drawback in respect to multilayer approaches is the lack of detailed control. By using the approach of this research it is only possible to change to another author's path, including all its dependencies, wording, explanations, etc. However, it would be very beneficial if the concept's simplifying effects on creation of adaptive content structures would enable and motivate lecturers to create adaptive content.

3.5 What's next

This chapter has laid the theoretic background of an adaptive content structure concept that is based on authoring for linear content. The following chapter outlines authoring aspects of this concept, including content preparation, import, workflows, and presents a proposal for an authoring environment that supports this concept.

Chapter 4

Authoring Aspects

Based on the concept developed in the previous chapter, the focus here is on its proposed usage by authors. First, a general look is given at adaptive authoring and therefore interactive content and its influences on the definition of authors and authorship. Secondly, an explanation is given of how an existing content structure is transferred to a Coherence structure. Then typical scenarios for collaborative authoring are presented – including how consumers become coauthors. Lastly, an outlook shows how an authoring environment can support work with Coherence structures.

This research only focuses on the concept for the creation of adaptive eLearning content. Besides an editor, no authoring environment has been realised. However, such an environment would be required to profit from the concept's features. Thus this chapter describes methods and tools that are derived from the concept and should be used as a guideline for further development, and so this chapter describes the practical ideas behind the concept.

4.1 Consequences of Interactivity on Authorship

This section discusses general theoretical aspects of the influence of interactivity on the authorship in respect to this concept, and has been motivated by several

discussions in passing with lecturers which were neither recorded nor analysed, but have been seen to be relevant enough to be mentioned.

Most of these discussions had been partly about authorship and the loss of control of their content. The question raised was who would be the author of adaptive content if students controlled the flow of the presentation. The result of such an adaptive-presented content should be tailored to the student's needs and can therefore be individual. Because the student influenced the presentation of the work he could be seen as coauthor.

This question is not new. For example, in 1932, Bertolt Brecht stated the following in his radio-theory [21, p 236]:

“Radio broadcasting has to be transformed from a distribution apparatus to a communication apparatus. Radio broadcasting would be the conceivably biggest communication apparatus of the public life, [...] if it would know not only how to emit, but also how to receive, thus make the listener not only hear, but also speak and does not isolate him, but establish a relationship.”

Brecht demands that radio broadcasting not only transmit but also receive. Nevertheless, for him the recipient does not become the producer of the radio transmission and therefore also not the author. The recipient thereby instead becomes an interaction partner of the author rather than (co-) author of the radio transmission. Although Brecht's radio-theory probably is rather a politically motivated media theory, it already indicates what appears now – 80 years later: The dismantling of the classical mass media model and communication model *television station – media – receiver* and the softening of the term “author”. However, Brecht does not explain how the new term of “author” has to be defined in a networked world. Therefore, an alternative approach for a network-like structure has to be looked at.

Gilles Deleuze and Félix Guattari created an early approach to a perfect network-like structure and therefore defined non-linearity within the context of their so-called

rhizome. They proclaimed ecstatically that the writing “in this open, (vectored, projective or topological) smooth space in contrast to concluded, (metrical) scalloped space is no more the monologic, linear production of sense, but the cartography of a network, where authors are involved in a variety of varying identities” [117, p 22]. The rhizome describes a network-like and non-linear structure in which a huge number of authors create these nodes. Despite this mention of the large number of authors, interestingly for Deleuze and Guattari the authorship is still indisputable and the term “act” is still valid.

This concept uses inter-textness for its presentation; it establishes references between single content sections. The traditional term act is resolved consciously, because content is no longer a creation in the traditional sense. Nevertheless, an adaptive content contains references and these can be treated as original. Regarding Deleuze’s and Guattari’s statements as to who determines the authors as network creators, the author of a non-linear content is the creator of the content’s network.

This point of view is currently of topical interest due to the appearance of Web 2.0 and the shifts in eLearning towards the same changes in eLearning 2.0 [14]. This encourages students to learn by contribution, but it also means that lecturers have to give up some control over their content and how it is used. Their content gets rated, annotated, and meshed with other content. To enable these procedures lecturers have to open their content but many lecturers do not like that idea for various reasons. If this is because of losing control and the difficulties of defining the author for the content, Deleuze’s and Guattari’s definition could help them overcome their reservations and make themselves clearly more equal than the other contributors. If students act as recipients by consuming the content, including interacting with it, and therefore influencing the presentation, the lecturer would be still the author of his content while the students would be interacting partners. As soon as students contribute by meshing and editing content or structures they are authors of their changes, but not of the underlying content. In respect to the adaptive content and

structure as a whole, they should be treated as coauthors. If lecturers control the overall quality, they would be part of the editor team.

4.2 Structure Transfer

Normally even linear content is already organised in chapters, sections, and paragraphs. For slide-sets it is good practice to have one message per slide, which is an additional help to understanding and adopting the given structure. These obvious elements can be adopted easily into a structure that follows the concept of this research. Further information can be given such as the importance of a section, or interdependencies between sections. This kind of meta data is normally hidden within the linear order of the content and therefore does not need to be given by the author. But sometimes it needs to be added explicitly.

This section shows how existing linear content structures can be transferred to Coherence structure elements. These elements themselves are described in detail in section 3.3.2 *Components and Design* (page 77).

To simplify explaining the corresponding structure elements and the necessary transfer steps, this section uses the presumption that the content source is a well formed slide set. This means that the slides are already organised as stated above, using one message per slide as well as chapters, sections, and paragraphs. Additionally, the content should be available in a format that is compliant to World Wide Web Consortium (W3C) web standards like HTML or Scalable Vector Graphics (SVG).

4.2.1 Adopting Basic Linear Structure

After creating the Coherence itself (the top level element), it has to be filled with the original basic structure of the source content and links to the content itself. It is a good starting point to create one content section for each slide and one content type for each content section. Of course if a message goes through several slides they

might be clustered to one content section. The content sections' names should be just the slides' names. For the beginning the content types could be named the same as the content sections, though an individual, more general description, simplifies the work for the next coauthors who extend the Coherence with their content.

The content sections' position could be numbered beginning with one and increasing by one each step, or could use the source's numbering. This will take over the source's original linear order to the Coherence structure.

An accurate duration for each content section helps the pathfinder plan a suitable path. This is easy for eLectures, where the video's duration could be taken. It is also a good start to set a duration that is the overall duration divided by the number of slides.

The following example demonstrates the described steps using a title slide of the content that has been used for evaluation purposes. The slide itself contains the information for the content section's name ("Objektorientiertes Design") and the position (121) as marked in following figure 30. The average duration of 40 seconds has been taken from a video of the lecture. For minimum and maximum duration it was subtracted or added ten seconds from/to the average duration. The author is the original author of that slide, Prof. Dr. Ralf Hahn, marked by his username "hahn" in the content section. The url points to the position of the slide on the web server. Lastly, the weight is the default value of 0.5.

For the content type the content section's name was taken over. Because it is the set of starting slides it has been weighted with 1 as discussed in section 4.2.4 *Weighting the Structure* on page 111. The root element's (coherence) duration is the overall duration of all the slides used for the example.

Putting all this information together would appear as follows:

```
{ "type": "Coherence",  
  "name": "OOAD eLectures",  
  "minDuration": 3630,
```

The slide content includes the following text and logos:

- Hochschule Darmstadt
Fachbereich Informatik
- Objektorientierte Analyse und Design
- 5. Objektorientiertes Design
- h_da
HOCHSCHULE DARMSTADT
UNIVERSITY OF APPLIED SCIENCES
- fbi
FACHBEREICH INFORMATIK
- author
- OOAD, Prof. Dr. Ralf Hahn, Prof. Dr. Wolfgang Weber SS2011, h_da, Fachbereich Informatik
- 121

Red arrows point from the labels 'name', 'author', and 'position' to the corresponding text on the slide.

Figure 30: Content section information taken from source: From this example slide, the information marked by red arrows and red labels can be taken to create a corresponding content section: Name (“Objektorientiertes Design”), position (121), and author(“hahn”). Depending on the document type this kind of information is part of the document and can be extracted and used automatically for the importing process as discussed in section 4.4.1 *Import* on page 117.

Permission to reproduce the slide in this figure has been granted by Ralf Hahn and Wolfgang Weber

```
"maxDuration": 4525 ,  
"avgDuration": 4082 ,  
"treeItemChildren":  
[ { "type": "ContentType",  
  "name": "Objektorientiertes Design",  
  "weight": 1,  
  "treeItemChildren":  
  [ { "type": "ContentSection",  
    "name": "Objektorientiertes Design",  
    "avgDuration": 40,  
    "minDuration": 30,
```

```

        "maxDuration": 50,
        "position": 121,
        "url": "/Coherence/OD/Hahn/OD_1.html",
        "weight": 0.5,
        "author": "hahn"
    } ]
} ]
}

```

Each coauthor does the same, but will set his content sections or repeats to existing content types that are about the same topic. In this way the different structures get related to each other. If nothing comparable can be found, the coauthor should create a new content type.

This is the first step to delinearise the structure: By building bridges between the authors' different structures, the pathfinder knows where and whereto it can break out to another structure.

4.2.2 Structure Organisation

Linear content is normally organised in chapters, sections, and paragraphs. Coherence structures are organised in nested repeats. Transferring the source structure can be done using a one to one relationship: Each chapter, section, and paragraph is one repeat, nested in the same way as the source (see figure 31). A simplified structure that corresponds to the figure but without conditions, content types, and content sections would appear as follows:

```

{ "type": "Coherence",
  "name": "OOAD",
  "minDuration": 3630,
  "maxDuration": 4525,

```

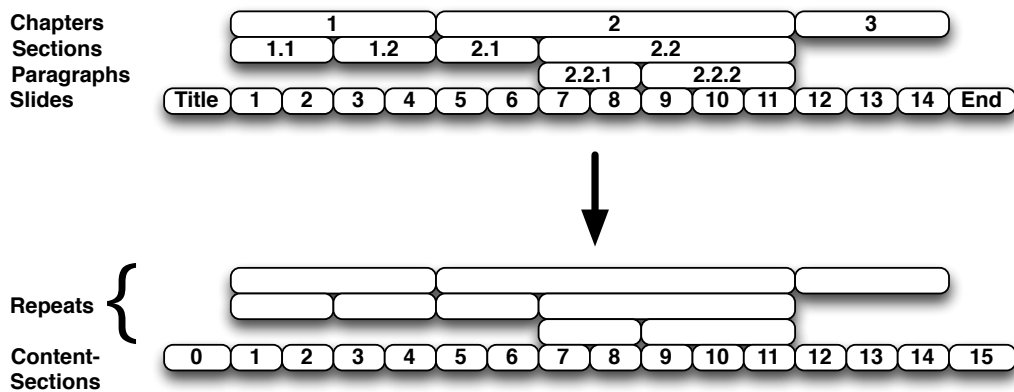


Figure 31: Structure organisation: The structure can be taken over from the source. This figure shows that each chapter, section, and paragraph of the source content, shown as numbered bricks in the top half of the figure, correspond to one repeat of the adaptive structure, shown as empty bricks in the bottom half.

```

"avgDuration": 4082,
"treeItemChildren":
[ { "type": "Repeat",
  "treeItemChildren":
    [ { "type": "Repeat",
      "treeItemChildren": [...]
    },
    { "type": "Repeat",
      "treeItemChildren": [...]
    }
  ]
},
{ "type": "Repeat",
  "treeItemChildren":
    [ { "type": "Repeat",
      "treeItemChildren": [...]
    },
    { "type": "Repeat",

```

```

        "treeItemChildren":
        [ { "type": "Repeat",
            "treeItemChildren": [...]
          },
          { "type": "Repeat",
            "treeItemChildren": [...]
          } ]
      } ]
    },
    { "type": "Repeat",
      "treeItemChildren": [...]
    } ]
  }

```

It is proposed to leave the title (first content section) and end (last content section) outside of any repeat. This helps the author, student, and pathfinder have a fixed starting and end point of the content.

4.2.3 Fitting into an Environment

Each section of the content is presented within an environment. This could consist of the content itself, the student, the presenting device, the language, the university, and more. Coherence uses contexts to determine accuracy of any content's part to the environment. This is not done in a binary manner but with fuzzy values that allow a trade-off of all aspects and states of the current situation during path creation. Binary behaviour can be simulated by using the limiting values 1 (must) and -1 (must not) of the contexts' `needed` parameter.

There are two different ways to work with contexts: They can be used like traditional preconditions, but also seen as the golden thread through the content.

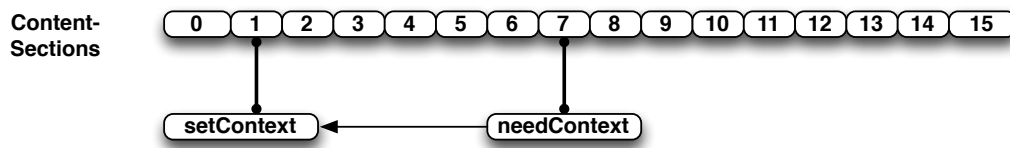


Figure 32: Content section 1 as a precondition for content section 7

For more details how to use `setContext`, `needContext`, and `releaseContext` see section 3.3.2 *Components and Design* (page 77).

Contexts Used as Preconditions

Contexts as preconditions can be used to refine the content structure (see figure 32) especially if some context must be set. This could be a section of the content that needs a special topic to have been learned before, a linear part of the content (although in most cases a linear part would be represented by only one content section), or a gatekeeper that tests if all conditions are fulfilled before the learner can proceed.

Typically, precondition contexts are used to control the flow of the presentation at some selected points within the content: It is tested at one point that needed conditions are set appropriately before. Referring to figure 32, the according parts of a structure may look as follows:

```
{ "type": "Coherence",
...
  "treeItemChildren":
  [ { "type": "ContentType",
...
    "treeItemChildren":
    [ { "type": "ContentSection",
        "name": "1",
        "position": 1,
```

```
...
    "treeItemChildren":
    [ { "type": "SetContext",
        "max": 2,
        "min": 1,
        "name": "someContext"
      },
      ...
    ]
  } ]
},
...
{ "type": "ContentType",
  ...
  "treeItemChildren":
  [ { "type": "ContentSection",
      "name": "7",
      "position": 7,
      ...
      "treeItemChildren":
      [ { "type": "NeedContext",
          "max": 2,
          "min": 1,
          "name": "someContext",
          "weight": 1,
          "needed": 1,
          "comparisonMethod": "overlapping"
        },
        ...
      ]
    },
    ...
  ]
},
```

```
        ...
    ]
} ]
},
...
]
}
```

Authors should be aware that using hard conditions (`needContext` with the attribute `needed` set to 1) induces the requirement of alternative possibilities. This is fulfilled if either the content section is not required to be shown, which is true if the parameter `weight` of a content section is < 1 . Or the content section is within a loop and there are alternative content sections within the same content type. If it is part of a repeat's end condition then a content must be set as an emergency exit.

In most cases no refinement with conditional contexts is needed, because much information is already hidden in the order of the linear structure. In particular the dependencies of content that should be presented beforehand and afterwards are explicitly expressed by using the `order` as a structure element.

Contexts Used as Thread

Contexts can be used like threads – especially the golden thread – in narratives. Therefore they are used slightly differently (see figure 33): A series of content types need contexts, sometimes varying their parameters. This results in preferring one content section to any other. It is most often used for external contexts like learner preferences, the learner's device, location, or similar, but also content related.

As many of these contexts as possible should be set automatically. For example, the prototype Coherence Editor links the logged in editing person as author, including his contexts – that are his learner preferences – to the content section he creates.

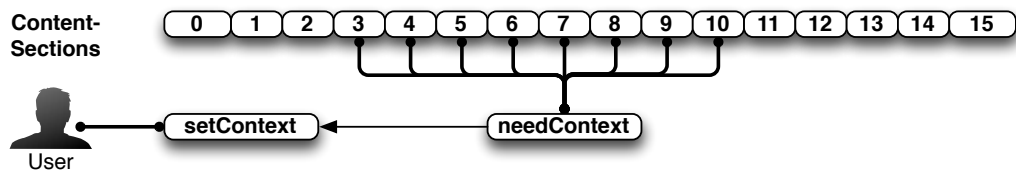


Figure 33: Content sections that are preferred for users with a special context: If one sort of NeedContexts is used for all or a group of content sections, these can be preferred over others of the same content type. The user’s contexts, for example his learner preferences, can be used to prefer some type of content. In this case one author’s content may be preferred for this user.

Example structures can be found in section C.3 *Content* on page 318. The user structure defines a set of contexts that are set and also contexts that are needed. The example given of a Coherence structure shows in `ContentSections` the property `author` that is set to, for example, `hahn`. This carries the implication that all these sections have `Needcontexts` as defined for user `hahn`. A learner’s contexts, like the example user structure, would be compared with the author’s `needContexts`. Thus one author’s whole content is preferred for the user in relation to other authors’ content, like a thread through the complete content space.

4.2.4 Weighting the Structure

Finally, content sections, content types, and contexts can be weighted to fine-tune their importance. It is not needed very often, the default value of 0.5 ($\hat{=}$ should) seems to fit for common content sections and types, but useful for critical parts to learn or for assessments and tests that must be passed. It is also a good idea to weight the title and the end content type (the first and the last, respectively) with 1, so that one of their content sections must be presented.

4.3 Authoring Workflows

Throughout this research several workflows for authors have been extracted and are based on different scenarios: Extending content, merging content, and adding new structures without new content.

All of the following workflows need one prior step: At least one content that has been already authored into a Coherence structure like that described in the previous sections.

4.3.1 Adapting Existing Content

This scenario assumes that a module is based on preexisting content like a book, script, or slide set. The content is then adapted to the lecturer's needs: Some parts will not be changed, while others will be edited and moved onto other positions, deleted, or created.

If these steps are done with Coherence or tracked and then imported, a new structure is built automatically. Also most relations are set without additional effort and only new created parts have to be related.

In this scenario nearly no additional work is needed as most of it would have been done anyhow.

An example for different orders of explanation is having first an overview and then practical tutorials, the opposite way, or a mixture. For example, an online tutorial [129] for the open source 3D modelling, animation, and game engine software Blender [18], explains its particle system in this order:

1. Overview
2. Fire
3. Fur
4. Fireworks

5. Particles forming Shapes

6. Billboard Animation

A lecturer who prefers to give examples first, followed by an explanation of the background of particles, might use these pages as source, change the order and adapt the content until it flows. His order would be:

1. Fire

2. Fur

3. Fireworks

4. Particles forming Shapes

5. Billboard Animation

6. Overview

Another lecturer might give a jump start, give technical details after that, followed by more practical tutorials. His order then might be as follows:

1. Fire

2. Overview

3. Fur

4. Fireworks

5. Particles forming Shapes

6. Billboard Animation

Figure 34 illustrates the steps. If all editing steps are done within a Coherence based authoring environment, copying would automatically create all relations that are kept through the whole editing process, giving the learner readily related content.

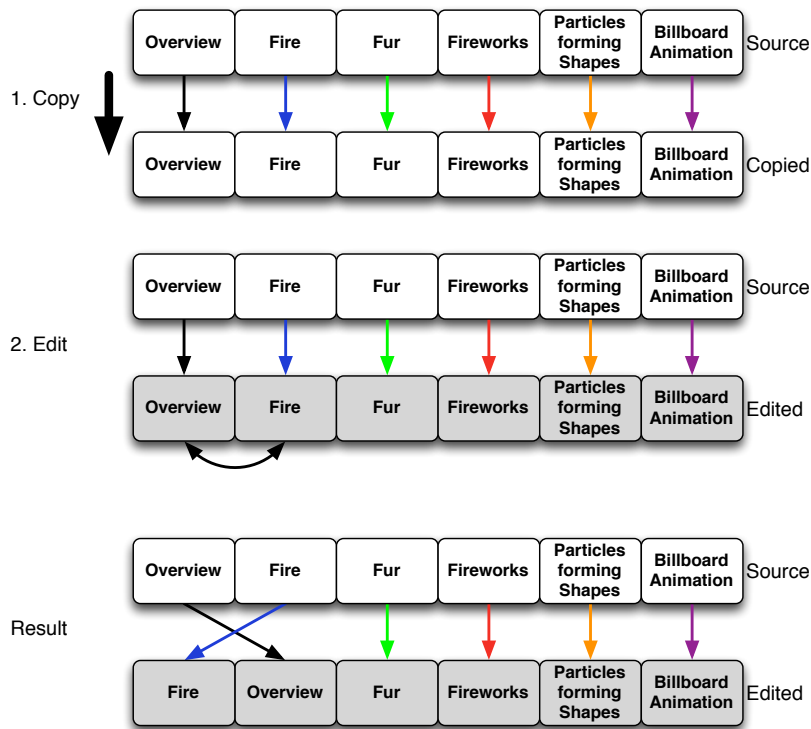


Figure 34: New structure based on an existing one: First the source structure is copied and all relations are created automatically. These relations are kept through the whole editing process.

4.3.2 Adding Content

Some more effort is needed if existing content has to be added to an existing Coherence content structure. In this case, the structures need to be related by content types. This could be done very coarsely by only linking the high level repeats. However, adaptation quality increases by relating more (correct) elements. Of course, the best case would be linking all the structures' content sections. However, this also means the largest amount of work.

Although the effort needed to create an adaptive structure is reduced, this amount of extra work should not be underestimated. Including eLearning 2.0 aspects may reduce the workload for lecturers (vide infra).

Figure 35 illustrates this workflow. First the new content is added to the system and then it is related to the already existing structure. In this example all the content sections are related, which is the finest but also the most elaborate way of doing it.

4.3.3 Adopting Learner Structures

The following scenario adds new structures, but in most cases no new content: Each individual path reflects a personal way to learn. Sometimes it is the same as the author’s structure but it can also be completely different. Sharing this path with other students by adding it to the corresponding Coherence structure enhances the overall structure without any additional effort. It already includes the right relations and the right order. Figure 36 gives an overview.

4.3.4 eLearning 2.0 Aspects

According to Ghali and Cristea, eLearning 2.0 aspects could be included by “allowing students to contribute in the authoring process of e-learning, with different privileges” [49]. This method of student participation is comparable to Atlantis University’s CoCoMa (see section 1.1.2 *Technological Platform to Support the Learning Process*

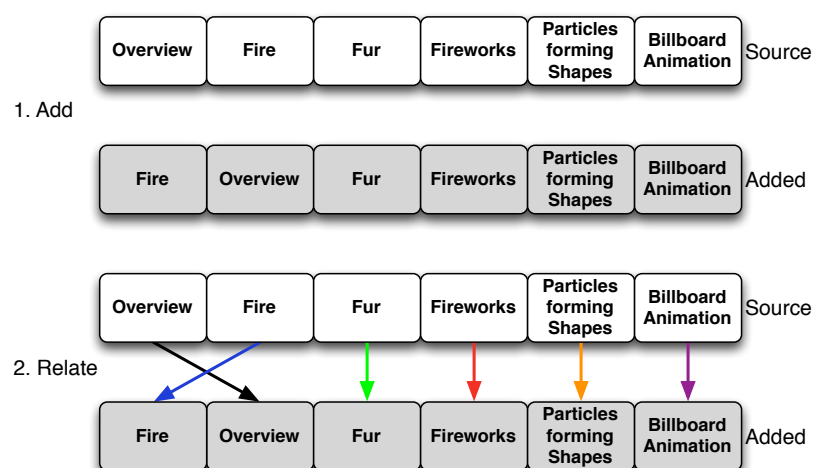


Figure 35: Structure added to an existing one: First a new structure is added to the system. Then it is related to an existing structure.

on page 27 for further details). A typical scenario explains how students could contribute to the structure creation process of the *Adding Content* workflow (vide supra): Nowadays it is common that students, especially learning groups, send links to alternative content to each other, for example in case they need additional explanations. If these are integrated into an environment based on the concept, they would delinearise the structure step by step without adding any extra work. Also the *Adopting Learner Structures* workflow (vide supra) can be seen as similar to eLearning 2.0.

To motivate students to contribute to the authoring the technology should be accessible. Editing should be easily possible whenever it is useful, following Alan Cooper’s axiom: “Allow input wherever you have output.” [29, p 231] Therefore, an in-place editor meets those needs. Also templates should be provided to give anyone an idea of how to start. A well balanced rights management system is crucial: “Don’t make users ask permission.” [29, p 230] It should be as open as possible to support sharing and any kind of restriction should be easy to grasp.

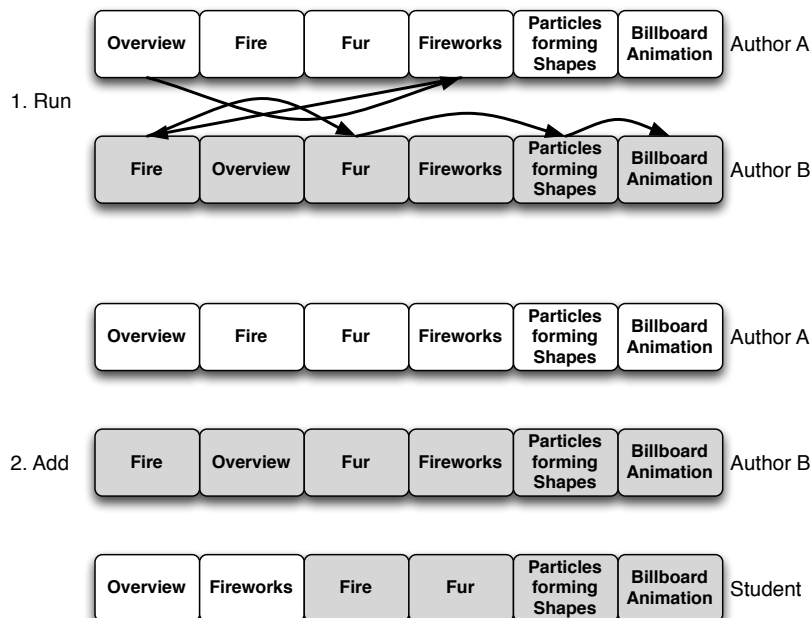


Figure 36: Adopting Learner Structures: The learner follows his individual path through the content. His path is recorded for his own history and can be added as an additional path to the structure.

4.4 Proposed Authoring Environment

The concept of this research is based on taking any information that already exists. Although additional meta information is needed, most of this can be collected automatically, which again reduces the effort for creating adaptive learning content.

The editor of the Coherence prototype helps to build structures but everything needs to be done manually, while beside a tree there is no graphical interface that helps display the structure in a human-friendly manner. This section discusses the basic elements that are needed for an authoring environment that supports the workflows presented in the preceding section. It abstains from general editing functionality like drag and drop, but focuses onto the special tasks for authoring a content structure which are necessary for the concept of this research project.

4.4.1 Import

An import helper can reduce to a minimum the work needed for creating a Coherence structure. Section 4.2 *Structure Transfer* (page 102) shows all steps that have to be done by authors. By using an import filter that looks inside the source documents nearly all the information can be extracted.

Depending on the format future players are able to present, the content itself should be converted. As a first guess, for each slide a content section will be created and linked to the content. The content sections can be automatically numbered so that the original order is copied to the Coherence structure. The same happens to the titles of the slides. Also the author should be set automatically, including all his contexts. During this research, learner preferences have been used but other possible contexts include country, language, university, faculty, and more. Many document formats include sectioning information that can be used directly for building corresponding repeats. For example, Open Document Text (ODT) contains among others author, title, chapters, and paragraphs, while Open Document Presentation

(ODP) does not provide this kind of structuring information (chapters, sections, ...) but the position as embedded information about the slide's order.

The first authors will have no additional work in most cases: Import, and then they are done. All other authors have to relate their content to the existing one, which is the largest amount of work that occurs when working with Coherence. The next section shows how authors can get help for this.

4.4.2 Relation Manager and Editor

Coherence's main structure consists of named and therefore semantic relations by using content types that span a network of alternative routes through the content space. Hence, setting these relations is the most important task to build a Coherence structure because it enables the different content structures to cohere. It is also the most difficult and time consuming task, because on the one hand appropriate content has to be found, while on the other hand the different structures and their interconnections can be confusing to authors and therefore need to be presented in a comprehensible way.

Currently the Coherence Editor is fixed on displaying the Coherence tree structure as is – without variations. Related content sections are only shown as offspring of one content type and no sorting regarding any other attribute is possible. There is also no help for finding relations and no graphical interface that supports displaying and drawing relations.

One main task of an authoring environment should be the visualisation of the Structure for monitoring and editing purposes. It should be easy to create and extend relations with dragging operations. The structure should also be sortable by various criteria like different authors and importance.

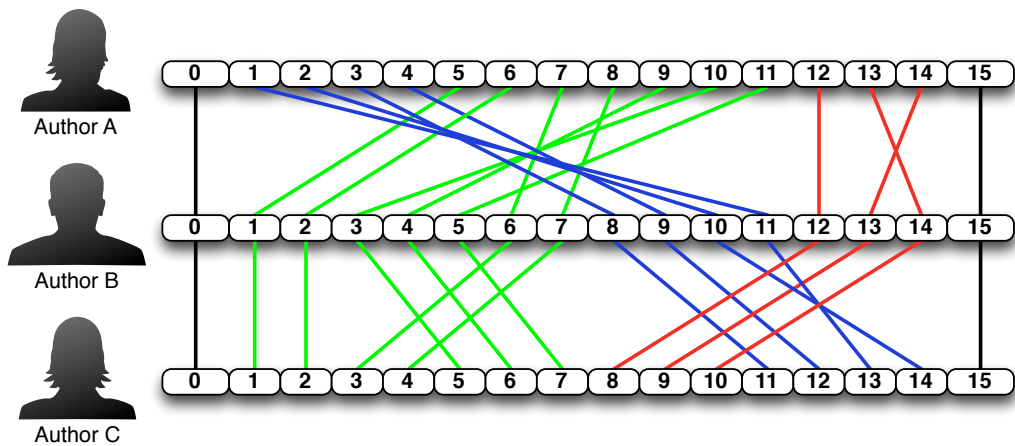


Figure 37: Coherence structure sorted by each author: The bricks are the corresponding content sections and the number shows their position that increment for each author. The coloured lines show the relations between these content sections. It can be seen that the relations seem to be unordered. Thus this view highlights the differences of the order between the different authors' content.

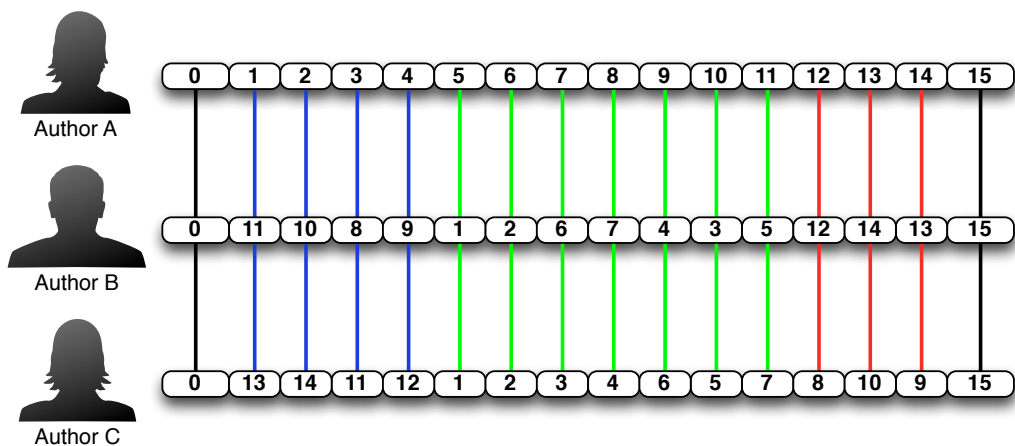


Figure 38: Coherence structure sorted by author A: All relations are sorted by the order of author A's content sections. This gives an overview of all related alternatives in respect to author A's content structure.

For example, figure 37 shows the Coherence structure sorted by each author and highlights the differences between their individual order. Figure 38 shows the Coherence structure sorted by author A, figure 39 shows the structure sorted by author C, highlighting the related alternatives, respectively.

Finding the appropriate relations should be supported by a combination of fast previews, sorting, and different finding algorithms. These algorithms could be based on keywords and typing in search queries, and be semi automatic by using, for example, the slides' titles. Of great help would be more advanced algorithms that compare the figures or that are based on text mining or image recognition to find related content sections.

4.4.3 Context Manager and Editor

While the authors' linear structures in conjunction with the relations tell the pathfinder which step *could* be next, the contexts tell the pathfinder which step *should* be next. Changes to the contexts' values can originate from the structure itself, from the presented content, or from external setters such as presets and sensors.

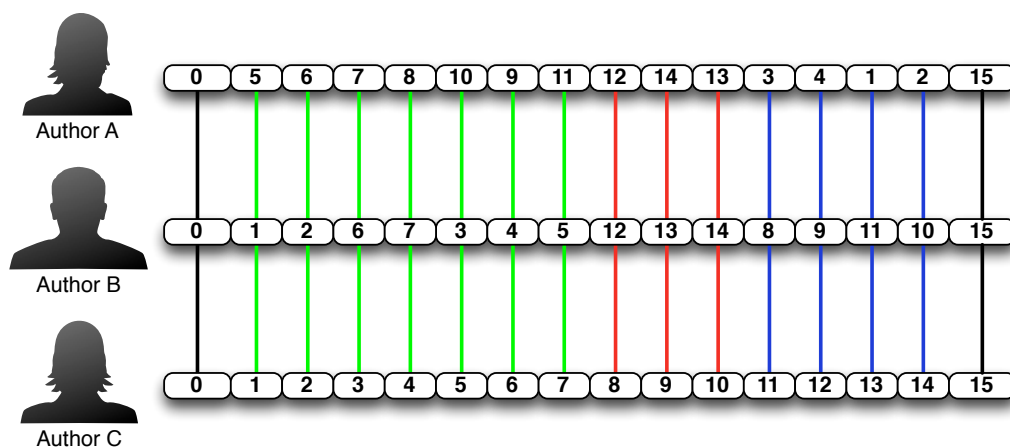


Figure 39: Coherence structure sorted by author C: Similar to the preceding figure 38, but all relations are sorted by the order of author C's content sections. This gives an overview of all the related alternatives with respect to author C's content structure.

The authoring environment should take care of the sources, editing, and binding of the contexts.

Currently no rules have been defined for the naming and application of contexts. As contexts are metadata to the content, for interchangeability reasons they should use existing learning specifications such as Learning Resource Meta-data Specification [10] and Vocabulary Definition Exchange [65].

Many of the contexts could and should be set automatically while authoring. These should all be author relevant information such as his university, language, and learner preferences. The Coherence Editor already links all author relevant information to the corresponding content sections, and for testing purposes learner preferences have been used as described in section 3.3.2 *Contexts* on page 83. In case of content for smart phones, as a preset more contexts such as device and location should be set additionally.

All context sources relevant to the currently edited Coherence should be available in a container, sorted by their origin and showing if they are static or dynamic. Contexts should be editable via drag from the source and dropped into the content section, content type, or condition. Corresponding context setter and getter should be highlighted. Because contexts might also influence the content, the valid range should be marked. Runtime control of contexts and their implications on the pathfinder are tasks for the debugger as discussed in the following section.

4.4.4 Debugger

The Coherence-Monitor (see section 5.2 *Scope of Services*) was very helpful during the application development phase, and it turned out to be crucial for content structure creation. It presents the necessary information if the pathfinder does not behave as expected, and enables fine tuning, for example through changing parameters and testing their influence. This kind of experience is confirmed in another, but in this respect, comparable research context by Pizzi and Cavazza [94], Swartjes and Theune

[120], and Spierling [111, p 238]: “‘debugging’ in the context of IDS (author’s note: Abr. for Interactive Digital Storytelling) creation is more than repairing software. It refers to the constant necessity to iterate changes in the model and test the result, due to the unlikelihood of guessing optimised rules before running a test.”

In the context of this research project’s concept, the Coherence-Monitor only provides the basic functionality: It presents the current state by showing the values of the runtime and model structures. To be helpful for authors, it needs a redesigned user interface and more functionality that hints at critical aspects of the structure and helps to author the expected behaviour. The following information is needed:

- That there is an error.
- What is the error?
- Where does the error occur?
- Why is it an error?
- Hints to debug the error.

Authors need clear signals in case of critical errors. Critical errors are, for example, impossible paths, which occur if a context must be set (`needContext` with a `needed` value of 1), but it is not set at any position before. Also more than one content section that must be shown (`contentSection` with `weight` set to 1) within one content type causes undefined behaviour of the pathfinder. Authors also need to be alerted to critical aspects of their structure, for example repeats that have a condition that need contexts (`needContext` with a `needed` value of 1) but no emergency exit.

To gain more control, authors need help to interpret the influences of the particular parameters on the results of the pathfinder. This includes the parameter’s influence on the overall rate, but also which parameter leads to change to another author’s path, and similar occurrences.

4.5 Summary

This chapter starts with a general discussion about the role of authors creating interactive content. It is shown that they are still authors of their original content even if learners go their individual path through the content space due to their selections and interactions. However, as soon as content is added or related by others, they should be seen as coauthors of the overall adaptive content.

The following sections discuss practical applications of the concept that are based on getting adaptive content with tools and workflows that support the common linear thinking of authors. First, the transfer of linear structures to a Coherence structure is discussed step by step. Then workflows are presented for different scenarios. Lastly, aspects of an authoring environment are proposed that fulfil the demands for the concept of this research.

4.6 What's next

The theoretical and practical aspects of the concept of this research have been discussed in the previous chapters. The following chapter presents the prototype that has been developed to gain experience with the concept and to get a feeling for its behaviour.

Chapter 5

Prototypical Implementation of the Adaptive eLearning Concept

To test the theoretical basics of the previous chapters, the prototype “Coherence” has been developed and consists of three applications: Player, editor, and monitor. The prototype realises most of the aspects of the concept described in chapters 3 *Adaptive eLearning Based on Authoring* and 4 *Authoring Aspects*. While of course far from being perfect, it is developed in a way to support all the basic steps that are needed for a complete workflow. Due to their prototypically nature, none of the applications include all of the features that would be needed for a fully-fledged environment. In particular a real authoring environment is missing and instead an editor has been implemented that provides some help for editing the adaptive content structure.

This chapter describes the concept’s realisation, its usage and how it is used for testing. Therefore, firstly, the specifications are discussed, followed by a description of the necessary and possible services provided by the applications of the prototype. The following section provides technical details about the implementation. To give the reader of this thesis a better understanding of its look and feel, the application’s graphical user interface is also shown and described. Lastly, the requirements for installing and running the prototype are given.

5.1 Application Specification

This section describes the environment within which the application has been developed. As a result the objectives are defined at the end.

5.1.1 Actual State Analysis

There are no adaptive learning tools at Hochschule Darmstadt (University of Applied Sciences Darmstadt) or within the Atlantis University Project. Beside the research described in this thesis no projects are planned to create such a tool.

Hochschule Darmstadt uses Moodle [83] as a LMS [40]. The version rolled out at the time of undertaking this research project was Moodle 1.9. It was upgraded to Moodle 2.x in 2013. Moodle 2.x provides a very basic tool for automated course adaptation called “conditional activities” [84]. It can show or hide activities using criteria like viewing, receiving a certain score, or a student marking it as complete. It also might be used for adaptive learning paths [85] but because it works by describing all the preconditions for each conditional activity it is not suitable for complex learning path arrangements. Additionally it does not support learning preferences as adaptation criteria, because Moodle does not know about learning preferences.

It is not planned to introduce any other Learning Management System that may provide adaptive technology, though there have been some experiments with the user-modeling-module for adaptation of an eLearning-system Chameleon [43] at Hochschule Darmstadt. Integration with the Hochschule Darmstadt’s own Learning Management System ELAT (Environment for Learning and Teaching) was considered [50, p 7], but never realised. ELAT was replaced by Moodle in 2010 and shut down in the same year.

Research has also been undertaken in the area of learner preferences at Hochschule Darmstadt [101] and within the Atlantis University Project [107]. The test content for the evaluation is annotated in relation to Röll’s first version of his model. At the

time of writing Röll is revising his model, but work on this is still ongoing. Hence it cannot be used for testing for the purpose of the research described in this thesis.

5.1.2 Environment Analysis

Moodle 1.9, used as learning management system at Hochschule Darmstadt, does not provide any functions to automatically adapt content to different learning styles.

Chameleon has never been integrated or used at Hochschule Darmstadt. It had been used at Universität Heidelberg (Heidelberg University), but according to the author of Chameleon, Daniel Eichelsbacher, there is no running instance because it needs the obsolete learning management system WebCT. Hence no groundwork can be used from that.

Coherence should be able to be used with Moodle and other LMS. It is considered to use IMS-LTI for that.

5.1.3 Definition of Objectives

Three different objectives can be distinguished for each project:

- Objectives that must be reached – otherwise the project fails. They are called *main objectives*.
- Objectives that should be reached and enrich the project's outcomes. They are called *additional objectives*.
- Objectives that might be reached. As above, they are also called *additional objectives*.

On the other hand, projects also have some non-objectives:

- Objectives that are not part of the project and therefore do not influence the outcome.
- Objectives that must not be reached.

The main question of this chapter is

What is a concrete implementation of a software that realises the authoring concept of this research, creates adapted learning paths, suggests them to the learner and takes into account the implicit and explicit interactions of the learner, providing a minimum level of functionality to test the concept?

This question leads to four main-objectives as follows:

1. A software needs to be implemented that realises the concept of chapter 3 *Adaptive eLearning Based on Authoring* on page 57.
2. For evaluation purposes, the software must be usable without any learning management system. Hence it needs the basic implementation of some additional functions like user and content management.
3. To ease integration into any learning management system the software should be implemented in a web-based manner.
4. The objective of the implementation is a prototype.

The non-objectives are as follows:

1. It is not an objective to implement any more functionality than is needed for a prototype.
2. It is not an objective to deploy the software in a working environment.
3. It is not an objective to provide the interfaces that are needed to integrate the software within any existing learning management system without effort.
4. Any kind of learning management system functionality is not part of the implementation (except of a very basic user and content management, vide supra).

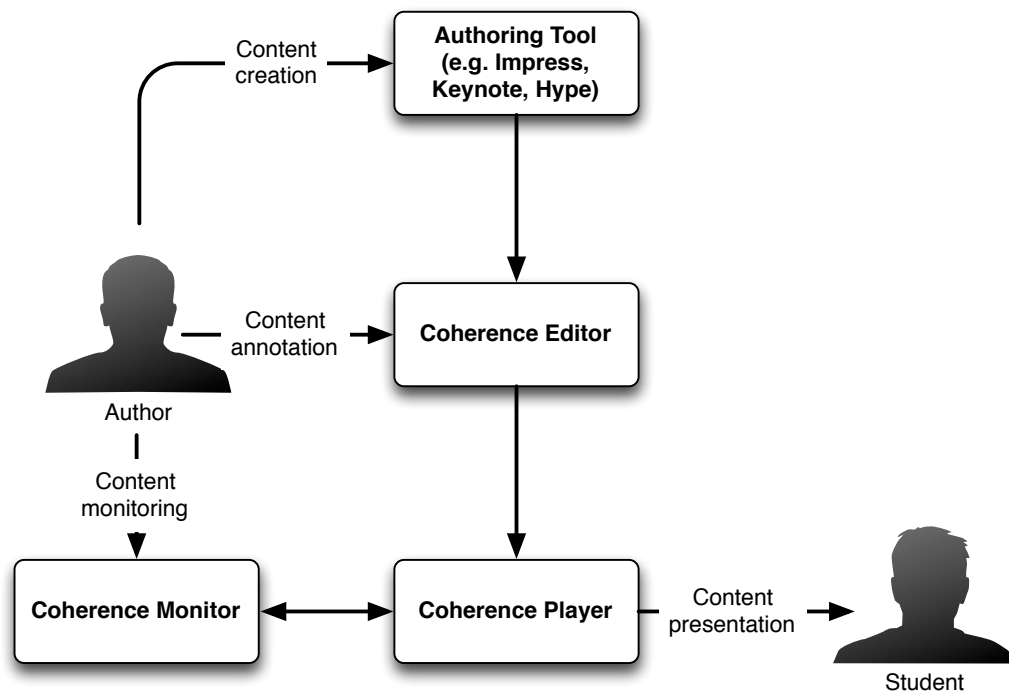


Figure 40: Minimum services needed for creation and presentation of adaptive content following the concept discussed in this thesis. The content itself is authored with external tools like slide set or HTML authoring applications, while Editor, Monitor, and Player have been implemented as Coherence services to annotate, monitor, and present adaptive content respectively.

5.2 Scope of Services

The minimum functionality that is needed to fulfil the demands for this research is as follows (see also figure 40):

- Content creation
- Content annotation (structure and contexts)
- Content presentation
- Monitoring (not needed during runtime, but essential for developing and content-structure debugging)

Content creation is out of the scope of this research. For test purposes, some technical HTML content has been created to test functionality. For further testing and

evaluation, real existing learning content has been used. This has been transformed to any W3C compatible document format like HTML and SVG, so that it can be presented by any internet browser.

The three web applications player, editor, and monitor have been developed to fulfil the following functionalities: content presentation, annotation, and monitoring. Content and data for all three applications are stored on a web server and a database. The applications themselves are also stored on the same web server and use the same methods for creating and editing the data. For testing purposes these applications provide basic user management for creating new users and login.

The Coherence-Player provides a content view to present the content, a history, and input facilities for navigation and rating. Furthermore, it contains the pathfinder algorithm. The Coherence-Editor is a very basic editing application for creating and editing Coherence-Models. Beside capabilities of visualising and editing the structure, it provides custom editing fields, previews, and helpers like automatically linking the editing user to the sections he creates. The Coherence-Monitor provides functionality to monitor and edit the Coherence runtime data, including the history. It can be used to test new models and to monitor the current state of the Coherence-Player.

5.3 Implementation

Coherence has been implemented as HTML 5 [125] Rich Internet Application (RIA) [1], to decrease the time needed for server-responses and to get reactive applications. It is programmed using the following paradigms:

- Object Orientation
- Statecharts [58]
- Model View Controller [7, pp 197]
- Key Value Observing [8] including bindings [6]

The application data is handled by a data store. It connects to the server through a datasource. The client-server communication protocol is based on Representational State Transfer (REST) [99], the data format is JavaScript Object Notation (JSON) [42, pp 202].

5.3.1 Programming Language and Framework

Because Coherence is a HTML 5 application, it has been implemented in JavaScript. It uses the SproutCore framework [119] that provides a clean Model View Controller (MVC) architecture and has been proven to be scalable and reactive in large web applications.

5.3.2 Code Organisation

The code is organised in frameworks for all the code that is shared by all the applications and the code for applications themselves (see figure 41):

Frameworks

The four frameworks `CoherenceModel`, `CoherenceRuntime`, `TreeModel`, and `SCUDS.CouchDBDataSource` contain all the shared code. It is used for data handling and to describe the models.

CoherenceModel This framework contains the Coherence-model itself and supporting classes for context comparison, custom views for editing purposes, and a controller to bind the views to the model.

CoherenceRuntime This framework contains the Coherence-runtime-model. Additionally, it provides all the user-related states, controllers, and views, including the login and registration logic.

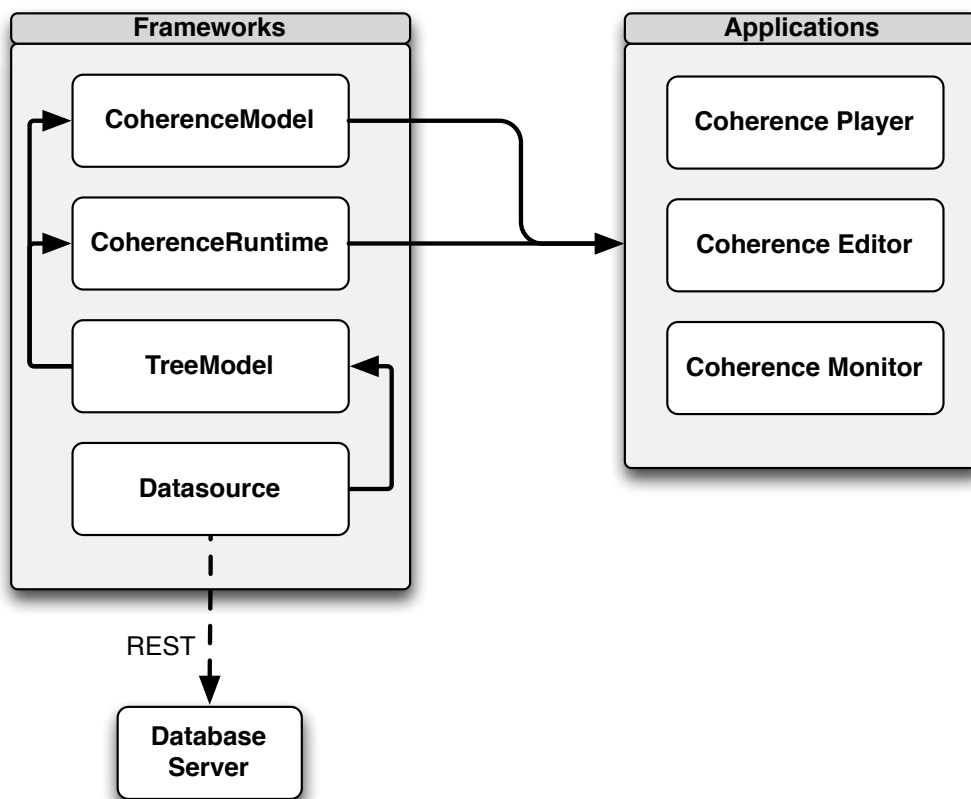


Figure 41: Organisation of the Coherence code: The frameworks provide data handling such as models and datasource for database connectivity to the three applications.

TreeModel `CoherenceModel` is organised as a tree-based model, each object accumulating all of its children objects in one list called `treeItemChildren`, even if the objects are of different types. `CoherenceRuntime` is organised in plain JSON, children with different value or object types have separate keys.

The `TreeModel` framework provides all functionality to display and edit tree-based structures. To ease including the different types of model structures, it also visually harmonises the differences by organising plain JSON objects as two-level tree models.

Datasource The applications use the `CouchDBDataSource` from the `SproutCore-Universal Data Source (SCUDS) Library` [52] to connect to the database. It has been extensively debugged.

Applications

The applications `Coherence-editor` and `Coherence-monitor` are just small runtime wrappers around the `TreeModel` framework. They add methods to load the right models. `Coherence-editor` also uses a statechart to let a user login. The user's meta data is used to pre-annotate new created content-sections, for example it automatically adds the right learning preferences.

The `Coherence-player` is the most complex application. It contains the pathfinder and a GUI that lets the user start the pathfinding process, lets him choose the content he wants to have presented, and lets him navigate through the history. Additionally, the prototype provides functionality for login and shows a list of all the available Coherences the user can choose from.

Figure 42 gives a schematic overview of the player's MVC classes. The user controls the player only by interacting with the view classes.

The player's statecharts are responsible for the overall control of the application. They can be seen as two parts: First, the init phase with login and the user choosing a Coherence. Most of this is deprecated in case of integration into an eLearning environment, as the user will already be logged in and will have chosen the Coherence as part of his module, for example, by clicking a link. These states are pretty simple (see figure 43), as they only handle standard procedures. The `player` state is a bit more complex. It includes the two concurrent substates `history` and `coherence`.

The `history` substate is responsible for all user interaction with the history: Initialising, selecting the right pass after path-creation, and deleting the history on user request. Therefore it communicates with the `historyController` (that in turn controls the history-view which is in fact the `PlayerView.masterView`).

The `player` substate is the main part of the application and is illustrated by figure 44. It starts at the `ready` substate. This state presents the content and waits for any user interaction. The user can toggle between this and the `pause` state that just stops the time measurement.

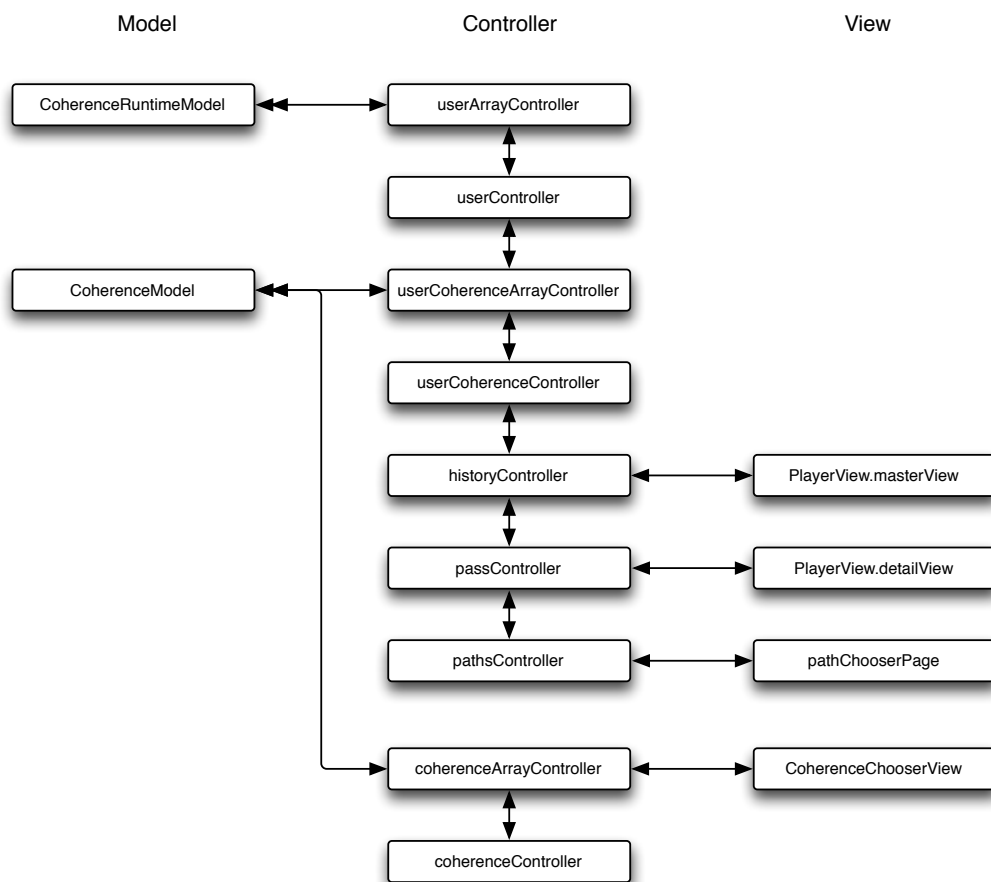


Figure 42: Schematic player MVC class information flow diagram. View classes provide functionality for user interaction. Controllers interpret user input and manipulate the data in the models if necessary.

The user decides how he wants to go to the next content step by accepting or dismissing the current content. If he accepts it, the player goes to the `complete` substate, if he dismisses, the player jumps directly to the `proceed` substate.

The `complete` substate marks the current content-section as completed and copies the current content-sections' `setContexts` and all GUI contexts into the current `Pass`' (runtime-) contexts. Then it goes to the `proceed` substate.

The `proceed` substate temporarily stores the current pass. If the user cancels the pathfinding process, it is needed to restore the current state. Additionally it prepares the history for the path creation process, creates a new `Pass`, and starts the pathfinder.

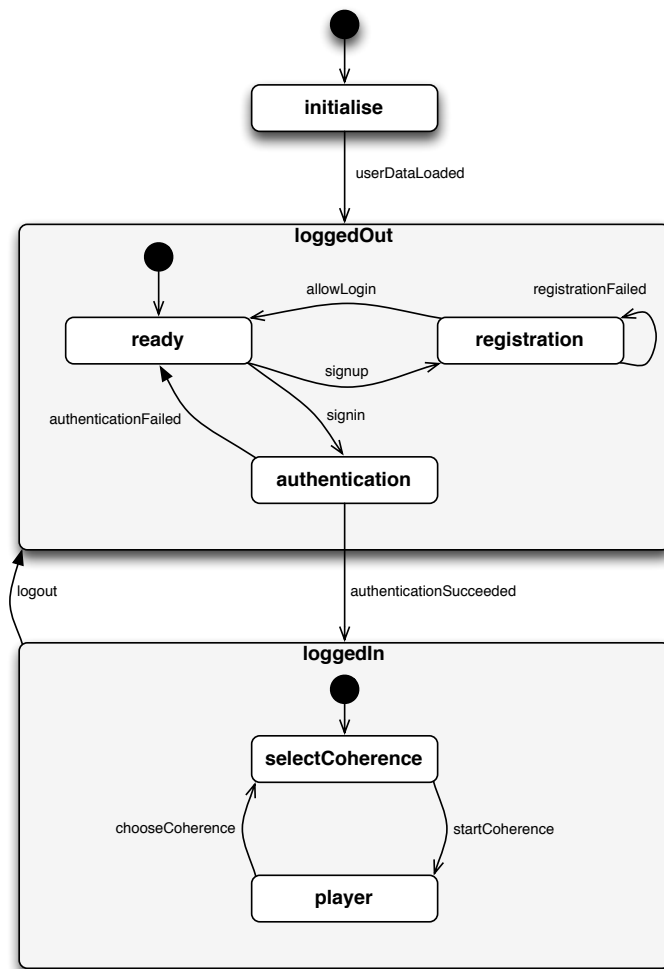


Figure 43: Statechart diagram of player's init state: After initialisation, the loggedOut state waits for user login. The loggedOut state provides functionality to select and present a Coherence.

The `pathfinder` substate consists of the two concurrent substates `gui` and `pathCreation`. While the `pathsController` is responsible for controlling the `pathChooserPage` and the direct user interaction, the `gui` substate is responsible for actions that are needed after the user has chosen what to do. In case of cancelation, the `gui` substate just restores the conditions as before starting the pathfinding process and stops all pathfinder that might still work. If the user has chosen the next step it sets the selected content-section, restarts the timer, deletes the temporary history, and saves all changes to the server. Lastly, the `coherence` state is restarted so that the user can go on.

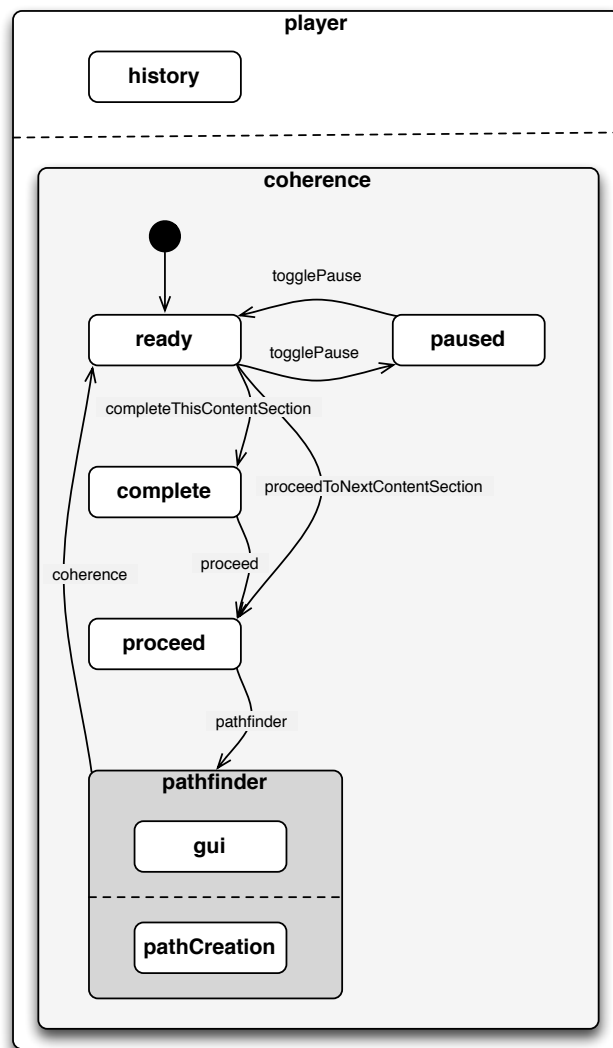


Figure 44: Statechart diagram of player’s main state: It includes the two concurrent substates *history* and *coherence*. The former controls the history and the latter is the main part of the application. It displays the content and reacts on user interaction.

The *pathCreation* substate controls the pathfinding process. Therefore it uses the *pathfinder* class and its subclasses that implement the different pathfinding strategies. Their functionality is described in detail in section 5.3.6 *Pathfinding* on page 142.

5.3.3 Client Server Communication

The format to exchange data between the server and the clients is JSON. Resources are addressed via Resource Oriented Architecture (ROA)-based REST. The most important characteristics of REST are [99, pp 89]:

- Everything of importance is a resource.
- Each resource can be addressed directly with a Uniform Resource Identifier (URI).
- Only Hypertext Transfer Protocol (HTTP)-methods are used (GET, HEAD, PUT, DELETE, POST, and OPTIONS).
- The protocol is stateless.

No other methods should be hidden behind any HTTP-method (this would be Remote Procedure Call-style). For example, it is dangerous to create an object using the GET-method (like `GET http://rpc.style.rest/create?path="something"`). Also, using GET to delete a resource could be called accidentally and might have disastrous effects that have not been foreseen (like `GET http://rpc.style.rest/delete?path="/"&options=Rf`). Therefore GET is defined that it must only fetch data from the server, but must not change any data. It must not make any distinction between 1 or 1000 fetches with GET. If there is no other possibility, POST might be overloaded, but this usually signifies a bad design.

Hence REST has all the attributes that made the World Wide Web (WWW) and therefore HTTP so successful. It uses the web as it is, but transfers machine readable data instead of human readable data. The results are less overhead and scalability: Because of the stateless protocol additional server can be added relatively straightforwardly.

This is in contrast to the Simple Object Access Protocol (SOAP) protocol. SOAP uses HTTP only as a transmission layer, but behaves completely different. It normally

uses only one resource, but hides lots of methods behind it. Therefore it needs a lot of overhead and scalability has to be planned.

Coherence uses two resource types, `CoherenceModel` and `CoherenceRuntime`. Both are JSON documents that are stored in the database. Each document can be addressed by a unique URI.

The stand-alone prototype of Coherence is purely RESTful. But as soon as it becomes integrated into a learning management system it cannot work stateless anymore because the well-known eLearning protocols use state-based communication.

5.3.4 Database

All the data needed for Coherence is stored in a database on the server. The document oriented NoSQL [56] database CouchDB [2] has been chosen because it fits very well to Coherence's demands:

CouchDB is a RESTful database. It communicates natively via HTTP and uses only the standard methods. All data is accessible by unique URIs. The data itself is stored as JSON documents.

CouchDB is an open source Apache project [4], licensed under the Apache License, Version 2.0 [3]. It can be used free of charge which makes it an ideal candidate for cost effective deployment. It could also be tailored and adapted to special needs, though this was not needed in this research.

CouchDB runs on many platforms, for example Unix (Berkeley Software Distribution (BSD), Mac OS X, Solaris), several Linux flavours, Windows, and even mobile platforms like Android and iOS. This makes it easy to change the platform at any time as necessary, such as Mac OS X for development and deploying on a Linux server.

Evin Grano provides a CouchDB datasource [52] that can be included in Sprout-Core applications. After some debugging it could be used right away. It fits any kind of project or application.

Although CouchDB provides the possibility of scripting the business logic on the server with JavaScript, while Coherence follows the more and more common two-tier paradigm. CouchDB is only used as a database that connects via REST with the web application. Beside data access no other logic is implemented for CouchDB or by any server side PHP script (or any other program language). Coherence includes all the necessary business logic and is directly connected with the CouchDB server.

5.3.5 Data Models

The model of the research prototype has been reduced to fulfil the basic demands. Additionally it has been split into two data models: `CoherenceModel` and `CoherenceRuntime`. Both are modelled in JSON, because it is the native modelling, store, and exchange protocol for both sides, web application and database.

`CoherenceModel` structures the content of a Coherence, see figure 45. It is described in detail in section 3.3.2: *Components and Design* (page 77). The differences are as follows:

- The `User` has been moved to the `CoherenceRuntime` model.
- The contexts cannot be nested, hence `ContextGroup` is missing.
- Only `ContentSections` can be related by `ContentTypes`, but not `Repeats`.

Technical details can be found in appendix E *Technical Details of the Coherence Model Components* on page 367. Example models can be found in section C.3 *Content* on page 318.

`CoherenceRuntime` implies all data that is needed to run any Coherence by a user, see figure 46. Again in contrast to the complete model the contexts cannot be nested.

`User` is the top level entity. It contains his name and username (for login). These data should normally be provided by a LMS, but is needed for this standalone prototype.

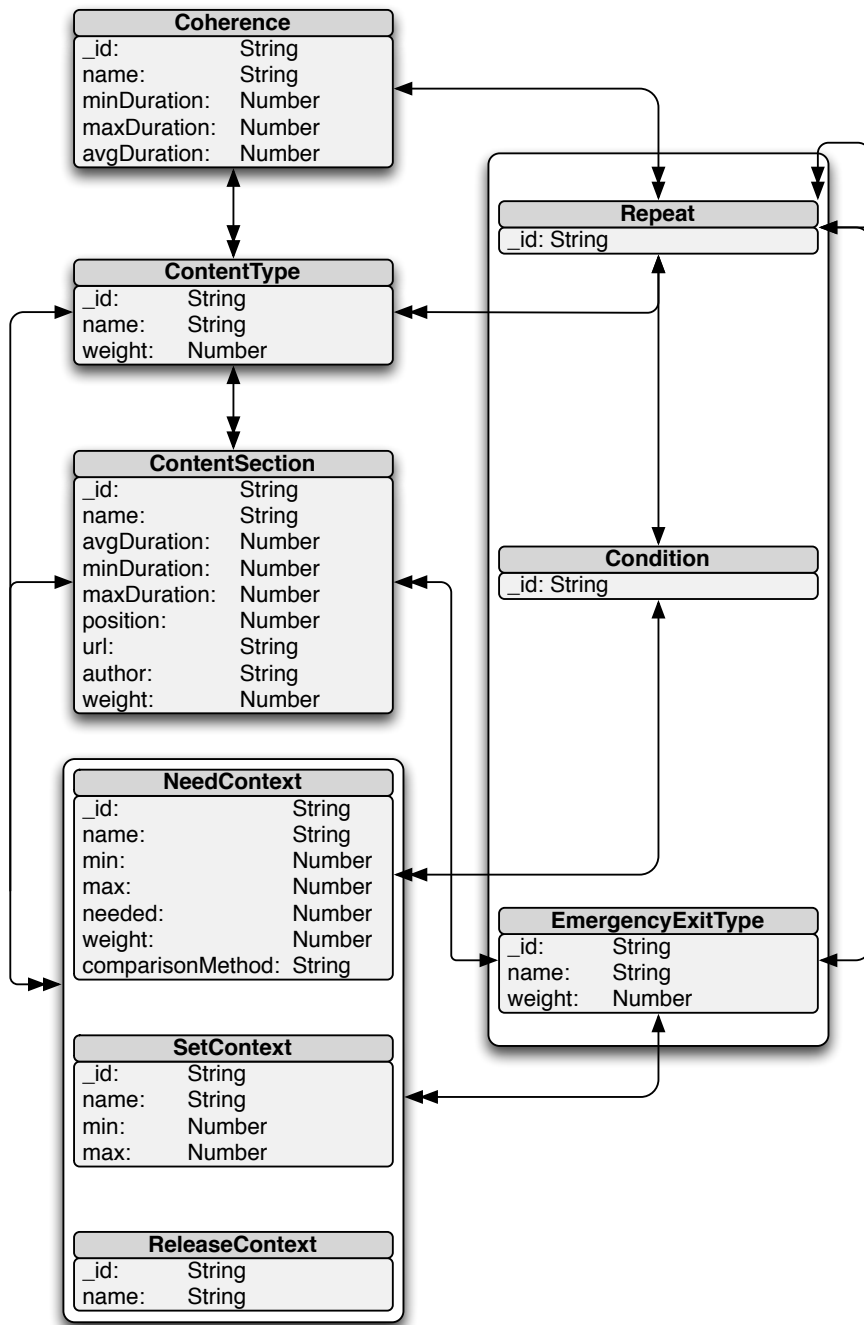


Figure 45: Coherence Model

The user has **NeedContexts**. These contexts are used to annotate content-sections with author information. They will be used like normal **needContexts** that are defined in the Coherence-model to find the best fitting content for the learner. The user also has **contexts**. These contexts describe the user, for example his learner preferences. Last, all the started Coherences are collected with **Coherence** entities.

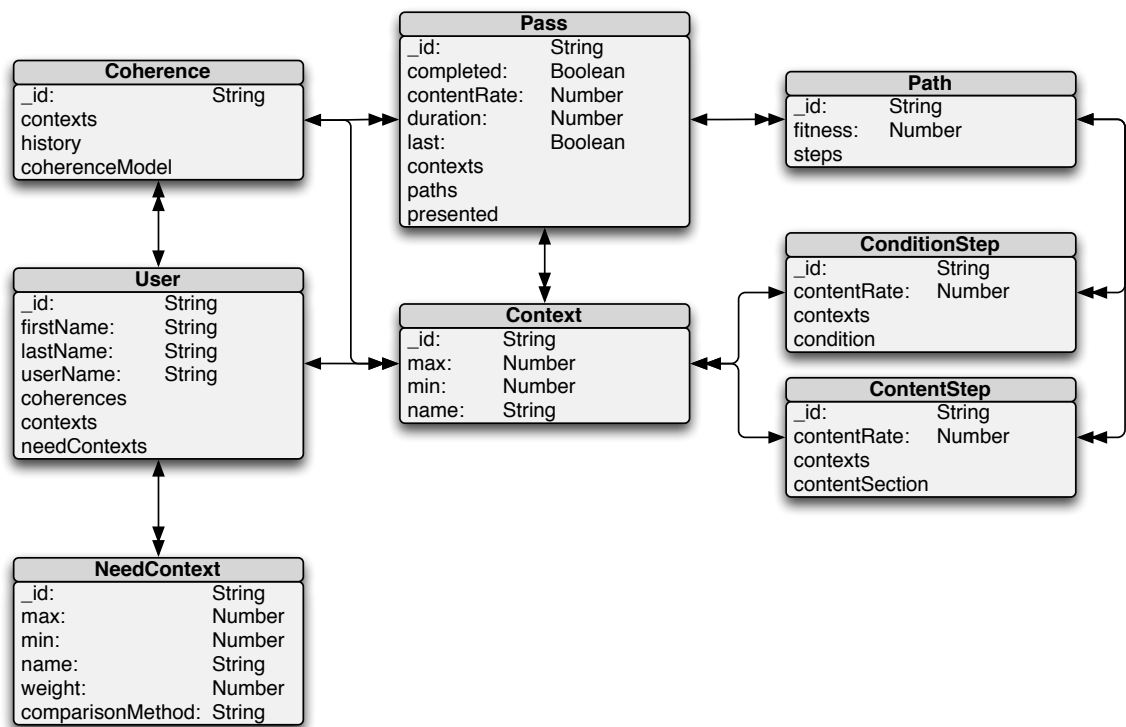


Figure 46: Coherence Runtime Model

The `Coherence` entity collects all the needed data for a Coherence run by the user. This includes the contexts and the history.

The `history` consists of `Passes`. Each pass is a step the user has done through the content. Each pass gathers the following information:

- All the paths that have been recommended by the pathfinder for this pass (`paths`)
- The content section the user has chosen (`presented`)
- All related contexts (`contexts`)

With this information the user can navigate through the history, and the pathfinder uses it to find suitable paths.

5.3.6 Pathfinding

The pathfinder consists of the main class `Pathfinder` and its subclasses `MustPathfinder`, `AuthorPathfinder`, `AlternativePathfinder`, `DecreasePathfinder`, and `IncreasePathfinder`. Therefore it first starts the `MustPathfinder` that creates paths containing only content-sections that must be presented. After this, all the other pathfinders are started. They get the must-be-presented paths as input parameter.

Pathfinder

The `Pathfinder` class provides the functionality that is needed by all or most of the pathfinding algorithms. It adds conditions from the end of repeats to the paths, rates steps and whole paths, and merges paths.

addConditions The pathfinding algorithms create paths without taking care about the conditions of the repeats. This method adds the conditions at the right place of the path as `conditionSteps`.

rateStep Before the whole path can be rated, each step has to be rated. Therefore each `needContext` of all steps is compared to the current state. That is any `setContext` that might have occurred beforehand. As an example, two nearness and one overlapping comparing algorithms have been implemented.

Two possibilities to check the nearness are implemented: One that uses a limited value range and can compare in a linear way:

$$n = \begin{cases} \frac{\min_p - \max_n}{\max_l - \min_l} & \max_n < \min_p \\ \frac{\min_n - \max_p}{\max_l - \min_l} & \max_p < \min_n \\ 1 & \text{for all other cases} \end{cases} \quad (5.1)$$

\max_l : limit maximum value

\min_l : limit minimum value

\max_n : need maximum value

\min_n : need minimum value

\max_p : set maximum value

\min_p : set minimum value

n : nearness

However, in cases where no limit can be given, the following algorithm is used:

$$n = \begin{cases} \frac{1}{1 + \min_p - \max_n} & \max_n < \min_p \\ \frac{1}{1 + \min_n - \max_p} & \max_p < \min_n \\ 1 & \text{for all other cases} \end{cases} \quad (5.2)$$

\max_n : need maximum value

\min_n : need minimum value

\max_p : set maximum value

\min_p : set minimum value

n : nearness

The overlapping algorithm investigates how much the set context and the needed area overlap:

$$I = \begin{cases} \max_n - \min_n & \min_n > \min_p \wedge \max_n < \max_p \\ \max_p - \min_p & \min_n < \min_p \wedge \max_n > \max_p \\ \max_n - \min_p & \min_n \leq \min_p \wedge \max_n \leq \max_p \\ \max_p - \min_n & \min_n \geq \min_p \wedge \max_n \geq \max_p \end{cases} \quad (5.3)$$

$$i = \begin{cases} 0 & \max_n \leq \min_p \vee \max_p \leq \min_n \\ 1 & \max_n = \max_p \wedge \min_n = \min_p \\ \frac{2I}{\max_n - \min_n + \max_p - \min_p} & \text{for all other cases} \end{cases} \quad (5.4)$$

\max_n : need maximum value

\min_n : need minimum value

\max_p : set maximum value

\min_p : set minimum value

I : overlapping

i : standardised overlapping

rateAndCreate This method rates the whole path, creates a **Path**-record and sorts the paths regarding the outcome of the rating.

As a first possibility, all the parameters that have to be taken into account are averaged using the arithmetic mean. The algorithm itself is not focus of this work, but as one is needed for evaluating the approach, the following algorithm has been developed as an example. It must be evaluated in further research.

The rating formula determines the so-called path quality q for every path. First, the content-types are looked at. All the content-types' weights W are cumulated:

$$\sum_{i=1}^{n_t} W_i \quad (5.5)$$

n_t : Number of the content-types within the whole path

W : The content-type's weight

The result of all context-comparisons K of each content-type is taken into consideration. Therefore these values are also cumulated for each content-type. The better the single context comparisons are and the higher the weight of the respective content is, the better this value becomes. Last, the result is divided by the number of content types n_t to normalise it. If there are five content-types within a path, then all the content-type weights are cumulated and divided by five. The greater the weights of the single content-types are, the greater the value gets. However, if there are negative weighted content-types, thus they are better-not-in-path, this value decreases.

$$\frac{\sum_{i=1}^{n_t} \left(W_i + \frac{\sum_{j=1}^{n_K} K_{ij}}{n_K} \right)}{2n_t} \quad (5.6)$$

n_K : Number of the weighted contexts of a content-type

K : Weighted context, thus the result of a context-comparison

A similar calculation is needed for the content-sections:

$$\frac{\sum_{i=1}^{n_c} \left(w_i + \frac{\sum_{j=1}^{n_k} k_{ij}}{n_k} \right)}{2n_c} \quad (5.7)$$

n_c : Number of the whole path's content-sections

w : The content-sections's weight

n_k : Number of the weighted contexts of the respective content-section

k : Weighted context, thus the result of a context-comparison

The last factor is the content's overall duration for a specific path. Every content-section defines a minimum, a maximum, and an average duration. While minimum and maximum duration are used as limitations for the path generation, the average duration is used in this formula. All the single duration t of each content-type regarding a specific path are cumulated and divided by the desired overall duration T . Because the best result (1) should be reached if the path's duration is the same as the desired overall duration, some corrections are done:

$$1 - \left| 1 - \frac{\sum_{i=1}^{n_c} t_i}{T} \right| \quad (5.8)$$

t : The respective content-section's duration

T : Desired average whole duration

The overall path quality is the sum that is divided by 3 to get a 1 as the best possible result:

$$q = \frac{1}{3} \left(\frac{\sum_{i=1}^{n_t} \left(W_i + \frac{\sum_{j=1}^{n_K} K_{ij}}{n_K} \right)}{2n_t} + \frac{\sum_{i=1}^{n_c} \left(w_i + \frac{\sum_{j=1}^{n_k} k_{ij}}{n_k} \right)}{2n_c} + 1 - \left| 1 - \frac{\sum_{i=1}^{n_c} t_i}{T} \right| \right) \quad (5.9)$$

- q : The path-quality
- n_t : Number of the content types within the whole path
- W : The content type's weight
- n_K : Number of the weighted contexts of a content-type
- K : Weighted context, thus the result of a context-comparison
- n_c : Number of the whole path's content-sections
- w : The content's weight
- n_k : Number of the weighted contexts of the respective content-section
- k : Weighted context, thus the result of a context-comparison
- t : The respective content's duration
- T : Desired average whole contents' duration

After this calculation, the path is sorted into one of the following categories:

- good: Everything is o.k., the path is presented to the user
- too short: The path's duration is less than the minimum Coherence duration
- too long: The path's duration is more than the maximum Coherence duration
- impossible: One or more precondition tests failed

mergePaths Each pathfinder needs to merge in the content-sections that have been found by the **mustPathfinder**. Additionally, the **increasePathfinder** also needs to merge the found content-sections into the path that it should increase. To get a

coherent result, this methods adds these content-sections grouped by authors at the end of their corresponding repeats.

MustPathfinder

This pathfinder is started at first. It finds content-sections that must be presented but have not been already shown. These are content-sections with a weight of 1 or at least one content-section of content-types with a weight of 1. The result is treated as a normal complete path. However, because it is too short in most cases, it will not normally be shown directly but used as the input path for the **IncreasePathfinder**.

AuthorPathfinder

The **AuthorPathfinder** collects all content-sections that still need to be presented and groups them by authors. These collections are sorted by the content-sections' position.

AlternativePathfinder

Some of the paths created by the preceding pathfinders are not possible because at least one condition could not be fulfilled. First, this pathfinders find the step where this happened. Then it looks for content-sections with contexts that fulfil the condition. These content-sections are grouped by their authors, and all remaining content-sections of these authors that are part of a repeat are concatenated to paths.

DecreasePathfinder

This pathfinder removes steps from the path until its duration is less than the Coherence's maximum duration. Therefore it removes as many of the worst rated content-sections as needed to go below the duration limit.

IncreasePathfinder

The `IncreasePathfinder` is the opposite to the `DecreasePathfinder`: it adds steps to the path, until its duration is more than the Coherence's minimum duration. It rates all the remaining content-sections and collects as many of the best rated content-sections as needed. These content-sections are grouped by authors and repeats. These collections are added to the path using the method `mergePaths` of the `Pathfinder` (see page 147).

5.3.7 Adaptation

The runtime contexts describe the current state of a Coherence. They are listed as `contexts` in each step. The current contexts are the contexts of the selected step in the history. Any context relevant action causes adaptation by varying the current contexts:

- user goes ahead by pressing the *like* or *dislike* button
- user selects any other content-section than the proposed one
- content changes (e.g. by any manipulated context-relevant GUI element, or by the result of an assessment).

As contexts are only relevant for pathfinding, changes are updated directly before pathfinding and after the user has selected the next step. Some user actions also directly influence the rating of paths.

If the user has pressed the *like*-button, all context changes caused by the current content-section and content-type are performed: `setContexts` create or update the current contexts, `releaseContexts` delete contexts with corresponding names. Additionally all changes by the content create or update the current contexts. If the user has pressed the *dislike*-button, no contexts are changed as described previously, but the user-contexts are approximated to the author contexts, and paths that are assigned to the same author as the rejected content-section are rated worse.

Choosing any other content-section than the proposed one may have two impacts: If the user skips any steps, the omitted content-sections are collected in `skipped` of the `userCoherenceController`. Henceforth, the pathfinder creates paths with and without the skipped content-sections, where paths containing skipped sections are rated worse. For testing, the demonstrator decreases the rating rather harsh by -1 to easily illustrate the changes. If the user selects a content-section of any other path than the proposed path, the user-contexts are approximated to the author contexts of the selected content-section.

In summary: If the user acts as proposed by clicking the *like*-button and choosing the first step of the best rated path, then the current context is changed by the content and its metadata (`setContexts` and `releaseContexts` of the current content-section and type). Otherwise the contexts and path ratings are adapted regarding to his action.

5.4 Graphical User Interface

To get an idea of the look and feel of the prototypical implementation of Coherence, this chapter presents its graphical user interface. First the login is shown, because it is the same for all the three applications. Thereafter the GUIs of the three applications are shown in their own sections. Details of editor and monitor views in the application scenario of the evaluation test content are shown in section 6.5.3 *Arranging the Coherence Prototype* on page 185.

Because Coherence is a web application, no installation is needed. It can be started by just navigating to the right URI with an Internet browser just like a normal website. After the browser has loaded the application and all the necessary data, it presents the login screen, see figure 47.

The username is only used to distinguish between different users. A security layer with password input or the similar is normally part of a learning management

system. Security is not part of this research, so no kind of security layer has been implemented. Hence, Coherence does not ask for a password or any other credentials.

If the user does not exist in the system, he can register and type in the necessary information: first name, last name, and username, see figure 48.

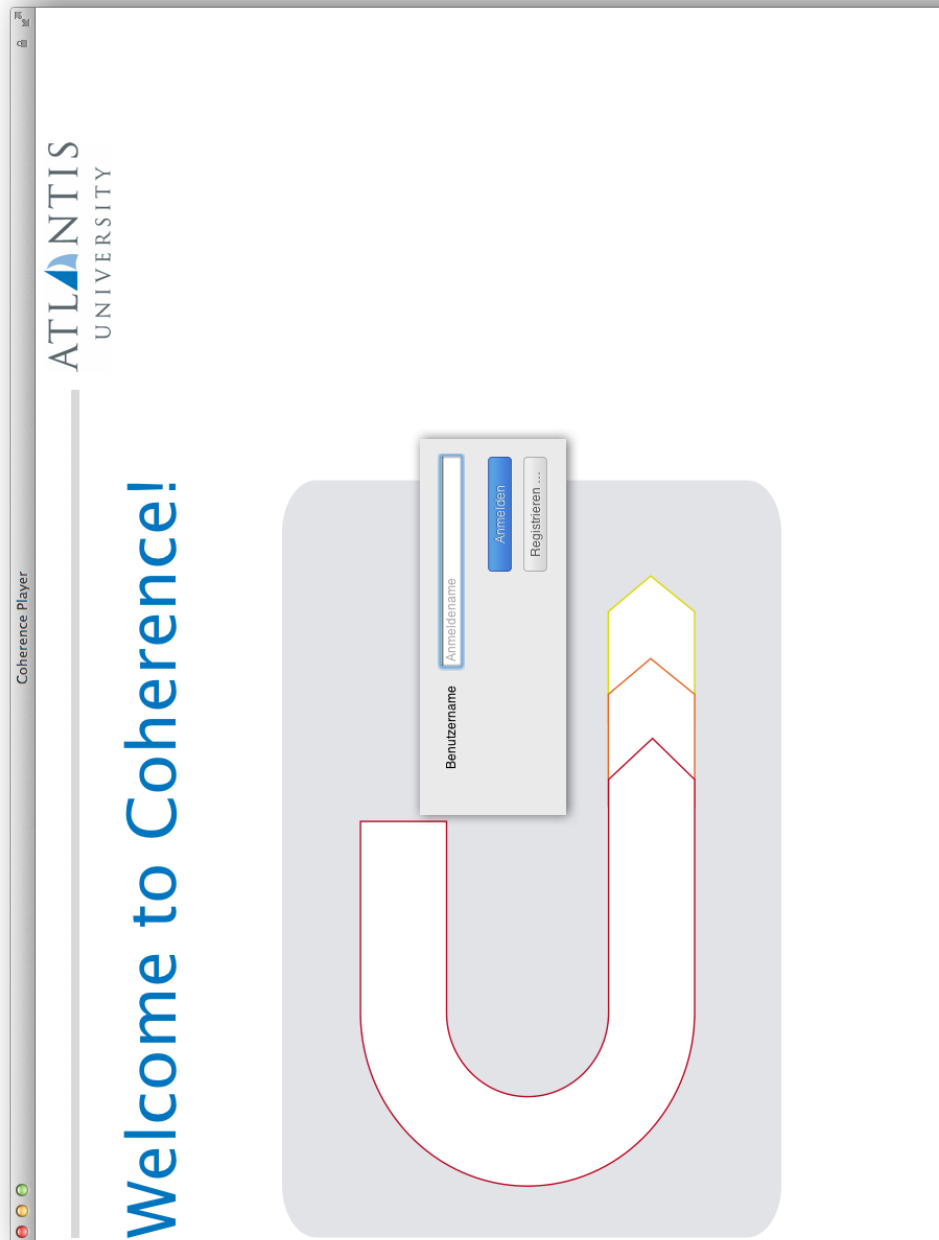


Figure 47: Coherence Login: The username is needed for login. Alternatively a new user can start the registration process.

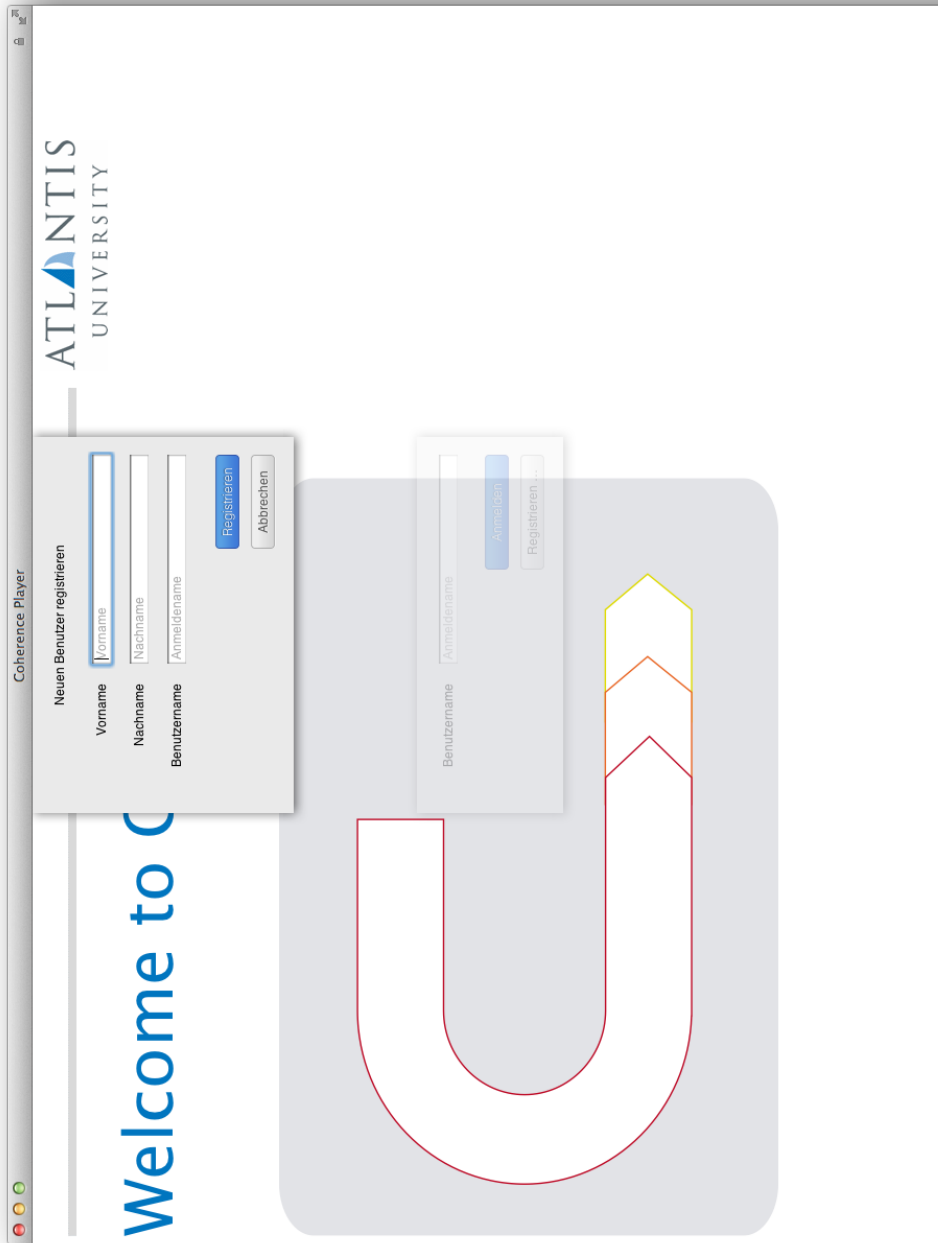


Figure 48: Register new user: A dialogue window asks the user for the necessary information.

5.4.1 Player

After login the user gets all available Coherences presented. He can choose the Coherence he wants to start or continue out of the list, see figure 49.

Then the player starts presenting the content, see figure 50. With the history on the left side of the window, the user can revise already presented content. The progression bar on the top right shows the user's progression within this Coherence. With the buttons on the bottom right the user can pause the Coherence or start the pathfinder to continue to the next step.

After starting the pathfinder, a pane shows the already found paths, ordered by their rating (see figure 51). The best rated path is on top, so that the suggested next step is the one that can be found in the top left corner. Meanwhile, the pathfinder looks for further paths in the background, hence the list increases while it is shown. The user can pick one of the content sections to proceed. After he has chosen the next step or cancelled the pathfinder process, the pane disappears to show the next step of the Coherence.

5.4.2 Editor

The editor enables authoring Coherence structures, see figure 52. The GUI follows the master-detail paradigm: A tree on the left side represents the Coherence structure. The right side shows the editing interface that is customised for each element. If applicable, it also presents a preview.

The Coherence Editor is not a real authoring suite. The editing structure just follows the technical structure of the Coherence. This is suitable for technically oriented people, but others might need some help to use this tool.

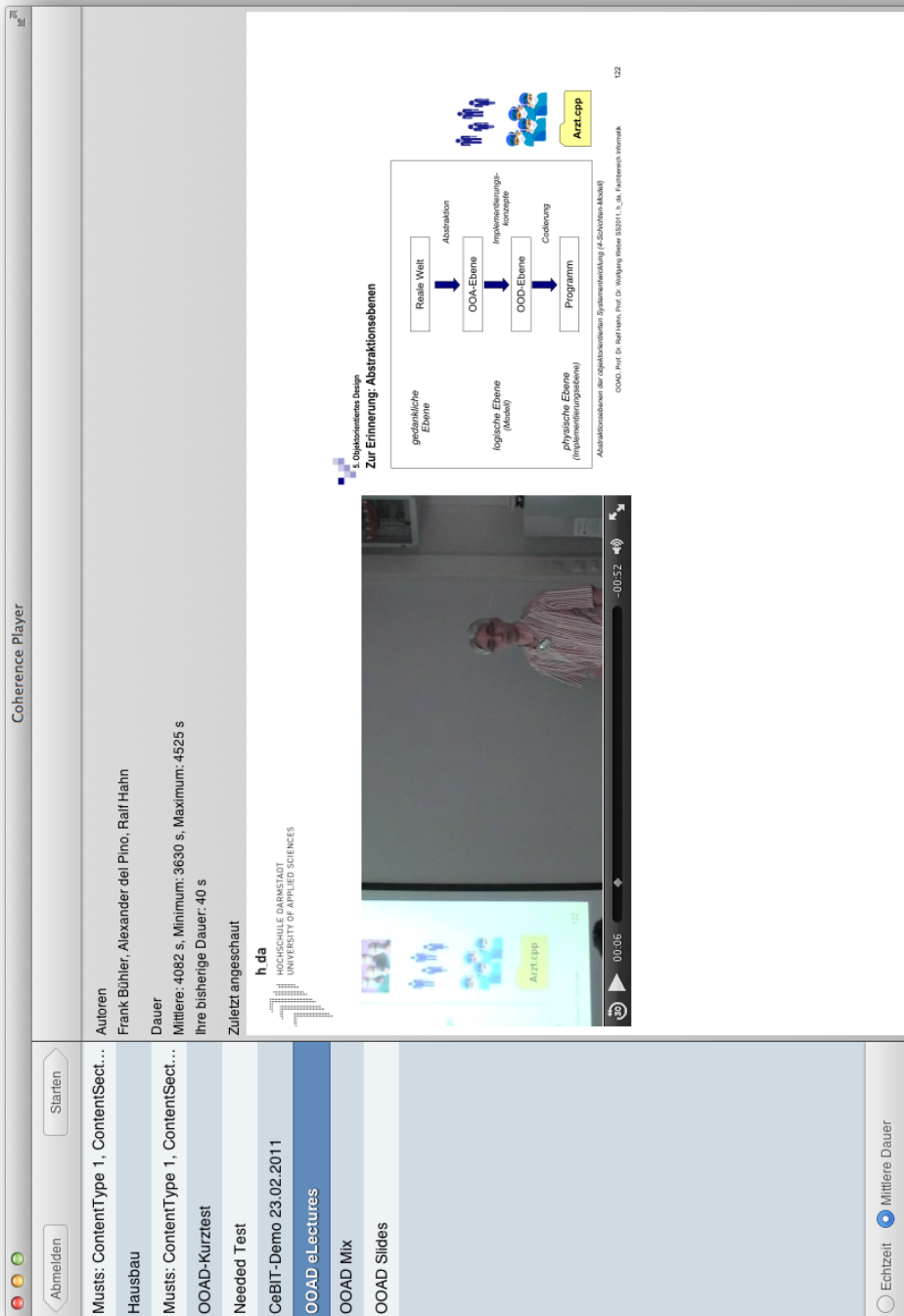


Figure 49: Select Coherence: The desired Coherence can be chosen from the list on the left side. Details about the selected Coherence, such as duration and a preview, are shown on the right side.

Permission to reproduce the slide and the screenshot of the eLecture in this figure has been granted by Ralf Hahn and Wolfgang Weber.

The screenshot displays the Coherence Player interface. At the top, it shows 'OOMD eLectures' and 'Coherence Player'. The main content area is split into two parts:

- Left Panel (History):** A list of previously viewed content sections, including 'Hahn eL 121 Titel Objektorientierte...', 'Hahn eL 122 Erinnerung: Abstraktio...', 'Hahn eL 123 Erinnerung: Phasenm...', 'Hahn eL 124 Zwischenstand', and several 'del Pino' entries related to UML 2. The current section, 'Hahn eL 127 Darstellung von Kla...', is highlighted in blue.
- Right Panel (Content):** A video player showing a lecture slide. The slide title is '5.1.1 Darstellung der statischen Systeme, Klassen und die UML Darstellung von Klassen, Attributen und Methoden'. The slide content includes:
 - UML Class Diagram:** A class named 'Window' with attributes: '# grossesX: Integer', '# grossesY: Integer', '# position: (x: Integer, y: Integer)', and '# standardGrosse: Floats'. It has methods: '+ darstelle: None()', '+ maximiere()', '+ minimiere()', '+ verändere: Grosse (floatX, floatY)', and '+ ausgabe: Flaeche () - Flaeche'. A 'Parameter' box points to the 'ausgabe' method, and a 'Rückgabewert-Typ' box points to the 'ausgabe' method's return type.
 - Legend:**
 - geschütztes Attribut (indicated by #)
 - privates Attribut (indicated by #)
 - öffentliches Attribut (indicated by +)
 - Klassenattribut (indicated by #)
 - Öffentliche Operation (indicated by +)
 - Klassenmethode (indicated by +)
 - Specification Beschreibung:** A box labeled 'Typ' pointing to the 'ausgabe' method.

At the bottom of the interface, there is a 'Verlauf' (Progress) section with a 'Löschen' (Delete) button.

Figure 50: Coherence Player presents a content-section: The right side presents the actual content and above it the played time in relation to the Coherence’s overall duration. The left side is the history that lists all the already presented content-sections of the user’s personal path.

Permission to reproduce the slide and the screenshot of the eLecture in this figure has been granted by Ralf Hahn and Wolfgang Weber.

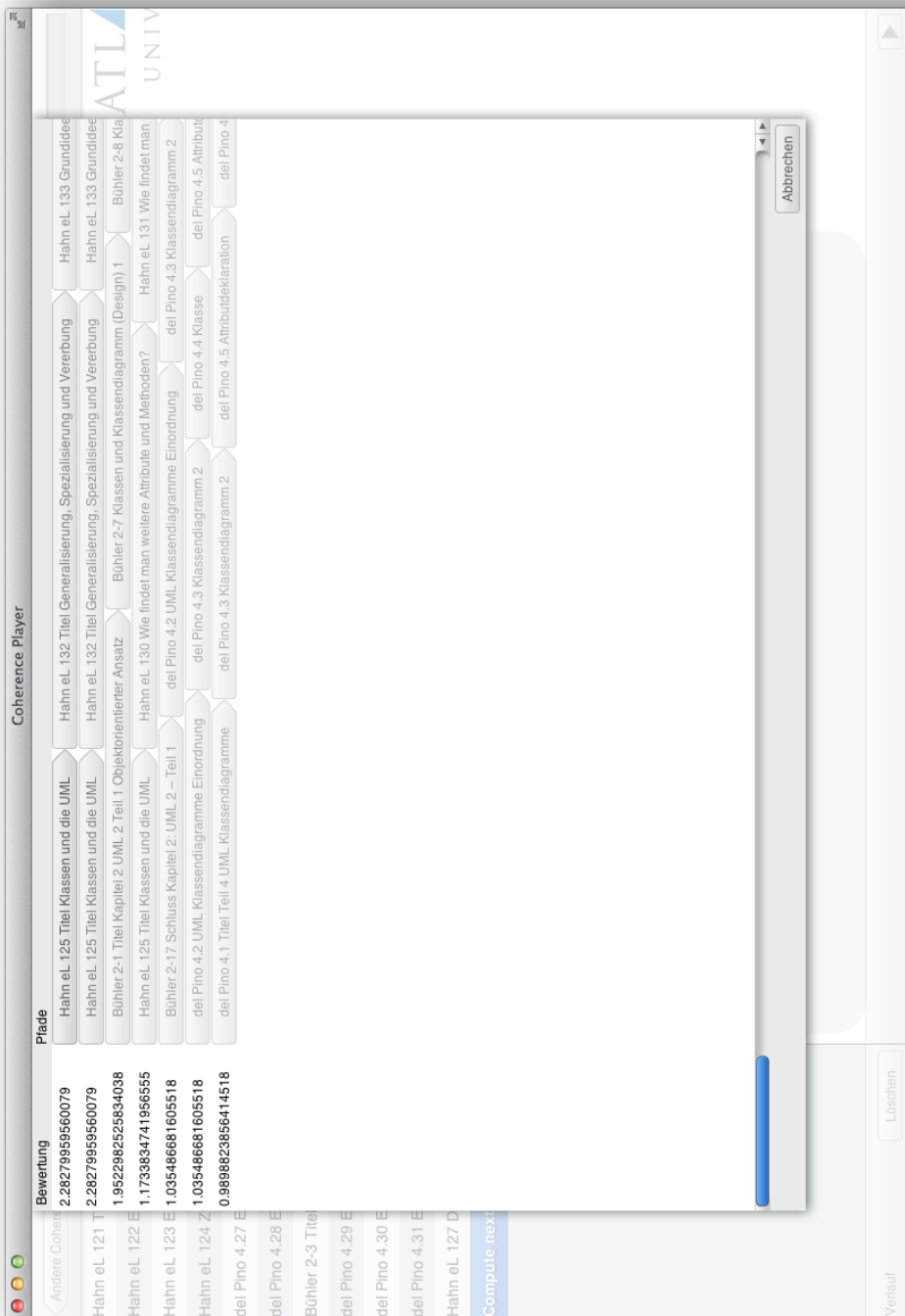


Figure 51: Pathfinder pane to select the next step: It displays a sorted list of paths, the topmost path being the best rated one. Each path lines up all its steps in chronological order. Top left is the best rated step and therefore the system's suggestion to the user.

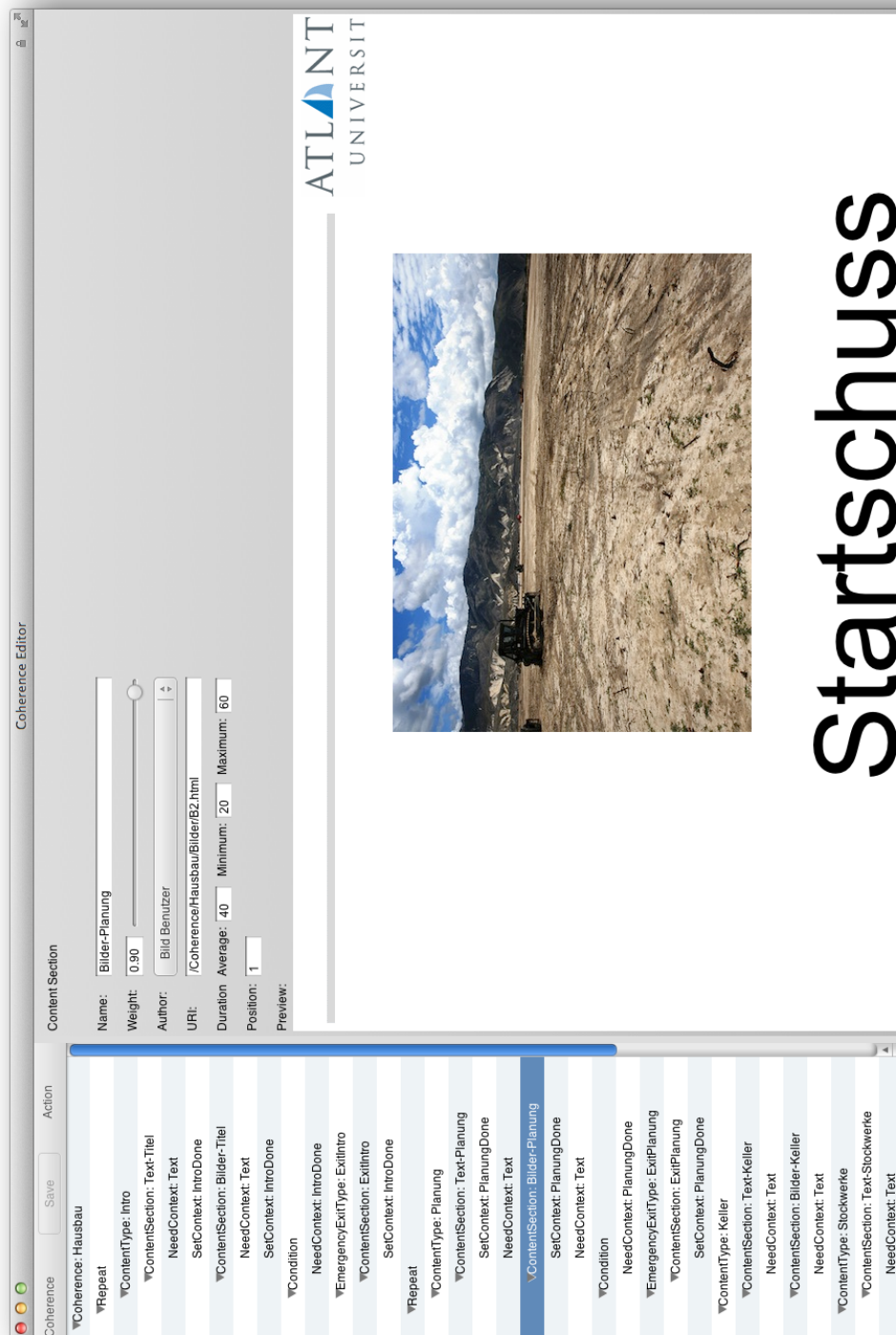


Figure 52: Coherence Editor: The left side shows the tree structure of the Coherence Model. On the right side the details of the selected item are displayed and can be edited. As shown in this screenshot, there is a preview for ContentSections.

5.4.3 Monitor

The Coherence Monitor presents the runtime structure, see figure 53. Like the editor, it uses a master detail view: The left side shows the structure, while the details of a selected element are presented according to key values on the right side. The values can be edited.

The monitor is a very basic but helpful tool to monitor running Coherences. Comparable to a debugger, it shows all the details of the current state. For testing purposes the possibility of editing the values helps a lot. In this way, changing the contexts can be simulated, or the duration can be changed to fit specific needs.

5.5 System Requirements

Coherence is a typical web based client server application. Hence, the basic requirements are a web server on the server side and a web browser as a client. The following paragraphs provide some more details.

5.5.1 Server

The demands to the server operating system are very common: It could be any system that is able to run a web server and CouchDB. The operating system's filesystem has to provide symbolic links. Additionally, standard mechanisms for interprocess communication like (named) pipes are needed. Last, the system must provide a real shell with input/output redirection. Each Unix or Unix like system fulfils these demands, but Windows cannot be used. The installation has been tested to work on Mac OS X 10.8 Mountain Lion, Mac OS X Server 10.8 Mountain Lion, and Ubuntu 11.10 Linux.

The document based CouchDB is used as database server. Any 1.x version should work, and the Coherence prototype has been developed and tested to work with CouchDB 1.0.2.



Figure 53: Coherence Monitor: Works nearly the same as the editor (see figure 52). The left side shows the tree structure of the Coherence Runtime Model. The middle view lists all attributes, and their corresponding values are shown and can be edited in the list on the right side.

The requirements for the web server are very basic: It needs to serve the content as HTML. For integration of CouchDB it needs a reverse proxy to redirect URIs to other ports. Apache 2.x has been tested to work.

5.5.2 Client

Each modern W3C compliant Internet browser can be used as client (of course no text based browsers such as Lynx). Coherence uses a lot of HTML 5 technology like SVG, Cascading Style Sheets (CSS) 3 transitions and animations, and web workers, so it needs to be supported by the browser. The current versions of the web rendering engines WebKit, Gecko, and Presto fulfil these demands, but Trident does not. This means that among others Firefox, Safari, Opera, and Chrome are supported – but Internet Explorer is not. Coherence has been tested to work with Safari 6.0 on Mac OS X and Firefox 10.0.2 on Linux, Mac OS X, and Windows.

5.6 Summary

This chapter has shown how the prototype that is based on the findings and concept presented in the previous chapters has been implemented. Therefore, the scope has narrowed to an application that is usable for prototypical testing and evaluation, but not a fully featured or integrated system. Authoring annotations needed for adaptive learning content can be added and modified using the Coherence Editor. The player presents the adaptive content, while the Coherence Monitor is used to monitor the internals of content presentation while playing the content.

The applications have been designed and developed as web applications and so that they can be used as online services. This makes it also easier to integrate it with common LMSs.

To generate the paths proposed to the learner, pathfinders that demonstrate the concept have been implemented. There are additional pathfinders possible to

handle other scenarios, like optimising the path to one lecturer's content instead of optimising to the learner's decisions. These should be designed, implemented, and tested in future research.

5.7 What's next

After having implemented a prototype, the concept can be tested and evaluated on a working system. The following chapter describes the evaluation, using parts of real lectures, authored and presented using the Coherence Services.

Chapter 6

Evaluation of the Concept by Research Interviews

The theoretical and practical work on this research project has been described in the preceding chapters. Within this chapter the evaluation of the outcome and the thesis is presented.

After discussing the aim of this evaluation, the expert interviews themselves described and why this kind of inquiry has been chosen. This is followed by sections that provide an in depth look at the evaluation process for this research project. Lastly the outcomes of the interviews are discussed.

6.1 Aim of Inquiry

As the objective of this PhD research project is a new concept that simplifies the authoring of adaptive learning content compared to current concepts and approaches, the main question of this inquiry can be formulated as follows:

Does this concept of structuring content have the capability of simplifying authoring of adapted eLearning content?

This can be seen as evaluating the usability of the concept for authors who, in this case, are usually lecturers.

In order to answer the main question secondary questions have been formulated that should be also discussed with the evaluation:

- Does the concept support common ways of authoring (learning) content?

One of the main approaches of the concept developed in this PhD research project is supporting authors by adopting their common ways of thinking and creating content structures. It is of interest if this goal has been achieved.

- Does the concept support creation of adaptive (learning) content?

As the concept of this research project should help the creating of adaptive content structures, it is crucial that it not only supports authoring but that the outcomes can be used as structures for adaptive content.

- Is the concept suitable for learning purposes?

This PhD project focuses on the learning purposes of created content structures. Although it would be excellent if this goal could be achieved for other purposes or in general, it should first be checked that the results can be used for learning settings.

- Does the adaptation support common ways of helping learners, for example in the case of comprehension problems?

This question focuses on the kind of adaptation that is supported by the concept and specifies whether it is expected to support learning in a way that learners are used to.

It is not only of interest to confirm whether the goals have been achieved but also if the underlying assumptions are correct and have been met by the concept. Whether the concept support authors in other ways than intended should also be clarified. Hence, additional secondary questions that are based on those above have been added:

- How does the concept support common ways of authoring (learning) content?
- How does the concept support creation of adaptive (learning) content?
- How is the concept suitable for learning purposes?
- How does the adaptation support common ways of helping students, for example in case of comprehension problems?

Some additional aspects have influenced the way the evaluation has been undertaken: The target group and the way the prototype Coherence should be used for evaluation purposes.

While a completely implemented and integrated concept would target both lecturers and learners, in both the roles of author and consumer, this research and therefore its evaluation focuses on lecturers as authors. Learners are the target group for any adaptive eLearning outcome that has been created within an authoring process designed for that. A perfect environment that might be realised based on the concept and approaches described in the previous chapters would and should ultimately help learning. As an essential preceding step before anyone can start learning with adaptive content, the content itself and its structure still need to be created. But whilst even a perfect authoring environment – of course – cannot guarantee that premium content is created, it is a requirement that the intended authors can get along with the concept, the workflows and the tools.

Evaluation of the technical feasibility of the concept has already been carried out by realising the research prototype which is also used to test the workflow by creating the content and structure for the evaluation. Additionally, it is used during the evaluation to enable the evaluators to get an impression of the look and feel of the envisaged realisation of a completed system.

However, it was necessary to make sure that the concept was evaluated, but not the prototype, because the realised tools should only demonstrate its feasibility and give an idea about intended usage. Arrangements are needed that prevent the

prototype, including its interface and the demonstration content, creating a bias in the results of the evaluation.

The following sections will describe how these aspects have been used to find a way to evaluate the concept, and how the evaluation has been performed.

6.2 Method: Expert Interviews

After formulating what should be evaluated a discussion is needed about how this could be done. Therefore a suitable evaluation approach needs to be selected and adapted to the needs of this research project.

As has been described in the preceding section an evaluation should be carried out to see if and how the concept simplifies authors' work in creating adaptive learning content. This research project focuses on users' perceptions of the developed concept, and as such it has been seen as testing the concept's usability.

Van Velsen et al. have noted that in contrast to user-centred design practices, questionnaires are extremely popular for the evaluation of adaptive and adaptable systems and even for usability questions. They remark that questionnaires seem to be the "quick and dirty way". However, "Issues that call for an extensive review of the system, like usability, require other, more exhaustive methods" [122, p 274]. Regarding more exhaustive methods they suggest qualitative research methods that are well known in social sciences, like interviews or focus groups.

Qualitative research interviews have been adopted from social science and are used to get individuals' points of view on an investigated subject. Because any influence may disturb individuals' perceptions and maybe even more their ability to realise and talk about them, there needs to be as little as possible that might disturb the interviewees. Social scientists need to be extremely careful about this because often they investigate highly sensitive subjects, welfare cases and fringe groups like HIV infected persons, vagrants, immigrants, delinquents, etc. Hence,

these interviews have and need to sustain a very intimate character and therefore need to be in confidence.

According to Lamnek, interviews are usually individual surveys of a mediative character [74, p 60]. Qualitative interviews investigate the interviewees' interpretive and action patterns and develop them in the course of a conversation. Interviewees are not only seen as a data-source, but as individuals who determine the conversation. They define the point of view and perception and should not be influenced by the interviewer. Thus the researcher needs to adapt to an interviewee's conversation style by being open and flexible and thus amenable to unexpected information while being able to react to an interviewee's demands [74, p 64].

Even though usability researchers usually do not work in and with highly sensitive subjects, they still need to consider that reflecting on usability is a fragile process that can be easily biased and therefore may lead to invalid results. As in the social sciences, anything may influence an interviewee such as design, content, keyboard and screen, but also factors like environment, mood, lunch, light, temperature, etc. The questions that should be asked during the interview need special attention because not only how and what is asked may bias the outcome but also the very fact that a question *is* asked. In more technical terms: Measurement itself influences the item to be measured and therefore the measurement result.

Qualitative research methods are relatively new in information science, including research in usability as well as adaptive and adaptable systems. In 2000, Hartson et al., for example, did not even mention methods like interviews. Moreover, because of "Not being statistically significant", they criticised the fact that qualitative data cannot "contribute (directly) to the science of usability, but are valuable usability engineering measures within a development project" [59, p 149]. Additionally, they noted the general problem that "researchers are far from agreement on a standard means for evaluating and comparing UEMs" (usability evaluation methods) [59, p 146].

Earlier in 1988 Kaplan and Duchon propagated combining information system researchers' traditional evaluation methods with social research evaluation methods [69]. They stated that information systems researchers' exclusive reliance on the methodology of formulating hypotheses that are tested through controlled experiment or statistical analysis have been criticised in the social sciences: "... the simplification and abstraction needed for good experimental design can remove enough features from the subject of study that only obvious results are possible" [69, p 572]. Combining methods introduces testability and context into research and increases the robustness of results through triangulation [69, p 575]. Because social research often demands the involvement of many uncontrolled and unidentified variables, "Qualitative strategies emphasize an interpretive approach that uses data to both pose and resolve research questions" [69, p 573]. While interpreting the collected data, social researchers usually attempt to understand an other's way of construing, conceptualising, and understanding events, concepts, and categories [69, p 572]. Although quantitative methods provide better results in statistical terms, they see the value of qualitative social research methods in giving "richer explanations of how and why processes and outcomes occur" [69, p 573].

The strength of qualitative methods in interpreting data through understanding other individuals' ways of seeing, feeling, and doing, makes them attractive for usability testing. Both research disciplines investigate human perceptions of items and conditions, something necessary for this research project that concentrates on user experience of the developed adaptive learning concept. Weßel states that qualitative methods target understanding and explaining [127, p 928]. Using these methods is user centred because a computer scientist's point of view changes from information technology to the user's view [127, p 934]. Qualitative methods focus on learning about backgrounds and reasons and are able to gather information that cannot be captured in the same form by quantitative methods. Regarding IT-projects, interviews are used to investigate concrete possibilities of software development

and implementation [127, p 929] and to understand relationships. In particular, semi-structured interviews facilitate the obtaining of new insights [127, p 927].

As mentioned above, van Velsen et al. confirm this opinion: “Interviews may also be used to assess the usability issues that are typical for personalized systems since it allows detailed feedback. As a result, not only can problem areas be identified, but also perceived causes and solutions.” [122, p 270] They state that interviews can be used to analyse a system’s usability and to get information about the intention behind its usage [122, p 275]. They go one step further and criticise methods like closed item questionnaires as being limited to accessing only known variables. As a result they prefer more exploratory methods such as interviews, and may use the gathered data later as input, for example to create questionnaires: “Because little is known about the interaction between user and personalized systems, it may be best to use exploratory methods to assess important variables. In a later phase, these variables can serve as input for confirming methods (like questionnaires).” [122, p 274]

Van Velsen et al. divide the development process into four phases, see figure 54. For testing the concept of this research with the help of an early stage prototype, regarded as low-fidelity prototype, the second phase seems to be most suitable for the goal of this evaluation: “The second phase in the development process deals with the ideas behind the system and the techniques that are supposed to embody these ideas. A low-fidelity prototype can visualize them, and from this moment on, UCE (User-Centred Evaluation) becomes an option.” [122, p 274] The evaluation variables of this phase, appreciation, future system adoption, and perceived usefulness, address comparable research questions to those formulated in the preceding section of this thesis. Not addressed until now, the variable *trust and privacy issues* becomes a very important variable through the interviews and will be discussed subsequently.

The low-fidelity prototype Coherence can be additionally used to locate critical issues. It enables evaluators to look at and discuss the concept behind the system

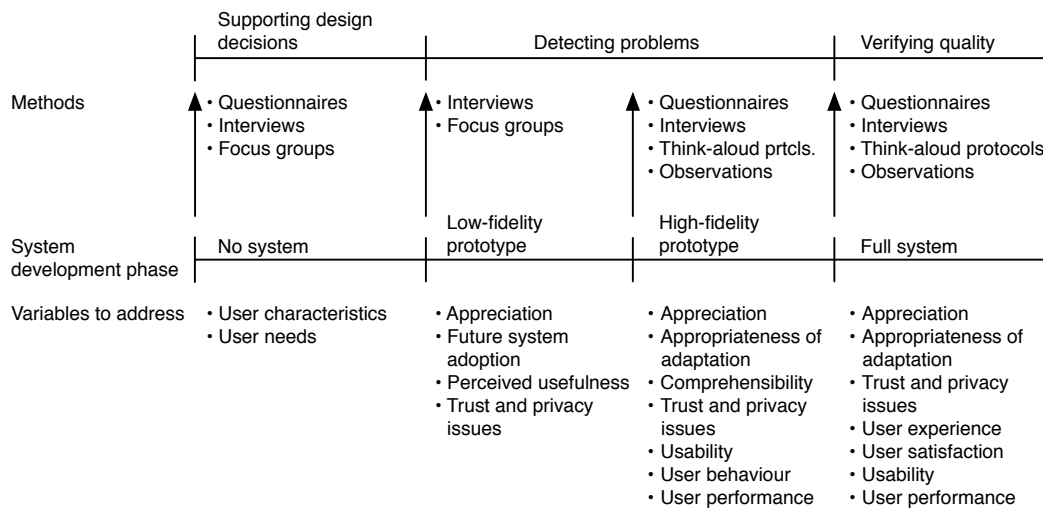


Figure 54: The iterative design process and the role of user-centred evaluation for personalised systems [122, p 273]

Permission to reproduce this figure has been granted by Cambridge University Press.

and the content. But it needs to be considered that discussing a concept is abstract and as such will generate abstract outcomes – discussing a concept’s usability is even more abstract. “Therefore, in low-fidelity prototyping, one needs methods that are flexible and can cover aspects in depth, like interviews and focus groups.” [122, p 266]

The user’s view, and more precisely the expected experience of authors using an environment that needs to be developed and will be based on the concept of this research project, should be investigated in this evaluation. Thus not only direct answers to questions are of interest but also background information about the answer and, additionally, gathered aspects that have not been foreseen.

It was thus decided to use interviews, partly in conjunction with the low-fidelity prototype. The interviews are analysed using quantitative and qualitative methods that are discussed later in section 6.8 *Analysis Process* on page 200.

6.3 Methodological Aspects

Van Velsen et al. give a short and general overview about research interviews: “In interviews, participants are asked questions in person by an interviewer. Interviews can be structured, with fixed questions, or semi-structured, if the interviewer can also ask questions that come up during the interview.” [122, p 269]

In [74, p 68], Lamnek gives more details but has a stricter view: He states that qualitative interviews should not be standardised, meaning that questions are not worded in advance and there is no specific order to the questions. Because interviews are not standardised he sees closed ended questions as unfeasible. Instead open discussion techniques should be used and the interviewer should be stimulative passive (all [74, p 68]).

He also formulates additional aspects: According to the interviewees, to obtain genuine information, qualitative interviews should take place in the interviewees’ daily environment to allow a natural setting. Qualitative interviews are not suitable for large number of cases. Compared to standardised surveys, qualitative interviews demand greater competence of the interviewer and he needs to ensure that audio or video recording equipment is used to record the abundance of information [74, p 68].

Weßel holds a similar view [127]. She states that interviews in the area of software engineering should be semi-structured and based on guidelines. The interviewee is treated as an expert in his domain and for this reason semi-structured interviews are also called expert interviews. Guidelines on the one hand allow the interviewer to follow a structured approach during the interview while on the other hand it enables the interviewee to feel free to discuss. This gives the interview a freedom for the detection and describing of issues and solutions of unforeseen and therefore new aspects [127, p 929].

The evaluation was prepared and conducted having assessed such advice and tending towards Weßel’s view. She has previous experience of reporting on a computer research project’s evaluation, is more specific in terms of the research area than

Lamnek, and gives more details about how to perform an expert interview than van Velsen without contradicting his explanations. Additionally, and in contrast to social research, it seemed to be more important what the interviewees discuss than how they discuss. The interviewees' social milieu is not decisive for discussing the questions, but their experience with and opinion about the concept and related topics is uppermost. No closed ended questions were used so as to encourage the interviewees to discuss their own opinion and raise new aspects. Thus an interview guide was prepared and used as a guideline for these semi-structured interviews. To ensure that the interviewer met the desired requirement of having sufficient knowledge and background in the research area and project, the author of this thesis conducted the interviews himself. The interviews were mostly recorded using a notebook's audio recording facility.

6.4 Interview Guide

In preparation for the interviews an interview guide was developed that is based on the main and secondary questions of section 6.1 *Aim of Inquiry* on page 163. A semi-structured interview with open ended questions was used to facilitate a free and in-depth discussion about the aspects of the concept under evaluation regarding its expected usability for authors. The questions were used as a guide throughout the interview using the prototype of proposing one possible way of run time implementation based on the concept to enable the interviewees to get an idea of its mode of operation.

Weßel has described four phases of a semi-structured interview [127, p 931]:

1. Introduction
2. Exploration of the current situation
3. Exploration of the prospective situation

4. End

The exploration phases have been reformulated more precisely and adapted to the needs of this evaluation. The introduction and end did not need any adaptation as they were used to welcome and say good-bye to an interviewee. Additionally, a short overview of the objectives was provided.

The goal of the second phase, the exploration of the current situation, was to gather the interviewee's opinion about the current situation in authoring adaptive content, and in particular authoring adaptive learning content. Additionally, to get more background information, their favoured way of teaching, creating learning content, and their adaptive behaviour while lecturing was of interest. This phase needed to remain unbiased by the work of this research project, so nothing was explained or demonstrated beforehand.

The third phase, the exploration of the prospective situation, was used to discuss the concept as an outcome of this research project regarding its expected influence on the work of authors in the future. Therefore, the purpose of the third phase was twofold:

1. Presentation of the concepts and demonstrating the prototype Coherence, including a hands on approach.
2. Discussion of the concept.

This interview design allowed a comparison of the interviewees' general expectations expressed through their comments on the concept. Additionally, the demonstration and hands on phase allowed the collection of valuable data about their impressions and immediate feedback while seeing and using the prototype, as well as discussions that occurred during the presentation.

Because the presentation and hands on aspect were expected to deliver important data, they were seen as an additional phase in the evaluation design. An adapted list would thus consist of five phases as follows:

1. Introduction
2. Interviewees' background and opinion
3. Introduction to the concept and hands on
4. Discussion of the concept
5. End

Introduction and end have not been prepared in the interview guide. The other three phases are described in more depth in the following sections.

6.4.1 Interviewees' Background and Opinion

To get a detailed impression about the experts' background regarding the topics of this PhD research project, each interview started with questions about the interviewees' experience with creating learning content, either linear, adaptive, or cooperative in teams. Additionally, the interviewees' opinion about current workflows and concepts was questioned, as well as their thoughts about how these could be improved.

This phase should reflect the interviewees' unbiased thoughts and as such they only received a short introduction to the purpose of this interview, without any details about the research project itself.

Questions about the Creation of Learning Content

These questions aimed to capture information about the interviewees' usual way of lecturing and preparation, including content creation. Their answers showed whether their way of preparing and handling students' requests matched the assumptions that led to the concept of this research.

- What is your usual way of creating learning content?

This question should gather data about the interviewees' common content creation workflow that can be compared with the intended workflow of the

concept of this research project. Additionally, letting the interviewees reflect without bias on their workflow is expected to help them rate the concept in the fourth phase by benchmarking it with their statements made in this phase.

- How do you prepare for a lecture?

This is asked to see if any additional preparation is done before starting a lecture that might complete their workflow but which has not been mentioned before.

- What do you do if a student does not comprehend a topic?

The interviewees should reflect on their behaviour while lecturing, as well as if and how they invite, recognise and adapt to occurrences and interruptions. This gives information about how the concept's way of adaptation can be seen to be useful.

Questions about Cooperative Content Creation

The following questions gather information about the interviewees' experience in cooperative content creation. It is not expected that the interviewees prepare most of their content for real life usage in teams, but any experience, whether for real life modules or for research projects, is of interest. In particular their way of cooperating, for example anonymously by reusing and adapting a predecessor's slide set or working on the same content concurrently in a team, how they merged or adjusted the content and what difficulties they had.

- Have you already created learning content cooperatively with other colleagues?

This closed question is used as a starter for the discussion.

- How did you take joint action?

The interviewees should describe how they worked in teams or adapted already existing content.

- How did you find it?

The interviewees should reflect on their experiences.

The following questions gather more detailed information in case of areas that have not already been addressed by the interviewees.

- Did you complement each other?

The interviewees should give more details on how they distributed the work. For example, if there was a leading author, if they worked together on the same topic or if each author worked on his own section, etc.

- Was it hard to make compromises to merge your content?

This question was an option for gathering more information about the merging process and its difficulties.

- How did you address your different (teaching-) styles?

A more detailed question about the difficulty of merging different styles. It is of interest whether it has been addressed and how it has been addressed. It is important to stress this because the concept of this research allows the merging of content without any adaptation to other authors' style.

Questions about Experience in Adaptation

The experts should subsume their experience in authoring, concepts, and the technology of interactive or adaptive content presentations. They are also asked about the applications of their work. Most interesting was its use in any teaching related way.

- What kind of experience do you have with adaptive content (for modules)?

This opener should stimulate the interviewees to report on their work with adaptive content. If necessary, the following questions were used to gain more detailed information.

- How did you create any adaptive content or structures?

As the concept was designed to simplify authoring, the interviewees should

reflect on their experiences of authoring adaptive or interactive content with existing tools and concepts. This information can be compared with the workflows proposed by the concept of this research. Additionally, in conjunction with the following question, it should be clarified whether the interviewee has been working on content creation or more technically.

- How did you design and develop any concepts or engines for adaptive or interactive content?

The interviewees' practical background in adaptive concepts and engines is important in conjunction with the later interview phases, when the interviewees are asked to rate the concept of this research.

Estimation of Current Authoring Concepts

The experts should estimate the current state of authoring concepts and environments for Interactive Storytelling as well as interactive or adaptive content. This information needed to be gathered before the concept was presented and demonstrated, to eliminate any influence on their answers.

- Are existing concepts/environments suitable for authors/lecturers?

The interviewees should give their opinion about current authoring concepts and tools.

- What should be improved?

This question should collect any ideas on possible improvements in the current situation.

- How would you estimate the content/structure creation effort for String of Pearls/Branching/Rule Based Logic?

The interviewees should benchmark the existing basic concepts. This should prepare them for making a comparison of the concept of this research with existing concepts in the third phase.

6.4.2 Introduction to the Concept and Hands On

The experts received inside information about the concept, its authoring aspects, and its runtime behaviour. This began with a slide-presentation that helped to explain the concept and the theoretical aspects. Then the Coherence prototype was shown with a demonstration content described in the following section 6.5: *Preparing the Prototype* on page 180. To prove that the concept can be implemented and to give the experts a practical idea about its mode of operation, they had some hands on experience with the player, the editor, and the monitor. They also could change the structure to see the influence on the result.

No questions were prepared for this phase. However, the interviewees had been encouraged to ask, comment, or discuss whenever they wanted to. This immediate feedback was also recorded to capture data that might otherwise be forgotten and to get direct, straight, and unreflected comments and experiences. It also addresses one point of van Velsen's criticism that "In almost all cases, interviews were conducted after the interviewee had used the system. As a result, experiences and possibly important comments might be forgotten or not deemed relevant, and thus never be reported." [122, p 269]

6.4.3 Discussion about the Concept

The third phase was a discussion to get the interviewees' opinions about the outcomes of this PhD research project. Information was sought as to whether, based on the experts' knowledge and experience, the concept simplifies authoring, supports different content-structures, and is fit for learning purposes. Additionally, limitations as well as improvements were to be discussed.

The collected data was to reflect the interviewees' impressions and ratings, following their own interpretation. Thus the questions were formulated in a way that should encourage the discussion without influencing their opinion. Even though this

phase is, of course, intentionally biased by the presentation and the prototype, it was to give room for the interviewees' own thoughts.

- How would you estimate the effort required for authoring structures for this concept?

The interviewees should formulate their expectations regarding the amount of work needed for authoring using a tool based on the concept of this research.

- How would you estimate its adaptivity?

It is of interest what the interviewees think about the adaptivity provided by the concept and if it meets their needs. Simplifying the authoring process should not result in unusable adaptivity or no adaptivity at all.

- Does the concept support different content-structures?

As the concept of this research is based on merging different authors' structures, the interviewees are asked to reflect on this.

- Is the concept appropriate for lecturing purposes?

The purpose of the concept is to simplify the creation of adaptive learning content. The interviewees should rate its applicability.

At the end the interviewees were encouraged to report their overall thoughts through responses to the three following questions. Because they are self-explanatory, no further explanations are given.

- What are the highlights?
- What should be improved?
- What are the limitations?

During the discussion different tools have been used for explanations whenever that seemed appropriate: the slides, the demonstrator, and a hardcopy of the demonstration content (see appendix C: *Test Environment* on page 317).

6.5 Preparing the Prototype

Besides demonstrating the concept's feasibility, the low-fidelity prototype had been included in the evaluation to enable the interviewees to get an impression of a possible look and feel of the concept that can be gathered and therefore used as additional data to the interviews. Van Velsen et al. state that "Creating a working prototype is relatively easy and cheap compared with creating a full system, and it can help to verify the quality of a product." [122, p 266] However, he indicates that a prototype behaves differently than a finished product. Thus, the results of a prototype evaluation are also expected to be different compared to the results of the finished version. A very valuable feature for this evaluation is that "Participants can comment on the concept behind the system or discuss the functions the system comprises" as long as the low-fidelity prototype provides the evaluator with an idea of the system functions [122, p 267].

Although the results of testing the low-fidelity prototype may differ from a full working system, it was decided that including the prototype is better than getting no additional data. Especially because discussing a concept's usability only in theory is very abstract, the prototype is expected to simplify apperception, and therefore will increase the depth of the following discussion phase. Thus the prototype should help the interviewees gain an overall picture of its look and feel, gain a practical idea about authoring possibilities, and understand what happens behind the scenes. The content should be close to a real life scenario and therefore comply with the following requirements:

- The content should be taken from a real module.

Using real life content gives a better picture of a real life scenario than synthetic test content. It provides real life complexity such as different structures, different wording, etc. It is also expected to demonstrate the real life difficulties of the concept.

- The content must be created by at least three different authors.

The concept does not provide the possibility of adapting one author's linear content. Using two different sets of content would be the minimum. However, it was expected that having only one alternative would behave and feel too binary. Therefore it was decided to use the content of a minimum of three lecturers.

- The content must be about the same topic.

One basic presumption for the concept is that content that should be adapted needs to be about the same topic, which is met with this criterion.

- The topic must be explained differently.

The concept uses differences between content for adaptation, thus the content must be different. As different authors usually have different styles, this criterion should be met automatically as soon as content from different authors is used.

- The structure of the content should be different.

Comparable to the previous point, this stresses the content structure.

- The modules should address the same students (same semester, same study path, same faculty, same university).

Even though differences are needed for adaptation, the target group – students – stay almost the same during a modules. These similarities are demanded with this criterion.

The following sections give more details about the content that has been chosen and how it has been prepared. Additionally they show the steps that have been undertaken to configure the prototype.

6.5.1 Choosing the Content

Because the research project mainly took place at Hochschule Darmstadt, appropriate modules were sought from that university. However, finding suitable content has not been easy. Most modules are associated with one professor and do not provide alternative content from other lecturers. Most of the modules that are given by different people use the same content which has in most cases been provided by one lecturer or developed in teams. Disappointingly the reason for sorting out all but one of the remaining modules was that some lecturers declined to let their content be used for evaluation and testing purposes.

At the end of this process, the lecture “Objektorientierte Analyse und Design” (object-oriented analysis and design – OOAD) was chosen which is part of the bachelor computer science degree course at Hochschule Darmstadt. To tackle the amount of students this course is separated into tracks. Hence, some modules are held by different professors simultaneously.

Choosing a part of the module that should be used for testing and evaluation purposes presented another difficulty. As already discussed the concept and therefore the algorithm need alternatives for adaption. In consultation with one of the lecturers the section “Manuelle Prüfverfahren” (manual test methods) was chosen. However, one lecturer’s content did not include that section at all, while the third lecturer had prepared too little as it consisted of one slide only. Therefore it was not considered usable and so another part was looked for that fulfilled the necessary demands.

The beginning of the second part of the lecture was thus chosen because it met the criteria. Its chapter “Objektorientiertes Design” (object oriented design) is part of all three lectures which are different in structure and design. The first three sections have been imported and used for demonstration as well as evaluation purposes.

6.5.2 Preparing the Content

Due to the lack of an authoring environment the content had to be prepared by hand. It needed to be converted into a proper file format and arranged in a way that the files could be imported easily.

The lecturers provided their content as Portable Document Format (PDF) files. Because the player is internet browser based it needs a web compatible file format. Although most web browsers are able to render and display PDF files it is not a real web (aka W3C) format and the browsers normally use the complete window and cannot be used with other web content at the same time. Therefore the PDF files were converted to SVG using the tool pdf2svg [12]. As a welcome side effect pdf2svg wrote separate SVG files for each page or slide of the PDFs. The converted SVGs could be referenced and therefore integrated into the content structure as shown in the next section.

The concept is based on linking similar content. A graphical tool would support authors in managing and relating content. However, the Coherence editor only provides functionality to set references to content. Ordering and relating needs to be done manually. Therefore ordering and relating the content was done with the help of a paper prototype.

All the content that should have been included for the evaluation had been printed. The hardcopies had been cut to the size of playing cards with each card corresponding to one content-section. These cards were laid on the floor and sorted by their individual slide numbers and grouped by authors (each lecturer got his own row). Next, one of the authors was chosen to be the “first” one and he would be the lecturer who starts the authoring process. The second lecturer’s slides were laid in relation to the first author’s order. If a slide matched, it was laid nearby, visually indicating a similar meaning, so that they are one content-type. If no matching content could be found it was laid to the right of the same author’s previous slide,

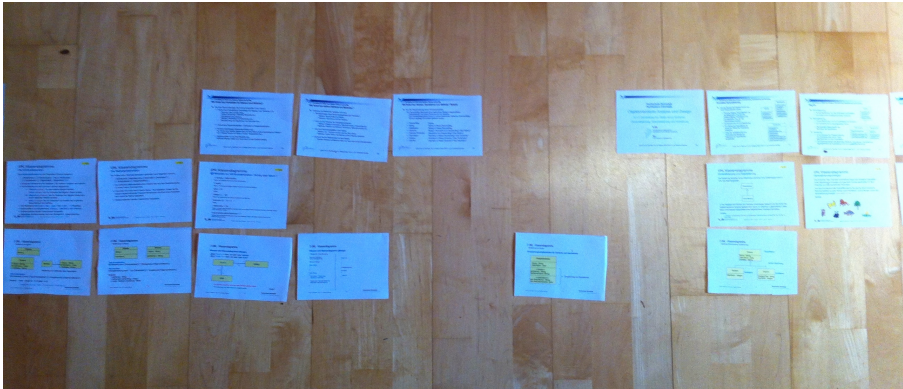


Figure 55: Coherence paper prototype: The photography shows how the hardcopies of the content were ordered on a floor. Each of the three rows consists of one author's content.

building a new content-type. Additionally, a high level classification could be identified that corresponded to the Coherence concept's repeats:

1. Title
2. Introduction
3. Representation of classes in UML
4. Generalisation, specialisation, and inheritance
5. End

Figure 55 illustrates the paper prototype. The content of the three authors was lined up in three rows, one row for each author. It also indicates the grouped order, showing that sometimes the content of all three authors could be related, while in other cases content of only two authors or of none could be related.

After the content was prepared it was then imported manually into the Coherence prototype as presented in the following section. All the preparatory steps discussed in this section should be covered by an authoring environment in a later phase of development that is beyond the scope of this research project.

6.5.3 Arranging the Coherence Prototype

Before the prototype can present any content it first needs to be imported and annotated. Additionally users have to be created in the Coherence prototype: One for each author and one for each consumer (student) that should be tested. To define the users' properties, Coherence's contexts are used. This section will discuss these steps in detail. One user's and the Coherence structure's data can be found in appendix C.3 *Test Environment* on page 317.

As parameters for adaptation, Röll's learner preferences have been used [101] (for further details see section 1.1.1 *Learner Preferences* on page 26). For rating the content, all learner preferences of the current user have been compared with the contents' learner preferences. As described in section 3.3.2 *Content Types* on page 81, in Coherence structures these kinds of parameters are represented by contexts.

Each content-section is linked to the author who has created it. During runtime, the author's context information is added to the list of content-section's contexts. To rate the context-sections, the *nearest* algorithm was used, which means that the content that has the nearest context values compared to the current user's context values is rated best. As a result the content of that lecturer with the nearest learning preferences is rated best. This approach is based on the assumption that a lecturer's preferred teaching style is related to his learning preferences and would be best understood by students that have nearly the same learning preferences and therefore nearly the same learning style. It needs to be stated that this assumption is not proven but is only used for testing purposes.

All users – learners and lecturers – have taken Röll's learner preferences test [104]. Because users belong to Coherence runtime data and the Coherence editor can only edit Coherence structures, the users needed to be edited with the Coherence monitor. First, one user has been created for each author. Six contexts have been added to the users: *Creator*, *Communicator*, *Perceiver*, *Organiser*, *Constructor*, and *Analyst*. The contexts' minimum and maximum both had the same value which was populated

Coherence	Action	Keys	Values
▼User: Oliver Schneider		_id	Oli-Context-Creator
▶Coherences		max	17.53
▼Contexts		min	17.53
Text		name	Creator
Double Test		type	Context
Test 2.1			
Creator			
Communicator			
Perceptor			
Organiser			
Constructor			
Analyst			
▼NeedContexts			
NeedContext: Creator			
NeedContext: Communicator			
NeedContext: Perceptor			
NeedContext: Organiser			

Figure 56: Example Context: This screenshot of the Coherence Monitor shows the context “Creator”.

with the outcomes of each user’s learner preferences test. As mentioned above, the author is automatically added to the content as context, hence the content-sections have been annotated with their corresponding author’s learner preferences. Figure 56 shows a screenshot of an example Creator context edited with the Coherence Monitor, resulting in the following listing:

```
{ "type": "Context",
  "max": 17.53,
  "min": 17.53,
  "name": "Creator"
}
```

Learners could be edited in nearly the same way. The only difference is that it is not *Contexts* but *NeedContexts* that have been added. Because the nearest fitting contexts are looked for, the *comparisonMethod* has been set to *nearness*. For *weight* and *nearest* the default values have been chosen. The values are percentages so they are between 0...100. These limitations have been set using the *limit*, *limitMin*, and

Coherence	Action	Keys	Values
▼User: Oliver Schneider		comparisonMethod	nearness
►Coherences		_id	Oli-NeedContext-Communica...
▼Contexts		limit	true
Text		limitMax	100
Double Test		limitMin	0
Test 2.1		max	19.59
Creator		min	19.59
Communicator		name	Communicator
Perceptor		needed	0.5
Organiser		type	NeedContext
Constructor		weight	0.5
Analyst			
▼NeedContexts			
NeedContext: Creator			
NeedContext: Communicator			
NeedContext: Perceptor			
NeedContext: Organiser			

Figure 57: Example NeedContext: The screenshot of the Coherence Monitor shows the needed context “Communicator”.

limitMax properties. An example for a *Communicator NeedContext* is shown in figure 57 and looks as follows:

```
{ "type": "NeedContext",
  "max": 19.59,
  "min": 19.59,
  "name": "Communicator",
  "weight": 0.5,
  "needed": 0.5,
  "comparisonMethod": "nearness",
  "limit": true,
  "limitMin": 0,
  "limitMax": 100
}
```

After the users were created the content, including its structure, could be imported with the Coherence editor. Its feature of automatically preselecting the logged

in user as the author of the created content helped to save time and avoid errors such as typos.

One *ContentSection* has been created for each slide. The author's name, the page number, and the slide's title was catenated to the *ContentSection*'s name. The duration had been stopped in cases where an eLecture with video was available, taken from the lecturer's notes, or guessed based on the complete duration of all the lessons. The *position* was taken over from the slide's page number. The *url* is a link to the file on the web server. For the *weights* the default value 0.5 was not altered – weighting was controlled with *ContentTypes* and will be explained later. The *author* has been selected based on the logged in user, but could be changed if needed. The following listing is an example for a *ContentSection*, also shown in figure 58:

```
{ "type": "ContentSection",  
  "name": "Objektorientiertes Design",  
  "avgDuration": 40,  
  "minDuration": 30,  
  "maxDuration": 50,  
  "position": 121,  
  "url": "/Coherence/OD/Hahn-eLectures/OD_1.html",  
  "weight": 0.5,  
  "author": "hahn"  
}
```

To build the structure, the order and grouping of the content was taken over to the Coherence prototype as laid out on the floor in the step presented in the previous section and without changes. The group of slides, indicating a similar meaning, had been related by collecting them in the same *ContentType*. Its name was copied from one of the contained *ContentSections* or a short description describing all of them. Again, normally the *weight*'s default value was not changed, but for example the first

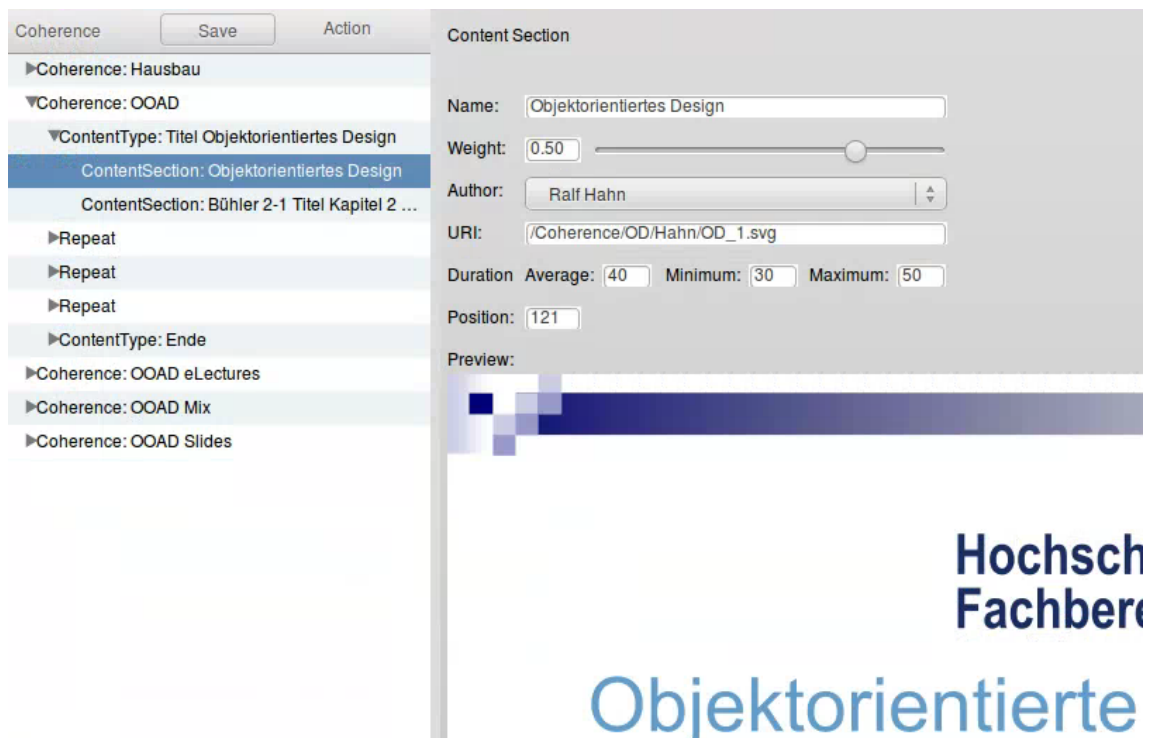


Figure 58: Example ContentSection: This is opened with the Coherence Editor. The values correspond to the listing. The preview shows the linked content. Permission to reproduce the clipping of the slide in this figure has been granted by Ralf Hahn and Wolfgang Weber.

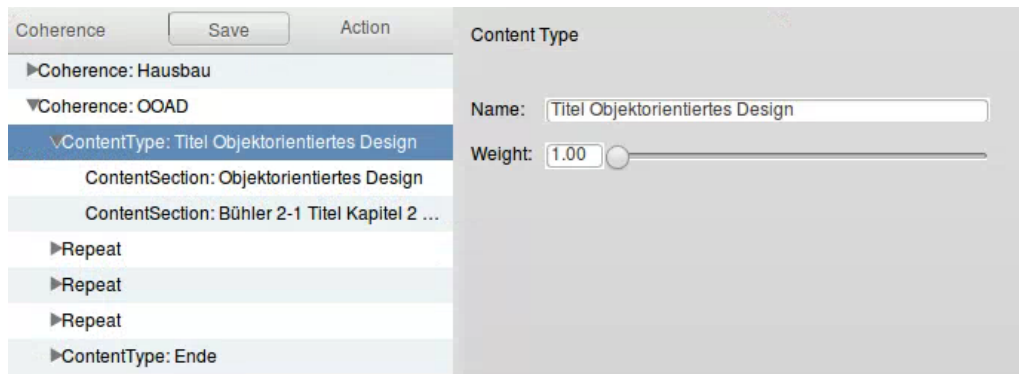


Figure 59: Example ContentType: This content type must be presented, which is indicated by the weight's value of 1. The tree view on the left shows that two content sections belong to this content type.

and last slide had been weighted to 1, indicating that one of the contained slides must be shown. This example shows a *ContentType* (see also figure 59):

```
{ "type": "ContentType",
  "name": "Titel Objektorientiertes Design",
  "weight": 1,
  "treeItemChildren": [...] // e.g. ContentSections
}
```

The overall structure was identified as described in the previous section. The concept uses *Repeats* to form this kind of structure. Each *Repeat* lists all *ContentSections* that belong together sequentially, like pages of a section or sections of a chapter. That content could be repeated until a *Condition* is fulfilled. The title and the end should not be repeated. The slightly adapted structure looks like the following (figure 60 shows the structure presented by the editor):

1. Title
2. Introduction [Repeat]
3. Representation of classes in UML [Repeat]

4. Generalisation, specialisation, and inheritance [Repeat]
5. End

There is no condition for the first repeat, but for the other ones: The second repeat needs the contexts *Class*, *Attribute*, and *Method* to be fulfilled. These contexts are needed with a value of 1. Hence, they must be set. The corresponding contexts are set at different content-sections of each author that presents the corresponding topics. The third repeat needs the context *Inheritance* to be set before the user is asked to proceed. This happens if the user marks any content-section of the content-type *Vererbung Einleitung* (introduction to inheritance), which explains all the necessary basics for this topic. The following examples demonstrates this and additionally figure 61 shows its representation in the editor:

```
{ "type": "Repeat",
  "treeItemChildren":
  [ { // ContentTypes
    },
    { "type": "Condition",
      "treeItemChildren":
      [ { "type": "NeedContext",
          "max": 1,

```

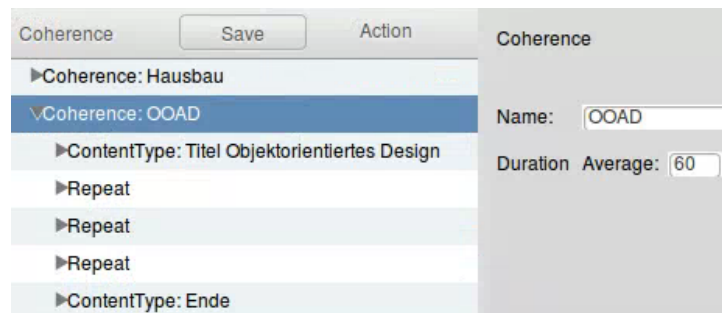


Figure 60: Example Structure: It can be seen that it looks the same as listed in the text: 1. title, 2. repeat for introduction, 3. repeat for UML, 4. repeat for inheritance, finally 5. end.

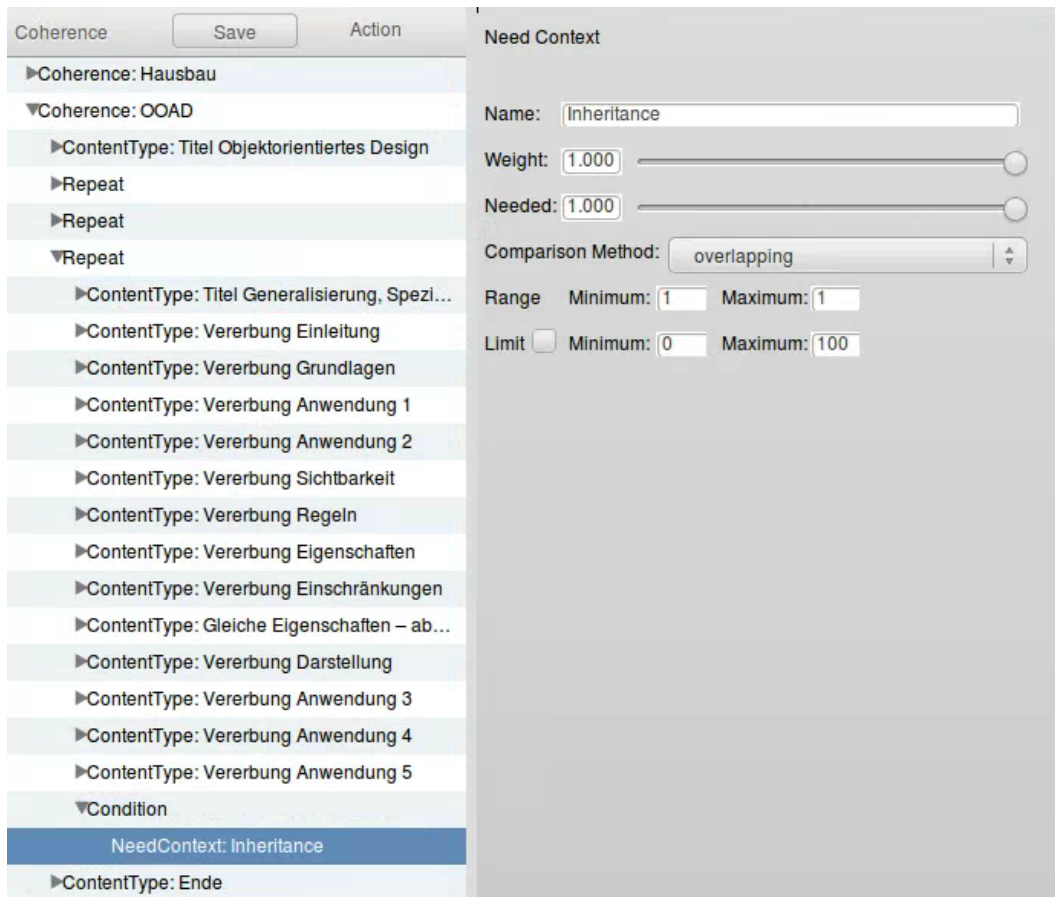


Figure 61: Example Condition: It requires the context Inheritance to be set with the value 1 as can be seen on the right side. The left side shows that it controls the condition of the third repeat.

```

    "min" :      1 ,
    "name" :     "Inheritance" ,
    "weight" :   1 ,
    "needed" :   1 ,
    "comparisonMethod" : "overlapp"
  } ]
} ]
}

```

On finishing these steps the content was imported and structured, thus the prototype was arranged for the interview sessions. It was then ready to present the prepared

content and could also be used to alter the content with the editor and observe the presentation state with the monitor.

6.6 Interviewees

After preparing the interview guide and setting up the prototype there is still a need for adequate interviewees. This section discusses the search criteria and presents the interview partners who were disposed to do research interviews.

According to Lamnek, individual cases are taken for qualitative interviews in contrast to random samples, because this kind of evaluation is about typical cases, not about representativity [74, p 94]. He also states that “Qualitative interviews are not suitable for large number of cases.” [74, p 68]

There had been a dispute about the right sample size for usability studies. Some magic numbers are cited, namely that five [123] or fewer than ten [88] samples are enough, while more recent research inclines to nine samples [64]. Schmettow criticises that all these numbers are based on knowing the total number of existing problems, stating that “The true total number of existing problems is typically unknown a priori, thus violating the completeness assumption.” [105, p 66] and “strong incompleteness usually occurs for datasets smaller than $n = 30$ participants” [105, p 68].

However, this evaluation is not geared to finding all the problems inherent in the concept but the typical problems that should be discussed in more depth. It also should be seen that Schmettow does not write about qualitative interviews but about empirical usability testing and usability inspections [105, p 65]. As a result, the question of the sufficient number was delayed until after the first wave of evaluations had taken place. 14 possible interview partners had been asked to act as interviewees for this qualitative evaluation, with nine agreeing to be interviewed.

The name “expert interviews” does not mean that experts are interviewed, but that the interviewees are seen as experts for the domain of the interview. Special

knowledge was needed to be able to answer the questions that had been formulated in the preceding section's *Interview Guide*. All interviewees should have an expertise in interactive or adaptive content, for example, to be able to compare the concept of this research with existing ones. Additionally, no end-user software has been developed, and many parts that have been integrated for a working prototype have on the one hand to be seen as vague in respect to testing, and on the other hand as influencing an evaluation's outcome:

- It is not confirmed that or how adaptivity helps learning. Hence, the right means of adaptivity is also still being researched.
- This prototype uses Röll's learner preferences model as an application example. Currently the right model and its usage is under discussion. A unified model [95] has been developed, but has not been evaluated in terms of wide usage and different scenarios.
- The content itself may or may not be attractive. Additionally, the content selected for the evaluation fits for that purpose, but that does not mean that all kinds of content may fit – as was demonstrated by the first content that was chosen: Because of missing alternative explanations it could not be used (see section 6.5.1 *Choosing the Content* on page 182 for details).
- The content's preparation influences the user's notion of the content – including the structure and the adaptation behind it.
- The same is true for the application and its appearance. It might happen that the concept itself works, but a user cannot confirm this because of, for example, a badly designed GUI.
- During the research project no authoring environment could be implemented but an editor could help technically oriented people to realise the structure. Without a working authoring environment authors and lecturers cannot see

the concept, because without profound experience in that topic they cannot look behind the curtain.

This highlights the need for interviewees with a profound background knowledge in interactive and adaptive concepts to evaluate the concept behind the low-fidelity prototype. Even with a completely developed authoring environment laypersons would be influenced by the content and the design like the GUI.

Because this interdisciplinary PhD research project touches many fields of science and therefore different points of view are needed to get the complete picture, a heterogeneous group of interviewees was invited. All these interviewees have expertise in one or more of the fields of adaptive learning, eLearning, creation and authoring of non-linear content, research, development and realisation of non-linear content-structures, interactive storytelling, and serious games. Their focus is different, however, as some are computer scientists and some are designers. Nevertheless, all interviewees have a research background. The emphasis has thus been placed on researchers involved in interdisciplinary work, so that those designers interviewed understand the technical background of the concept and its realisation, and the computer scientists know what consequences the concept has to the authors. A complete list of all the interviewees follows with some details about their respective backgrounds:

- Prof. Manfred Gaida is professor of communication design at the Department Electrical Engineering and Information Technology at Hochschule Ulm (University of Applied Sciences Ulm), Institute of Communication Technology. He researches in the fields of Edutainment/Infotainment, Interactive Storytelling, audio-visual rhetoric, and User Interface Design.
- Dr. Stefan Göbel is head of the Serious Games group and scientist at KOM – Multimedia Communications Lab and htcc, both at Technische Universität

Darmstadt (Technical University Darmstadt). He is an expert in serious gaming, authoring, personalisation, and adaptation.

- Prof. Dr. Matthias L. Hemmje is professor of multimedia and internet applications at the faculty for mathematics and computer science of FernUniversität in Hagen (Distance University of Hagen). He is also co-founder of GLOBIT GmbH, a company that develops application solutions for web-based congress information systems and eLearning solutions for the medical profession. His research interests are information retrieval, multimedia databases, virtual working environments, information visualisation, visual man-machine-interaction, and multimedia. He also has experience in sequencing-based adaptive learning technology.
- Prof. Dr. Ido Aharon Iurgel is professor for Media Computing at the faculty Communication and Environment of Hochschule Rhein-Waal (Rhine-Waal University of Applied Sciences). His research interests are computer graphics, novel interactive applications, interactive storytelling, and virtual actors.
- Prof. Dr. Detlef Krömker is professor of computer graphics and vice dean of the faculty for computer science and mathematics at the Johann Wolfgang Goethe-Universität, Frankfurt am Main (Goethe University Frankfurt). He researches the design of graphical systems, visualisation, simulation, and the animation of complex life science systems, and authoring problems in multimedia, mixed reality, and eLearning. He is also director of “studiumdigitale”, the central eLearning institution of the Goethe Universität. These institutions developed “LernBar” [124], an authoring system for web-based training based on the String of Pearls concept.
- Prof. Dr. Wolfgang Müller is professor of computer science and member of the Media Education and Visualisation Group at Pädagogische Hochschule Weingarten (University of Education Weingarten) with a background in game-based

learning, interactive storytelling, eLearning 2.0, information visualisation, and human computer interaction. He has also conducted research into presentation and content adaptation.

- Dr. Heiko Rölke is the head of the Technology Based Assessment (TBA) department at DIPF – Deutsches Institut für Internationale Pädagogische Forschung (Educational Research and Educational Information – German Institute for International Educational Research). He has a profound expertise in the development of complex and distributed systems for large scale assessments. He conducts research on adaptive assessments and process mining of test result data.
- Prof. Dr. Ulrike Spierling is professor of Rich Media Design at Hochschule RheinMain (RheinMain University of Applied Sciences), Department DCSM (Design, Computer Science, Media). She has a deep knowledge of interactive storytelling, interaction design, 3D graphics, user adaptation, and authoring. She has conducted research in these fields since 1998 and has a PhD focused on authoring for interactive narratives. She has worked on interaction and the adaptive presentation of content in many facets, including user experience, authoring, and structures. She also has experience in serious games.
- Dr. Ingo Stengel is a lecturer in computer science at the University of Plymouth, School of Computing and Mathematics (Faculty of Science and Technology). He is an expert in eLearning and has experience with adaptive lectures and their realisation.

All these interviewees have undergone interviews to evaluate the outcomes of this research project. The conducting of the interviews themselves is described in the following section.

6.7 Interview Situation

After the prototype and the introduction slides had been prepared and the interviewees had been invited, the data for evaluation was acquired using interviews and including a demonstration of the prototype and hands on use. Lamnek has stipulated that the interviews be controllable and reliable. The interview situation should be comfortable for the interviewees [74, p 99].

To meet the first stipulation, the interview session should be recorded. On the one hand, because the recordings document the data acquisition, it becomes controllable. On the other hand, remarks can be included to the interpretation making them more reliable. Additionally, technical manipulations like denoising and speed manipulation may allow further findings [74, p 102].

The second stipulation should be to ensure that the interviewees' opinion is primarily leading the conversation. Therefore the location should be comfortable to interviewees, for example by choosing familiar surroundings [74, p 99]. As the interviewees are the experts, not the interviewer, the interviewer should behave as an interested and involved listener and the interviewee should guide the interview's course [74, p 106]. The wording should be the interviewees' own common wording. Of course, the interviewee needs to know the interview's object, purpose, and subject-matter, but without predetermining the interview's course. A tolerant atmosphere is mentioned as being important to obtain reliable data. To establish an atmosphere of trust Lamnek states that confidentiality and anonymity need to be guaranteed [74, p 106]. Of course, the interviewees should be asked their permission to allow recording equipment. The equipment itself should be located discreetly in the background so that it does not influence the interview situation.

These arrangements are recommended for social research interviews when seeking to meet the requirements to get valid data from problematic situations such as interviewing drug abusers. Though this was not the case in this evaluation, it was expected that a trustful atmosphere would lead to truthful and more detailed results.

Hence, accordance with the following list of recommendations for the arrangements were maintained:

- The interviews were audio recorded using a notebook's (MacBook Air) built-in microphone.
- The interviewees had been asked if they agree to the interview being recorded.
- Whenever possible, the interviews were performed via face-to-face sessions at locations the interviewees had proposed. In all other cases videoconferences were tried. If this did not work Voice over IP was used.
- Open-ended questions were used.
- The interviewer tried to give the control of the discussion to the interviewees.
- Before biasing the interviewees with the outcomes of this research project, they were asked to reflect on the state of the art and possible improvements in authoring of adaptive learning structures and related research areas.
- It was promised that no part of the interview would be published without the interviewees' permission.
- Confidentiality and anonymity was assured.

The interviews were very involved and intense due to the fact that it had been previously agreed not to publish them. Altogether they produced 16 hours of recorded audio source material. However, it was necessary to deal with the problem of verification of the authenticity of the collected data. Hence, the interviewees were first asked if they would mind if approved abstracts were published including a section introducing the interviewees themselves. All agreed to this. Later the request needed to be extended to include publication of the transcriptions of the interviews. Only some of the interviewees agreed, mainly because most of them would not have given so much detail if they had known beforehand of any intention to publish the

transcripts. Thus not all the interviews were completely transcribed and only two of those transcriptions could be published.

The following section provides all the translated interview abstracts. The published transcriptions can be found in appendix B.2 *Selected Transcripts* on page 298.

6.8 Analysis Process

After recording the interviews, this source material needed to be analysed. Looking from the side of software engineering and usability, van Velsen et al. propose several systematic approaches, such as using the questions or steps of a process as a thread [122, p 269]. Weßel gives more details on the possible approaches and states that source material should be analysed inductively and deductively [127, p 932]: Codes can be inductively developed from the content. For the deductive analysis, predefined codes are used that are based on the subjects of the interview guide.

As mentioned in section 6.2 *Method: Expert Interviews* on page 166, these methods have been adopted from the social sciences. For example, Lamnek describes four phases for analysing qualitative interviews [74, p 108]: Transcription, individual analysis, generalising analysis, and the control phase. The second and third phases correspond to the inductive and deductive analysis. Lamnek mentions the remaining first and fourth phases because he describes a complete workflow, which includes these steps explicitly.

The analysis of the recorded interviews as source material is based on the proposed steps, using inductive and deductive analysis, with a focus on the latter because no new theory should be developed, but with the research outcomes rated and evaluated. Details are given in the following sections.

6.8.1 Transcription

Before the real analysis could begin the audio recordings needed to be transcribed. The proposed workflow of Dresing et al.'s booklet *Manual (on) Transcription* [41] has been used as a guideline. The focus was set on readability using simple transcripts and omitting paraverbal and non-verbal elements. In contrast to the manual's proposal to position the timestamps at the end of each turn take, the timestamps were placed at the beginning, because it seemed to increase readability. The software F5 [45] utilised the transcription process by providing special functions, for example automatically adding timestamps to the text.

Three interviews had been transcribed completely, at a minimum of one interview with a designer and one with a computer scientist (unfortunately, the names or exact number cannot be revealed for reasons of confidentiality and anonymity). They have also been used to find additional codes (see following section 6.8.2 *Typification*). Because the code structure was kept stable and due to the vast amount of recorded audio data, the remaining six interviews were transcribed selectively, using the following parameters for selection:

- Focus was on the interviewees' statements, hence almost only their speech was described (and not the interviewer's).
- The statements should be directly related to the research, not a side comment.
- The statements should give important and new information.
- They should fit one of the questions or lead to the adding of a new code.

The result was about 250 pages of transcribed text of which 150 pages were full transcriptions. If all the interviews had been transcribed completely this would have resulted in about 400 pages. As a result, about $400 \text{ pages} / 150 \text{ pages} = 37.5\%$ of all interview pages have been transcribed completely. These texts have been used as source material for typification as described in the following section.

6.8.2 Typification

To get the basis to discuss the interview outcomes, the source material needed to be typified, which is done by coding the text with respect to the aims of the inquiry as discussed in section 6.1 *Aim of Inquiry* on page 163. The software f4analyse [44] has been used to support the analysis process. For this evaluation the codes have not been developed from scratch by starting with no codes, but instead the interview questions have been used as a start code structure. Although most of the questions had been open ended and the interviewees were guided through the interviews to a large extent, it was designed in a way that the interviews sought to answer the questions in the interview guide. Hence, most of the source material could be directly assigned to one or more of the questions in the guideline. During the process, a few more codes were added that reflected important topics that came up during discussion. After some revisions, the following new codes were added:

- Introduction/Hands on

Statements that came up during the presentation and about the hands on session have been marked with this code. Most of the comments also fit one of the topics of the discussion phase. Those statements have been marked with multiple codes.

- Definition Adaptation

The interviewees' own definition of adaptation. This was sorted as a subcode of *Background and Opinion/Experience in Adaptation* (vide infra for the complete code structure).

- Scenario

Any kind of application scenario for the concept that came up during discussion, focused on authoring aspects. This was sorted as a subcode of *Discussion about the Concept* (vide infra for the complete code structure).

Additionally, where appropriate, subcodes were added to Highlights, Proposed Improvements, and Limitations to get a finer grained coding system. It also helped in comparing the different statements according to their subjects regarding the concept and prototype. These subcodes are as follows:

- Authoring Workflow

Besides *Authoring Content-Structures*, this subcode reflects the main interest of the evaluation, namely to gather the interviewees' detailed views of the authors' workflows, how and if the concept suits the authors and their workflows, and expected improvements to the concept.

- Theory

This subcode is about the theory behind the concept. Any agreements, but also gaps and limiting aspects, are gathered here.

- Learning and Teaching

This is a collection of discussions about the concept's consequences on learning and teaching.

- Feedback and Community

Any kind of feedback to the user, author, and system are discussed here. This includes feedback for direct interactions, action collection such as histories and log files, and community aspects concerning Web 2.0 and eLearning 2.0.

- User Interface/Presentation

While the prototype's GUI itself is not directly part of this evaluation, aspects that have been realised appropriately or could be optimised are still of interest for further development and therefore are discussed in the sections with this subcode.

- Miscellaneous

Anything that does not fit into one of the other subcodes but which is too important to be left out.

As a result, the complete coding structure including all codes and subcodes is a tree-based structure. Further details about the intentions can be found above and in section 6.4 *Interview Guide* on page 172.

- BO: Background and Opinion

- BO-CLC: Creation of Learning Content
 - * BO-CLC-CW: Common Workflow
 - * BO-CLC-LP: Lecture Preparation
 - * BO-CLC-CP: Comprehension Problems Behaviour
- BO-CCC: Cooperative Content Creation
 - * BO-CCC-CCC: Created Content Cooperatively
 - * BO-CCC-JA: Joint Action
 - * BO-CCC-FI: How did you find it?
 - * BO-CCC-CEA: Complement Each Other
 - * BO-CCC-CMC: Compromises to Merge Content
 - * BO-CCC-ADS: Addressed Different Styles
- BO-EA: Experience in Adaptation
 - * BO-EA-DA: Definition Adaptation
 - * BO-EA-EAC: Experience With Adaptive Content
 - * BO-EA-CS: Content or Structures
 - * BO-EA-CE: Concepts or Engines
- BO-CAC: Estimation of Current Authoring Concepts
 - * BO-CAC-SA: Suitability for Authors

- * BO-CAC-SI: Suggested Improvements
- * BO-CAC-AE: Current Authoring Effort

- I: Introduction

- HO: Hands On

- CD: Concept Discussion
 - CD-ACS: Authoring Content-Structures
 - CD-A: Adaptivity
 - CD-DCD: Support of Different Content-Structures
 - CD-LP: Applicability for Lecturing Purposes
 - CD-H: Highlights
 - * CD-H-AW: Authoring Workflow
 - * CD-H-T: Theory
 - * CD-H-LT: Learning and Teaching
 - * CD-H-FC: Feedback and Community
 - * CD-H-UI: User Interface/Presentation
 - * CD-H-Mi: Miscellaneous
 - CD-PI: Proposed Improvements
 - * CD-PI-AW: Authoring Workflow
 - * CD-PI-T: Theory
 - * CD-PI-LT: Learning and Teaching
 - * CD-PI-FC: Feedback and Community
 - * CD-PI-UI: User Interface/Presentation
 - * CD-PI-Mi: Miscellaneous
 - CD-L: Limitations

- * CD-L-AW: Authoring Workflow
 - * CD-L-T: Theory
 - * CD-L-LT: Learning and Teaching
 - * CD-L-FC: Feedback and Community
 - * CD-L-UI: User Interface/Presentation
 - * CD-L-Mi: Miscellaneous
- CD-S: Scenario

The coded source material is then prepared for further analysis steps, starting with the creation of a topic matrix, followed by the discussion of the interview outcomes.

6.8.3 Code Matrix

In this evaluation the codes reflect the topics that have been discussed. The following code matrix presents which topic has been discussed with which interviewee. Second level subcodes of the *Concept Discussion* code are not listed here. The numbers show the number of relevant interviewee's statements in the interview. To abridge the interviewees' names the following initials have been used:

- MG: Manfred Gaida
- SG: Stefan Göbel
- MH: Matthias L. Hemmje
- II: Ido Aharon Iurgel
- DK: Detlef Krömker
- WM: Wolfgang Müller
- HR: Heiko Rölke

- US: Ulrike Spierling

- IS: Ingo Stengel

Code	MG	SG	MH	II	DK	WM	HR	US	IS
BO									
BO-CLC									
BO-CLC-CW	4	–	2	2	8	2	3	2	7
BO-CLC-LP	3	–	–	1	1	1	1	1	–
BO-CLC-CP	4	3	–	4	10	2	3	4	2
BO-CCC									
BO-CCC-CCC	3	–	2	2	3	1	3	1	–
BO-CCC-JA	–	2	3	3	2	1	1	1	2
BO-CCC-FI	–	–	–	–	–	1	–	–	–
BO-CCC-CEA	–	2	–	2	1	1	–	1	1
BO-CCC-CMC	–	1	–	1	2	–	–	2	–
BO-CCC-ADS	–	2	–	–	–	–	–	2	–
BO-EA									
BO-EA-DA	–	–	3	–	1	1	4	3	1
BO-EA-EAC	3	3	2	3	14	6	6	3	4
BO-EA-CS	1	1	1	3	4	1	–	4	–
BO-EA-CE	2	2	1	1	1	1	2	1	–
BO-CAC									
BO-CAC-SA	3	3	1	4	7	3	2	2	–
BO-CAC-SI	3	2	4	1	1	3	–	8	–
BO-CAC-AE	3	2	3	1	1	3	1	6	–
I	7	6	4	5	6	–	–	19	1
HO	3	7	–	3	4	–	16	16	6
CD									

Code	MG	SG	MH	II	DK	WM	HR	US	IS
CD-ACS	–	3	–	9	1	1	2	3	–
CD-A	5	2	1	8	1	–	1	3	2
CD-DCD	3	–	–	2	2	–	–	–	–
CD-LP	3	2	–	1	1	–	3	–	1
CD-H	16	3	1	8	10	4	3	14	4
CD-PI	7	6	3	6	–	2	1	18	9
CD-L	9	3	3	6	8	7	3	7	9
CD-S	17	1	1	1	3	8	3	9	7

Table 5: Code Matrix: The left column lists the codes. The numbers show the number of relevant interviewees’ statements.

This table shows that all topics have been discussed but not with each author. In some interviews the course of discussion did not touch on every topic, which is common for interviews that are semi or not structured. The two cases with missing statements for the hands on session (code *HO*) have different reasons: Due to an installation bug the prototype could not be started during the interview with Hemmje. Müller began such an intense discussion about the concept when the concept was introduced that the prototype was not shown.

The next section discusses the data in depth. The discussion follows the code structure shown above.

6.9 Outcomes of the Interviews

After transcribing, reducing, and coding, the data was prepared for discussion and is based on the code structure. Spierling’s interview has been chosen to lead the discussion, because:

- it was one of the longest and most intense interview sessions,
- she has made statements regarding almost all the codes (see also table 5 *Code Matrix* on page 208),
- she has conducted an EU research project on authoring for adaptive content, and
- although she is not a computer scientist she has extensive experience of collaborations with computer scientists and knows about common computer science structures.

Interview citations have been coded with the interviewee's initial as listed in section 6.8.3 *Code Matrix* on page 206, followed by a timestamp. Because all the interviews were in German, a translation of the cited part is given followed by the original text.

6.9.1 Common Workflow for Creation of Learning Content

For face-to-face sessions, Spierling outlined a generic learning content creation workflow over time: “As a new professor, the first year it needs to be assured that all the knowledge is collected (...). It needs to be complete, accurate, and put on slides. The second year didactic elements are worked into the content: The sequence might be adapted to simplify absorbing the knowledge and maybe some exercises are added.” [US, 00:32:40] (Im ersten Jahr als neuer Professor gibt es eine Sorge: Ich muss das Wissen überhaupt erst mal zusammentragen (...). Dass das Wissen vollständig ist, dass es nicht falsch ist, dass es irgendwie in Folienform da ist. Im zweiten Jahr macht man sich wahrscheinlich zum ersten Mal über Didaktik Gedanken, und überlegt, wie kann ich das Wissen in einer Reihenfolge anders darbieten, dass es besser aufgenommen wird, und vielleicht auch noch mit ein paar Aufgaben verbinden.) In the following years she would further optimise the content.

If she needed to create content for new lectures she would first look for already existing content: “First, I look for already existing textbooks to gain a common sense about a specific topic.” [US, 00:33:37] (Das erste was ich mache, ich suche nach Lehrbüchern, die es schon gibt. Ich suche nach einem Konsens, der zu einem bestimmten Thema herrscht, unter anderen Lehrenden.) She used this source material as a basis for her content. If she could not find any source material, she would need to build it from scratch.

Spierling reported a common workflow that was confirmed by all the other interviewees: First, looking for existing material to provide a hopefully proven basis that is adaptable to specific needs. The subsequent years see the content optimised if the lecture is repeated.

It seems to be also common to work with a mixture of structuring and writing phases. For example Rölke stated: “Some topics are very clear, so that I can just write from the beginning to the end. For other topics that are not clear enough for me, I create a rough structure and develop the content, gaining a finer structure step by step.” [HR, 00:10:05] (Bei einigen Sachen ist es so klar, wie das Ganze vorangeht, dass ich es einfach von vorne nach hinten durch erstelle. Bei anderen Bereichen, bei denen ich noch nicht so klar bin, da mache ich eine Grobstruktur und erarbeite mir die Inhalte, sodass ich nach und nach zu einer feineren Struktur komme.) He adds, that, like other lecturers, he not only uses slides but also tries to interact with the students and address various reception channels: “Question/answer games with the students. Or flip charts and writing on the blackboard and so on, to develop content by myself or in interaction with the students.” [HR, 00:11:04] (Frage/Antwort Spiele mit den Studenten. Oder auch Flipchart und Tafelbeiträge und so weiter, wo ich alleine oder in Interaktion mit den Studierenden versuche, die Inhalte zu entwickeln.)

Krömker added interesting aspects about the learning content itself. The first observation was about personalisation and genuineness: “You will always slip in your personal experiences. I think that this is important for students, because it makes content genuine. Otherwise machines could just do that.” [DK, 00:24:41] (Du wirst aber immer Deine persönlichen Erfahrungen einfließen lassen. Ich glaube, das ist auch wichtig für die Studierenden. Weil es das letztlich authentisch macht. Ansonsten könnte es auch eine Maschine machen.) Relating to the way of explaining he states: “You always try to explain in the easiest and most obvious way. However, it is extremely hard to decide if this is really the easiest for an individual person.” [DK, 00:41:44] (Man versucht immer, die einfachste und naheliegendste Erklärung zu bringen. Ob das für das Individuum das Einfachste ist, kann man extrem schwer entscheiden.) Spierling confirms that from another point of view: “If I try to explain the best I can, then I explain it in a way I would understand best.” [US, 00:54:12] (Wenn ich so gut erkläre, wie ich nur irgendwie kann, dann erkläre ich es so, wie ich es am besten verstehen würde.)

Interestingly, although the experts’ experiences might have a deep impact on their way of creating learning content, their workflow and tools are the same or at least comparable to those used by lecturers that are not used to interactive systems: For face to face sessions the content, including its structure, is created with word processors and presentation programs. The prepared content is linearly structured, and it is also mostly presented in a linear manner, except for interruptions, for example, by students’ questions (see section 6.9.3 *Comprehension Problems Behaviour* on page 212). This corresponds to the idea that creators of linear content are an important target group for adaptive learning content that should be addressed by the concept of this research.

Each of the interviewees created his or her content themselves. Krömker and Spierling have given additional hints on how they use individual explanations that also match quite well with the assumptions underlying the concept.

6.9.2 Lecture Preparation

Although mentioned by most of the interviewees, this topic did not bring further insights that are of use for evaluating the concept. Spierling made the following typical comment: “As preparation before a lecture, at a minimum I need to look through the slides.” [US, 00:35:32] (Eine konkrete Lehrveranstaltung muss ich mindestens in der Form vorbereiten, dass ich mir die Folien noch mal ansehe.) If enough time is left, the content is optimised as mentioned in the previous section.

6.9.3 Comprehension Problems Behaviour

All interviewees have a similar strategy if some students do not understand a topic, and this has been summarised by Spierling as follows: “As soon as you think that the students cannot get your content, then you need to adapt it.” [US, 00:04:39] (Wenn man den Eindruck hat, die Inhalte (...) werden nicht aufgenommen, dann muss man sie anpassen.) However, she has seen two main difficulties: “First, the big trick is to suss out that students do not understand.” [US, 00:36:33] (Erst mal ist die große Kunst herauszufinden, dass Studenten etwas nicht verstehen.) Second, she has seen challenges in adapting the content or the way of explanation: “I would like to adapt, but quite often it is difficult. Mostly I try to explain using different examples. I really would like to have a vendor’s tray full of examples.” [US, 00:37:44] (Versuchen würde ich gerne etwas zu ändern. Es ist oft schwierig. Ich versuche es meistens mit anderen Beispielen zu erklären. Was ich gerne hätte – ich hätte gerne so einen richtigen Bauchladen voller Beispiele.)

All the interviewees reported similar strategies and challenges. The next step to developing an explanation that is more comprehensible is to identify the real comprehension problem and the way of adaptation. For example, Gaida states that: “... first I want enquire into the problem that causes a person to not understand. It is the first important task to suss that out. If this succeeds, secondly I try to explain in a more understandable way.” [MG, 00:16:11] (... dass ich erstens nachfrage und

rausfinden möchte, was das Problem ist, dass die Person das nicht versteht. Das ist der erste wichtige Punkt, das rauszubekommen. Zum Zweiten, wenn mir das gelungen ist, versuche ich, der Person es noch mal verständlich zu erklären.)

The way of adaptation depends on the context, including the topic, the kind of problem, the student who is asking, the discipline, in addition to other factors. Like the other interviewees, Gaida sees different possibilities for solving a problem. For example, “If facts have not been understood, then I explain again using a different context.” [MG, 00:17:23] (Wenn Fakten nicht verstanden wurden, dann erkläre ich das noch einmal in einem anderen Kontext.) If the didactic approach causes comprehension problems, he would use another method.

Many of the interviewees have stated that they try to adapt the explanation to the student. For example Göbel said: “I try to find the way the student would understand best, to reply in his language.” [SG, 00:06:04] (Ich versuche herauszufinden wie der Fragende es am besten versteht, um entsprechend in seiner Sprache zu antworten.) And: “Replying as context oriented as possible. Specific to the user.” [SG, 00:05:42] (Möglichst kontextbezogen antworten. Userspezifisch.) Krömker added examples: “One person understands best in an abstract way (...). The other does not want it the abstract way but first wants to understand with an example.” [DK, 00:54:32] (Der Eine versteht das Abstrakte (...). Der Andere will das Abstrakte nicht, der will erst was am Beispiel verstehen.) He reflects that “There are differences. You can adapt to them. It may also depend on the learner types.” [DK, 00:55:17] (Da gibt es Unterschiede. Da kann man schon adaptieren. Es kommt auch oft auf die Lerntypen an.)

However, Krömker has seen difficulties in finding good alternatives: “Alternatives are often very hard. From my own personal experience an example seems to be more helpful.” [DK, 00:42:26] (Alternativ ist oft richtig schwer. Was eher hilft ist meiner Erfahrung nach ein konkretes Beispiel zu machen.) Most of the other interviewees have also reported similar difficulties. In more complex cases, additional resources

have been reported as being used, for example Stengel has explained: “Then I look for materials in the internet that describe it differently.” [IS, 00:28:30] (Dann fange ich an im Internet nach Materialien zu suchen, die es ein wenig anders darstellen.)

The way the interviewees react to the comprehension problem of students seems to be very similar: They try to find an alternative means of explanation that is hopefully easier to understand. However, their difficulties could be summarised as:

1. First notice that somebody cannot understand.
2. Identify what was not understood.
3. What was the problem?
4. How should one adapt?

In the context of the concept of this research, including its prototype of Coherence, most of those difficulties have been addressed in a simple way:

1. If a user presses thumbs down or he chooses a different content from the list, then he might have problems in understanding. At the least he wants additional information.
2. The alternative is searched for in the context of the slide the user has reacted to.
3. Finding the real problem is not addressed. Perhaps the user can be asked for the reason using a dialogue box.
4. An alternative explanation is tried. As an application example, learner preferences have been used to rank the alternatives.

While not perfect, it seems thus far that this research tries to address common workflows as well as the interviewees’ adaptation behaviour in case of the comprehension problems of students. The interviewees’ view is discussed below, after they received the introduction to the concept.

6.9.4 Cooperative Content Creation

Spierling has educated media informatics students collaboratively. She recalled: “I remember working in an interdisciplinary way. I do the design part, and the colleague the computer science part. We train media informatics students, so it is clear: Computer science is one part, I do the other part. Some parts did not fit very well, but we have seen this as a feature, not as a problem. It clarified the fact that these are two different points of view.” [US, 00:40:43] (Also ich erinnere mich an interdisziplinäre Sachen. Wenn ich den Designteil mache, und der Kollege den Informatikteil. Wir unterrichten Medieninformatiker. Dann ist klar: Informatik ist der eine Teil, dann mache ich meinen Teil. Die Tatsache, dass es an manchen Stellen gar nicht so richtig zusammenpasst, haben wir als Feature verkauft, und nicht als Problem. Das wurde dann klar, das sind zwei verschiedene Sichtweisen.) However, sometimes this was confusing for students, giving them practically a shock: “There are two or maybe even three people, each of them telling them something different. What counts? Then we needed to explain with a lot of discussions that all of the information is valid, but they need to find the right compromise. We guided them, of course.” [US, 00:46:05] (da sind zwei oder sogar drei Leute und jeder erzählt etwas anderes. Was gilt denn jetzt? Da war man immer in der Pflicht, mit viel Diskussionsaufwand klar zu machen, dass das im Prinzip alles gilt, aber sie müssen den Kompromiss dazwischen suchen. Mit unserer Anleitung natürlich.)

This seems a common form of collaboration and is confirmed by four of the other interviewees, especially on project-based modules: “For a project we tried to merge different domains.” [HR, 00:15:29] (Wir haben versucht, unterschiedliche Bereiche zusammenzubringen. Für ein Projekt)

Interestingly, in terms of working on the same topic, none of the experts created a learning content for face-to-face sessions cooperatively. However, all but one of them have experience in customising existing learning material by using it as basis, and adjusting and restructuring it to their needs – in addition to the reference by

Spierling in section 6.9.2 *Lecture Preparation* on page 212, Krömker said: “If you are creating something from the ground up, (...) you will always follow already existing curricula, modules, or others.” [DK, 00:25:13] (Wenn man etwas ganz neu aufbaut (...) wird man sich immer an vorhandenem Curricula, Kursen oder so etwas orientieren und wird da mal reinschauen.)

It seems that creating learning content cooperatively is not very common, except for project based modules, where lecturers from different disciplines teach at the same time, and for reusing existing learning content as a basis for one’s own content. Two statements are of special interest:

- Reusing and rearranging existing learning content corresponds to one of the workflows that are proposed for the concept of this research.
- While merging cooperatively created content, none of the interviewees has smoothed out the differences, but they have seen these as benefits that clarify the different styles and points of view.

6.9.5 Experience in Adaptation

All the interviewees have experience in adaptivity. Gaida and Spierling are designers and have more experience in content creation, while the other interviewees have developed concepts and engines.

Spierling told of her experience: “I focus on integration of authors who want to tell stories that are interactive in a way that people, who I would call ‘endusers’, participate in the story by interacting with it. In this respect these endusers become coauthors.” [US, 00:02:31] (Ich befasse mich besonders mit dem Thema der Integration von Autoren, die Geschichten erzählen wollen, die sie in einem interaktiven Format in der Form mitteilen wollen, dass die Menschen, die damit interagieren, das was ich als Enduser bezeichnen würde, dass die durch ihre Interaktion an der Geschichte irgendwie teilhaben. In sofern eine gewisse Co-Autorenschaft eingehen.) She also

limits her knowledge: “I have never programmed an engine, but I have always worked with people who do that.” [US, 00:14:24] (Ich habe noch nie eine Engine programmiert. Ich habe aber immer schon eng mit Leuten zusammengearbeitet, die so was tun.) She would define adaptation as follows: “I would say adaptive content in a literal sense means that content adapts to situations. These situations are set by a user. Not only users, but maybe also algorithms and contexts. Consciously or unconsciously.” [US, 00:03:42] (Ich würde sagen, adaptive Inhalte im Wortsinne hieße, dass Inhalte sich an Situationen anpassen. Und diese Situationen werden bestimmt durch Benutzer. Aber nicht nur, sondern auch vielleicht durch Algorithmen, durch Kontexte, in die man hineinkommt. Bewusst oder unbewusst.) With regard to authoring she stated for example: “What we did is: O.k., if it seems that human authors are thinking in a linearly graphically way, then it means that I need to start with an ideal story path. This is my starting point and I create events for that. Then I take these events and reflect on how those events could be used as preconditions. Then I think about alternative paths through the story, for example: What could be the worst case scenario?” [US, 00:26:47] (Und was wir da gemacht haben, ist zu sagen: O. k., wenn wir jetzt davon ausgehen, dass menschliche Autoren erst mal linear graphisch denken, dann heißt es auch, ich mache mir erst mal einen idealen Storystrang im Gehirn klar. An dem arbeite ich mich erst mal ab, und mache dafür die Ereignisse. Dann nehme ich die Ereignisse aus diesem Strang heraus, nehme sie auseinander, und überlege mir, was ist davon eigentlich die formalisierte Pre Condition jeweils. Dann überlege ich mir, was könnte der Worst Case sein? Wie könnte die Geschichte noch ablaufen?) She does not use adaptive systems for lecturing purposes. However she sees adapting content in real time as a natural process for a human lecturer: “Nevertheless, of course I use adaptation as a human being.” [US, 00:04:35] (Davon unabhängig gebrauche ich natürlich so etwas als Mensch.)

The technically oriented interviewees offer a similar definition for adaptivity. For example Stengel stated: “I would think about adaptivity as follows: The user can

choose his own way.” [IS, 00:45:14] (Unter Adaptivität verstehe ich, wenn der User sich aussuchen kann, welchen Weg er geht.) Hemmje focuses more on adaptivity for learners: “We look at adaption as a choice that is related to the learner’s profile of interest. We try to behave adaptively to meet his needs. Dependent on the context, other elements are chosen that are ordered differently (...)” [MH, 00:01:06] (Bei uns ist eine Adaption in der Regel eine Auswahl, und zwar auf das Interessenprofil des Lerners hin. Wir versuchen uns adaptiv zu verhalten, um sein Bedürfnis zu befriedigen. Es werden andere Elemente in anderen Reihenfolgen ausgewählt. Das hängt vom so genannten Kontext ab (...)) However, like all the other interviewees, he does not use adaptive learning systems for teaching purposes: “I am experienced with adaptive content for research purposes. We still do not use them for productive operation in teaching.” [MH, 00:00:16] (Ich habe Erfahrung mit adaptiven Inhalten in der Forschung. Wir verwenden das noch nicht produktiv in der Lehre.)

Krömker is sceptical about adaptive systems: “First of all I know of many, many unsuccessful attempts in the past. Mainly because the enduser felt teased. Or they had a feeling that they missed something, and the like. All this adaptivity generated more uncertainty than benefits. At least seen from the learners’ point of view. In this respect I am cautious.” [DK, 00:0:36] (Vor allem kenne ich die vielen, vielen Fehlversuche in der Vergangenheit. Im wesentlichen darauf beruhend, dass die Enduser sich verulkt fühlten. Oder das Gefühl hatten, nicht alles mitzubekommen, und der gleichen mehr. Diese ganze Adaptivität hat mehr Unsicherheit erzeugt als sie Vorteile haben. Auf jeden Fall aus der Sicht der Lernenden. Insofern in der eigenen Praxis zurückhaltend.) Based on his experience he has added: “They (the students) are anxious about maybe not knowing enough for an exam. You should not underestimate that. They need to trust in the tools.” [DK, 00:20:13] (Sie leben immer in der Angst, für eine Prüfung möglicherweise nicht alles zu wissen. Das darf man nicht unterschätzen. Das Vertrauen in diese elektronischen Tools muss hoch sein.) He has also seen the problem of too much effort for creators of adaptive learning content:

“There are problems to the extent that it is much more effort. You need to try to cover all the possible reactions. As soon as the students notice misinterpretations, they certainly do not like it. Some caution and, above all, accuracy is needed.” [00:04:11] (Probleme gab es insofern, als dass es viel zusätzlicher Aufwand ist. Man muss ja versuchen, das gesamte mögliche Spektrum der Reaktionen abzudecken. Wenn die Studierenden mitbekommen, dass da Fehldiagnosen drin sind, mögen die das garantiert überhaupt nicht. Eine gewisse Zurückhaltung und vor allem Dingen Sorgfalt ist notwendig.)

Göbel shares the opinion about the cumbersome nature of the creation process: “We did this in the project ‘80Days’. It was about adaptive learning with storytelling and serious games. (...) Therefore we have developed the Narrative Game Based Learning Objects model. It is based on Bartle’s model, plus story models, plus learner-game model. And topical learning dependencies. (...) Of course, all (the content) needed to be annotated laboriously.” [SG, 00:01:33] (Im Projekt „80Days“ haben wir das gemacht. Da ging es um adaptives Lernen mit Storytelling und Serious Games. (...) Da haben wir das Modell Narrative Game Based Learning Objects entwickelt. Basierend auf dem Modell von Bartle, plus Storymodelle, plus Lerner-Gamer Modell. Und thematische Lernabhängigkeiten. (...) Musste natürlich vorher alles mühsam im Autorenwerkzeug annotiert werden.)

It is conspicuous that although all of the interviewees are experienced in adaptive systems or content, none of them uses adaptive learning systems for teaching purposes. Research and development seems not to be ready for daily usage even for experienced people. Krömker has given some reasons: On the one hand, students seem to be suspicious of adaptivity because the fear of missing something important that they might need for any examinations. Additionally, if the adaptation does not feel right and may happen for elusive reasons, they feel teased and decline to use it. The prototype tries to address this by showing the completeness by a progress bar and giving the students the choice of the next step. However, there is room for

improvement, for example by ensuring that all the content of one lecturer is shown, so that the students are prepared for an examination.

On the other hand, it seems that authoring is a cumbersome process that requires much more effort than creating normal linear content. The following section elaborates on this topic.

6.9.6 Estimation of Current Authoring Concepts

Chapter 2 *Authoring for Adaptive eLearning* discussed the current situation regarding authoring in an adaptive learning context. The interviewees' thoughts on this topic had been requested to perhaps help adjust the findings of chapter 2 and to get additional ideas about authoring including possible improvements. These suggestions and estimations should, irrespective of the concept, be developed during this research project. Thus, these questions were asked before the concept was introduced.

Spierling summarised the current situation as follows: "State of the art is terrible." [US, 00:15:11] (der Stand der Technik ist furchtbar.) She added more details: "There are authoring tools that are intuitive and can be used in a simple way, but these tools provide very little smart processing. There is also the other side, originating from AI and providing intelligent processing. However, most of them offer authoring systems that do nothing other than showing all the complexity of its engine in their user interface. Additionally, mostly programming is needed." [US, 00:15:17] (Es gibt Autorenwerkzeuge, die entweder intuitiv sind und leicht zu bedienen, dann aber wenig intelligentes Verarbeiten möglich machen. Und es gibt die andere Seite, die von der KI kommt, intelligente Verarbeitung ermöglicht, und meistens mit Autorensystemen aufwartet, die nichts anderes machen, als die Komplexität, die in ihrer Engine drunterliegt, irgendwie an der Oberfläche abzubilden. Und meistens ist es erforderlich, dass jemand die programmiert.)

In her opinion, authoring systems need to become more user friendly, but also the authors need to learn: "There is a 'gap'. This gap can be bridged from two

sides. One side is: Authoring tools for AI based systems need to be improved to be more intuitive. However, also the authors need to move. They need to be eager to learn.” [US, 00:16:12] (da gibt es ein „Gap“. Dieses Gap kann man von zwei Seiten überbrücken. Die eine Seite ist: Wir kommen von der KI Seite – da müssen bessere Autorentools gemacht werden, die intuitiver werden. Und die andere Seite muss sich auch bewegen. Das ist die Autorensseite. Die muss willig sein, dazu zu lernen) Therefore she has conducted research into helping authors create interactive storytelling content: “One year ago we created ‘Educational Material for Authors’. It should bring the concepts a bit nearer. Without knowing the concepts, or at least the basics, I do not need to start using tools.” [US, 00:17:06] (Was wir damals gemacht haben, vor einem Jahr, ist „Educational Material for Authors“. Was im Prinzip die Konzepte ein bisschen näher bringen soll. Weil ohne die unterliegenden Konzepte zu verstehen, zumindest vom Prinzip her, brauche ich nicht Tools anfangen zu verwenden.) She also had good experiences with a card game, comparable to a paper prototype: “We (...) have found out that the aha-experience comes up more likely by doing it manually – slowly – with a card game, than by explaining the algorithm.” [US, 00:24:48] (Wir (...) haben festgestellt, wenn wir das auf die händische Tour mit einem Kartenspiel mit jemand durchgehen – langsam, dann kommt der Aha-Effekt eher, als wenn man dem den Algorithmus erklärt.) However, she would also like more intelligent systems: “Basically, we need a machine that is so intelligent that it is able to detect similarities. (...) And with enough knowledge about the context that it does not make any wrong decisions.” [US, 00:28:35] (im Prinzip müsste man eine so intelligente Maschine haben, dass die in der Lage ist, Ähnlichkeiten festzustellen. (...) Und genug Kontext-Wissen hat, damit es auch nicht daneben liegt)

Spielerling compared the effort needed for the basic concepts as follows: “String of pearls and branching can be apprehended faster, if I assume that it is always describing events and what could happen to proceed to the next event. (...) The

same is true for string of pearls, because its structure is simple, and it can be presented in a finite graphical way. However, preconditions are problematic in a way that it is impossible to draw its structure as map.” [00:23:13] (Hineindenken schneller in String of Pearls und Branching, wenn ich davon ausgehe, dass der da immer Ereignisse beschreibt, und was passieren kann, dass das nächste Ereignis stattfindet. (...)) Dementsprechend ist String of Pearls auch, weil die Struktur übersichtlich ist, und sie lässt sich endlich grafisch darstellen. Nicht so bei den Pre Conditions. Da ist das Problem, dass es nicht möglich ist, die Struktur als Map zu zeichnen.) She points out two additional reasons, namely abstract concept and control over presentation: “Authoring preconditions is an abstract concept. Authors prefer to sit there for hours and make all the little explicit connections (like branching) than learning the (precondition) concept. The second aspect: By using the first concept (string of pearls and branching) they have full control, which they do not have using the second (preconditions)” [US, 02:18:10] (Die Pre Conditions einzugeben ist ein abstraktes Konzept. Autoren sitzen lieber stundenlang da und machen fein, fein, klein klein, explizite Verbindungen, als dieses Konzept zu lernen. Der zweite Aspekt ist: In dem ersten haben sie die Kontrolle, im zweiten nicht.)

The other interviewees have comparable opinions. They all think that current concepts and systems do not fit with authors’ needs. For example Gaida explained: “You need to differentiate. If a lecturer or an author has the background or special knowledge to use such an application, for example a computer scientist, then I think it is much easier. Because you can derive certain concepts from the computer technology domain. As soon as you lack that knowledge and maybe think in a more intuitive way, like for example a designer, then it is difficult to work with such concepts or applications.” [MG, 00:05:39] (Das muss man differenziert betrachten. Wenn ein Dozent oder Autor oder Dozentin oder Autorin Hintergrund- oder Spezialwissen hat, diese Applikation zu bedienen, wenn man zum Beispiel aus der Informatik kommt, dann empfinde ich es so, dass es wesentlich einfacher ist. Weil man aus dieser

programmiertechnischen Welt schon bestimmte Konzepte ableiten kann. Wenn man das nicht hat und vielleicht intuitiver denkt, wie zum Beispiel ein Designer oder Designerin, dann ist es relativ schwierig, mit solchen Konzepten oder Applikationen überhaupt arbeiten zu können.) Besides Spierling, both Göbel and Müller are currently conducting research in that area and agree on the issue of improper concepts and tools. “More likely not. Especially for non-programmers. (...) It is one of the main obstacles and currently one of our research topics.” [SG, 00:02:53] (Eher nicht. Speziell für Nichtprogrammierer. (...) Ist eine Hauptschwierigkeit und bei uns ein aktuelles Forschungsthema.) “Very difficult. It is one of the challenges we face at the context Sceneo. It is focused on authoring tools.” [WM, 00:08:06] (Sehr schwierig. Das ist eine der Herausforderungen, mit dem wir uns im Kontext Sceneo beschäftigen. Dort liegt der Fokus auf den Authoring Tools.) Müller sees research in this topic as still in its infancy: “Generally I would say that we are still in a phase that is not clear what the best methods could be.” [WM, 00:12:14] (Generell würde ich sagen, dass wir immer noch in einer Phase sind, dass es unklar ist, wie die besten Methoden aussehen.) This seems to be common feeling among all interviewees. Most of them demanded a more user centric development without being able to give details on how this might appear. For example Göbel said: “First you need to know the common workflow. Depending on the group of users and authors. How do they work, how can computers support them beneficially? How can you map this workflow?” [SG, 00:03:13] (Zuerst muss man wissen, wie die normalerweise vorgehen. Je nach Anwender- oder Autorengruppe. Wie arbeiten die sonst, und wie kann man diesen Prozess computergestützt sinnvoll unterstützen? Wie kann man diese Vorgehensweise abbilden?)

Comparing the concepts, all the interviewees’ notions are comparable to Spierling’s. For example, Göbel benchmarked the concepts as follows: “Branching is the simplest. String of pearls is similar. Rule based: The input process itself might be easy, but the result might be questionable ...” [SG, 00:04:02] (Branching ist am einfachsten.

String of Pearls sehe ich ähnlich. Rule Based: Jain. Man kann es auch recht einfach eingeben. Aber was dabei herauskommt ist die Frage ...)

In summary it can be stated that all interviewees seem to agree that current authoring concepts for adaptive and interactive content do not meet the needs of authors: Easy concepts like String of Pearls have simple outcomes that are not adaptive, and authors understand the concept of branching but it is not usable for complex content structures, while rule-based concepts may help authors avoid getting lost with complex structures, but they are confused by the concept itself. The following sections elaborate on the interviewees' agreement that the result of this research project addresses these obstacles appropriately.

6.9.7 Introduction and Hands on

After the interview session about the interviewees' experiences and opinions about general aspects of adaptive content, structures and their creation, the concept was first introduced with the help of a slide set. Second, the interviewees could try out the prototype. While the introduction had been essential to understand the concept, the hands on session had been almost equally important to give them a feel for the concept – and therefore help them understand the concept as a whole and its (possible) implications for authors.

The discussion started in all the sessions immediately after the first slides. Most of the comments had been direct feedback used to understand the concept, its background, and the prototype and are therefore not noted in this section. When they were relevant to the discussion about the concept they are discussed in the following sections.

The questions and comments that occurred in this session had been more direct and more practical, such as “How do I ...?”. As such they were technical, usability and interoperability questions. The most frequently asked question was about the size of the learning units or content sections. For example Spierling asked: “What is

the smallest atomic entity of that?” [US, 01:25:31] (Was ist eigentlich die kleinste atomare Einheit von so etwas?) *The concept does not predetermine the unit of the content sections. They could be learning units, slides, a page of book, and so on.*

During the hands on session the interviewees commented naturally about usability. As Coherence is still an early prototype, it was often unclear where and how to do or find something. That brought up comments like: “I only see cryptical numbers and cryptical titles that are only subtly different: ‘Author A 121’, ‘Author A eL 1’ – I cannot see the differences.” [US, 02:31:21] (Ich sehe nur hier kryptische Zahlen und ich sehe für mich kryptische Titel mit geringfügigsten Unterschieden: „Autor A 121“, „Autor A eL 1“ – ich sehe die Unterschiede nicht.) *Name of author and the number of the slide had been added to the title to simplify checking the results of the pathfinder.* Or open questions like: “What can I do now as a student?” [SG, 00:34:14] (Was kann ich jetzt als Student machen?) There is a lot of room for improvement, but it is not critical for this development stage: “It is o.k. for now. It is proof of a concept and not a completed tool.” [HR, 00:31:28] (Ist ja o. k. erst mal. Es ist ein Proof of Concept und noch kein fertiges Werkzeug.)

While editing the structure, more support for the creation of content types had been requested by all interviewees. For example Göbel asked: “How is the creation of dependencies supported?” [00:25:38] (Wie wird das Erstellen der Querbeziehungen unterstützt?) This is a crucial usability aspect and should be given a high priority in its future development.

Additional interesting aspects were quality assurance and groups: “How does quality assurance work?” [SG, 00:17:53] (Wie erfolgt Qualitätssicherung?) and “Whom do you follow? Commonly you have to use a heterogeneously learner group.” [SG, 00:12:20] (An wem orientierst du dich? Du hast normalerweise ein heterogene Lerngruppe.) Both are not part of the concept and therefore not discussed.

The interviewees did not test the prototype intensively. However, it was obvious that touching a living system helped them greatly in rating the concept.

6.9.8 Authoring Content-Structures

All the interviewees agreed that the concept developed in this PhD research project simplified the creation of adaptive content structures. For example Spierling stated: “Do I think it is intuitive to put this structure in? Of course. Because it is simple. For authors. (...) it is definitely much easier than all this complexity of one author controls all the alternatives.” [US, 02:08:39] (Finde ich das intuitiv, das als Struktur einzustellen? Auf jeden Fall. Weil es auch einfach ist. Also für Autoren. (...)) Auf jeden Fall viel einfacher als die ganze Komplexität – also wenn ich sonst davon ausgehen würde: Ein Autor kontrolliert die ganze Alternativstruktur.) Krömker shared Spierling’s opinion: “It is clearly less effort. This is for sure.” [DK, 01:41:12] (Der Aufwand ist deutlich geringer. Das ist klar.) He has added: “It identifies the weaknesses of the traditional concepts and submits a new proposal.” [DK, 01:43:54] (Es identifiziert klar die Schwächen der bekannten Ansätze und macht einen neuen Vorschlag.) Iurgel was taken with how little effort was needed and how much the rest of it could be decreased: “I think that the system may need no effort at all. It is a system that could work with statistical methods.” [II, 01:59:23] (Ich denke, dass das System im Grenzfall überhaupt keinen Aufwand mehr benötigt. Das ist ein System, das mit Statistik arbeiten kann.) Some interviewees were more cautious, for example Göbel said: “It is evident that the concept is better. Less effort. However, one ought to see how it works in the real world.” [SG, 00:45:54] (Es ist einleuchtend, dass es vom Konzept her gesehen besser ist. Weniger Aufwand. Aber man müsste sehen, wie sich das praktisch auswirkt.)

That all the interviewees confirmed the simplifying effect of the concept can be seen as a confirmation of the main research question as framed at the beginning of this chapter: “Does this concept of structuring content have the capability of simplifying authoring of adapted eLearning content?” It should be kept in mind that this evaluation is not statistically relevant, therefore other evaluation methods and far more samples are needed. However, the fact that no interviewee doubted

the simplifying effect itself can be seen as a strong hint. More details about the background of the interviewees' ratings are given in the sections 6.9.12 *Highlights*, 6.9.13 *Proposed Improvements*, 6.9.14 *Limitations*, and 6.9.15 *Scenario*.

6.9.9 Adaptivity

Concerning the adaptivity of the concept Spierling states: “The structure of the presentation adapts to the wishes of the user.” [US, 02:09:50] (Die Struktur der Darbietung adaptiert sich nach Nutzerwünschen.) But the system does not only adapt in the background, it gives the user the choice: “It is a recommender system. It is not a system that chooses for me – Hobson’s choice – but it is a system that recommends.” [US, 02:08:08] (es ist ein Vorschlagssystem. Es ist nicht ein System, was mir etwas auswählt – friss oder stirb – sondern es ist ein System, was mir Dinge zum Vorschlag bringt.) Göbel rates the adaptivity as macro-adaptivity: “Adaptive in terms of sequencing. But not adaptive in terms of presenting one learning unit differently.” [SG, 00:47:45] (Adaptiv im Sinne von Sequencing. Aber nicht adaptiv im Sinne eine Lerneinheit anders darstellen.) Stengel sees similarities to string of pearls: “(pointing to the slide that presents the String of Pearls concept) Actually, it is this linear structure with those branches to the left and right.” [00:50:07] (Das ist quasi das Lineare mit den Auswüchsen links und rechts.)

Rölke discusses the concept’s grade of adaptivity: “It depends heavily on the user. And of course on the number of provided alternatives. The grade of interactivity is determined by two variables: How many alternatives do I have, and how engaged are the users in respect to this adaptivity? (...) This system can only be beneficial if several alternatives exist. Otherwise it cannot handle the user feedback and the users become frustrated because their feedback does not change anything.” [HR, 00:40:45] (Das hängt stark vom Benutzer ab. Und natürlich von der Anzahl der angebotenen Alternativen. Der Grad der Interaktivität wird durch diese zwei Sachen determiniert: Wie viele Alternativen habe ich, und wie weit lassen sich die Benutzer

auf diese Adaptivität ein? (...) Das System ist nur dann sinnvoll, wenn mehrere Alternativen vorhanden sind. Ansonsten kann mit der Nutzerrückmeldung nichts angefangen werden und die Anwender werden frustriert, weil sie zwar Feedback, sich aber nichts ändert.)

The interviewees' statements can be summarised as follows: They agree that it is a macro-adaptive concept. Rölke addressed the limits of the concept's adaptation: It cannot adapt without alternative content, and the user needs to trigger the process. Otherwise the concept behaves like a linear presentation.

6.9.10 Support of Different Content-Structures

Not many interviewees had been asked about this topic, but the three interviewees who were agreed. For example Krömker answered: "Of course it supports different content structures." [DK, 01:57:04] (Das unterstützt natürlich unterschiedliche Inhaltsstrukturen.) Iurgel adds: "Of course they are supported. But they are just there, implicitly, and I can search for them." [02:08:09] (Natürlich werden sie unterstützt. Aber die sind implizit da, und ich kann sie durchsuchen.) This sentence is interesting, because it highlights that this feature is there, different content structures are supported, but it is implicitly there. Authors just can use it without the need to think about it.

6.9.11 Applicability for Lecturing Purposes

Krömker thinks that such a system would have applicability in a learning context: "I think it is applicable. Yes." [01:59:33] (Halte ich für einsetzbar. Ja.) But Stengel also sees the limitations: "Yes, if the material exists." [00:45:59] (Ja, wenn das Material da ist.) Iurgel would like to have his own content prioritised: "The system would be very good for students. However, I would have my own slides in parallel. And those slides would not be just any slides between others. My slides should be in an exceptional position." [02:10:41] (Es wäre für die Studenten sehr gut das System zu haben.

Aber ich würde trotzdem parallel dazu meine Folien haben. Und die wären nicht einfach Folien unter anderen. Meine Folien sollen eine gewisse Sonderstellung haben.) Rölke sees the concept's application in conjunction with learning material that is openly available over the internet, for example Open Educational Resources (OER): "Especially in the course of growing distribution of content that is freely available on the internet it make sense to create links. Therefore reuse the existing material. More and more universities put their content onto the net, partly gratuitously. Some of them do it for their own students only, but sometimes also for external students. Hence, there should be enough content. Lectures like 'Programming Basics' or 'Computer Science 1 – 3' do exist everywhere." [HR, 00:42:10] (Gerade im Zuge zunehmender Verbreitung von offen zugänglichen Lehrinhalten die über das Internet verfügbar sind, macht es sehr viel Sinn, Verknüpfungen herzustellen. Vielleicht eine Art Metaportal dafür einzusetzen. Und somit die vorhandenen Sachen gut nachzunutzen. Immer mehr Universitäten stellen ihre Inhalte ins Netz, teilweise auch unentgeltlich, teilweise nur für die eigenen Studenten, aber auch für andere Studenten, sodass eigentlich an Material kein großer Mangel sein sollte. Veranstaltungen wie „Grundlagen der Programmierung“ und „Informatik 1 – 3“, die gibt es überall.)

Beside those interviewees mentioned above, the other interviewees either also agreed, or the topic has not been discussed explicitly. Most critical was Hemmje's comment that a didactical layer should be added, as discussed in section 6.9.13 *Learning and Teaching of Proposed Improvements* on page 241. However, he also did not disagree with the concept's applicability in learning contexts.

6.9.12 Highlights

Beginning with this section the properties of the concept are discussed that the interviewees saw as important, without introducing bias by telling them about which properties they should reflect upon. These sections are structured using the subcodes that have been developed during the analysis process.

In this section the concepts' highlights as seen by the interviewees are discussed. Limitations and proposed improvements are discussed in the following sections.

Authoring Workflow

Basically, the interviewees see two main advantages of the concept: First, it involves less authoring work. Beside the aspects already discussed in section 6.9.8 *Authoring Content-Structures* on page 226, for example Spierling said: "One author is creating only one alternative. This alternative is in fact linear. The only work needed is adding the meta information. The better I do that, the better the system can work." [US, 02:08:48] (ein Autor macht nur eine Alternative. Die ist eigentlich linear. Das Einzige, was man machen muss, ist die Metainformation liefern. Und je besser ich die liefere, desto besser kann das System nachher arbeiten.) Rölke sees it similar: "If you enter new content you have no effort. Because the system adopts the structure automatically. (...) The second author has some more effort. However, he has the advantage of the already existing links. This way the existing one can be referenced and used. That is an advantage of the system." [HR, 00:47:30] (Wenn du neuen Inhalt einpflegst, hast du keinen Arbeitsaufwand. Weil das System automatisiert meine Struktur übernimmt. (...) Beim zweiten hat man mehr Aufwand, dafür hat man ein Vorteil aus dem System, weil die Verknüpfungen schon vorhanden sind. Dadurch kann das Vorhandene referenziert und benutzt werden. Das ist ein Vorteil des Systems.)

Second, the interviewees agreed that the concept simplifies the work for authors in various ways. Göbel likes its simplicity: "The basic approach is definitely very good. To look first at the essentials of the authors's workflow. This is very good. It is also good to use a simplified approach without all these levels. (...) I like it very much that you build upon the linear sequential approach and not the rule based approaches. Because it is more realistic." [SG, 00:48:22] (Auf jeden Fall ist der Grundansatz sehr gut. Erst zu schauen, wie die Autoren vorgehen und auf was

es da ankommt. Das ist sehr gut. Es ist auch gut als Zielsetzung einen möglichst vereinfachten Ansatz ohne die vielen Schichten. (...) Ich finde es sehr gut, das Du auf den linear sequentiellen Ansatz setzt und nicht auf Rule Based. Weil es realistischer ist.) Krömker likes the fact that for adapting only the other authors' content needs to be comprehended: "The good thing about this approach is that you can do it. You only need to understand the content, but not the colleagues' didactical concepts." [DK, 02:00:25] (Das Starke an dem Ansatz ist, dass man es machen kann. Man muss nur den Inhalt verstehen, man muss gar nicht die didaktischen Konzepte der Kollegen verstehen.)

Only the most typical and significant comments have been cited here. All other interviewees also agreed that the concept simplifies and reduces the effort needed to create adaptive structures. Hence, based on the interviewees' statements, again the research goal can be seen to have been achieved. More of the interesting aspects, both pro and con, were discussed with the interviewees and reported on below.

Theory

Two interviewees also commented on positive aspects of the theory behind the concept. Iurgel emphasised that content and structure are left in their original form as much as possible, and that theory is used sparingly: "What I like about your approach is that it uses theory sparingly. Very much is just implicit. The teaching methods and structures are just kept as they are. It only adapts where absolutely necessary, the same happens with creating the suggestions. It would always make the system second-rate. You only use the system if there is no other possibility, where it is clear that you cannot move on with the existing material. Then system's suggestions are allowed. It is supposed that something created at runtime is worse compared to something that has been carefully prepared. That is a known problem of interactive storytelling. If you compare a story that has been created at runtime with a story that has been written by an author, those are completely different things. I think it

is similar.” [II, 01:38:09] (Da gefällt mir Dein Ansatz sehr gut. Dass es so Theoriearm ist. Weil so viel implizit ist. In den Lehrmethoden, in den Lernstrukturen, dass man es am besten einfach behält, und nur dort, wo es unbedingt notwendig ist etwas anpasst, oder alternative Strukturen von einem System vorschlagen lässt. Das würde das System immer zweitklassig machen. Man benutzt das System nur, wenn es nicht anders geht, wo es klar ist, dass man mit dem was bereits vorhanden ist nicht weiterkommt. Dann darf das System etwas vorschlagen. Es ist anzunehmen, dass etwas, was zur Laufzeit erzeugt wurde, schlechter ist als etwas, das gründlich vorbereitet wurde. Das ist ein altes Problem von Interactive Storytelling. Wenn man vergleicht, eine Geschichte die zur Laufzeit erzeugt wurde mit einer Geschichte die von einem Schriftsteller, von einem Autoren erzeugt wurde. Das sind völlig verschiedene Dinge. Das Prinzip wird auch hier so ähnlich sein.) Based on that he deduces for the concept’s realisation: “It is relatively free of theory. It does not request too much from the system. I think, in the edge case the structure could be created using statistical methods. Thus, there would be no authoring effort at all in the edge case. I like that.” [II, 01:41:34] (Dass es relativ theoriefrei ist. Es verlangt nicht zu viel von dem System. Ich glaube, dass man im Grenzfall über statistische Methoden die Struktur aufbauen könnte. Das heißt, dass der Authoringaufwand im Grenzfall bis null geht. Das gefällt mir.)

Krömker likes the merging idea: “It is really a good idea to merge different lecturing concepts.” [DK, 01:40:11] (Die Idee ist wirklich gut, unterschiedliche Lehrkonzepte zusammenzuführen.) He thinks that it is a new approach: “A priori I would not have got the idea to reinterpret traditional approaches in that way. I think in this respect it is new.” [DK, 01:44:13] (Wäre ich a Priori nicht darauf gekommen, dass man traditionelle Ansätze so uminterpretieren kann. Scheint mir in der Hinsicht neu zu sein.)

These statements support the idea behind the concept of not predetermining structures, content, or didactics, but giving the author the freedom to choose his

own way. It seems that this on the one hand simplifies creation, and on the other hand the outcome is more hand made and therefore expected to be better than any content created at runtime by a machine or an algorithm.

Learning and Teaching

Most of the interviewees have also seen positive effects of the concept regarding the contexts of learning and teaching. Typical statements have been about the students' possibility of choosing their own way and adaptivity itself. The former has been particularly noted and commented on in various facets.

A welcome functionality of the player has been the possibility to choose. For example, Iurgel stated: "I like this autonomous search through learning materials. I know these kind of situations very well: I want to get the same thing, just explained differently, because the first time I only partially understood it, because it was explained badly, or the book contains mistakes. The other one has the missing part." [II, 02:03:39] (Interessant finde ich dieses selbstständige Durchsuchen der Lernmaterialien. Ich kenne solche Situationen als Lernender sehr gut: ich möchte genau dasselbe auf eine andere Weiser erklärt bekommen, weil ich das beim ersten mal nur halb verstanden habe, da es nicht gut erklärt ist oder das Buch Fehler hat. Der andere bringt gerade das, was noch fehlt.) This opinion is confirmed for example by Stengel: "It is good that you can choose." [IS, 00:48:33] (Gut ist, dass du es auswählen kannst.) Gaida sees the possibility of choosing one's own way in conjunction with different preferences regarding learning styles: "One possibility is using it for self instruction: How can I appropriate knowledge? I choose a way intuitively: I like this, for me it has been proven for knowledge transfer. If I choose that way I get a path that is good for my learner type." [MG, 01:15:09] (Der erste Weg ist, dass es ein für Studierende selbst gestütztes eLearning System ist: Wie kann ich mir Wissen aneignen? Ich wähle intuitiv einen Weg aus, indem ich abstimme: Das gefällt mir, oder das hat sich für mich bewährt von der Wissensvermittlung.

Wenn ich das so abstimme, dann bekomme ich einen Weg, der sich für mich als Lerntyp bewährt.) Relating learner preferences he emphasises the possibility of using different didactical concepts: “It serves different learner types and provides different learning concepts with choices. Although you did not tell me, I can see this. I think that there is potential.” [MG, 01:30:53] (Das bedient unterschiedliche Lerntypen und hat ganz unterschiedliche Lernkonzepte zur Auswahl. Das sehe ich auch abgebildet, obwohl Du mir das nicht mitgeteilt hast. Und da sehe ich das Potenzial.) Spierling sees also a social component in choosing: “To put it in a nutshell: I like the fact that the students are the central point the most. They choose and rate what they understand best.” [US, 02:24:15] (Auf den Punkt gebracht: Am besten finde ich daher, dass die Studenten im Zentrum stehen. Dass sie aussuchen, und dass sie raten (Englisch, bewerten), wie sie es am besten verstanden haben.)

Seeing the concept as a model, Spierling and Gaida added an interesting interpretation about its representation. During a discussion about usefulness of adaptivity in the learning context Spierling has stated: “What else do you need lecturers for? If adaptivity is not useful ...? The question is: Should content be adaptive? You substitute the lecturer with adaptive content.” [US, 03:01:53] (Wozu benötigst Du sonst einen Lehrer? Wenn Adaptivität nicht sinnvoll ist ...? Die Frage ist: Muss der Content adaptiv sein? Du ersetzt den Lehrer durch adaptiven Content.) Gaida reflects on the model itself: “Essentially it is a model of how a good lecturer teaches. During a lecture I react to the audience all the time. I try to adapt, or to relate, clarify if everything has been understood ... Basically I am adaptive all the time. You try to automatise the mechanisms that already exist in the learning domain, and provide them for eLearning applications.” [MG, 01:25:48] (Im Grunde genommen ist es eine Abbildung, wie ein guter Dozent lehrt. Das heißt, wenn ich eine Vorlesung mache, dann reagiere ich sowieso die ganze Zeit auf mein Publikum. Und versuche anzupassen, oder noch mal Bezug zu nehmen darauf, zu klären, ob alles verstanden wurde ... Im Grunde genommen bin ich selbst adaptiv die ganze Zeit.

Du willst versuchen, diese Mechanismen, die es in der Lehre sowieso schon gibt, zu automatisieren und für eLearning Anwendungen zur Verfügung zu stellen.)

On the one hand, this part of the discussion gives a first hint to the question if it is better to hide alternatives or to present them as prioritised. Most of the interviewees think that it is a good idea to let the students choose their path to support them. Even though there is work necessary to have real support that does not confuse more than it helps, for example by a badly designed GUI, and it should be confirmed by students, it seems it is worth following that path.

On the other hand, the two designers' interpretations of the concept are a possible explanation of what could be necessary for a successful adoption of an implementation of the concept: They see their way of lecturing modelled here, hence they feel comfortable with its behaviour. Even if the concept is not modelling their way of teaching, as long as it feels like this, it is modelled well enough as a first important step.

Feedback and Community

Based on the authoring process that uses the students' personal paths additional to the original authored paths of the lecturers, Spierling developed the idea of feedback for the lecturer: "It is nice that it does not need to happen in a hidden system where students help each other and the lecturer cannot notice that. (...) I could imagine it as follows – students say: 'I use the slides this way, this is how I understand them best.' Then others could say 'Nice, this is the way I also understood it best.' The lecturer looks at those newly arranged slides and says: 'My arrangement is rated worse than the student's own version. Maybe next time I will try his way.' Good thing. Want to have that." [US, 01:43:33] (Und das Schöne ist: Nicht in einem heimlichen System, wo die Studis untereinander sich mal helfen, und der Dozent kriegt das wieder nicht mit. (...) Ich stelle mir das gleich wieder so vor: Studenten sagen: „Ich nehme mal die Folien in die Reihenfolge, so habe ich es am

besten verstanden.“ Und dann können andere sage: „Gefällt mir, so habe ich es auch am besten verstanden.“ Dozent schaut rein und sagt: „Meine Reihenfolge hat weniger Punkte, als was der Student zusammengebastelt hat. Vielleicht mache ich es das nächste Mal so wie er.“ Schöne Sache. Haben will.) She adds another form of possible feedback for the lecturer: “And there would also be another feedback process that enables the students to tell me via ‘like’ or ‘dislike’ in a roundabout way that I talk trash and should do it another way.” [US, 02:06:01] (Und es gäbe natürlich den anderen Rückkopplungsprozess, wo mit „Gefällt“ und so weiter sie mir durch die Blume mitteilen können, dass ich Blödsinn erzähle, und ich soll es anders machen)

Krömker sees possibilities of self-regulation for the students: “I think it is also exciting that the system is able to learn the students’ behaviour. Based on the students’ changes and choices, indications could be found that point out – say – suboptimal parts. In respect of unfulfilled requirements, because they have been assumed implicitly, and the students do not know them. It is often about tiny details.” [DK, 01:41:17] (Ich finde auch noch spannend, dass das System lernen kann, wie sich die Studierenden verhalten. Dadurch, dass die Studierenden wechseln, Indikationen gefunden werden können, wo etwas – sagen wir mal – suboptimal ist. In der Hinsicht, dass Voraussetzungen nicht erfüllt sind, weil sie implizit angenommen wurden, aber es den Studierenden nicht klar ist. Das sind oft Kleinigkeiten.) Like Spierling, he thinks also about help for the lecturers: “It also may help lecturers restructuring their content, if they get feedback where students back out.” [DK, 01:59:33] (Ich finde Deinen Ansatz wirklich klasse. Es hilft den Lehrenden vielleicht auch ihre Inhalte neu zu strukturieren, wenn Sie Rückmeldung bekommen, wo die Studierenden aussteigen.)

This kind of feedback could be directly built from the students’ histories; better would be anonymised data, for example from log files. Some extra processing and filtering would be needed to leave only the important data and visualise it properly. It should be kept in mind that changing the path or pressing the dislike button does

not necessarily indicate bad content. However, concentrations of such actions at some certain locations may hint at problematic parts.

Of course, restructuring their own content does not decrease effort. However, this kind of feedback could be a time saver for lecturers who already attempt to optimise their lectures, because they could use this feedback as a starting point and as hints for the process of revising. In that case an integrated authoring environment should help them adopt the changes they want to integrate – or to adopt the new version as a whole.

User Interface/Presentation

The user interface is a prototypical proof of concept and therefore not really usable in a productive environment. However, most of it has been understandable, at least after some brief explanations. Beside the history that was asked for by each interviewee, the progress bar turned out to be remarkable during the interviews. For example Spierling noted: “Such things are important for that kind of hypermedia. Otherwise it is a money sink. You have seen, say, only ten percent of the content, but you have already done 80 percent. That must be indicated anyhow. Emotionally.” [02:50:57] (Ja, aber so etwas, glaube ich, ist wichtig bei so einer Art Hypersalat. Sonst ist es ein Fass ohne Boden. Du hast, sagen wir, nur zehn Prozent des Contents gesehen, aber Du bist 80 Prozent durch. Und das musst du irgendwo abbilden. Gefühlsmäßig. Schöne Sache. Man muss so etwas wirklich mal ausprobieren.)

This short part of the discussion highlights the importance of GUI details that make the users feel comfortable. Therefore they need to be accurate, easy to grasp, and attractive. More details are not discussed at this point because it is the concept that is to be evaluated not the GUI's usability.

Miscellaneous

In the last part of this *Highlights* section, one of the most critical interviewees is cited. Like the other interviewees, he sees a lack of usable concepts and systems in that area, and that it is addressed by this research and its prototype: “Actually we need more such systems.” [01:23:09] (Eigentlich benötigen wir mehr Systeme, die in diese Richtung gehen.)

6.9.13 Proposed Improvements

The concept including the prototype has room for improvements. Those that have been proposed in the interviews and rated as typical in the analysing process are discussed in this section.

Authoring Workflow

According to the workflows, the interviewees have seen possible improvements especially in the area of creating the content-types – links for similar content – and reusing existing content. These demand extensions to the system itself. Spierling also has a proposal that is system independent – every author should tag and link – which means creating content types and possibly contexts – his content right from the beginning: “Indeed it would be of value that also the tenth author adds his content – but then he has to review nine other slide sets in advance. That is an insoluble problem. It would be better to tag them (the content sections) from the beginning. Thus, I could see if the engine can match already existing keywords with mine.” [US, 01:36:52] (es wäre durchaus wertvoll, wenn auch der Zehnte seinen Content noch eingibt – aber dann muss er neun andere Foliensätze vorher durchsehen. Das ist unlösbar. Besser wäre, die wären schon vom ersten voll vertaggt, und ich kann durch die Stichworte, die ich selbst eingebe, sehen, ob die Engine bei den anderen matcht)

Having this information, an authoring environment could help find similar content. For example Iurgel has proposed: “Probably an authoring system would suggest

existing tags. It could also be necessary to be able to look up what I have already tagged.” [II, 01:56:56] (Wahrscheinlich würde ein Autorensystem die Tags, die man schon hat, vorschlagen. Ich müsste wahrscheinlich auch das, was ich vorher getaggt habe, nachschlagen können.) Stengel demands search support: “You would need support for searching to be able to look for existing content and tags using different criteria.” [IS, 00:48:59] (Man bräuchte Unterstützung bei der Suche. Damit man nach verschiedenen Kriterien sehen kann, was da ist.)

Going a step further Stengel suggests: “Would it be imaginable that authors would get links suggested automatically on the basis of keywords? And that they could view these documents and correct the links?” [IS, 01:29:38] (Könnte man sich vorstellen, dass Autoren anhand von Stichwörtern automatisch Verlinkungen vorgeschlagen bekommen? Und sie in die Dokumente reinsehen und Verlinkungen korrigieren können?) Iurgel proposes text and speech analysis as further help to find similar content: “With speech analysis it should be possible to identify that these people are talking about the same thing. As a further step.” [II, 1:57:31] (Das müsste doch möglich sein mit Sprachanalyse zu identifizieren, wie in dem Videobeispiel, dass die Menschen über das selbe reden. Als weiterer Schritt.)

To simplify reusing existing content Stengel asks for an integrated authoring environment: “It would be advantageous for authors to reuse existing content, hence to not recreate it. If a system existed that not only supports importing slides, but also creating slides including reusing existing material that would be ideal.” [IS, 01:20:11] (Für einen Autor wäre von Vorteil solche Dinge wiederzuverwenden und nicht neu erstellen zu müssen. Wenn ein System existieren würde in dem Folien nicht eingepflegt werden würden, sondern die Folien entwickeln und passende Materialien wiederverwenden kann. Das wäre ideal.) For such an integrated editor Göbel suggests templates: “Do other kinds of interactions, modules, and templates exist? That might also be helpful.” [SG, 00:53:56] (Gibt es andere Interaktionsformen, Module, Templates? Das wäre vielleicht auch noch hilfreich.) Reusing material also demands

interchanging possibilities as stated by Hemmje: “To be able to interchange materials the question exists, how this could be supported by a file format that also represents such properties.” [MH, 01:23:35] (Da ist auch die Frage, inwiefern kann das von einem Datenformat unterstützt werden, dass solche Eigenschaften mit repräsentiert und dadurch Materialien ausgetauscht werden können.)

The interviewees proposed two kinds of workflow related improvements: Help to establish the semantic links and an authoring suite that integrates editing functionality and an interchange file format. The more the realisation tends towards automatic help or to fully fledged authoring tools, the more the effort for developing and designing rapidly increases. However, only implementing these kinds of features might incentivise lecturers to start using such systems. Further relevant research would be the development of helper functionality.

Theory

For finding the best fitting content, Hemmje proposes heuristics: “what enables a student to choose? He is the learner. He ought to say that he wants to deepen this or wants to examine that. He ought to comment. It is questionable if he is able to decide in which situation he is? In this area heuristics are becoming interesting. That you not only determine the didactical function, but to say: From 100 students that have done this component, 30% also have done this and that to deepen this subtopic. Or they have conducted a self examination that can be found there, it fits well at this point. Just like Amazon’s recommender system. However, this makes demands on a lecturer, because only he is able to detect useful additions.” [MH, 00:56:49] (Was befähigt den Studenten, eine solche Auswahl zu treffen? Er ist der Lernende. Wenn, dann müsste er sagen, dass er dieses vertiefen oder sich über jenes prüfen möchte. Er müsste sich selber äußern. Die Frage ist, ob er selber entscheiden kann, in welcher situation er sich gerade befindet? Da werden Heuristiken interessant. Dass man nicht nur die didaktische Funktion bestimmt, sondern man könnte sagen:

von 100 Studenten, die durch diesen Baustein gegangen sind, haben danach 30% das und das auch noch angeschaut, um dieses Unterthema zu vertiefen. Oder sie haben eine Selbsttestaufgabe gemacht, die befindet sich dort und passt an diese Stelle gut dazu. So wie das Empfehlungssystem bei Amazon. Aber dazu wird wieder ein Dozent benötigt, weil nur er erkennen kann, was hier noch sinnvoll getan werden könnte.) Iurgel would try to investigate statistical methods: “Eventually it would be interesting to think about making that matching of lecturers and students free of theory. For example this professor fits to that kind of student, for whatever reason. (...) If you were independent from theories of cognitive styles or similar, but only have statistical relations, then you could use recommender systems: Who buys this book also buys that one – for whatever reason. Therefore no theory at all is needed.” [II, 01:22:58] (Es wäre eventuell interessant zu überlegen, ob man es nicht theoriefrei machen kann, dieses passen zwischen Lehrenden und Studenten. Zum Beispiel dieser Professor passt zu dieser Art von Studenten, warum auch immer. (...) Wenn man nicht abhängig wäre von Theorien über kognitive Stile oder ähnliches, sondern einfach statistische Zusammenhänge hat. Dann kann man Recommender Systeme einsetzen: Wer dieses Buch kauft, kauft auch jenes – warum auch immer. Da benötigt man überhaupt keine Theorie dazu.)

Indeed, these community-related approaches are very interesting. As a next step it should be investigated if and to what extent these kinds of statistical methods could be used to supplement, verify, or maybe replace explicitly arranged relations and dependencies. Beside technical difficulties, the need for user tracking could be a problem for such approaches.

Learning and Teaching

Gaida and Hemmje have proposed including didactical concepts. For example, Gaida stated: “However, didactical concepts are not so much modelled: As a lecturer, how can I communicate my subject or content?” [MG, 01:30:25] (Aber was noch nicht so

abgebildet ist, sind unterschiedliche didaktische Konzepte: Wie kann ich als Dozent meinen Stoff oder meine Inhalte rüberbringen?) Hemmje has taken the same line: “I think, the didactical dimension is missing a little bit. (...) As soon as you break up the structure, it (the didactical function) gets lost. This raises the question, how to retain the function of individual components. This is a major problem of such constructive approaches: If you import material, you retain the structure. However, the didactical intention gets lost by decomposing it, because it is nowhere represented explicitly. It is only implicitly – thus not explicitly – coded in that one structure. He has brought it into that order for whatever reason – but that reason is not described anywhere.” [MH, 00:51:16] (Was mir hier noch ein bisschen fehlt ist die didaktische Dimension. (...) Sobald Sie anfangen die Struktur aufzulösen, geht das (die didaktische Funktion) verloren. Die Frage ist dann, wie kann die Funktion einzelner Komponenten bewahrt werden. Das ist ein wesentliches Problem bei solchen konstruktiven Ansätzen: Wenn sie das Material importieren, erhalten sie die Struktur, aber die didaktische Intention geht bei der Dekomposition verloren, weil sie nirgendwo explizit repräsentiert ist und weil sie nur in dieser Struktur und nur implizit – also nicht explizit – kodiert ist. Der hat es aus irgendeinem Grund in diese Reihenfolge gebracht – warum hat er aber nirgendwo beschrieben.)

The demand for adding didactical concepts is understandable, and adding a didactical dimension would certainly be possible (the theory behind it is not simple, but adding it technically is, for example by adding an existing one). This could be achieved for example by adding a didactical structure to the content structure, or by adding adequate contexts and appropriate rating algorithms. However, layering structures have been seen to be one of the major problems of traditional approaches. Thus, one of the foundations of concepts is using only three layers for structuring the content. Adding an additional layer or making didactical information indispensable would contradict the attempt to reduce layers and additional structure information. This would not only increase the effort, because of the extra work needed to input

that information, but also possibly complicate the content structure creation process, because this layering of structures does not seem to be the normal human way of thinking and creating content structures.

Of course, this research direction should be pursued. Balancing the number of layers and demanding meta information will be an important task to increase user acceptance. However, it could also be seen as a limiting aspect of the concept.

Feedback and Community

Proposals derived from feedback and community activities have been twofold: Using students' feedback for influencing the system's recommendations, or using their learning activities for authoring proposals.

As already mentioned in section 6.9.13 *Theory*, the learners' vote by using the like and dislike buttons or choosing a different section than the recommended one could be tracked and used for recommendations. For example Hemmje has stated: "What has been good for the majority of people who have successfully passed this module, cannot be bad for you. This would add a social component that allows recommendations, even if it is ambiguous as to why the students decided that way. However, at least I can be positive that students that have passed have seen this." [MH, 00:59:32] (Was für die Masse der Leute, die diesen Kurs erfolgreich bestanden haben gut war, das kann auch für dich nicht schlecht sein. Dann wäre eine soziale Komponente drin, die eine Empfehlung ausspricht, auch wenn unklar ist warum die Studenten diese Entscheidungen getroffen haben. Aber ich habe dann zumindest die Sicherheit, dass die Studenten, die bestanden haben, das angesehen haben.) Göbel has a similar opinion: "Feedback would be good. If the students' ratings get logged they could be used for recommendations for the next run." [SG, 00:49:04] (Rückkopplung wäre gut. Wenn die Studenten bewertet haben und es wird alles geloggt, dass diese Analyse als Empfehlung im nächsten Durchlauf mit enthalten ist.)

Spierling would like to get additional feedback as to why students dismissed a content section and to use them as feedback for lecturers: “I would have said that one should do a longer investigation of what essential criteria we would like to know. (...) Thus, one could get an idea if the students just do thumbs down quickly, or if they have other reasons. At least it would be clear if they have done it for personal reasons, for example they do not like the professor, which could be possible. Then it would not be used for the didactical evaluation.” [US, 02:37:32] (ich hätte eher gesagt, dass man durch eine längere Untersuchung überlegen müsste, welche sind unsere wesentlichen Kriterien, die wir wissen wollen. (...) Man könnte darüber eine Ahnung bekommen, ob die Studenten nur schnell Daumen runter machen, oder ob die andere Gründe haben. Und wenn sie zum Beispiel persönlicher Natur sind, weil sie mögen den Professor nicht, kann ja auch sein, dass das zumindest klar ist. Dann geht das nicht in die Evaluierung von Didaktik ein.) Even after a short discussion about whether any further steps in the interface might hinder acceptance of the system she thinks that getting additional information is needed: “You are right, it needs to be quick. However, perhaps it needs a differentiation like: I did not understand that. Or: You could explain that better.” [US, 02:39:41] (Ich gebe Dir recht, es muss schnell gehen. Aber es muss vielleicht eine Unterscheidung geben, wie: Ich habe das nicht verstanden. Oder: Man könnte es besser erklären.) However, Rölke does not like that idea at all: “No, using that as feedback for professors is codswallop, because it should help the students. The student does not necessarily choose an alternative because it was daft, but he may need more or another kind of explanation. But not because the professor has explained that badly. Maybe he has done a great job for 99 of 100.” [HR, 00:49:08] (Nein, das ist Quatsch, das als Feedback für die Professoren zu nehmen, weil es den Studenten helfen soll. Der Student wählt nicht unbedingt eine Alternative, weil es blöd war, sondern weil er selber vielleicht ein wenig mehr Erklärung oder eine andere Art der Erklärung benötigt. Und nicht, weil der Professor das vielleicht doof erklärt hat. Vielleicht hat er super erklärt für 99 von 100.)

In Spierling’s opinion, at least including some kind of social network in a useful way would help the system’s acceptance: “Thinking about social media is necessary because nowadays students want and can do that. They have all mobiles with them. An interface to this would be absolutely conducive to success, I would say.” [US, 02:25:24] (Die Überlegung mit Social Media deswegen, weil die Studenten heute in dem Alter sind, wo die das alle wollen und können. Die haben alle ihr Mobile dabei. Da eine Schnittstelle hin, würde zum Erfolg auf jeden Fall beitragen, würde ich sagen.)

While feedback from students for students could and should be integrated, for example as already mentioned in the authoring workflows or to create ad hoc links, using and extending the feedback for evaluation and comparable purposes could be problematic. For example, both, students and lecturers may feel observed. Integrating feedback that way – even just thinking of it – may hinder acceptance and should be on the one hand investigated thoroughly and on the other hand introduced extremely carefully.

User Interface/Presentation

Due to its prototypical stage, there have been many proposals for optimising the user interface, especially during the hands on phase. Many of them have been unspecific GUI improvements with a limited influence on the workflow. Hence, only the important ones are discussed here.

The overall need for interface improvements has been noted by all interviewees. For example, when an interviewer asked the question about possible improvements, Göbel answered immediately: “Visualisation, that is for sure.” [SG, 00:49:01] (Visualisierung, ist klar.) Spierling has stressed the motivational factors of an interface: “It is always dependent on the authoring tool. It needs to work smoothly. It needs to look good. We have some examples that put off authors, because they look ugly. It becomes important. Do I like to use it?” [US, 02:24:56] (dann hängt es immer vom Autorentool

ab. Das muss geschmeidig funktionieren. Es muss schön aussehen. Wir haben ein paar Beispiele, die schrecken Autoren ab, weil die so hässlich aussehen. Es spielt eine Rolle. Benutze ich das gerne.) Of course, she also demands a better usability: “That is, I would need to create an interface that is not only nicer, but also clearer.” [US, 02:32:06] (Das heißt, ich müsste ein Interface basteln, wo das nicht nur schöner, sondern auch klarer wird.) Typically, there have been some very specific suggestions like drag and drop or drawing links: “It would be interesting to simply connect these different structures with an arrow. Thus you would really create a semantic net of it all.” [IS, 01:01:01] (Was interessant wäre, wenn du die verschiedenen Strukturen einfach mit einem Pfeil verbinden könntest und wirklich ein semantisches Netz von dem Ganzen produzierst.)

The interviewees also framed suggestions for the learners’ point of view. For example, the reasons for the recommendations of the system should be transparent to the user: “Now I have been recommended for that, but why? If I am interested, then I can click on it. Then the system would prompt: You have said three times that you do not like his explanations. Due to this we have pushed those to the end . . . That it is transparent to the user, why this is chosen, but not anything else.” [US, 02:41:56] (Ich habe das jetzt vorgeschlagen bekommen, und ich habe einen kleinen Punkt: Warum? Wenn mich es interessiert, kann ich es anklicken. Dann sagt mir das System: Du hast vorher drei Mal gesagt du magst dessen Erklärungen nicht, deswegen haben wir die nach hinten . . . Dass man so viel transparent macht, warum jetzt das kommt, und nicht was anderes.) Spierling and Iurgel have demanded the highest priority for their content, because their content is relevant for passing the exams. Spierling explains it from the students’ view: “Do I have to be examined by the first author? It is not a good feeling maybe if I have missed some of his slides. If I think about examinations. Then I need to know everything he has taught. If I – say – did not understand a concept, I would like to get other content. To see, how others explain it. That is very useful. However, I would like to return to the first

author's path, anyway. Simply so I do not miss what he is doing." [US, 02:48:36] (Muss ich bei dem ersten Autor eine Klausur schreiben? Das Gefühl, etwas verpasst zu haben von seinen Folien ist kein gutes. Wenn ich an die Klausur denke, dann muss ich wissen, was er alles gebracht hat. Dann bediene ich mich gerne bei den anderen Sachen, um, sagen wir, habe ich ein Konzept nicht so verstanden. Mal sehen, wie die anderen das erklären. Das ist sehr nützlich. Aber ich würde trotzdem gerne wieder zurück auf den Pfad vom ersten Autor kommen. Einfach, damit ich nicht verpasse, was er macht.) The lecturer's view, as Iurgel sees it, is: "It is supporting material, it will never be my material. I do my material and my lecture. Like I say: There is a textbook. If you do not understand something or you want to look up something, you can use it. However, that is your decision. (...) I do not want my material to disappear in the ocean of material. My material is relevant for the examination." [II, 01:42:14] (Es ist unterstützendes Material, es wird niemals mein Material sein. Ich mache mein Material und meine Vorlesung. So wie ich sage: Es gibt ein Lehrbuch, und wenn ihr etwas nicht versteht oder nachschlagen wollt, könnt ihr dort nachsehen, aber das ist eure Sache. (...) Ich möchte nicht, dass mein Material im Meer der Materialien verschwindet. Prüfungsrelevant ist mein Material.)

These are only a few examples among others of how to simplify and unclutter the interface. If the background, theory, and algorithms of the concept remain relatively simple, it will be one of the developmental parts that need most effort and (usability) testing. In particular it is assumed that the path related visualisations, especially the author's view for relating the sections, will be very difficult to design until they are acceptable.

Miscellaneous

Even if this concept reduces the effort for the creation of adaptive eLearning content compared to existing approaches, it is still more work than creating linear content. This is a limitation that will be discussed in more depth beginning with the following

section. Because of this extra work, an inducement may be needed: “I just thought about that: Two people not knowing each other. They feed a system, so that the system will use their material afterwards. This is only of use for students who can choose the best way of learning for themselves. The professors do not get anything out of that. You could use gamification that they get rubber points for brilliant tagging. We should do that. Any kind of motivation. Inducement.” [US, 01:36:06] (Ich habe mir gerade vorgestellt: Zwei Leute, die sich nicht kennen. Die füttern ein System, auf dass das System nachher ihr Material verwendet. Um nur einem zu nützen, nämlich dem Studenten, der sich die beste Art des Lernens da aussucht. Die Professoren haben nichts davon. Man könnte jetzt Gamification anwenden, dass die Gummipunkte dafür kriegen, wie toll sie vertaggen. Sollten wir unbedingt machen. Irgendeine Motivation. Anreiz.)

6.9.14 Limitations

This section discusses the limitations of the concept as seen by the interviewees. Most of these limitations are constituent parts of the concept’s nature. Thus, they should be identified in order to be able to handle them: Either to accept them, or to cope with them, or to get around them. They also provide hints as to whether further developments or, later, usage is promising for the intended objectives.

Authoring Workflow

During the introduction phase, Göbel asked about one of the most characteristic features of the concept: “The system only works if alternatives exist?” [SG, 00:37:21] (Das ganze System funktioniert nur dann, wenn eine Auswahlmöglichkeit vorhanden ist?) Later, like all the other interviewees, he sees this fact as a natural limitation: “I think a practical limitation is that not always different versions of the same subject exist.” [SG, 00:50:30] (Ich glaube eine Grenze aus der Praxis ist dass nicht immer zu den gleichen Themen mehrere Versionen existieren.)

The concept solves this demand for variations by relating content from different authors. Thus these authors need to at least agree to open their content for such kinds of relations. Spierling has commented on this characteristic: “Works best in a world without vanity.” [US, 00:55:11] (Funktioniert besonders gut in einer Welt ohne Eitelkeiten.) Back to real world she remarks: “There are still colleagues who would not even provide PDFs, because this is too open and usage of electronic stuff for them – and you never know. Students could copy all that.” [US, 02:12:50] (Es gibt immer noch Kollegen, die noch nicht mal PDFs zur Verfügung stellen, weil das für sie zu viel Öffnung und Benutzung von elektronischem Kram ist – und man weiß ja nie. Dann könnten die Studenten alles auch kopieren.) Rölke has seen additional obstacles: “A, of course, only their own teaching is good. B, it makes someone controllable and comparable. This is unpopular, nobody wants that. Students should be tested, not professors.” [HR, 00:48:16] (A, dass natürlich nur die eigene Lehre gut ist. B, dass man sich dadurch kontrollierbar und vergleichbar macht. Das ist unbeliebt, das möchte keiner haben. Es sollen die Studenten getestet werden, nicht die Professoren.) Additionally, legal issues may also hinder opening and therefore relating content. This has been noted by Göbel: “The legal or the willing side to provide content in a pool. These are practical and administrative limitations.” [SG, 00:50:51] (Die rechtliche oder die willens Seite, Inhalte in einen Pool zu geben. Das sind praktische und administrative Grenzen.) Krömker has observed that it is getting more and more difficult to access or even find other lecturers’ content: “I regret very much that now everything gets hidden in learning platforms. It was a wonderful period 2000 – 2004. All colleagues and more and more colleagues have put everything onto the internet. Nearly everything was freely accessible. Due to the learning platforms most of that is not free on the internet anymore – including my own content.” [DK, 00:25:50] (Ich bedauere sehr, dass inzwischen wieder alles in Lernplattformen verschwindet. War eine wunderschöne Zeit 2000 – 2004. Wo alle Kollegen und immer mehr Kollegen alles

ins Internet gestellt und eigentlich war fast alles frei zugänglich. Durch die Lernplattformen – mich eingeschlossen – ist es nicht mehr frei im Internet.)

In addition to the issues of the overall concept, also several steps of the workflow could be problematic. For example, because relating and setting context could be seen as a way of tagging the content, Iurgel hints at a standard difficulty: “You have the common problem of tagging: What are the appropriate tags to describe for example a lecture? It is not trivial: What is the ontology for an object oriented programming lecture?” [II, 01:25:34] (Du hast das übliche Problem des Taggings: Was sind denn die geeigneten Tags um zum Beispiel eine Vorlesung zu beschreiben? Das ist nicht trivial: Was ist die Ontologie für eine Vorlesung über objektorientierte Programmierung?) Krömker has seen the main issue in defining learning units: “One has to define the learning units first. It is far from certain at which granularity level this should be seen.” [DK, 01:19:26] (Man muss erst mal die Lerneinheiten definieren. Es ist keineswegs klar, auf welcher Granularitätsstufe das betrachtet wird.) Of course, finding fitting relations is also a very likely difficulty. For example, Krömker has stated: “It appears the problem is to specify what is identical. Thus, what can be exchanged. And at which level exchanging is possible.” [DK, 01:46:07] (Es tritt das Problem auf, zu sagen, was identisch ist, also was kann man austauschen. Und auf welcher Ebene kann man es austauschen.) Gaida has added that the more unfamiliar the discipline of the subjects is the harder this task seems to be: “If the discipline becomes unfamiliar, the more these disciplines move away from each other (these modules which are offered/run in parallel), the more effort is needed by the authors to estimate whether or not there is a relationship.” [MG, 01:40:08] (Wenn es Disziplin fremd wird, je weiter sich die Disziplinen entfernen voneinander, dieser Kurse, die da parallel dargeboten werden, desto höher ist der Aufwand für den einzelnen Autor, einschätzen zu können: Wo gibt es eine Verknüpfung?)

For authoring, the necessary steps have to be performed to create an adaptive content structure. Even in the case that they would be absolutely unproblematic,

this means extra effort compared to creating linear content. And even the concept of this research is supposed to decrease effort, however it is still more work. This *more* can be decisive for acceptance, “simply because it is effort and therefore potentially an obstacle.” [US, 02:14:29] (Einfach weil es Aufwand ist, und das ist was, wo eine Hürde potenziell da ist.) Like the rest of the interviewees, Stengel sees it similarly: “If this should be implemented, it is necessary that it means nearly no work for authors. Then it works. Otherwise it will not work.” [IS, 01:30:36] (Wenn das umgesetzt werden soll, dann dürfen die Autoren fast keine Arbeit haben. Dann funktioniert das. Ansonsten funktioniert es nicht.)

The interviewees mainly identified two reasons with respect to the authoring workflow, as to why lecturers might not use a system that is based on the concept of this research, even with an optimal player and authoring environment: Additional work and sharing their content. This additional work can be an obstacle for acceptance, in particular because a realised authoring environment would mean somehow introducing new tools that need to be learned or at least got used to, which would result in additional extra work. This could be reduced by assistants or students, but at least the lecturers would still like to check the outcomes. Another problem is that, of course, the lecturers’ content has to be shared, so that it can be used in the manner of this concept. But many lecturers do not want to share their content for various reasons. This depends on the country, the university, and the lecturers themselves. For example, the content created from lecturers at Plymouth University and Fernuniversität Hagen is property of the universities, thus it can be used by all the other lecturers of those universities, even if the author has left the institution, which would support the reusing workflow of this concept. Implementing a university directive that demands using a system based on this concept has already been done in many universities for LMS would force adoption, as Stengel mentioned: “It very much depends on the university. I see it here in Plymouth. There is pressure regarding lecturing, for example to record lectures, etc. If people are required to make content

available from the beginning, then such practice should have a good chance to be adopted more widely.” [IS, 01:36:09] (Es hat sehr viel mit der Hochschule selber zu tun. Ich sehe es hier in Plymouth. Da gibt es bezüglich Lehre Druck. Ob das Aufnahmen von den Lehrveranstaltungen sind und so weiter. Wenn das zumindest am Anfang entsprechend gehandhabt wird, die Leute zu ihrem Glück gezwungen werden, kann es sein, dass es eine gute Chance hat, sich durchzusetzen.) However, the quality could also decrease in such scenarios.

The concept is based on relating linear content. Thus, different versions of one subject are needed. Compared to creating all different versions by oneself it reduces effort to use content shared by others. One of the simplest ways would be sharing and collaborating with lecturers from the same university. Indeed, then it needs to be a module that is held by different lecturers, for example like the parallel OOAD tracks at Hochschule Darmstadt. However, it would then need to be demanded by lots of students, which is more likely at bigger universities and popular courses. Another possibility would be networked universities that share courses, modules, and content, as is intended with Atlantis University. Also content that is freely available on the internet could be used. However, there needs to be an assurance that the contents’ license permits such links as needed for the concept. It remains to be seen whether there will be more open content available in the future, for example because of initiatives like OER, or if it becomes hidden in LMSs as Krömker stated.

The workflow related limitations mentioned in this section show that the concept of this research does not fit all kind of workflows and environments.

Theory

The concept of this research proposes relating similar content. Iurgel sees a possible problem in only one kind of relation having been specified: “There might be overlaps. Or one contains another. Probably the relations are much more complex than having equivalence classes only.” [II, 01:44:28] (Es mag Überschneidungen geben. Oder das

eine ist in dem anderen enthalten. Die Beziehungen sind wahrscheinlich sehr viel komplexer als nur über Äquivalenzklassen.) More research and practical experience is needed to see if this will turn out to be a real problem. It is possibly a big issue and should be kept in mind for further development. To handle this limitation, the relations could be handled like contexts and describe related sequences instead of only one related content type.

Krömker and Gaida have stated a possible duration issue: “Assuming a graph, and everybody has an additional learning unit. (pointing to an imaginary author) However, only this author has this learning unit, but no one else. This would mean that three learning units would be attached to the end. Imagine, everybody has a section that the others do not have. It does not vanish, but keeps existing in the overall module.” [DK, 01:32:42] (Angenommen man hat einen Graphen, und jeder hat eine Lerneinheit zusätzlich. Aber nur er hat die und kein anderer. Das hieße, dass drei Lerneinheiten hinten dran gehängt werden. Stell Dir vor, jeder hat ein Teilkapitel, das die anderen nicht haben. Das verschwindet nicht, sondern bleibt im Gesamtkurs enthalten.) This could be addressed by using the concept’s weights and duration properties. Thus, the overall duration can be constrained to limits. This is untypical especially in a self-learning context where students are used to allot time by themselves. It also means more effort for authors, accurate measuring is complicated, and it may raise another issue: “The problem might be to specify a duration for the module – working time. This could mean in the worst case that one needs to process the green phase three, four, five times until he has sussed out the subject. Thus, he would be behind schedule.” [MG, 00:36:10] (Was das Problem sein könnte, wenn man sagt, für den Kurs gibt es eine bestimmte Zeit – Bearbeitungszeit, dann könnte es im schlechtesten Fall so sein, dass man die grüne Phase drei, vier, fünf Mal durchlaufen muss, bis man die durchschaut hat und dann von der Zeit relativ weit im Rückstand ist.) A system based on the concept would sort out content sections until it fits into a given maximum duration. However, in self-learning situations this

might not be the expected behaviour. Hence, more research is needed to see if a duration parameter is useful and how to handle it.

Stengel sees a problem with the workflow that adopts students' paths as new possible paths through the content: "Adopting each student's path results in getting all possible combinations." [IS, 00:54:37] (wenn von jedem Student ein neuer Pfad übernommen wird. Am Ende hast du fast alle Kombinationen.) While it is possible in theory that the "white noise" of relations is created, it is expected to be unlikely. Therefore all learners would need to randomly select content sections as well as like and dislike.

Learning and Teaching

Because the prototype lets the students choose the next step, Spierling sees a possible source of frustration: "The typical lost-in-hyperspace problem. A problem that we had with Interactive Storytelling several times: Because of alternative paths the feeling could arise: What might have happened if I had clicked on this other one? Am I missing anything? It is a psychological phenomenon, the sense of loss, not having done everything." [US, 02:43:44] (Das typische Lost-in-Hyperspace Problem. Ein Problem, das wir im Interactive Storytelling ein paar Mal hatten: Wenn man das Gefühl hatte, man hat Alternativzweige im Angebot, dass Leute das Gefühl haben: Was wäre passiert, wenn ich den anderen angeklickt hätte? Verpasse ich jetzt was? Dies ist ein psychologisches Phänomen, das Verlustgefühl, nicht alles gemacht zu haben.) Not giving the students a choice, but directly prompting the next step could address this. In some statistically irrelevant discussions with students all of them wanted to choose, and no one was fine with a Hobson's choice. Hence, one way this has been addressed is by showing the history and the progression bar. Additionally, the paths that can be chosen from are all complete, and following any of them should give a complete lecture. Lastly, an additional orientation could be the prioritisation of the lecturer currently teaching, as discussed in the *Proposed Improvements* section.

A side effect of reusing existing content may raise another problem: “In my opinion it does not work with pure text slides. If I was to take a student’s point of view, I would have big problems to work through such a slide, to find the motivation to do it by myself to ensure I understand it.” [MG, 01:36:04] (Nicht funktioniert es bei reinen Textfolien meiner Meinung nach. Wenn ich mich in die Sichtweise eines Lernenden setzen würde, hätte ich große Probleme, dass ich so eine Folie durcharbeite, dass ich erst mal die Lust aufbringe, und es selbst durcharbeite, dass ich es verstehe.) This is because slides are made and should be made to support a lecture. Hence, in most cases they are not (and should not be) understandable on their own. This makes them hardly usable for self-learning contexts.

Miscellaneous

A psychological problem could arise due to the many failed attempts to create an adaptive system for general usage: “It is the following situation: I create adaptive learning material. In reality, nearly no one does this. (...) Today it is the opinion of many, a great many, that it is (...) dead. More dead is absolutely impossible. A great many have tried to solve it using learner models, domain models and so on. There had been research projects to give it a trial. However, in reality it has absolutely no relevance. Thus, I do not know any authors who do such things. It has always been a research toy for me. Without practical relevance.” [WM, 01:31:39] (Die Situation ist aber zu sagen: Ich erstelle tatsächlich adaptive Lehrmaterialien. Das macht kaum einer in der Realität. (...) Heute gibt es Viele, sehr Viele, richtig Viele, die sagen, das ist (...) tot. Töter geht es gar nicht. Da haben tierisch viele Leute was versucht, mit der Lernermodellierung, die Domänenmodellierung und so weiter, das zu lösen. Da gab es Forschungsprojekte wo das ausprobiert wurde. Aber eine Relevanz in der Praxis hat es überhaupt nicht. Das heißt, ich kenne auch keine Autoren, die so etwas machen. Es ist für mich immer nur ein Forschungsspielzeug gewesen. Ohne praktische Relevanz.)

Mainly due to these failed approaches in the past (and in his opinion not real world relevant scenarios) it has needed a great amount of interview time until he has accepted even thinking about the concept of this research. But since he was persuaded he discussed the concept enthusiastically, trying to find solutions. This has lead directly to a scenario discussion which is part of the next section. One result of this interview has been that a kind of negative attitude could be an obstacle especially by people who know about the history of research in adaptive learning.

6.9.15 Scenario

A main discussion topic has been the scenario of application. Although the scenario has been open for discussion, it has been seen as relatively fixed. Thus it was not prepared for in the interview guide. Its importance has been detected during the analysis phase. Therefore a subcode for scenario *CD-S* has been added to the code Concept Discussion *CD*. The code matrix (see table 5 *Code Matrix* on page 208) also hints at its importance: Many related statements have been found in the recorded data.

Because the concept is based on parallel linear content threads, and that content must be about the same subject, these content threads need to exist somewhere or be created by someone. Scenarios that are expected to conform to those requirements are, for example, parallel tracks of one module and university networks. Additionally, the lecturers should be motivated to open, share, and tag their content.

This scenario has been criticised various times, for example by Gaida: “A scenario where a lecturer has three or four lectures on the same topic is unlikely.” [MG, 01:15:47] (Das Szenario für einen Dozenten, dass ich drei oder vier gleiche Vorlesungen habe zum gleichen Thema, die sind relativ gering.) Whilst agreeing that the concept would simplify creation, Müller has questioned the scenario, which would impact on the problem itself: “The problem definition is irrelevant. That is my main criticism. When would someone do that? (...) Maybe the scenario is wrong.” [WM, 01:46:45]

(Die Problemstellung ist irrelevant. Da ist meine hauptsächliche Kritik. Wann macht man denn so was mal? (...) Vielleicht ist das Szenario falsch.)

The proposed alternative scenario has been to let the students do the main work using social community concepts. For example Müller has suggested: “In my opinion it would be a completely different story, if it was not the lecturers who authored the relations, but the students.” [WM, 01:48:00] (Ganz anders sähe die Geschichte aus meiner Sicht aus, wenn du sagen würdest: Das sind gar nicht die Lehrenden die die Verbindungen herstellen, das sind die Lernenden.) Such a consecutively developed scenario goes beyond using students’ paths or using Amazon like recommendations, for example, students who passed examinations have chosen that path, to include it in their learning workflow: “They work through my slides. Then they did not understand something. What do they do? They search the internet. What do they find? Somebody has published something in the internet. They post it to the other students: There it is explained in a better way. They send links pointing to the parts that explain it better.” [WM, 01:50:39] (Sie schauen meine Folien an. Dann haben sie etwas in einem Bereich nicht verstanden. Was machen sie? Sie suchen im Internet. Was finden sie? Da hat im Internet jemand etwas veröffentlicht. Das posten die auch an die anderen: Da ist es aber besser erklärt. Sie schicken die Links mit den besser erklärten Stellen.) Spierling has a similar idea: “One could think about solving it in a different way, doing it generally with social media. Let students create it in learning groups. Like that: ‘Does anybody know anything about the semiotic triangle?’ ‘Yes. I know somebody who studies there, he has got the slides.’ Assemble it the social way. Maybe this would be pragmatically faster. I really think that would be faster than lecturers breaking through the obstacle to get it together and use such a system.” [US, 02:14:49] (Man könnte sich überlegen, ob man das auch anders lösen kann, dass man sagt, man macht generell Social Media, und lässt Studenten als Lerngruppen aufbauen. Nach dem Motto: „Weiß jemand etwas zu dem semiotischen Dreieck?“ „Ja. Ich kenne einen, der studiert dort, der hat die Folien.“ Social mäßig

das zusammenfügen. Das ist vielleicht etwas, was sogar pragmatisch schneller geht. Ich glaube inzwischen daran, dass das schneller passieren wird, als dass Dozenten diese Hürden überwinden, sich zusammenraufen und etwas da reinstellen.)

This describes a workflow that would slightly change students' tools, and only touches on their workflow. Instead of sending links with eMail or distributing it with one of the chat systems, they would create a relation using a system that is based on the concept of this research. They would need to change their habits regarding the use of the tool.

Of course, for that scenario the learning material needs to be accessible to the students and legal questions need to be resolved upfront. As already discussed in this chapter, on the one hand the learning content gets more and more hidden in learning systems. On the other hand, it seems that more and more material is available on the internet. European-wide projects could help to create open content: "The European Union funds the building of learning material pools. Maybe something of the kind is developed there soon." [II, 01:43:38] (Die Europäische Union fördert die Bildung solcher Lehrmaterialien Pools. Vielleicht entsteht bald so etwas.)

As a next step, this scenario should be further developed. It fits the learners' workflow, and the concept does not need to be adapted for that. Compared to the scenarios propagated in this thesis so far, it seems to be more likely to have a chance to be accepted and adopted.

6.10 Summary

At the beginning of this chapter the aim of the evaluation has been defined. Therefore the main question has been raised, namely whether this concept of structuring content has the capability of simplifying authoring of adapted eLearning content. Additionally secondary questions should support the main question during the evaluation.

As an evaluation method, the expert interview was selected. This kind of evaluation has been adopted from social research and is common for finding user related results. Interviews are used in particular during early stages of development to see if a concept should be rated. In this case the interviews have been used twofold: To rate the concept and to find new aspects. Thus, it was decided to conduct semi-structured interviews.

For the interviews an interview guide has been created. Therefore open ended questions have been developed that have been based on the first and secondary questions. The interviews should consist of three main parts: *Interviewees' background and opinion, introduction to the concept and hands on,* and *discussion about the concept.* This was done to let the interviewees have the possibility of guiding the interview to a large extent, and to get more unbiased comments and ideas than would be possible by introducing the concept right at the beginning or with closed questions.

Additionally the prototype has been prepared with the demonstration content that has been taken from real life lectures. Because of missing – not developed – tools, for the authoring process a paper prototype was used that supported ordering and relating the content sections.

Then the interviewees had to be selected. Because it was an abstract evaluation where a concept should be rated, and the Coherence prototype should only be seen as a proof of the concept, the interviewees should have deep knowledge about adaptive and interactive structures and concepts, as well as have experience in lecturing and creating learning content, optimally in an adaptive manner. This was also important for estimating the current situation from their point of view, and developing new ideas. Nine researchers with an appropriate expertise agreed to partake in interviews.

Where possible, the interviews took place at locations that were familiar to the interviewees as face to face sessions. The interviews were recorded, including the introduction and hands on parts. The result was 16 hours of audio source material.

During the analysis process the recordings were transcribed, three of them completely. The other six were transcribed selectively, using the code structure that was developed with the first three interviews. The code structure itself is based on the questions of the interview guide and extended with new codes during the typification phase.

This code structure was used as a guideline for discussing the outcomes of the interviews. The most important outcomes are recapitulated briefly in the following sections.

6.10.1 Current Authoring Situation

One of the most interesting aspects of the first interview phase has been the fact that although having experience in creation and usage of adapted content, none of the interviewees use them in real life. They use common methods for learning content creation like other lecturers. This already points to the assumption that today's concepts and technologies in that field are not ready for every day usage, which has been agreed by all the interviewees. They have stated that current authoring concepts for adaptive and interactive learning content do not meet the needs of lecturers. Easy concepts like string of pearls can only manage simple outcomes, concepts that allow the creation of more complex adaptive content are not usable by laypersons. Thus it is still seen as an open research question. However, most of them could only give vague answers regarding the question of necessary improvements. Most statements have been along the lines of "It should be developed to be more user centred" or "A learning content authoring environment like the common presentation applications should be developed.", and therefore have not given enough details as to how to tackle the usability problems. However Spierling has already performed research in the area of authoring, thus she could refer to her own experience – as a non-programmer, but a designer. Beside the statement that, of course, if authors want to work with new concepts, they also need to learn these new concepts, she

demands “a machine that is so intelligent that it is able to detect similarities. (...) And enough knowledge about the context that it does not make any wrong decisions”. Without knowing it she had built a bridge to the Coherence concept that is also based on similarities. However, in the case of Coherence the authors need to help the system to find these similarities.

Statements about the interviewees’ learning content authoring habits confirmed the assumptions of the concept. For example, while the interviewees normally do not work in teams on content creation, most of the interviewees use existing material as a basis for own content, or at least they try to. This behaviour is the basis of one of the proposed workflows for using the concept of this research. Additionally, in the case of comprehension problems, the common reaction of the interviewees is to find an alternative means of explanation, which is similar to the adaptation behaviour of the concept.

6.10.2 Interviewees’ Estimation of the Concept

The most important result of the interviews was, of course, that all interviewees have stated that the concept developed in this PhD research project simplifies the creation of adaptive structures: In their opinion it is more intuitive, because it adopts most aspects of the common authoring workflow. Additionally, it decreases the effort needed to create an adaptive structure, because the concept basically only demands relating different content, without the need to care about the other authors’ didactical concepts. One interviewee highlighted that the concept uses theory sparingly and that it works largely implicitly, just like much of the common (linear) content creation process is implicit. Which leads to another statement, which highlights that the concept would be a realistic approach, because it is based on linear content structures instead of, for example, preconditions.

The interviewees also stated possible improvements. Some of them have been necessary due to the concept’s and the prototype’s early development stage. For

example, that the player's recommendations should be transparent to the user. Some comments have been about improvements to the already implemented pathfinding algorithm, for example that the current lecturer's content should be prioritised so that students get the examination relevant content. A deeper change to the algorithm that has been suggested would be the development of a heuristic based recommender system.

The interviewees demanded the inclusion of more social community interactions. This could be done by getting more detailed feedback in the case of disliking a content section, which could help authors rating the suitability of their content in respect to the learners. Going a step further, some interviewees have criticised the intended scenarios as not being relevant for real world applications because parallel modules and lecturers that like to share their content are rare. They have thus forwarded an alternative scenario: Relations should be created by learners, as it fits to their workflow in learning groups.

Besides changing the scenario, the interviewees also demanded some more basic improvements regarding authoring, in particular that the GUI should be improved and additional helper functionality should be implemented. For example, the system should help authors find the relations they should create.

More problematic is adding a didactical layer to the concept, as demanded by one interviewee and proposed by another. This contradicts the concept's aim of simplifying the authoring process, which is based, among others, on using three layers only, because layering of structures seems not to be the normal human way of thinking and creating content structures. Balancing the number of layers and the demanded meta information will be an important task to increase user acceptance.

6.10.3 Remarks on Using the Prototype for the Evaluation

The prototype has been a valuable tool during the evaluation. During that phase the interviewees have commented, asked, and discussed a lot, inspired by working with

system. This allowed them to get a better sense of the concept, which increased the overall comprehension and deepened the discussions.

All interviewees criticised the prototype's GUI. That confirms on the one hand, that it really needs to be improved, but also on the other hand that it would distract non-experts from the concept, making it hard or impossible to evaluate it.

6.10.4 Wrap Up and Further Notes

As a summary, the interviewees have stated that the concept fulfils the research question and simplifies creation of adaptive eLearning content, at least within the assumed scenarios. New scenarios that are based on social communities should be included to soften the limiting effects of the currently proposed scenarios.

It should be remarked that this was a qualitative evaluation using semi structured interviews and qualitative data analysis. This kind of research is not about statistical relevant statements, but about typical aspects, even to confirm existing ones or to find new ones. Therefore typical interviewees have been interviewed and they have given typical statements and opinions. Even though all the interviewees agreed that the concept simplifies workloads, this cannot be seen as a fact, but as an outcome that is typical for the research outcomes that have been discussed. Hence, there is a good chance that these outcomes can be generalised, but it is not certain. Therefore there need to be other forms of evaluation. But it can be taken for granted that important aspects have been identified and discussed.

It is also not certain that all relevant aspects have been found. It is more likely that a lot of aspects have not been found and therefore not mentioned. Again, this kind of evaluation is not about completeness. Additionally, after having conducted the initial interviews, the kinds of comments and the points of criticism did not increase, but only facets for discussion did. Therefore it has been agreed that nine discussions had been sufficient.

6.11 What's next

In this chapter, expert interviews have been used as a basis for evaluation of the concept. The outcomes of the discussion can be used in combination with the results of the previous chapters for final conclusions and to offer an outlook for further research directions, as given in the following chapter.

Chapter 7

Conclusions and Outlook

This thesis has reported the investigation of the research project on simplifying the authoring process for adaptive eLearning content structures. This chapter concludes the thesis, summarises the achieved research results and findings presented in the previous chapters, and explains the limitations. It also presents possible directions for further research.

7.1 Achievements of Research

The contents contained herein emerged in response to the project Atlantis University that motivated this PhD research project to focus on two of its aspects: Learner preferences and the cooperative network aspect. On the one hand, the learner preferences model describes different learning styles that demand different ways of teaching and at the use of adapted content. On the other hand, the university network in many cases repeats the most common modules more than once, including the content prepared by different lecturers. This content has been mostly created using different styles of using various aspects such as content structure, didactics, etc. Additionally, the ideas of Cooperative Content Manipulation (CoCoMa) have been promising. Originally it was intended to be used just for updating or improving content and thus only linear presentation paths were possible. To overcome this

limitation, a concept needed to be developed that could help lecturers offer their content in a manner adapted to the varying demands of different students. Therefore research began into developing a concept of structuring content that has the capability of simplifying authoring of adapted eLearning content for non-technical users.

In order to find methods that support adaptivity in an eLearning context, related methods and structures were investigated and presented in chapter 2 *Authoring for Adaptive eLearning* on page 35. Based on the analysis of the effort needed to create content structures for these approaches and their evaluations with authors working with these structures and environments, their outcomes showed that authoring is still an unsolved problem. This was seen to be particularly true if lecturers, instead of large specialised teams, were addressed in order to gather existing knowledge and didactical strategies that have been proven over years in applied teaching situations.

A concept that addresses difficulties of authoring adaptive content has been introduced in chapter 3 *Adaptive eLearning Based on Authoring* on page 57. To this end, linear content structures have been investigated in relation to storytelling methods leading to information that can be used for sequencing purposes. An approach that combines existing models to ease the authoring process for adaptive learning content by relating linear content from different authors is also introduced in this chapter. Additional information on the intended authoring workflows regarding the concept of this PhD research project were presented in chapter 4 *Authoring Aspects* on page 99.

The feasibility of the authoring methods for adaptive learning content has been proven by implementing the essential parts in a research prototype, presented in chapter 5 *Prototypical Implementation of the Adaptive eLearning Concept* on page 125. It consists of an editor, a player, and a monitor that together enables the creating, playing, and verifying of the content structure respectively.

Typical aspects of the concept were intensively discussed with experts through the use of semi structured interviews. The interviews were recorded and then analysed

using quantitative and qualitative research methods. In a summary of the outcomes, all the interviewees agreed that at least within the assumed scenarios the concept significantly reduces authoring complexity and potentially increases the number of lecturers that are able to create adaptive content as presented in chapter 6 *Evaluation of the Concept by Research Interviews* on page 163. This could be achieved because the concept represents the authoring process for linear content to a large extent. The additional work needed is limited compared to existing approaches, and authors do not need to delve into adaptive structures or other authors' content structures and didactical approaches. However, the interviewees have expressed some doubts about the scenario and the concept having only three layers, and in particular no designated didactical layer. Among others, these aspects are discussed in the following sections, the former in section 7.2 *Limitations of Research*, the latter in section 7.3 *Future Work*.

Several aspects of the results achieved in this research project have been presented at refereed conferences or published in journals (see appendix A *Publications* on page 279). They have received positive comments from reviewers and delegates, and because of the concept's novelty and the delegates' interest in the topic, some of the presentations have subsequently led to long and valuable discussions.

7.2 Limitations of Research

This research project has two kinds of limitations: Limitations that are caused by decisions for practical reasons and by general issues of how such a design problem can be approached. These limitations are summarised as follows:

- The concept of this research project is based on alternatives. Alternative content is crucial for adapting sequences. Because of the effort needed for creating content, normally more than one author is needed who provides his content for an adaptive lecture. In consequence, the lecturers need to open and

share their content. Additionally, all the content gets related, and is therefore directly comparable. Best results are expected from using an eLearning 2.0 approach, letting anybody do the work of authoring the relations, including students. For various reasons, many lecturers do not want to publish their content, and they do not want to have it compared with other content. Some doubts could be addressed by restricting the access and edit functionality so that only members of the institution can work with the system.

- Codality should be the same across merged content. Otherwise, a learning path changing from one lecturer's content to another may result in comprehension problems if the students have not learned the presentation before. The only solution is setting preconditions, but the therefore partly repeated learning subject is likely to distract students too much from the actual learning content.
- One basis of the concept of this PhD research project is the usage of content with intertwined structure information. The disadvantage is, of course, that this information is not coded explicitly as meta information. For example, there is no additional didactical or content structure information. This complicates more advanced applications that specifically react to the learner's actions, like specifically presenting assessments, further, in more depth, or just other kind of information related to the current topic.
- For the same reason the adapted content path of a pathfinder based on the concept of this research will not be a continuous experience, like a story that flows. As soon as the path gets adapted, the original sequence gets interrupted with a more or less fitting content in terms of continuity. However, in contrast to many other sequencing concepts, this is not the main aim of the concept, as discussed in section 3.2.1 *Delinearise Content* on page 67. Because the adaptation is always signalled in the path selection view and is mostly done on user request, this is not seen as a problem. It is instead expected that

these differences signal the change to the context of another author's content and therefore help to orientate it in the adapted path. However, this aspect limits the concept's applicability for other scenarios, for example gaming or storytelling.

- In contrast to the aim of quantitative research methods to gain outcomes that can be generalised, qualitative data analysis produces typical outcomes. Its strength include, for example, aspects like in depth consideration of the subject to be evaluated and finding new aspects that should be considered. However, it is likely that this evaluation is not completed in terms of finding all the relevant aspects or problems. For example the fact that most interviewees stated that the concept simplifies authoring cannot be generalised, but it can be seen as a typical aspect of the concept.
- Due to the nature of this kind of research project, a quantitative evaluation of the result claiming to lay the ground for simplifying the creation of adaptive content needs a long-term commitment. Because many aspects are biased towards authors and students working with an adaptive environment, they all have to be taken into account and this needs to be tested on both the lecturers and students' side.

Despite these limitations, the research project has advanced the field of authoring for adaptive eLearning and provided sufficient proof of the concept for the approaches proposed.

7.3 Future Work

This research project achieved valid contributions to knowledge in the field of adaptive eLearning and simplified its authoring. However, this research has identified several open questions that build on the results achieved. Thus some pointers to future work are discussed in the following sections:

7.3.1 Concept

A lot of the concept's aspects can be seen as fragile and could be improved or would reward further investigation. It is a difficult process because most of the features work in conjunction with other features of the concept. Thus changing one of them will very likely demand changes and adaptations of other – or maybe all – features. Additionally, after each change the whole system needs to be rebalanced. For example, changing the layering could influence the relations and contexts.

Research could be conducted into whether and how to fulfil the demand for including didactic information in the concept. This could be achieved by adding an explicit layer or by standardising and extending the Coherence contexts. Adding this kind of information does increase the effort required for authoring and also learning the concept. If any kind of didactical information is to be added to the concept, it should be ascertained if the necessary information is either optional or can be automatically inserted in most cases otherwise adoption of the concept could be even more difficult.

This leads to a major question: How many layers are useful? Separating the information seems a good idea for getting more information for adapting and composing a path. However, it also complicates comprehension of the concept and might increase the effort of authoring. Layering can also decrease workload because it is clear what kind of data should be set and where it should be set. As such they are easier to find for others and hence they can act as an interface between different interpretations of content. For example, the Layered WWW AHS Authoring Model and their corresponding Algebraic Operators (LAOS) has been developed with authoring in mind and consists of five layers, each of them having a very good reason [37]. However, even after years of optimisations, in particular of authoring aspects, the evaluations of LAOS see improvements but thinking in layers and non linearity is still a problem [20]. Thus adding a layer should be done very carefully. Seen from the authoring side, each layer should feel natural.

These considerations are also valid for the contexts. There is room for improvement, for example, if the comparison needs justification. However, first it should be considered whether to rethink the contexts at all. Maybe it would be enough and easier for authors to treat them as normal variables with one value but not spanning a range limited by two values. Another way would be to offer different specialised contexts, for example location, lists, etc.

Another major question is the adaptation process. While the concept is designed to react to different user behaviour, it has not been investigated in depth in this research. Also it has only been implemented very roughly: Currently the system adapts only because of the user's demand to see further content. It neither recognises any interactions with the content, nor does it implement any idle behaviour or remain balanced for every day usage, which leaves a lot of room for further interdisciplinary development. Such an improved and stable system is important for authors so that they are able to estimate the presented outcome while authoring, but it is also important for students so that they can correctly assess and trust such a system. For example additional pathfinding strategies should be implemented and tested, in particular an algorithm that assigns the highest priority to the current lecturer's content to ensure that students get all the relevant content to be able to pass exams.

The way of relating content should be extended so that all kind of content nodes (that also means content types) and also content sequences can be related. On the one hand this should reduce the effort even more, because with that extension not all content sections need to be related but only groups of them. On the other hand more precise relations can be expressed, which would also enable the merging of completely different structures such as one author having all the analytical aspects first, then explaining design, and another author merging analysis and design within one learning unit.

Lastly, the system is limited on single user usage. Further research should investigate the needs for a multi learner system, supporting learning groups or classes,

in particular in a networked context. This would also open the field for embedded contests and add gamification aspects, for example to test who is the fastest in solving an exercise.

7.3.2 User Interface

Within this PhD project the user interface itself was not the focus of the research. The current user interface was designed to show only that information that was absolutely necessary. However, a fully functional, effective, and pleasant interface is important, even perhaps crucial for adopting a system based on this concept. Thus further research is needed to explore what information should be presented in which manner and when. For example, the current implementation of the pathfinding pane is confusing. It should be improved so that it clarifies the suggestions, the prioritisation of the paths and the reasons for it, and the relations between the paths. The user needs to be enabled to easily orientate himself.

7.3.3 Authoring

Because the concept of this research is about authoring adaptive content and its structures, of course an authoring environment should be realised as outlined in chapter 4 *Authoring Aspects* on page 99, so that not only the concept but also the overall system becomes usable by non-technical lecturers. One of the main aspects of such an authoring environment will be finding the right content to be related, and presenting the current structure in a well arranged manner. Additionally, comprehensive importing functionality is needed to enable reuse of already existing learning content. Not only the content itself, but as much content structure information as possible should be imported from the sources.

Another authoring aspect is the target group for authoring the adaptive structures. In many cases, linear content is or will be created by the lecturers. However, creating the adaptive structure by relating to another content may not be within a lecturer's

natural workflow, but could be integrated well into a learning workflow, as proposed by many of the interviewees. Therefore it is also necessary to reach as many users as possible. eLearning 2.0 seems to be the appropriate approach, but also motivational aspects are needed to encourage users to contribute work to the adaptive structure or maybe the content itself. For example, alternatives could be weighted based on student ratings, comparable to Amazon’s recommendations.

7.3.4 Integration

The system should be integrated into existing infrastructures. This could be seen from the eLearning side: Coherence could be embedded into LMSs using IMS LTI, but also other specifications should be taken into consideration, like exploring how far IMS Simple Sequencing could be used to describe the underlying model. Further integration might use the content already stored in a LMS. However, because general specifications like the IMS specifications LIS [109] and Learning Object Discovery and Exchange (LODE) [80] are not widely adopted in today’s LMSs, such kinds of interface would be need to be developed.

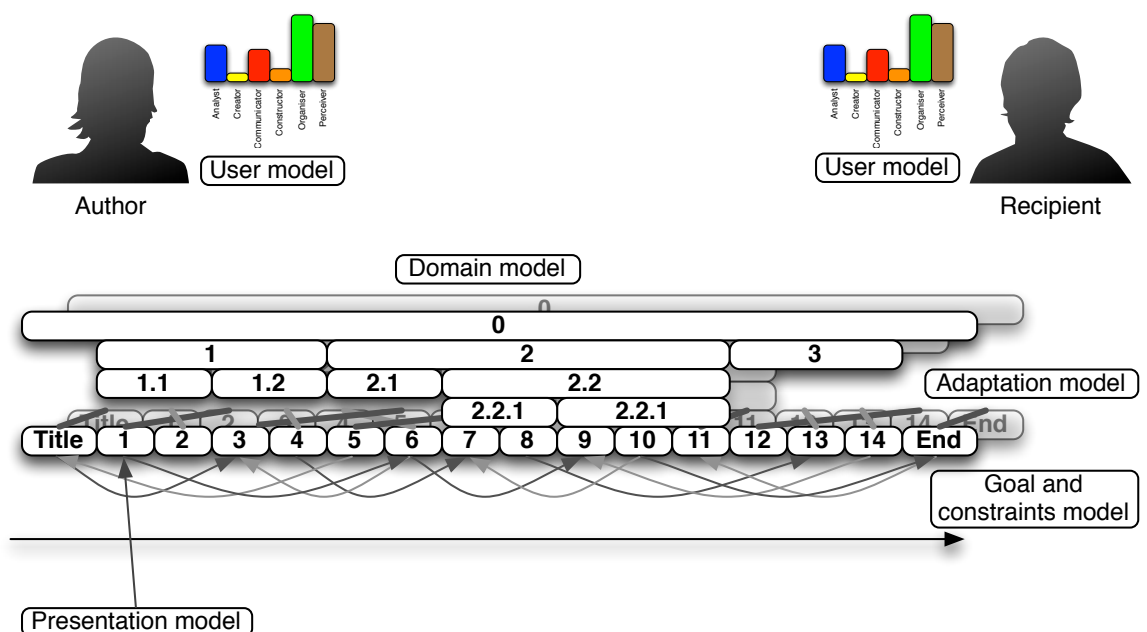


Figure 62: Mapping Coherence to LAOS layers (see section *Integration* for details).

Also the integration with existing AEHSs should be considered. This could be done in two ways: Using the experiences with Coherence to describe workflows and build authoring environments for existent concepts and systems based on the concept. Or a technical integration with another system, for example by performing an inter-system conversion of different platforms to LAOS as described by Cristea and Stewart [38]. Its layers could be mapped as shown in table 6 and illustrated in figure 62.

LAOS	Coherence
Domain model	Tree-based content structure
Goal and constraints model	Last content-section Linear sequence, context-tree
User model	User model (context-tree)
Adaptation model	Semantic relations
Presentation model	Interweaved in content

Table 6: Mapping Coherence to LAOS layers

7.3.5 Miscellaneous

No matter which path further research and development takes, long-term evaluations are needed to reveal if the proposed conceptual models are persistent or need to be adapted, pertaining to authors but also learners. For this an effective user interface with workable authoring tools is needed, bringing us again to the beginning of the *Future Work* section.

It would also be interesting to extend the scope to other research fields. For example, as some basic ideas have been taken from storytelling, the Coherence concept might also be worthy of further investigation in relation to authoring aspects of interactive storytelling, even only for some kind of content. Examples could be the adaptation of a story that is told from different perspectives, the officer and

the murderer, or that is optimised for different locations and mainly using Location Based Services (LBSs) to propel the flow of content. However, as valuable as these ideas might be for other disciplines, many parameters of the concept are tied to eLearning purposes and need to be adapted carefully.

Appendices

Appendix A

Publications

A.1 Conference Proceedings

Bleimann, U., Dowland, P.S., Furnell, S.M., Schneider, O.: *Proceedings of the Eighth International Network Conference (INC 2010)*, ISBN 978-1-84102-259-8 (2010)

A.2 Journals

Schneider, O., Bleimann, U., and Stengel, I.: *Atlantis University: Learn Your Own Way*, Int. J. Mobile Learning and Organisation, Vol. 3, No. 2, pp. 184 – 201 (2009)

A.3 Conferences

- Stengel, I., Schneider, O., Bleimann, U.: *Exploration of Learner Preferences and their Impact Within a Media Module*, in Bleimann, U., Dowland, P. S., Furnell, S.M., Schneider O. (Eds.): “Proceedings of the Eighth International Network Conference (INC 2010)”, pp. 279–288, ISBN: 978-1-84102-259-8 (2010)
- Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen-Mühlbauer, B.: *Simplified Creation and Presentation of Non-linear Adaptive Content*, in M. Chang et al. (Eds.): “Learning by Playing. Game-based Education System

- Design and Development, Edutainment 2009, Banff, Canada, August 9–11, 2009. Proceedings”, Lecture Notes in Computer Science, Volume 5670, pp. 239 – 250, Springer Verlag, Berlin Heidelberg, ISBN 978-3-642-03363-6, DOI 10.1007/978-3-642-03364-3_30 (2009)
- Schneider, O., Bleimann, U., Phippen, A.D., Harriehausen, B.: *Find Your Own Path: Path Construction Strategy for Atlantis University’s Coherence Service*, in Bleimann, U. et. al: Proceedings of the Fourth Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2008), Glyndŵr, UK, 6–7 November, p. 46–55, ISBN: 978-1-84102-196-6 (2008)
 - Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen, B.: *Inside Coherence: Concept for a Non-Linear eLearning Solution*, Proceedings of the Seventh International Network Conference (INC2008), Plymouth, UK, 8–10 July, pp 223–233, ISBN: 978-1-84102-188-1 (2008)
 - Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen, B.: *Learn Your Own Way: Decision Way through Narrative Approaches, Methods and Paradigms for Learning Purposes*, in Bleimann, U. et.al: Proceedings of the Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007), Plymouth, UK, 14–15 June, pp 99–114, ISBN: 978-1-84102-173-7 (2007)
 - Grüter, B., Gröning, S., Milszus, W., Oks, M., and Schneider, O.: *Mobile Gaming Experience – Working on an Empirical Prototype*, NordiCHI’06 Workshop: User Experience – Towards a unified view. Oslo, Norway (2006)
 - Schneider, O., Bleimann, U., Harriehausen, B., and Phippen, A.D.: *Non-Linear Extended Blended Learning*, Proceedings of the Sixth International Network Conference (INC2006), Plymouth, UK, 11–14 July, pp 377–384 (2006)

A.4 Conferences (Presentations)

- Schneider, O., Bleimann, U.: *Adaptive Learning Using Storytelling Approaches*, Collaborative European Research Conference (CERC2012), Darmstadt, Germany (2012)
- Schneider, O.: *Einbindung externer Aktivitäten mit IMS-LTI (Learning Tools Interoperability)*, MoodleMoot 2012, Münster, Germany (2012)
- Schneider, O., Phippen, A.D., Bleimann, U., and Harriehausen-Mühlbauer, B.: *Coherence: The personal-individual way of learning*, in S. Wheeler (Ed.): “Digital Futures: Learning in a Connected World”, pp. 23, 6th Plymouth e-Learning Conference 2011, Plymouth, UK (2011)
- Schneider, O.: *Atlantis University Project: “Learn Your Own Way”*, Moodle 2010, Universität Duisburg-Essen, Germany (2010)
- Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen-Mühlbauer, B.: *Cooperative Creation of Non-Linear eLearning Content*, in S. Wheeler (Ed.): “Learning without Limits: Facing the Challenges”, pp. 59, 5th Plymouth e-Learning Conference 2010, Plymouth, UK (2010)
- Martens, T., Hatteh, A., Schulmeyer, M., and Schneider, O.: *Integrating Motivation in e-Learning*, 4th Plymouth e-Learning Conference 2009, Plymouth, UK (2009)
- Bleimann, U., Stengel, I., and Schneider, O.: *Atlantis University: The Future of Learning and Teaching*, 4th Plymouth e-Learning Conference 2009, Plymouth, UK (2009)
- Schneider, O.: *ODF for Blender in an eLearning Context*, Blender Conference, Amsterdam, Netherlands 24–26 October (2008)

Appendix B

Expert Interviews

This appendix contains all interview abstracts and those transcriptions that had been allowed to be published.

B.1 Expert Interview Abstracts

In this section, a translation of each of the evaluation expert interviews is summarised. These abstracts have been validated, revised where appropriate, and approved by the interviewees.

B.1.1 Prof. Manfred Gaida

Manfred Gaida teaches communication design with a focus on the pictorial disciplines as well as design conception and management. To create his learning content, at the beginning a lot of research is needed, because of steadily changing trends and technical requirements in communication design. Then he creates a module schedule followed by an outline that is the basis for a slide set. Having this, he creates a script and eLearning content, for example for self assessments, links to films, and additional learning content. Preparing project works is even more labour-intensive, because of complex prearrangements.

In the case of comprehension difficulties he first tries to find the problem, usually by broaching the student's question again. Then he tries to explain the subject matter in another context, if possible he includes the students by starting a discussion concerning the subject matter.

Manfred Gaida thinks that the current authoring concepts for adaptive learning may be manageable by computer scientists, but these tools are very difficult for other non technical authors. The demands on content authors increase dramatically with the flexibility of the approach. String of Pearls is the easiest concept, but provides the lowest degree of freedom. The other extreme, rule based systems, is currently too complex for non computer scientists. Hence, simpler concepts are fitting best for learning purposes, rule based systems are far from usable.

Current applications and the concepts are not user friendly. If an author would like to use them, he has to gain deep knowledge of the underlying technical structures, hence a very long period of vocational adjustment is needed before he could start using it. One solution might be user centric development of adaptive learning architectures. Another approach might be authoring applications that are tailored to specific domains. These applications could get rid of all burdens that are needed for being generic, because more specific approaches are not as abstract as generic approaches, and therefore more understandable.

In Manfred Gaida's opinion, the concept of this PhD project simplifies the creation of adaptive structures, because lecturers do not need to create special adaptive content. They can author content and the corresponding structure according to their own teaching method. He thinks that the concept essentially maps a competent lecturer's behaviour, who would react adaptively on the student's comprehension problems and explain in an alternative way, for example with additional examples. Of course, some conditions need to be met: Content from different authors about the same topic is needed, and the lecturers are needed to work collaboratively, or do not mind that their content is linked to another author's content.

Manfred Gaida confirms that it is an adaptive concept in terms of adapting the content structure, not the content itself. He also agrees that the concept supports different content structures.

For being accepted by lecturers and students, of course an authoring environment is needed. Also the player needs further improvements on the user interface. He sees best prospect of adopting the concept in the eLearning 2.0 context, where students create the relations on the fly as needed.

Limiting aspects are lecturers that might not want to share their content. He is also very sceptical about reusing slides for eLearning purposes. Slides that have been prepared for face to face modules do not meet the needs of content to be used without a presenter, because they are intended to be used with additional vocal explanations. Slide sets use another kind of information presentation than full text media like scripts and books.

He sees further capability in using this concept for the modules of one lecturer. Not in the sense of an adaptive environment, but to relate all the sections of learning content on the same topic by semantical connections. By this means, students may jump between, for example, current content and past content, or theoretical content and applied content.

B.1.2 Dr. Stefan Göbel

Stefan Göbel has cooperatively created learning content for lectures. First, he has arranged with the partners about the intended content, sometimes already including a first draft. They also discussed the golden thread through the content. Then, they have divided the content into parts with each of the lecturers responsible for some of these parts. They have revised the content iteratively, but they retained their stylistic differences. These differences have not been problematic for lectures. The students liked that the particular expert was reading his part.

In case of comprehension difficulties, Stefan Göbel changes the point of view and explains the topic in a different way. He tries to figure out how the student would understand it best and tries to exemplify in the student's way.

In his opinion, the currently available concepts and authoring environments for adaptive structures like adaptive learning, game based learning, and interactive storytelling are only suitable for authors with programming background. It is one of the main obstacles in this area and one important research question in his department. He thinks, that String of Pearls and Branching are comparable regarding the authoring effort. Entering the needed data into rule based systems is not very difficult, but the results are nearly unpredictable.

To improve the authorability of such systems, the common authoring procedures need to be investigated, leading to the questions how this procedures could be modelled, and how this procedures could be supported with computer technology. A mixture is needed that enables authoring without programming knowledge.

In Stefan Göbel's opinion, the concept of this research project obviously fits better to the needs of authors, because it is simpler and decreases the authoring effort. The concept adopts the authors' workflow. He also likes that it uses a linear sequencing approach rather than a rule based approach, because it is more reasonable.

He says that the concept is adaptive in terms of sequencing. No units themselves are adapted. The concept itself fits to learning purposes. The player could be used already, although its visualisation has room for improvements. The editor needs a redesign to an authoring environment before it could be used by lecturers.

He sees possible improvements in the overall user interface design. Additionally, he encourages further investigation in any kind of help for authors to find the right content units that should be related. For content creation that fits across different authors he suggests templates that cover different didactical standard requirements. He also thinks that any students' decision during content presentation should be recorded and used to recommend paths to other students.

He thinks the main limitation of the concept will be the existence of different content about the same topic, because without having different content, any system that is based on the concept cannot provide any adaptivity. Even if content is available, usage could be hindered because of legal or administrative reasons.

B.1.3 Prof. Dr. Matthias L. Hemmje

On one hand, Matthias L. Hemmje creates his learning content traditionally: He starts with an outline that is enhanced with text and figures, until he has a complete slide set. After having presented the slides a few times, he transfers the slides into a text document. Because he is working at a distance university, this document has to provide everything other lecturers on “traditional universities” may present during face to face sessions.

Alternately, he creates learning content cooperatively. For example, a new topic might be the seminar subjects for two years: Students prepare and present them. After this period, he uses the student’s outcomes as raw material to create his learning content.

Matthias L. Hemmje agrees that currently adaptive learning authoring environments only fit to technical oriented people. All other authors will have problems using it. He proposes a kind of slide oriented presentation application for learning content that standardises the work flow of the authoring process. But the demand for such an environment comes only from lecturers (nursery school – university level). Hence, the market’s size is too small to be interesting for companies to realise an environment fitting the needs of learning content authors. It needs a process of rethinking about handling existing knowledge, before the demand could increase.

He also agrees that comparing the currently used concepts String of Pearls is the easiest for authors. Branching needs more background knowledge to be usable. Rule based systems need even more effort, because they need a well described semantic

and learning objective that are the basis for defining AI rules fitting to the learning domain.

In Matthias L. Hemmje's opinion, the concept of this PhD project is a good start to ease content structure creation, but he emphasises the lack of a separate didactical dimension. He stresses the difficulties of decomposition and recomposition of the learning sequences without having didactical annotations.

For further research and development he proposes a suggestion scheme to weight the possible branches that are edited by lecturers and other students. Hence, the system could rank the alternative paths based on earlier experiences.

B.1.4 Prof. Dr. Ido Aharon Iurgel

To create his learning content, Ido Aharon Iurgel first looks for already existing sources, for example textbooks or slides from the predecessor. Based on these sources he creates slides, but he also uses whiteboards to develop the content together with the students during lecturing. In case of comprehension difficulties he uses examples. Sometimes it is enough to repeat a step of calculation.

Ido Iurgel has some experience in cooperative lecturing: The topic learning systems was a cooperative lecture of computer science and pedagogy. Before starting this lecture, the lecturers discussed the topics. However, they did not teach together; they supervised the final project that was common to both courses from two different perspectives (computer science and pedagogy), and they did this rather independently. The modules themselves were independent, and the students got different exercises and tasks from both modules; only the major final project was a single integrated work that belonged to both modules, and that was evaluated from different perspectives at the end.

He thinks that more people would use technologies like Interactive Storytelling if easier authoring environments would be available. Comparing the main concepts of interactive and adaptive media, he says that String of Pearls is the easiest, but also

most restricted approach. Branching is easy for simple content structures, but as soon as these become complex, authoring also becomes more complex exponentially. All rule based approaches are too counterintuitive for non technical authors.

In Ido Iurgel's opinion the concept developed in this PhD research project significantly reduces the authors' effort needed to create adaptive content structures. He is also satisfied that the remaining effort could be reduced to nil by doing some more research in statistical methods concerning to authors using this approach.

In particular he believes that the approach is very promising, among others because no specific didactic or subject related theory or model is presupposed for the adaptation. The theory and knowledge is implicitly present in the original teaching sequences, and the conservative adaptation is likely to preserve a relevant portion of them, without requiring to make them explicit. He also likes the conservative sequencing algorithm that only changes the linear pre-authored sequence when absolutely necessary or by user's explicit demand, because completely automatic sequenced content is always only second best compared to content that has been structured by humans. The same problem can be found in the Interactive Storytelling research area.

Ido Iurgel thinks that an adaptive system using the concept of this research project would be helpful for students. Nevertheless, he suggests to assign the highest priority to the current lecturer's content, because among others this is the content that is relevant for examination. If students only learn by other authors' content, they might understand the topic itself better, but might miss some sections important to pass the test, or misunderstand questions because they are unfamiliar to the lecturers notations.

He thinks that one limitation of the system could be the simple assumptions with regard to the equivalence of content. On the one hand this simplifies the effort needed to create content structures, on the other hand real relationships are very likely more complex: Content might overlap, content might be part of another content, content

might be related in between two other parts of content, and so on. It should be investigated, if this is really a problem, and when it starts to be a problem, hence if there are measurable limits.

B.1.5 Prof. Dr. Detlef Krömker

In Detlef Krömker's opinion, Creating learning content is always a mixture of concepts. One of the most important aspects is including personal experiences. The content of an all-new lecture will always be based on something that is already existing – at least the lecturer will look into an existing book once. He has also created learning content cooperatively by splitting the topic into pieces. Of course, this workflow needs a common understanding.

In case of comprehension difficulties, Detlev Krömker immediately thinks about possible reasons and how to deal with them. If he just had been too fast, he repeats. However, usually it is a more complex problem. Then, for example, he tries to explain the topic with an example. However, the best way always has to be decided at the time and place the problem occurs.

The main problem of authoring adaptive learning content and structures is the vast amount of work for authors, because any kind of student's reaction and interaction with the system has to be foreseen. Additionally, the structure and adaptation have to be designed very carefully, because students are very sensitive to any kind of misinterpretation. It is also important that the students never think that they are deprived of something.

Currently Detlev Krömker uses a pragmatically approach: At the end of each of his online lectures the students find eight questions: Four are about facts, four about further understanding. It needs about 15 minutes to answer all the questions. In case of errors the students get hints about the section in the lecture explaining that topic or further readings. The lecturer gets the anonymised results, so that he can

react in the following lectures, if needed. Nearly all the students do the tests, because they see that trying to answer these questions is very helpful for them.

String of Pearls is an accepted concept that works well for authors and students but it is limited. He sees the main problem with branching in the risk that students miss any content, or they just think that they have missed a part that might be needed for examination. Rule based systems are problematic, because on the one hand most authors do not think in rules and preconditions, and on the other hand it is very difficult to find the right rules and preconditions. It might happen that students do not know about a concept, even if they have learned it before. Hence, a rule based system should always test if the knowledge is existent, but too many tests distract from the actual learning content.

He sees another challenge in the traditional adaptive sequencing concepts: Learning and teaching always works within big sequences. As soon as a learner uses one path of the sequence, there is nearly no way to replace parts of it for adaptation purposes. Alternatives always have to adapt bigger coherences including all their relationships.

In his opinion the concept of this PhD research project appreciably decreases the authors' amount of work for creating adaptive learning content structures. Therefore the weaknesses of the traditional concepts are identified and a new approach is presented with this PhD research project. Another strength of the concept is that authors collaborating on creating an adaptive structure just need to understand the other authors' content, but not their didactical concepts. Hence, there is also no need to rate the other's concepts or to discuss about them for content merging purposes.

The main difficulty will be finding the right learning units, and defining the right size for them. Also difficult will be linking to other content that is about the same topic, but needs other preconditions or uses different codalities. In this case, preconditions must be found and set explicitly, which is not easy and means additional work. It also might happen that the students' workload increases because

of alternative content that is merged into the learning path. This could be avoided by using a duration parameter.

B.1.6 Prof. Dr. Wolfgang Müller

Wolfgang Müller thinks that current authoring concepts are too difficult for authors. He has worked on this topic together with Ulrike Spierling in the Scenejo project [114]. Their first approach had been branching, but this was too immense workload for authors. They tried to ease the authoring process by combining different approaches. Authors think in a linear way, but interactive content always includes programming – and this is very hard for them. Currently it is still not resolved which concept to author content for interactive storytelling fits to authors, in case of eLearning the situation is even worse.

The effort for the different approaches depends on the background of the author. Technical approaches are easier for computer scientists, but normally they lack in dramaturgical competencies. For authors without technical knowledge even branching can be too difficult, all other approaches are nearly impossible for them. String of Pearls is nearly linear, hence it is manageable for each kind of author.

Wolfgang Müller normally uses slides for face to face sessions, but most of his modules are project based. Hence, in these cases he works as a coach. He tries to create his content by defining objectives and sub-objectives, but sometimes he uses the pragmatical way by just writing down the content. In case of comprehension problems during lectures he gives another point of view onto the topic.

He has experience in collaborative content creation. Each topic is assigned to another author. All these topics are fairly stand-alone, hence problems of merging teaching styles are easy to resolve or not existent. Also during lectures no problems occurred.

Although he thinks that the technical concept of this research is the right way of reducing complexity and effort of content creation, he does not see practical relevance

in current university environments. On the one hand even this reduced effort for creation the workload is still too much. He also sees a lack of content that can be merged – for example he is the only person at his university lecturing his topics. Additionally there are many lecturers that do not want to share their content.

He sees the solution for these problems in open content and adopting students' communication: More and more learning content is published as open content in the internet. Most of this content is already structured in chapters, sections, and more. Additionally, in case of eLectures (and others), this content is already annotated with meta information like objective, author, university, and section. While learning, students share links to other explanations of the same topic with other students by eMail or accessible to everyone on their blog. If students would use a service based on the concept of this research instead, they would relate the content with other content and therefore delinearise it step by step without any additional effort.

B.1.7 Dr. Heiko Rölke

Heiko Rölke did not work directly on adaptive content, but on adaptive assessments. Hence, he has deep knowledge in adaptive processes and adaptive structures. The concepts used for adaptive assessments are the same as String of Pearls, Branching, and Preconditions – or comparable. Authoring adaptive assessments needs specialists. Although the tests themselves could be created by everyone as long as they are not too complex, psychometricians are needed for skill rating of adaptive assessments.

He uses common tools for lecturing and creation of learning content: He creates slides and scripts if needed. During lectures he also uses quizzes, flip-charts, and examples on the black board. In case of comprehension problems he tries to change the explanation by changing the media. For example, he changes from slides to black board or tells explanatory examples.

He has some experience in collaborative content creation – not for big lectures but for parts of project based modules.

He thinks that the concept of this research is useful and plausible. Especially starting a new structure is easy, because the author only needs to put in what he already has produced. He thinks that it can be useful for lecturing purposes, especially for content that is available via the Internet. Because more and more universities share their content, there should be no shortage of content. He also likes the learner's possibility to have explicit and implicit influence on the path creation process.

Of course, the concept is only useful if there is enough content. Hence, it will work best for standard lectures, but will not fit very good for special content that is only used once.

He would like to combine the concept of this research with adaptive assessment concepts in future research projects.

B.1.8 Prof. Dr. Ulrike Spierling

For creating learning content, Ulrike Spierling first looks for sources like textbooks. For lectures she prepares slide sets that get optimised over time. She also has created learning content cooperatively, where each lecturer worked on one's own topics. She has experience with project based learning. It is common that these modules have two or three experts as supervisors, for example one designer, one computer scientist, and one economist. These different points of view on the one hand help the students, because they can consult experts for nearly all their questions. On the other hand, it may confuse students, because designers and computer scientists sometimes follow opposite workflows and principles.

In case of comprehension difficulties Ulrike Spierling has several strategies: She tries to explain by using (additional) examples. She encourages the students to ask questions while she reexplains. She builds groups of two students, so that they can explain each other and ask further questions afterwards.

In her opinion current authoring tools and structures are not optimally addressing authors without computing or programming background. They are either simple, but the outcomes are also simple, or they are too complex for non-programmers: String of Pearls is not adaptive, Branching is infeasible if a lot of decision points are needed, and authors do not savvy Preconditions, though it is a concept they are faced with daily in real life. This authoring gap should be bridged from both sides: More intuitive tools and concepts are needed as well as authors should start to learn new concepts.

She has worked out a promising concept: As traditional authors describe plots and processes in a linear way, they could start creation of non-linear content with an optimal linear thread, figure out the particular events, and describe the needed preconditions. If multiple paths are possible regarding to user interaction, these steps are repeated with an alternative thread, for example the worst case thread. She proposes paper prototyping [63], such as playing cards to get an idea about the relevant conditions of each step. It gives a feeling about the changes between each step and enables experiencing the possible states – resulting from the designed conditions – as intermediate snapshots.

She agrees, that linear content can be based on complex structures of pre- and post-conditions that are hard (or impossible) to describe.

In her opinion the concept of this research (called Coherence) primarily has two benefits:

1. Compared to existing concepts it is easier for authors to structure adaptive content.
2. Students may follow the content of their relevant (rating) lecturer, but also get content and structure-related alternatives in case they need it.

The latter is important, because lecturers are limited in different ways of teaching. Normally they teach best as they themselves like to learn. Hence, they cannot address all kind of students.

The player GUI needs improvements, especially the selection of the next step. It could be uncluttered by giving the steps the same length, but show the full title and a preview on, for example, mouse over. The main path could be highlighted to simplify reverting. Other students' ratings and topics that might be part of the examination could be shown. A feedback that explains why a concrete step is proposed would increase acceptance. Every step that is marked as "must-be-shown" could be highlighted.

The player could provide a connection to social networks, to share personal paths and ratings. If a student dislikes a step, a simple dialogue should ask for the reasons. These could be collected and presented to the lecturers, so that they can improve their content.

To enable non-technical lecturers putting in their content, an authoring environment is needed. Already the first author should try to tag his content (should give relevant names for the content-types, should create semantic connection stubs), because this would simplify including content for any additional author. These identifiers should be searchable, so that others could find relevant content sections fitting to their topics.

She thinks that the best way of creating structures would be sharing the annotated content and let the students link the relevant topics. This would be just another way of sending links of alternative explanations to their fellow students, hence it would be no additional effort for them.

This concept as a tool would be great especially for university networks like Atlantis University. Therefore, of course, lecturers must be open to share their content with others and must not mind that their content is linked to other content, which makes it comparable.

That is the main obstacle of this concept. Many lecturers do not want to publish their content, and they do not want to have it comparable with other content beyond their control. Further, they do not want to (or cannot) invest additional effort, even if it is small. Especially professors of the German so-called “Universities of Applied Sciences” have to teach that many semester hours, that they have limited time resources to do additional tasks.

B.1.9 Dr. Ingo Stengel

Ingo Stengel uses slide sets for lecturing. For the creation of learning content he first looks for the state of the art in research. He also uses other slides as source material that he adopts to his needs. He refines the content each semester. He also is experienced in Project Based Learning. In some of these modules the students created learning content typified according to Röll’s learner preferences theory.

In his opinion, this concept simplifies creating adaptive structures. It is a benefit that students can choose the next step that will be presented. He also thinks that the overall quality of the provided learning content will be increased. It is good to have different content with related topics. Nowadays, if the students do not understand a topic, he tries to explain it differently, but sometimes reaches his limits, of course. Then he looks for other explanations in books or in the internet and discusses the topic in the following lecture. This could be greatly improved by the concept developed in this research.

The GUI needs to be improved. The presentation of the paths should be clarified by adding information what the content of each individual step is about – only showing the names of the slides is not enough. He also encourages adding any kind of presentation that shows which steps of the different paths belong together and therefore discusses the same topic.

An authoring environment is a must before the concept can be used in real life. This should be integrated into the player to enable adjustments to the content and

its structure on the fly. It also should provide an algorithm that recommends content that may fit. Ideal would be some kind of text mining system. In sum, any help that decreases the effort for authors to find the fitting content of their co-authors is needed. This would also encourage to reuse existing bits and peaces, especially for content that does not change very often or any more, like Ohm's law.

Ingo Stengel thinks the biggest problem will be that most lecturers will not publish their content for any kind of reasons, but this also depends on the country and university. For example, at Plymouth University all slide sets are the property of the university. Hence, the lecturers must provide their content to the university before they leave. These kind of circumstances encourage sharing and merging content in the sense of Coherence.

B.2 Selected Transcripts

In this section, those evaluation expert interview transcriptions can be found that have been agreed by the interviewees to be published. These simple transcripts are in their original language german and omit paraverbal as well as non-verbal elements.

B.2.1 Transcript has been removed due to Personal Right restrictions

B.2.2 Dr. Heiko Rölke

Interviewees' Background and Opinion

#00:00:39-6# Interviewer: Du bist nicht so der Interaktionstheoretiker und -anwender, trotzdem: Hast Du mit adaptiven Inhalten zu tun gehabt? Erstellt?

#00:00:52-9# Befragter: Indirekt im Assessmentbereich bei adaptiven Testungen. Gedanken gemacht dazu und natürlich auch von der Theorieseite her auf der Implementationsseite zu tun gehabt. Selber erstellt habe ich die Inhalte dafür nicht,

sondern untersucht und implementiert, wie sich so etwas von der Informatikseite her implementieren lässt. Die Inhalte selber habe ich nicht die Implementationserfahrung. Aber von adaptiven Prozessen her eine ganze Menge Ahnung, weil das auch Forschungsthema von mir war, aber losgelöst von irgendwelchen Lerninhalten.

#00:01:45-3# Interviewer: Kannst Du das ganz grob zusammenfassen, was bei adaptiven Assessments passiert? Wie das gemacht wird? Was ist da die Adaption? Wie äußert sich diese? Und was für Parameter haben Einfluss?

#00:02:01-5# Befragter: Die Grundidee beim adaptiven Assessment ist, dass die Fähigkeit des Probanden zu jedem Zeitpunkt geschätzt wird, und die dazu am besten passende Aufgabe, also die Aufgabe, die den höchsten Diskriminierungsgrad oder den höchsten Entscheidungsinhalt hat, als nächstes ausgewählt wird. Das ist die Grundidee. Das ganze basiert auf „Item Response Theorie“, also der Theorie, dass jeder Mensch über eine latente Fähigkeit verfügt die man nicht direkt messen kann, sondern die man sich nur wahrscheinlichkeitstheoretisch über Fragen annähern kann, und die man zu diesem Zeitpunkt neu schätzen kann.

#00:02:55-6# Interviewer: Sind am Anfang die Fragen? Wird getestet, nur um das rauszubekommen, sein Kenntnisstand? Oder passiert das während ...

#00:03:03-8# Befragter: Während des eigentlichen Tests. Beim adaptiven Testen ist die Idee, dass das ständig stattfindet. Allerdings gibt es auch Abstufungen davon. Dass sozusagen Testlet-basiert, also Testteile ohne Adaptivität administriert und dann Sprünge durchführt. Also dass man erst eine gewisse Anzahl von Items einfach administriert, dann neu einschätzt, und dann entsprechend verzweigt. Sodass die Adaptivität nicht auf Item Basis erfolgt, sondern (unverständlich).

#00:04:27-8# Interviewer: Das heißt, wir haben zum Teil Vergleichbares.

#00:04:33-1# Befragter: Ich denke, das ist schon vergleichbar mit adaptiven Lerninhalten, weil eigentlich nichts großartig Anderes gemacht wird. Man hat vielleicht beim Lernen eher eine Selbsteinschätzung als eine Systemeinschätzung,

aber woher die Einschätzung kommt, ist unabhängig davon, wie der Auswahlalgorithmus arbeiten kann.

#00:04:55-6# Interviewer: Es ist organischer in dem Sinne, weil bei Assessments hat man Tests. Das ist der Sinn des Ganzen. Da hat man auch andere Zwischenergebnisse, was man bei Lehrveranstaltungen nicht unbedingt hat.

#00:05:08-5# Befragter: Richtig. Wobei, wenn Du da überhaupt Adaptivität haben möchtest, musst Du zu bestimmten Zeitpunkten eingreifen und sagen: Jetzt kann es auch anders weitergehen. Ansonsten macht das keinen Sinn. Du musst irgendwie Zeitpunkte definieren, zu denen verzweigt werden kann. Das ist der Unterschied, dass man beim adaptiven Testen ganz klar definierte Sachen hat, weil das alleine vom System getriggert wird. Während beim Lernen es eher selbstreguliert ist, wenn man selber Einfluss darauf hat. Dass man sagt: Jetzt soll bitte etwas anderes kommen.

#00:05:54-7# Interviewer: Das heißt, Du hast auch mit Konzept dafür erstellt, die umgesetzt worden sind? Oder hast Du nur welche übernommen?

#00:06:06-3# Befragter: Da sind noch Forschungsfragen offen. Ich habe einige Sachen diskutiert mit Ulf. Allerdings ist das noch nicht weitergekommen, einfach aus Zeitmangel, und die Sachen würden auch eher die informatorische Umsetzung betreffen. Es werden keine neuen Konzepte eingeführt, sondern eher überlegt, wie man das noch besser nachstellen kann, übertragen kann auf informatische Methoden.

#00:06:44-7# Interviewer: Die zurzeit existierenden Konzepte und Autorenumgebungen, hältst Du die für – sagen wir mal – normale Menschen geeignet? Oder muss immer ein Systemkenner ran?

#00:06:57-4# Befragter: Also für adaptives Testen auf jeden Fall. Alleine wegen der Fähigkeitsschätzung. Das bekommt man also normaler Mensch nicht hin. Mir ist kein System bekannt, das das voll automatisiert. Vielleicht gibt es so etwas, aber mir ist nichts bekannt. Die Tests zu erstellen, die einzelnen Fragen oder Items, da

gibt es Systeme, die von normalen Menschen bedient werden können, wenn es nicht zu komplex wird.

#00:07:27-4# Interviewer: Aber das große Ganze wird schwierig.

#00:07:30-7# Befragter: Ja.

#00:07:33-2# Interviewer: Sind die Ansätze vergleichbar? Bei Inhalten gibt es String of Pearls, Branching ...

#00:07:40-7# Befragter: Das gibt es alles auch beim Testen. Klar. Vielleicht eine bisschen andere Ausprägung. Aber man hat linearer Tests. Man hat Branching auf unterschiedlichen Ebenen. Wo Testteile aneinander kommen und verzweigt wird. Man könnte einen Ansatz wie String of Pearls auch übertragen auf Assessments, wo man vielleicht für einen Themenbereich nachfragt, solange bis dieser Themenbereich erschöpfend beantwortet ist. Oder man einfach merkt, dass man nicht weiterkommt, und dann geht es zum nächsten weiter. Das wäre eine Mehrstufiger adaptiver Test. Das wäre damit am ehesten zu vergleichen.

#00:08:32-6# Interviewer: Das ist dann bei Assessments beherrschbar? Es kommt eher auf die Frage an, wie man das einschätzt, das ist immer das Schwierige. Da benötige ich nicht die Techniker, sondern Leute, die das einschätzen können.

#00:08:43-9# Befragter: Man braucht Psychometriker, die überhaupt wissen, was sie da machen. Der normale Psychologe wäre schon allein von dem Konzept überfordert.

#00:09:11-1# Interviewer: Wie ich sehe, machst Du auch Lehrveranstaltungen.

#00:09:15-2# Befragter: Ich habe schon ziemlich viele gemacht, und ich mache auch noch.

#00:09:19-3# Interviewer: Wie erstellst Du normalerweise Lerninhalte?

#00:09:23-3# Befragter: Mit den üblichen Office Methoden. Also Folien, und aus den Folien übertrage ich Inhalte, wenn ein Skript erstellt werden soll.

#00:09:46-9# Interviewer: Machst Du erst eine Grobstruktur und erweiterst die mit der Zeit? Füllst die mit Inhalten? Oder fängst Du vorne an? Oder setzt Du Dir erst mal ein Lernziel? Und dann Unterziele? Oder eine Mischform?

#00:10:02-2# Befragter: Es ist eher eine Mischform. Bei einigen Sachen ist es so klar, wie das Ganze vorangeht, dass ich es einfach von vorne nach hinten durch erstelle. Bei anderen Bereichen, bei denen ich noch nicht so klar bin, da mache ich eine Grobstruktur und erarbeite mir die Inhalte, sodass nach und nach zu einer feineren Struktur komme.

#00:10:26-1# Interviewer: Hast Du noch besondere Vorbereitungen für die Veranstaltungen selber? Oder hast Du Deine Inhalte im Kopf?

#00:10:36-3# Befragter: Eigentlich eher so. Ich war bisher noch nicht in der in der glücklichen Lage, dass ich eine Lehrveranstaltung so häufig gegeben hätte, dass ich alte Materialien hätte wieder benutzen können, sodass ich mich nur mit den Materialien hätte auseinandersetzen müssen. Sondern ich habe bisher immer die Materialien direkt erstellt für die Lehrveranstaltung. Ich benutze nicht nur Folien – das ist natürlich für mich das Grobgerüst für eine Veranstaltung – aber ich versuche auch interaktive Inhalte einzustreuen. Frage/Antwort Spiele mit den Studenten. Oder auch Flipchart und Tafelbeiträge und so weiter, wo ich alleine oder in Interaktion mit den Studierenden versuche, die Inhalte zu entwickeln.

#00:11:36-8# Interviewer: Nehmen wir mal an, ein Student versteht etwas nicht. Was machst Du damit?

#00:11:51-6# Befragter: Erst mal muss er das äußern.

#00:11:54-6# Interviewer: Er muss wirklich aktiv werden? Wenn Du ein fragendes Gesicht siehst, dann fragst Du nicht aktiv nach? (unverständlich)

#00:12:01-7# Befragter: Das hängt auch von der Größe der Lehrveranstaltung ab. Bei wirklich großen Veranstaltungen kann man das nicht leisten, dass man sich einzeln die Leute ansieht. Bei kleineren Lehrveranstaltungen sehe ich auch gezielt ins Publikum und beurteile von mir aus selber, oben ich der Meinung bin, dass sie es

verstanden haben oder nicht. Das bekommt man auch mit durch die Dynamik, wie wird auf Fragen geantwortet, rafft sich einer auf und sagt, dass doch eigentlich alle wissen, oder weiß es einfach keiner. Das versuche ich auch mit interaktiven Inhalten rauszufinden. Ansonsten würde ich dann versuchen, das kann ich nicht generell sage, was ich dann mache, aber normalerweise versuche ich entweder das noch mal anhand der Folie oder anhand der vorgegeben Sachen zu erläutern. Wenn das nicht hilft, dann auf einen anderen Modus zu wechseln. Beispielsweise von der Folie auf die Tafel oder auf ein erläuterndes Beispiel.

#00:13:19-9# Interviewer: O. k. Also sozusagen ein Medienwechsel oder ein Beispiel.

#00:13:29-7# Befragter: Ich denke, das sind übliche Methoden. Aber das ist eine Einzelfallentscheidung. Ich habe kein Schema F, was ich immer mache, wenn jemand fragend schaut. Sondern ich entschiede im Einzelfall, je nachdem worum es gerade geht. Kann auch sein, dass man Sachen vertagt, weil das sowieso noch einmal aufgegriffen wird. Oder bei Veranstaltungen mit integrierten Übungen, oder bei denen Übungen sowieso dazu kommen, sodass später die Frage wieder aufgenommen wird.

#00:14:05-3# Interviewer: Hast Du schon mal mit anderen zusammen Inhalte erstellt? In Kooperation?

#00:14:10-3# Befragter: Ja, allerdings keine klassischen Lehrinhalte für Vorlesungen oder so, sondern in Projekten. Die haben wir hochgradig interaktiv erstellt.

#00:14:27-6# Interviewer: Bei Projekten. Bei welcher Art von Projekten? Projekte für die Studenten, Lehrprojekte?

#00:14:35-0# Befragter: Ja, Lehrprojekte, wo Studenten etwas erarbeiten sollen. Da haben wir unterschiedliche Expertisen hereingebracht: Von der Softwareentwicklungsseite, von der Überblicksseite, von der Anforderungsseite, und daraus die Lehreinheiten zusammen erstellt.

#00:14:54-3# Interviewer: An der TU? (Technische Universität Darmstadt)

#00:14:56-1# Befragter: Universität Hamburg.

#00:14:59-6# Interviewer: Ich kenne das – im Vergleich, damit ich das richtig verstehe – von der Hochschule Darmstadt in Media: Ab dem ersten Semester gibt es ein Projekt. Ab dem zweiten oder dritten sind drei Lehrende im Projekt. Einer ist der Medienspezialist, der andere ist ein Informatikspezialist, der dritte ist auf Projektmanagement spezialisiert.

#00:15:23-9# Befragter: So klar strukturiert ist das nicht an der Uni, jedenfalls das, was ich kenne. Wir haben versucht, unterschiedliche Bereiche zusammenzubringen. Für ein Projekt, das gab es als Veranstaltungsform in Hamburg. Das hat es auch woanders gegeben. Vielleicht wird es dort anders gemacht, das weiß ich nicht. Das ist schon ein erheblicher Zeiteinsatz für die Studenten. Die haben im Laufe ihres Studiums nur zwei solch große Projekte. Und da wollten wir auch schon das möglichst realitätsnah und umfassend gestalten, sodass auch wirklich hohe Motivation aufkommt. Aber auch, dass was Schönes herauskommen kann.

#00:16:06-2# Interviewer: Ich denke in diesem Zusammenhang – da ist Vorlesung so etwas wie Nebensächlichkei, da wird ad hoc eher etwas ...

#00:16:15-8# Befragter: Es gibt einen Vorlesungsteil am Anfang, wo in die Thematik eingeführt wird und ein Überblick gegeben wird. Aber das sind nur zwei, drei Veranstaltungen am Semesteranfang. Und dann gibt es Anteile während des Projektes, wo die Projektteilnehmer erzählen, was sie gemacht haben, wo Probleme aufgetaucht sind. Das wird dann im Plenum besprochen. Eventuell gibt es von den Veranstaltern noch mal Einheiten dazu, wie man weiter vorgehen kann. Aber das hat nicht wirklich Vorlesungscharakter. Von daher: Größere Vorlesungsinhalte habe ich noch nicht kooperativ erstellt.

#00:16:58-9# Interviewer: O. k., wenn man überhaupt Probleme am Anfang hat. Aber bei der Menge tauchen so die Probleme dann meine ich auf.

#00:17:07-7# Befragter: Nicht nur (unverständlich) klar abgegrenzt voneinander. Natürlich hat vorher ein Abstimmungsprozess stattgefunden. Aber der hat im Gespräch stattgefunden, bevor wir die Inhalte erstellt haben.

Introduction

[Der Vortrag war vorher vor einer Gruppe von Kollegen. Es gibt keine Aufzeichnung davon.]

#00:17:39-6# Interviewer: Nun hast Du schon meinen Vortrag gesehen. Ich könnte Dir das Ganze noch mal im echten Leben zeigen. Der Prototyp ist natürlich auch nicht viel mehr als die Bildschirmfotos.

Hands On

#00:19:56-7# Interviewer: Das hatte ich schon so ungefähr in den Bildschirmfotos gezeigt. Klar: Der Auswahl- und Anmeldeprozess verschwindet später im LMS (Learning Management System). Dort klickt man auf eine Aktivität, und dann erscheint direkt das (zeigt auf den Bildschirm). Das wäre der Anfang. Das System meint dann, dass das am geeignetsten für mich wäre, dass der (Dozent) Hahn mir am nächsten stehen würde.

#00:20:25-1# Interviewer: (Zeigt die Pfade der verschiedenen Dozenten) Wie man hier sieht, sind das verschiedene Dozenten, die das (selbe Thema) aufbereitet haben. Was fehlt, wird notfalls von anderen (Dozenten) genommen. Das System merkt, da fehlt was. Sieht man am Ende (zeigt das Pfadende): Schlussfolie von Hahn – ein sehr wichtiger Bestandteil. Die habe ich markiert, die muss sein.

#00:20:49-5# Befragter: Gut, aber woher weiß das System, dass etwas fehlt? Das muss in einer übergreifenden Struktur eingetragen sein.

#00:20:57-0# Interviewer: Genau. Das war was ich vorher mit den „weights“ gesagt hat, mit den Gewichtungen. Die semantischen Verknüpfungen können auch gewichtet werden. Das ist hier die Endfolie, die überall erscheinen soll. Die

semantischen Verknüpfungen heißen „Content Types“, also werden hier eher wie Container behandelt. Alles was zum Thema gehört wird reingeworfen. Und das ist hier mit Einz gewichtet. Deswegen wird das eingefügt, egal in wessen Dozenten Pfad.

#00:22:00-6# Befragter: Woher weiß ich, dass das ans Ende kommen muss?

#00:22:08-0# Interviewer: Die haben alle ihre eigenen Reihenfolgen.

#00:22:15-9# Interviewer: Stimmt. Da habe ich noch einen Bruch drinnen. In dem Fall hat es einfach funktioniert.

#00:22:30-9# Interviewer: Jeder Inhalt hat seine Position (im Pfad). Im Storytelling würde ich es „Narrative Position“ nennen.

#00:22:43-8# Befragter: Es gibt irgendwie eine Gesamtstruktur, ein Gesamtstrukturmodell.

#00:22:49-5# Interviewer: Diese narrative Position ist für jeden Dozentenpfad verschieden. Jeder hat seine eigene Reihenfolge. Diese wird durchnummeriert.

#00:23:02-7# Befragter: Jeder hat für sich schon mal eine lineare Ordnung der Inhalte. Das ist soweit klar. Aber wenn Du vermischt, musst Du feststellen bei der Ordnung von Dozent zwei: Da fehlt etwas. Das muss irgendwie feststellbar sein. Das kannst Du nicht aus den Einzelabfolgen herleiten.

#00:23:30-7# Interviewer: Wenn gesagt wird, es muss hinein – es fehlt also etwas ... Wie siehst gibt es hier noch die sogenannten „Repeats“. Das sind die Bereiche, die wiederholt werden können. Die ganzen Typen sind dort beinhaltet, die diese Verknüpfungen darstellen. Diese Repeats können auch geschachtelt werden. Meine Engine kann es noch nicht auflösen, aber vom Konzept her kann es geschachtelt wer-

den. Was wird in ein Repeat hineingesteckt? Genau die Kapitelstruktur, wie ich sie (linear) erstellt habe.

#00:24:27-1# Befragter: Was bedeutet das Repeat dann?

#00:24:31-3# Interviewer: Zum einen heißt es: Was nicht in einem Repeat ist, darf auch nicht wiederholt werden, das ist dann einmalig. Dadurch wird aber fast alles in einem Repeat sein. Heißt auch, dass der Inhalt blockweise getrennt ist. Wenn hier irgendetwas mit einem „Muss“ gekennzeichnet ist, dann wird rausgesucht: Hier fehlt etwas. Das wird innerhalb dieses Blocks eingefügt.

#00:24:55-4# Befragter: Wie kommst Du darauf, was Du in einen solchen Repeat Block hineintust?

#00:25:03-0# Interviewer: Das machen die Autoren nach ihrer Kapiteleinteilung.

#00:25:13-5# Befragter: Es kommt durch die Autoren hinein.

#00:25:15-5# Interviewer: Genau. Letztendlich, wie sie wollen, aber mein Vorschlag ist, das haben auch die Selbstversuche gezeigt, man nimmt sich einfach die Kapitelstruktur und übernimmt genau diese Struktur. Ich habe noch keine Sachen gefunden, die mich vollständig rausgerissen haben, aber ich habe es auch nicht extensiv über sehr viele Kurse hinaus getestet. Es wird bestimmt etwas geben, wo es herausfällt. Aber normalerweise passt es dadurch, dass erst die Reihenfolge des Dozenten genommen wird, der vorausgewählt ist, und dahinter einfüge, was noch fehlt von einem anderen Dozenten. Der vorausgewählte Dozent ist in sich schlüssig. Der meint, dieser Teil muss nicht in den Inhalt hinein.

#00:26:09-4# Befragter: Genau. Weil er bereits eine fertige Struktur hat.

#00:26:11-6# Genau. Nun sagt jedoch eine übergeordnete Struktur, zum Beispiel das Student Handbook: Das muss trotzdem hinein. Deswegen wurde der Teil markiert, dass er trotzdem hinein muss. Und dann wird es als Zusatz, damit das andere nicht auseinandergerissen wird, dahinter gehängt.

#00:26:26-9# Befragter: Du hast also immer eine Masterstruktur, die von irgendwo herkommt? Das ist eine Frage, weil Du sagst, es gibt eine übergeordnete Struktur, dann muss festgelegt werden, was wirklich bestimmt, wie es aussehen soll.

#00:26:50-3# Interviewer: Eigentlich nicht. Bei den Gewichtungen kann noch bestimmt werden, das hat dieser zwar noch nicht vorgesehen, aber es muss trotzdem von irgendjemanden hineinkommen. Insofern ein direktes Jain. Dadurch kann tatsächlich eine Masterstruktur drüber gestülpt werden.

#00:27:25-8# Befragter: Du siehst, ich schaue eher von der formalen Seite darauf. Ist eine Sichtweise, hast Du mich vorhin dazu gebracht, indem Du eine komplexe Struktur an die Wand geworfen hast, deshalb gehe ich genauer darauf ein. Das ist eine Frage, die Du beantworten musst, auch für den praktischen Einsatz. Du kannst es auch ganz pragmatisch beantworten. Du kannst sagen: Das, was zuerst erstellt wird, ist die Masterstruktur, bis jemand sagt: Nein, das taugt nichts. Vom Konzept her muss Dir klar sein, dass entweder sind alle Abläufe gleich wichtig und gleich richtig. Dann musst Du irgendwie Matching machen. Oder Du sagst, Du hast eine übergeordnete Struktur, dann müssen sich die anderen irgendwie einfügen. Für eins von beiden musst Du Dich entscheiden.

#00:28:19-9# Interviewer: Der anfängt, baut auch alle Blöcke auf. Das ist fast eine Masterstruktur. Der anfängt, gibt eine Struktur vor.

#00:28:34-5# Befragter: Wie schon gesagt, das muss nicht so sein, dass es eine gibt. Ich habe es nur daraus geschlossen, dass Du meintest, man kann feststellen, dass etwas fehlt. Feststellen, dass etwas fehlt, kann man nur durch einen Vergleich von dem, was da ist gegen etwas anderes. Sonst weißt Du nicht, dass etwas fehlt. Daher muss gegen irgendetwas anderes verglichen werden. Das war die Frage: Wogegen wird es verglichen?

#00:29:03-2# Interviewer: Das kann dann ja – wie ich in den Folien gezeigt hatte – es gibt Inhalte, die nicht von allen Autoren erstellt worden sind. Die würde normalerweise ignoriert werden – deswegen ist es ein Jain – außer ein Autor bestimmt,

dass dieser Teil für alle hinein muss. Zurzeit ist es noch ein kooperatives Modell ohne Rechte, sodass jeder alles bestimmen kann.

#00:29:40-1# Befragter: Du gehst von gutmütigen und gutartigen Benutzern aus, Dozenten unter sich haben sich alle lieb. Deshalb macht das kein Problem (Lachen).

#00:30:45-8# Befragter: Repeat. Du hast mir die Repeats gezeigt, und ich habe gefragt, wo die herkommen.

#00:30:51-6# Interviewer: Die werden initial vom ersten Autor eingerichtet. Die werden dann zum Teil erweitert. Um diesem ersten Autor das Leben leicht zu machen, sage ich: Nimm Deine Kapitelstruktur, und dann passt es.

#00:31:13-7# Interviewer: Man merkt, das (zeigt den Editor) ist nicht wirklich für Autoren gemacht. Es ist besser als direkte JSON Eingabe, aber es bildet eins zu eins die innere Struktur ab.

#00:31:28-6# Befragter: Ist ja o. k. erst mal. Es ist ein Proof of Concept und noch kein fertiges Werkzeug.

#00:31:45-0# Interviewer: (Bereitet die Auswahl des nächsten Schritts im Player vor) Ich sage jetzt: Gefällt mir, gefällt mir nicht. Erst mal den normalen Weg: Gefällt mir. Wie man sieht, wird hier der nächste Schritt vorgeschlagen. (Zeigt auf Pfad eines Dozenten) Er hat nichts am Anfang, deswegen wird nichts weggeschmissen. Hier sieht man, dass 2.1 nicht mehr vorgeschlagen wird, weil es deckungsgleich war.

#00:32:08-2# Befragter: Und die Deckungsgleichheit? Wie wird die festgestellt?

#00:32:14-8# Interviewer: Mit den semantischen Beziehungen zwischen Content Sections. Es werden zwei Content Sections verbunden. Technische ist es der Container „Content Type“, in dem die beiden sind.

#00:32:26-5# Befragter: Das machen also auch die Autoren.

#00:32:28-3# Interviewer: Ja.

#00:32:29-0# Der Autor sagt, dass dies und jenes der gleiche Inhalt ist.

#00:32:33-1# Interviewer: Genau. Oder mit den anderen Vorgehensmodellen. Das alle Inhalte freigegeben werden und die Studenten ...

#00:32:39-0# Befragter: Aber es ist eine manuelle Verknüpfung, keine automatische. Das war die eigentliche Frage.

#00:32:42-5# Interviewer: Nein. Aber jeder Ansatz, der einem weiterhilft, ist hochwillkommen.

#00:33:17-0# Interviewer: (Zeigt auf den Pfadauswahldialog) Wenn man bei dem gleichen Autor bleibt aber ein wenig weiter nach hinten geht, wird das hier (der übersprungene Teil) herausgenommen, aber es wird trotzdem weiter unten noch mal angeboten.

#00:33:32-0# Befragter: Ich habe jetzt nicht genau aufgepasst. Hat sich die Bewertung geändert, oder bleibt die fest? Ich habe gesehen, dass etwas Neues dazu gekommen ist mit einer niedrigeren Bewertung. Aber ich habe oben nicht genau aufgepasst, ob sich dort die Bewertungszahlen ändern.

#00:33:47-5# Interviewer: Die dürften sich gerade nicht ändern.

#00:33:56-5# Befragter: Wie kommst Du auf die Zahlen, berechnest Du die selber nach einem von Dir ausgedachten Algorithmus? Oder ist ein Bewertungsverfahren dahinter?

#00:34:06-1# Interviewer: Es ist der große Gleichmacher. Die (Content Sections und -Types) sind anstiert, momentan nur mit den Lernpräferenzen nach dem Röll'schen Test. Zusätzlich wird die Zeit bewertet. Und dann gibt es ein paar Eingriffe: Es werden für jeden Inhalt alle Kontexte verglichen, die des Autors mit denen des „Spielers“. Zum Beispiel wie nah sind sie beieinander. Es wird die Distanz bewertet. Was am nächsten ist, wird vorgeschlagen. Zusätzlich kann bei den Conditions der Repeats festgelegt werden, welche Kontexte erfüllt werden müssen.

#00:35:52-7# Befragter: Dann wäre für Dich auf jeden fall interessant mal einen Blick auf die interaktiven Testsachen zu werfen. Weil dort auch mit einer Bewertungszahl der Fähigkeitsschätzung gearbeitet wird. Aber in der Realität noch zusätzliche Seitenbedingungen mit hinein kommen. Wie zum Beispiel Verhinderung von „Over Exposure“, also das nicht alle Probanden das gleiche Testitem sehen. Oder „Content

Balancing“, also das man nicht nur Fragen zum Dreisatz bekommt, sondern auch noch andere Mathematikbereiche abgedeckt werden, und so weiter. Das hört sich nach einer ähnlichen Fragestellung an die Du auch hast, sodass Du vielleicht Ideen übernehmen oder Dich abgrenzen kannst.

#00:36:38-6# Interviewer: Ich habe erst einmal alle Einflüsse gleich gewichtet, um später die Gewichtung auszubalancieren.

#00:37:08-6# Interviewer: (Erklärt die Bewertung der Pfade) Eine Adaptivität ist, dass das runtergerankt wird, wenn etwas übersprungen wurde – das wollte man nicht sehen. Wenn ich einen anderen Dozent gewählt habe, werden zum einen die eigenen Kontexte, also die eigene Lernpräferenz, in Richtung des ausgewählten Dozenten geändert. Wenn der Student beharrlich einen anderen Dozenten auswählt, dann war zum Beispiel der Test falsch, oder es passt aus anderen Gründen nicht. Sodass der Pfad dieses (ausgewählten) Dozenten den Vorrang bekommt. Wenn man zum Beispiel sagt, das ist nichts für mich, dann wird der Pfad nach unten geschoben – der war nun auch schon vorher ganz unten.

#00:38:15-2# Befragter: Ja gut, Du hast schon wieder den anderen Dozenten oben statt des vorhergehenden, das ist deutlich.

#00:38:28-5# Interviewer: Mehr gibt es auch nicht zu zeigen.

Discussion

#00:39:12-6# Interviewer: Nun hast Du den Prototypen gesehen, und ich habe das Konzept erläutert. Du hast Erfahrung mit Konstrukten von adaptiven Tests, aber weniger mit Inhalten. Kannst Du für die verschiedenen Konzepte im Vergleich den Aufwand einschätzen, den ein Autor hat, um eine Struktur zu erstellen? Also zwischen String of Pearls und ...

#00:39:41-5# Befragter: Das kann ich eher schlecht. Mir erscheint jedoch dieses iterative Vorgehen sinnvoll und eingängig. Wenn ich etwas neu anfangen mich nicht abgrenzen muss, sondern einfach nur meine Inhalte so einstelle, wie ich es für richtig

halte. Wenn neue Inhalte hinzugefügt werden, muss man sich daran orientieren, was schon da ist. Das macht durchaus sinn. Wenn ich zusätzliche Inhalte einbringe, kann ich sehen, was schon vorhanden ist und wie meine Inhalte dazu passen: Was habe ich zusätzlich? Was habe ich weniger? Worauf habe ich mehr Gewicht gelegt? im Unterschied zu den vorhandenen Inhalten. Das erscheint mir vom Prinzip und meinem jetzigen Verständnis von Deinem Vorgehen – ohne dass ich es selber ausprobiert hätte – eingängig zu sein.

#00:40:35-0# Interviewer: Kannst Du einschätzen, wie adaptiv das Konzept für den Benutzer sein wird?

#00:40:45-3# Befragter: Das hängt stark vom Benutzer ab. Und natürlich von der Anzahl der angebotenen Alternativen. Der Grad der Interaktivität wird durch diese zwei Sachen determiniert: Wie viele Alternativen habe ich, und wie weit lassen sich die Benutzer auf diese Adaptivität ein. Sind sie ehrlich mit sich selber, dass sie sagen, sie benötigen noch etwas anderes. Oder sagen sie: Augen zu und möglichst schnell durchkommen. Das sind die beide Richtgrößen, die eine Rolle spielen. Das System ist nur dann sinnvoll, wenn mehrere Alternativen vorhanden sind. Ansonsten kann mit der Nutzerrückmeldung nichts angefangen werden und die Anwender werden frustriert, weil sie zwar Feedback, sich aber nichts ändert.

#00:41:40-2# Interviewer: Deswegen ist auch der erste Kurs, den ich einpflegen wollte, nicht möglich gewesen: Da gab es keine Alternativen.

#00:41:47-6# Befragter: Das macht nur für Veranstaltungen sinn, die von vielen Leuten überall immer wiedergegeben werden. Dann kann es sinnvoll sein. Für Sozialveranstaltungen eher weniger.

#00:42:04-5# Interviewer: Kannst Du einschätzen, ob das Konzept für die Lehre geeignet ist?

#00:42:09-3# Befragter: Ich denke schon. Gerade im Zuge zunehmender Verbreitung von offen zugänglichen Lehrinhalten die über das Internet verfügbar sind, macht es sehr viel Sinn, Verknüpfungen herzustellen. Vielleicht eine Art Metaportal dafür

einzusetzen. Und somit die vorhandenen Sachen gut nachzunutzen. Immer mehr Universitäten stellen ihre Inhalte ins Netz, teilweise auch unentgeltlich, teilweise nur für die eigenen Studenten, aber auch für andere Studenten, sodass eigentlich an Material kein großer Mangel sein sollte. Veranstaltungen wie „Grundlagen der Programmierung“ und „Informatik 1 – 3“, die gibt es überall.

#00:42:54-8# Interviewer: Da ist eher das Problem, das Richtige zu finden.

#00:42:58-6# Befragter: Richtig. Aber das Problem hast Du natürlich, wenn Du versuchst, hier eine Einschätzung vorzunehmen. Dann musst Du Experte für den Inhalt sein und Dir die Zeit dafür nehmen, dieses zu sichten. Sonst macht es keinen Sinn.

#00:43:18-5# Interviewer: Oder wie mir ein anderer Evaluator erklärt hat, dass sich die Studenten Links mit zusätzlichen Inhalten zu nicht verstandenem Lernstoff schicken. So könnte man mit dem Vorhandenem nach dem Konzept diese Verknüpfungen setzen. Es wäre nicht mehr Aufwand als solche eMails zu verschicken.

#00:43:47-1# Befragter: Richtig. Du schickst einmal die eMail und trägst es ein. Das nächste Mal ist es im System.

#00:44:04-3# Interviewer: Du hast schon einiges gesagt, was Du gut findest.

#00:44:14-9# Befragter: Was ich gut finde, ist die Möglichkeit Einfluss nehmen zu können, was geschieht. Und dass der Aufwand der Erstellung sich proportional verhält zum vorhandenen Material. Das finde ich gut.

#00:44:36-1# Interviewer: Was meinst Du, was verbessert werden könnte? Wo siehst Du die Grenzen des Systems?

#00:44:43-5# Befragter: Für Verbesserungsvorschläge müsste ich es ausprobieren. Ich sehe Risiken, dass die Annahme, dass der gerade daran arbeitende Autor den vollständigen Überblick hat. Das ist nicht immer gegeben. Oder es können Begriffsverwirrungen auftreten, dass unter demselben Stichwort verschiedene Sachen verstanden werden und deswegen die Verknüpfungen nicht nützlich sind. Weil zum Beispiel anhand einer oberflächlichen Ordnung gruppiert, das aber nicht inhaltlich

übereinstimmt. Das ist natürlich ein großes Risiko, was dazu führen kann, dass die Studierenden eher verwirrt werden, als dass ihnen geholfen wird. Grenzen: Es macht nur Sinn, wenn viel Material vorhanden ist, also das Gleiche mehrfach aufbereitet ist. Dann wächst jedoch der Aufwand quadratisch, weil jedes Materialstückchen mit allen anderen verglichen werden müsste, um wirklich sicher eine Einordnung vornehmen zu können, die thematisch passt. Dass es wirklich eine Alternative ist. Du gehst davon aus, dass Du austauschbar Inhalte hast: Dozent A erklärt eigentlich das Gleiche wie Dozent B, er erklärt es nur anders. Um wirklich sicher zu sein, dass das der Fall ist, muss alles mit allem verglichen werden.

#00:46:21-0# Interviewer: Warum ist es quadratisch? Ist es nicht eher linear? Bei zwei Inhalten muss es mit beiden verglichen werden, bei drei mit alle dreien ...

#00:46:29-1# Befragter: Nein. Wenn zwei vorhanden sind, ist es richtig. Aber wenn drei vorhanden sind, muss 1 mit 2, 1 mit 3 und 2 mit 3 verglichen werden.

#00:46:39-6# Interviewer: Wenn einer alles vergleichen will, auch schon vorhandenen Verknüpfungen?

#00:46:42-1# Befragter: Ja. Wenn etwas Neues hinzugefügt wird, dann muss es mit allen verglichen werden, die schon vorher da waren.

#00:46:51-9# Interviewer: Wobei jedoch die vorhandenen Verknüpfungen helfen können.

#00:46:59-7# Befragter: Das ist klar. Ich meine, wenn Du absolute Sicherheit haben willst. Wenn Du davon ausgehst, dass das System bisher korrekt ist, dann wird es einfacher, weil dann nur noch einer angesehen werden muss.

#00:47:11-5# Interviewer: Oder diese übergreifende Beschreibung.

#00:47:14-9# Befragter: Ja, genau. Aber das ist auch Vorteil des Systems, weil der Arbeitsaufwand proportional zu der Anzahl der Inhalte ist. Wenn Du neuen Inhalt einpflegst, hast Du keinen Arbeitsaufwand. Weil das System automatisiert meine Struktur übernimmt.

#00:47:38-4# Interviewer: Ja, darum geht es ja.

#00:47:40-3# Befragter: Darum geht es, genau. Beim zweiten hat man mehr Aufwand, dafür hat man ein Vorteil aus dem System, weil die Verknüpfungen schon vorhanden sind. Dadurch kann das Vorhandene referenziert und benutzt werden. Das ist ein Vorteil des Systems.

#00:47:59-2# Interviewer: Einen großen Hemmschuh sehe ich in der realen Welt. Die Vorbehalte der Professoren anderen gegenüber ...

#00:48:16-8# Befragter: A, dass natürlich nur die eigene Lehre gut ist. B, dass man sich dadurch kontrollierbar und vergleichbar macht. Das ist unbeliebt, das möchte keiner haben. Es sollen die Studenten getestet werden, nicht die Professoren.

#00:48:39-5# Interviewer: Das kommt natürlich auf Professor, Hochschule und Land an.

#00:48:41-9# Befragter: Richtig. Klar. Es gibt sicherlich jede Menge, die keine Probleme damit haben. Weil sie auch gerne selber lernen. Während für andere die Lehre sowieso nur ein ungeliebter Hemmschuh ist und eine Nebenbeibeschäftigung, die haben eventuell weniger Interesse daran.

#00:48:58-6# Interviewer: Wie eine Professorin vorgeschlagen hat: Die Bewertungen der Studenten kann als Feedback für die Professoren genutzt werden. Das wäre einigen bestimmt nicht recht.

#00:49:08-8# Befragter: Nein, das ist Quatsch, das als Feedback für die Professoren zu nehmen, weil es den Studenten helfen soll. Der Student wählt nicht unbedingt eine Alternative, weil es blöd war, sondern weil er selber vielleicht ein wenig mehr Erklärung oder eine andere Art der Erklärung benötigt. Und nicht, weil der Professor das vielleicht doof erklärt hat. Vielleicht hat er super erklärt für 99 von 100.

#00:49:33-2# Interviewer: Nur der eine nicht.

#00:49:33-9# Befragter: Nur für den einen nicht, genau.

#00:49:35-7# Interviewer: Man könnte bei Bedarf solche gesammelten Daten untersuchen. Das ist aber nicht mein Thema.

#00:50:15-7# Befragter: Ich denke es ist gerade mit den Assessment Sachen wirklich hochinteressant. Das reine Lernen kann ich nicht beurteilen, dafür ist es sicherlich auch sehr interessant. Das kann ich nicht beurteilen. Das liegt bei Dir. Aber wenn das verbunden wird mit Sachen, die im Assessment bereits laufen, dann kann man da sicherlich auch zu ein, zwei gemeinsamen Veröffentlichungen kommen.

#00:50:37-6# Interviewer: Was ich mir auch gut vorstellen kann das Wissen von adaptiven Assessments damit verbindet, deren Ergebnisse den Verlauf ändern.

#00:50:47-9# Befragter: Damit sind wir mitten im formativen Assessment beziehungsweise der Verknüpfung von Assessment und eLearning.

Appendix C

Test Environment

Before testing the evaluation had to be prepared. That includes a working system – the server and prepared content.

C.1 Server

Coherence has been installed on an Ubuntu Linux server at Hochschule Darmstadt. It got the Fully Qualified Domain Name (FQDN) `coherence.aida.h-da.de`, so that it could be reached in a familiar way. The following components have been installed on the server:

C.1.1 Ubuntu Linux

The operating system is the server edition of Ubuntu Linux 11.10 “Oneiric Ocelot” [27]. This system is very common for web-services, because it has included everything that is needed and administration is easy. There had been no special changes made, the system was used just from the shelf, installed on a virtual machine.

C.1.2 Web Server Apache 2

Apache [5] is the most popular web server. It is full featured, open source, platform independent, and seamlessly integrated into Ubuntu Linux. Version 2.2.20 has been installed and configured as follows:

- Only secure access is possible (https on port 443, port 80 is disabled).
- Login is needed.
- A Reverse Proxy für CouchDB was configured (see next section for details).

C.1.3 Database CouchDB

Coherence's database is CouchDB 1.02 [4]. It is included in the Ubuntu software repository, so installation is possible with the common `apt-get`. Because it listens on port 5984 but should be reached in the directory `/CouchDB` on port 80, a reverse Proxy was configured in the Apache web server that redirects any requests from `https://coherence.aida.h-da.de/CouchDB` to `https://coherence.aida.h-da.de:5984`.

C.2 Client

During the evaluation the web browsers Firefox 14.0.1 and Safari 6.0 have been used as Coherence clients. Because the Internet Explorer is not compatible enough to the W3C web standards, it cannot be used as a client.

C.3 Content

For the test a part of a real lecture had been prepared. Also users had to be created: One for each author, and one for each student. The following sections show important parts of the test content as JSON files, the native format of the database CouchDB.

C.3.1 Example User

As an example one user's data is listed in this section. Due to data privacy only this one example can be published.

```
{ "_id": "oli",
  "_rev": "642-bb828cbc9fd1c2b7b1e412b6d29bb837",
  "type": "User",
  "firstName": "Oliver",
  "lastName": "Schneider",
  "userName": "oli",
  "contexts":
  [ { "_id": "Oli-Context-Creator",
      "type": "Context",
      "max": 17.53,
      "min": 17.53,
      "name": "Creator"
    },
    { "_id": "Oli-Context-Communicator",
      "type": "Context",
      "max": 19.59,
      "min": 19.59,
      "name": "Communicator"
    },
    { "_id": "Oli-Context-Perceptor",
      "type": "Context",
      "max": 13.27,
      "min": 13.27,
      "name": "Perceptor"
    }
  ],
}
```

```
{ "_id": "Oli-Context-Organiser",
  "type": "Context",
  "max": 15.46,
  "min": 15.46,
  "name": "Organiser"
},
{ "_id": "Oli-Context-Constructor",
  "type": "Context",
  "max": 21.65,
  "min": 21.65,
  "name": "Constructor"
},
{ "_id": "Oli-Context-Analyst",
  "type": "Context",
  "max": 13.4,
  "min": 13.4,
  "name": "Analyst"
} ],
"needContexts":
[ { "_id": "Oli-NeedContext-Creator",
  "type": "NeedContext",
  "name": "Creator",
  "min": 17.53,
  "max": 17.53,
  "weight": 0.5,
  "needed": 0.5,
  "comparisonMethod": "nearness",
  "limit": true,
```

```
    "limitMin": 0,
    "limitMax": 100
  },
  { "_id": "Oli-NeedContext-Communicator",
    "type": "NeedContext",
    "max": 19.59,
    "min": 19.59,
    "name": "Communicator",
    "weight": 0.5,
    "needed": 0.5,
    "comparisonMethod": "nearness",
    "limit": true,
    "limitMin": 0,
    "limitMax": 100
  },
  { "_id": "Oli-NeedContext-Perceptor",
    "type": "NeedContext",
    "max": 13.27,
    "min": 13.27,
    "name": "Perceptor", "weight": 0.5,
    "needed": 0.5,
    "comparisonMethod": "nearness",
    "limit": true,
    "limitMin": 0,
    "limitMax": 100
  },
  { "_id": "Oli-NeedContext-Organiser",
    "type": "NeedContext",
```

```
"max": 15.46,
"min": 15.46,
"name": "Organiser",
"weight": 0.5,
"needed": 0.5,
"comparisonMethod": "nearness",
"limit": true,
"limitMin": 0,
"limitMax": 100
},
{ "_id": "Oli-NeedContext-Constructor",
  "type": "NeedContext",
  "max": 21.65,
  "min": 21.65,
  "name": "Constructor",
  "weight": 0.5,
  "needed": 0.5,
  "comparisonMethod": "nearness",
  "limit": true,
  "limitMin": 0,
  "limitMax": 100
},
{ "_id": "Oli-NeedContext-Analyst",
  "type": "NeedContext",
  "max": 13.4,
  "min": 13.4,
  "name": "Analyst",
  "weight": 0.5,
```

```

    "needed": 0.5,
    "comparisonMethod": "nearness",
    "limit": true,
    "limitMin": 0,
    "limitMax": 100
  } ]
}

```

C.3.2 Coherence Lecture Test Content

The test content data represents the Coherence meta data of three merged real lectures. It has been used for evaluation purposes.

```

{ "_id": "00AD eLectures",
  "_rev": "5-893314fd5cc2804a0973713476cca1ea",
  "type": "Coherence",
  "name": "00AD eLectures",
  "minDuration": 3630,
  "maxDuration": 4525,
  "avgDuration": 4082,
  "treeItemChildren":
  [ { "_id": "00AD eLectures
    af4c2be1-1017-41b9-9d2d-4d37d50fdca8",
      "type": "Repeat",
      "treeItemChildren":
      [ { "_id": "00AD eLectures
        ce18b39c-cc0e-4a81-9cda-df4939da16c6",
          "type": "ContentType",
          "name": "Titel Objektorientiertes Design",

```

```

"weight": 1,
"treeItemChildren":
[ { "_id": "00AD eLectures
    8b7d0525-5cc6-48f4-b4ef-8fd2b9bc8f7a",
      "type": "ContentSection",
      "name": "Bühler 2-1 Titel Kapitel 2 UML 2
        Teil 1 Objektorientierter Ansatz",
      "avgDuration": 314,
      "minDuration": 279,
      "maxDuration": 348,
      "position": 2001,
      "url": "/Coherence/OD/Buehler/OD_1.svg",
      "weight": 0.5,
      "author": "buehler"
    },
    { "_id": "00AD eLectures
      b307274d-1258-4970-914f-070e90cacab0",
      "type": "ContentSection",
      "name": "Hahn eL 121 Titel
        Objektorientiertes Design",
      "avgDuration": 40,
      "minDuration": 30,
      "maxDuration": 50,
      "position": 121,
      "url":
        "/Coherence/OD/Hahn-eLectures/OD_1.html",
      "weight": 0.5,
      "author": "hahn"
    }
  ]

```

```
    } ]
  },
  { "_id": "00AD eLectures
    e15b8731-50de-4cca-b40b-309b38a6c1de",
    "type": "ContentType",
    "name": "Einordnung 1",
    "weight": 0.5,
    "treeItemChildren":
  [ { "_id": "00AD eLectures
    ec3ccf45-1af1-46a7-84d5-f6516ff5ab28",
    "type": "ContentSection",
    "name": "Bühler 2-2 Einführung
      Objektorientierter Ansatz",
    "avgDuration": 314,
    "minDuration": 279,
    "maxDuration": 348,
    "position": 2002,
    "url": "/Coherence/OD/Buehler/OD_2.svg",
    "weight": 0.5,
    "author": "buehler"
  },
  { "_id": "00AD eLectures
    c9199f33-839a-4ed5-9881-1081d255b5fd",
    "type": "ContentSection",
    "name": "Hahn eL 122 Erinnerung:
      Abstraktionsebenen",
    "avgDuration": 60,
    "minDuration": 50,
```

```
        "maxDuration": 70,
        "position": 122,
        "url":
            "/Coherence/OD/Hahn-eLectures/OD_2.html",
        "weight": 0.5,
        "author": "hahn"
    } ]
},
{ "_id": "00AD eLectures
    f98acbcf-d91c-4ead-a546-dc84faafa12e",
  "type": "ContentType",
  "name": "Einordnung 2",
  "weight": 0.5,
  "treeItemChildren":
  [ { "_id": "00AD eLectures
      1c3a70cc-4523-4414-a92a-df414450de5e",
    "type": "ContentSection",
    "name": "Hahn eL 123 Erinnerung:
        Phasenmodell",
    "avgDuration": 29,
    "minDuration": 20,
    "maxDuration": 40,
    "position": 123,
    "url":
        "/Coherence/OD/Hahn-eLectures/OD_3.html",
    "weight": 0.5,
    "author": "hahn"
  } ]
```



```
  },
  { "_id": "00AD eLectures
    b8635688-f237-47c4-854a-0e1a8daba2d5",
    "type": "ContentType",
    "name": "Einordnung 3",
    "weight": 0.5,
    "treeItemChildren":
    [ { "_id": "00AD eLectures
      ee53df4a-f029-47d4-90a8-ad98800b12f1",
      "type": "ContentSection",
      "name": "Hahn eL 124 Zwischenstand",
      "avgDuration": 221,
      "minDuration": 200,
      "maxDuration": 240,
      "position": 124,
      "url":
        "/Coherence/OD/Hahn-eLectures/OD_4.html",
      "weight": 0.5,
      "author": "hahn"
    } ]
  },
  { "_id": "00AD eLectures
    acbd4da4-cde6-4de4-9d4a-9b9a1d30b2b0",
    "type": "Condition"
  } ]
},
{ "_id": "00AD eLectures
  67b72323-b525-45f7-a2f6-cc5fecfb4a35",
```

```

"type": "Repeat",
"treeItemChildren":
[ { "_id": "00AD eLectures
    4b9c2e24-dd13-4068-84fb-63e71767dba6",
    "type": "ContentType",
    "name": "Titel Klassendiagramme",
    "weight": 1,
    "treeItemChildren":
    [ { "_id": "00AD eLectures
        fa1f1e96-e23b-4efc-9862-a0a0b896708a",
        "type": "ContentSection",
        "name": "del Pino 4.1 Titel Teil 4 UML
            Klassendiagramme",
        "avgDuration": 255,
        "minDuration": 227,
        "maxDuration": 283,
        "position": 4001,
        "url": "/Coherence/OD/delPino/OD_1.svg",
        "weight": 0.5,
        "author": "delPino"
    },
    { "_id": "00AD eLectures
        b92c00df-4787-4ce1-9093-110653027bf0",
        "type": "ContentSection",
        "name": "Bühler 2-3 Titel Kapitel 2 UML 2
            Teil 1 UML-Klassendiagramme",
        "avgDuration": 314,
        "minDuration": 279,

```

```
        "maxDuration": 348,
        "position": 2003,
        "url": "/Coherence/OD/Buehler/OD_3.svg",
        "weight": 0.5,
        "author": "buehler"
    },
    { "_id": "OOAD eLectures
      e7d73593-31b9-4111-9e3a-567fe1687829",
      "type": "ContentSection",
      "name": "Hahn eL 125 Titel Klassen und die
        UML",
      "avgDuration": 26,
      "minDuration": 20,
      "maxDuration": 35,
      "position": 125,
      "url":
        "/Coherence/OD/Hahn-eLectures/OD_5.html",
      "weight": 0.5,
      "author": "hahn"
    } ]
  },
  { "_id": "OOAD eLectures
    583d1c73-ca89-40bd-b70a-6405f2020ccf",
    "type": "ContentType",
    "name": "UML Klassendiagramme Einordnung",
    "weight": 0.5,
    "treeItemChildren":
```

```
[ { "_id": "00AD eLectures
    14fe1021-9441-4f1a-bf34-6fe8cb658ff4",
    "type": "ContentSection",
    "name": "del Pino 4.2 UML Klassendiagramme
        Einordnung",
    "avgDuration": 255,
    "minDuration": 227,
    "maxDuration": 283,
    "position": 4002,
    "url": "/Coherence/OD/delPino/OD_2.svg",
    "weight": 0.5,
    "author": "delPino"
} ]
},
{ "_id": "00AD eLectures
    46adf7e2-fb3b-496b-a583-16faf78af5b5",
    "type": "ContentType",
    "name": "UML Klassendiagramme Einführung",
    "weight": 0.5,
    "treeItemChildren":
    [ { "_id": "00AD eLectures
        83726699-b2d8-4396-b03c-dc87c6df54c9",
        "type": "ContentSection",
        "name": "del Pino 4.3 Klassendiagramm 2",
        "avgDuration": 255,
        "minDuration": 227,
        "maxDuration": 283,
        "position": 4003,
```

```
    "url": "/Coherence/OD/delPino/OD_3.svg",
    "weight": 0.5,
    "author": "delPino"
  },
  { "_id": "00AD eLectures
    96c9c457-ab34-4494-b550-5b654e964832",
    "type": "ContentSection",
    "name": "Bühler 2-4 UML-Klassendiagramme",
    "avgDuration": 314,
    "minDuration": 279,
    "maxDuration": 348,
    "position": 2004,
    "url": "/Coherence/OD/Buehler/OD_4.svg",
    "weight": 0.5,
    "author": "buehler"
  },
  { "_id": "00AD eLectures
    bfa9008b-51d9-4a0c-85fe-2a56521a6b4b",
    "type": "ContentSection",
    "name": "Hahn eL 126 Darstellung Statik
      Lerniele",
    "avgDuration": 89,
    "minDuration": 80,
    "maxDuration": 100,
    "position": 126,
    "url":
      "/Coherence/OD/Hahn-eLectures/OD_6.html",
    "weight": 0.5,
```

```
        "author": "hahn"
    } ]
},
{ "_id": "00AD eLectures
60852887-b35c-4e23-98bc-f549d8871605",
"type": "ContentType",
"name": "Darstellung von Klassen 1",
"weight": 0.5,
"treeItemChildren":
[ { "_id": "00AD eLectures
0e7bb961-3169-4413-8ff2-9641362017af",
"type": "ContentSection",
"name": "del Pino 4.4 Klasse",
"avgDuration": 255,
"minDuration": 227,
"maxDuration": 283,
"position": 4004,
"url": "/Coherence/OD/delPino/OD_4.svg",
"weight": 0.5,
"author": "delPino"
},
{ "_id": "00AD eLectures
3673d353-c5dd-48a4-aa4c-5557606ff4b0",
"type": "ContentSection",
"name": "Bühler 2-5 Modellierung von
Klassen 1",
"avgDuration": 314,
"minDuration": 279,
```

```
        "maxDuration": 348,
        "position": 2005,
        "url": "/Coherence/OD/Buehler/OD_5.svg",
        "weight": 0.5,
        "author": "buehler"
    },
    { "_id": "00AD eLectures
      9bb938f8-ef48-4192-b5ac-983d4d0c9d29",
      "type": "ContentSection",
      "name": "Hahn eL 127 Darstellung von
        Klassen 1",
      "avgDuration": 410,
      "minDuration": 370,
      "maxDuration": 450,
      "position": 127,
      "url":
        "/Coherence/OD/Hahn-eLectures/OD_7.html",
      "weight": 0.5,
      "author": "hahn"
    } ]
},
{ "_id": "00AD eLectures
  7dc9a104-17d2-45f4-8b87-88a34a0e7bbd",
  "type": "ContentType",
  "name": "Darstellung von Klassen 2",
  "weight": 0.5,
  "treeItemChildren":
```

```
[ { "_id": "00AD eLectures
    2458ab2b-9520-4e36-9113-8f3bc5da231f",
    "type": "ContentSection",
    "name": "Bühler 2-6 Modellierung von
        Klassen 2",
    "avgDuration": 314,
    "minDuration": 279,
    "maxDuration": 348,
    "position": 2006,
    "url": "/Coherence/OD/Buehler/OD_6.svg",
    "weight": 0.5,
    "author": "buehler"
},
{ "_id": "00AD eLectures
    6b8f3c16-d38f-4133-b3fb-98a1e7cd1cca",
    "type": "ContentSection",
    "name": "Hahn eL 128 Darstellung von
        Klassen 2",
    "avgDuration": 285,
    "minDuration": 260,
    "maxDuration": 300,
    "position": 128,
    "url":
        "/Coherence/OD/Hahn-eLectures/OD_8.html",
    "weight": 0.5,
    "author": "hahn"
} ]
},
```



```
{ "_id": "00AD eLectures
  884777ab-98d3-4ed3-9e28-a667ac8f7ac2",
  "type": "ContentType",
  "name": "Attributdeklaration",
  "weight": 0.5,
  "treeItemChildren":
  [ { "_id": "00AD eLectures
    dfdf495f-bbb2-4985-840e-15587fb7564d",
    "type": "ContentSection",
    "name": "del Pino 4.5 Attributdeklaration",
    "avgDuration": 255,
    "minDuration": 227,
    "maxDuration": 283,
    "position": 4005,
    "url": "/Coherence/OD/delPino/OD_5.svg",
    "weight": 0.5,
    "author": "delPino"
  },
  { "_id": "00AD eLectures
    1af00944-b3c1-4f79-8e17-6e4f8a66b8ad",
    "type": "ContentSection",
    "name": "Bühler 2-9 Modellierung von
      Klassen Attributdeklaration",
    "avgDuration": 314,
    "minDuration": 279,
    "maxDuration": 348,
    "position": 2009,
    "url": "/Coherence/OD/Buehler/OD_9.svg",
```

```
        "weight": 0.5,
        "author": "buehler"
    } ]
},
{ "_id": "00AD eLectures
  462192a2-1022-461f-852f-4f48a5986f53",
  "type": "ContentType",
  "name": "Operationdeklaration",
  "weight": 0.5,
  "treeItemChildren":
  [ { "_id": "00AD eLectures
    4939c918-44eb-499b-9864-a7b0a8c20615",
    "type": "ContentSection",
    "name": "del Pino 4.7 Methodendeklaration",
    "avgDuration": 255,
    "minDuration": 227,
    "maxDuration": 283,
    "position": 4007,
    "url": "/Coherence/OD/delPino/OD_7.svg",
    "weight": 0.5,
    "author": "delPino"
  },
  { "_id": "00AD eLectures
    845cf136-7219-46c6-9619-8938e355dd58",
    "type": "ContentSection",
    "name": "Bühler 2-10 Modellierung von
      Klassen Operationdeklaration",
    "avgDuration": 314,
```

```
        "minDuration": 279,
        "maxDuration": 348,
        "position": 2010,
        "url": "/Coherence/OD/Buehler/OD_10.svg",
        "weight": 0.5,
        "author": "buehler"
    } ]
},
{ "_id": "00AD eLectures
3d6191f7-c9d5-43b0-b208-ff3dbc84945b",
  "type": "ContentType",
  "name": "Methodische Hilfen 1",
  "weight": 0.5,
  "treeItemChildren": [
    { "_id": "00AD eLectures
5c3157fe-15ba-4176-bdd8-e59cba73fd7b",
      "type": "ContentSection",
      "name": "Bühler 2-7 Klassen und
        Klassendiagramm (Design) 1",
      "avgDuration": 314,
      "minDuration": 279,
      "maxDuration": 348,
      "position": 2007,
      "url": "/Coherence/OD/Buehler/OD_7.svg",
      "weight": 0.5,
      "author": "buehler"
    },
  ],
}
```

```
{ "_id": "00AD eLectures
    45a91add-5285-4b5e-b61e-4b75c079a1ba",
  "type": "ContentSection",
  "name": "Hahn eL 129 Wie findet man
    Kandidaten für Klassen?",
  "avgDuration": 200,
  "minDuration": 180,
  "maxDuration": 220,
  "position": 129,
  "url":
    "/Coherence/OD/Hahn-eLectures/OD_9.html",
  "weight": 0.5,
  "author": "hahn"
} ]
},
{ "_id": "00AD eLectures
    a9f51003-5b94-410c-995d-9897a8b60005",
  "type": "ContentType",
  "name": "Methodische Hilfen 2",
  "weight": 0.5,
  "treeItemChildren":
  [ { "_id": "00AD eLectures
    0958fe28-fb1f-410c-bf2e-235e670da9df",
    "type": "ContentSection",
    "name": "Bühler 2-8 Klassen und
      Klassendiagramm (Design) 2",
    "avgDuration": 314,
    "minDuration": 279,
```

```
    "maxDuration": 348,
    "position": 2008,
    "url": "/Coherence/OD/Buehler/OD_8.svg",
    "weight": 0.5,
    "author": "buehler"
  },
  { "_id": "00AD eLectures
    a37e760b-f41e-4d48-8320-21334136f37c",
    "type": "ContentSection",
    "name": "Hahn eL 130 Wie findet man
      weitere Attribute und Methoden?",
    "avgDuration": 95,
    "minDuration": 80,
    "maxDuration": 110,
    "position": 130,
    "url":
      "/Coherence/OD/Hahn-eLectures/OD_10.html",
    "weight": 0.5,
    "author": "hahn"
  } ]
},
{ "_id": "00AD eLectures
  65453b93-3938-4223-af17-5a9f1f4ef9ff",
  "type": "ContentType",
  "name": "Klassendiagramm Beispiele für
    Attribute",
  "weight": 0.5,
  "treeItemChildren":
```

```
[ { "_id": "00AD eLectures
aaecb6b0-e24b-4db1-818d-f1cb33a4eaf6",
  "type": "ContentSection",
  "name": "del Pino 4.6 Beispiele zur
Attributsdeklaration: Richtig oder
falsch?",
  "avgDuration": 255,
  "minDuration": 227,
  "maxDuration": 283,
  "position": 4006,
  "url": "/Coherence/OD/delPino/OD_6.svg",
  "weight": 0.5,
  "author": "delPino"
},
{ "_id": "00AD eLectures
76ab8fb9-d88b-477c-b249-e60bdaaa4627",
  "type": "ContentSection",
  "name": "Hahn eL 131 Wie findet man
Klassen, Operationen und Attribute?
Beispiel",
  "avgDuration": 631,
  "minDuration": 570,
  "maxDuration": 690,
  "position": 131,
  "url":
  "/Coherence/OD/Hahn-eLectures/OD_11.html",
  "weight": 0.5,
  "author": "hahn"
```

```
    } ]
  },
  { "_id": "00AD eLectures
    8e15d132-6fd3-4587-8895-636e510165f0",
    "type": "ContentType",
    "name": "Gruppierungsmöglichkeiten",
    "weight": 0.5,
    "treeItemChildren":
  [ { "_id": "00AD eLectures
    74d60a72-cdc3-4339-8c73-8955a6416fb7",
    "type": "ContentSection",
    "name": "Bühler 2-11
      Gruppierungsmöglichkeiten für Attribute
      und Operationen",
    "avgDuration": 314,
    "minDuration": 279,
    "maxDuration": 348,
    "position": 2011,
    "url": "/Coherence/OD/Buehler/OD_11.svg",
    "weight": 0.5,
    "author": "buehler"
  } ]
  },
  { "_id": "00AD eLectures
    f157827c-2241-4ef6-86a7-9dfbcff2a370",
    "type": "Condition"
  } ]
},
```

```

{ "_id": "00AD eLectures
  7693b8f2-9e5e-4d04-96f3-845a8dbe7874",
  "type": "Repeat",
  "treeItemChildren":
  [ { "_id": "00AD eLectures
    d6c8dacf-4158-48da-a58e-9b9c837d0e6a",
    "type": "ContentType",
    "name": "Titel Generalisierung,
      Spezialisierung und Vererbung",
    "weight": 0.5,
    "treeItemChildren":
    [ { "_id": "00AD eLectures
      0df1f409-e8ae-45bb-b031-736a6fc16e0a",
      "type": "ContentSection",
      "name": "Hahn eL 132 Titel
        Generalisierung, Spezialisierung und
        Vererbung",
      "avgDuration": 23,
      "minDuration": 15,
      "maxDuration": 35,
      "position": 132,
      "url":
        "/Coherence/OD/Hahn-eLectures/OD_12.html",
      "weight": 0.5,
      "author": "hahn"
    } ]
  },

```



```
{ "_id": "00AD eLectures
  34e8fc07-588d-4ddc-9a03-c890038693df",
  "type": "ContentType",
  "name": "Vererbung Einleitung",
  "weight": 1,
  "treeItemChildren":
  [ { "_id": "00AD eLectures
    f9ec48b4-47e0-4fcd-9454-88e66fcc30c6",
    "type": "ContentSection",
    "name": "del Pino 4.23 Generalisierung und
      Spezialisierung",
    "avgDuration": 255,
    "minDuration": 227,
    "maxDuration": 283,
    "position": 4023,
    "url": "/Coherence/OD/delPino/OD_23.svg",
    "weight": 0.5,
    "author": "delPino"
  },
  { "_id": "00AD eLectures
    7a53ef1e-9875-42b6-9870-493f5a053917",
    "type": "ContentSection",
    "name": "Bühler 2-15 Vererbung 1",
    "avgDuration": 314,
    "minDuration": 279,
    "maxDuration": 348,
    "position": 2015,
    "url": "/Coherence/OD/Buehler/OD_15.svg",
```

```

        "weight": 0.5,
        "author": "buehler"
    },
    { "_id": "00AD eLectures
      d2bdb268-44f1-4736-8b4c-c2aa144a52a0",
      "type": "ContentSection",
      "name": "Hahn eL 133 Grundidee
        Generalisierung",
      "avgDuration": 181,
      "minDuration": 160,
      "maxDuration": 200,
      "position": 133,
      "url":
        "/Coherence/OD/Hahn-eLectures/OD_13.html",
      "weight": 0.5,
      "author": "hahn"
    } ]
  },
  { "_id": "00AD eLectures
    28fadfeb-8291-41ee-8729-748b1a62096e",
    "type": "ContentType",
    "name": "Vererbung Grundlagen",
    "weight": 0.5,
    "treeItemChildren":
    [ { "_id": "00AD eLectures
      ad54f168-c0f0-4185-a4ae-dd6971087492",
      "type": "ContentSection",
      "name": "Hahn eL 134 Begriffe",

```

```
    "avgDuration": 288,
    "minDuration": 260,
    "maxDuration": 320,
    "position": 134,
    "url":
      "/Coherence/OD/Hahn-eLectures/OD_14.html",
    "weight": 0.5,
    "author": "hahn"
  },
  { "_id": "00AD eLectures
    4577284b-0c90-49ff-bc42-4891fde237b2",
    "type": "ContentSection",
    "name": "del Pino 4.24
      Generalisierungsmengen 1",
    "avgDuration": 255,
    "minDuration": 225,
    "maxDuration": 283,
    "position": 4024,
    "url": "/Coherence/OD/delPino/OD_24.svg",
    "weight": 0.5,
    "author": "delPino"
  } ]
},
{ "_id": "00AD eLectures
  1427e5dd-cea7-43f1-b377-49431df48292",
  "type": "ContentType",
  "name": "Vererbung Anwendung 1",
  "weight": 0.5,
```

```
"treeItemChildren":
[ { "_id": "00AD eLectures
  12b0a4e6-f46f-44cd-85cb-3d186d03ab8e",
    "type": "ContentSection",
    "name": "del Pino 4.25
      Generalisierungsmengen 2",
    "avgDuration": 255,
    "minDuration": 227,
    "maxDuration": 283,
    "position": 4025,
    "url": "/Coherence/OD/delPino/OD_25.svg",
    "weight": 0.5,
    "author": "delPino"
  },
  { "_id": "00AD eLectures
    b9ea65d1-e7de-4c2d-9f44-1b941f9998a6",
    "type": "ContentSection",
    "name": "Hahn eL 135 Beispiel:
      Vererbungshierarchie",
    "avgDuration": 114,
    "minDuration": 100,
    "maxDuration": 130,
    "position": 135,
    "url":
      "/Coherence/OD/Hahn-eLectures/OD_15.html",
    "weight": 0.5,
    "author": "hahn"
  } ]
```

```
},
{ "_id": "00AD eLectures
  4a19384a-4bb3-408d-a3ec-5d19e6cd0555",
  "type": "ContentType",
  "name": "Vererbung Anwendung 2",
  "weight": 0.5,
  "treeItemChildren":
[ { "_id": "00AD eLectures
  d8147588-2040-4dc8-a94a-865cc88ab95c",
  "type": "ContentSection",
  "name": "del Pino 4.26
  Generalisierungsmengen 3",
  "avgDuration": 255,
  "minDuration": 227,
  "maxDuration": 283,
  "position": 4026,
  "url": "/Coherence/OD/delPino/OD_26.svg",
  "weight": 0.5,
  "author": "delPino"
},
{ "_id": "00AD eLectures
  28615c2d-6493-452d-9dc7-cb84d1dc3e4b",
  "type": "ContentSection",
  "name": "Hahn eL 136 Lösung: Welche
  Attribute besitzen die Objekte der
  Klassen?",
  "avgDuration": 43,
  "minDuration": 35,
```

```
        "maxDuration": 55,
        "position": 136,
        "url":
            "/Coherence/OD/Hahn-eLectures/OD_16.html",
        "weight": 0.5,
        "author": "hahn"
    } ]
},
{ "_id": "00AD eLectures
    9ef8ef02-f890-4477-8554-499198b35d84",
  "type": "ContentType",
  "name": "Vererbung Sichtbarkeit",
  "weight": 0.5,
  "treeItemChildren":
  [ { "_id": "00AD eLectures
      cb8e53a1-073c-4b85-b8fc-91195942f70b",
    "type": "ContentSection",
    "name": "Hahn eL 137 Sichtbarkeit",
    "avgDuration": 116,
    "minDuration": 100,
    "maxDuration": 130,
    "position": 137,
    "url":
        "/Coherence/OD/Hahn-eLectures/OD_17.html",
    "weight": 0.5,
    "author": "hahn"
  } ]
},
```

```

{ "_id": "00AD eLectures
  24b86e05-ae8c-421e-a31e-671dcc044e3f",
  "type": "ContentType",
  "name": "Vererbung Regeln",
  "weight": 0.5,
  "treeItemChildren":
  [ { "_id": "00AD eLectures
    d351ac5d-cf57-4c5f-b699-22665749d78a",
    "type": "ContentSection",
    "name": "Hahn eL 138 Regeln",
    "avgDuration": 209,
    "minDuration": 190,
    "maxDuration": 230,
    "position": 138,
    "url":
      "/Coherence/OD/Hahn-eLectures/OD_18.html",
    "weight": 0.5,
    "author": "hahn"
  } ]
},
{ "_id": "00AD eLectures
  be28abc5-920a-400d-b23c-61003f352ff2",
  "type": "ContentType",
  "name": "Vererbung Eigenschaften",
  "weight": 0.5,
  "treeItemChildren":
  [ { "_id": "00AD eLectures
    01ee9f51-eca6-431e-88f1-e7f40c7eaba0",

```

```

        "type": "ContentSection",
        "name": "del Pino 4.27 Eigenschaften von
                Generalisierungsmengen 1",
        "avgDuration": 255,
        "minDuration": 227,
        "maxDuration": 283,
        "position": 4027,
        "url": "/Coherence/OD/delPino/OD_27.svg",
        "weight": 0.5,
        "author": "delPino"
    },
    { "_id": "00AD eLectures
        f6a6a7ba-e508-4614-bacd-98b862ef4839",
        "type": "ContentSection",
        "name": "Hahn eL 139 Einschränkungen 1",
        "avgDuration": 240,
        "minDuration": 220,
        "maxDuration": 260,
        "position": 139,
        "url":
            "/Coherence/OD/Hahn-eLectures/OD_19.html",
        "weight": 0.5,
        "author": "hahn"
    } ]
},
{ "_id": "00AD eLectures
    9e68a1bc-fb07-45c4-92bd-44a79e7738ef",
  "type": "ContentType",

```



```
"name": "Vererbung Einschränkungen",
"weight": 0.5,
"treeItemChildren":
[ { "_id": "00AD eLectures
    2fe9ee72-3844-4aaa-9a4d-8a014952a04e",
    "type": "ContentSection",
    "name": "Hahn eL 140 Einschränkungen 2",
    "avgDuration": 202,
    "minDuration": 180,
    "maxDuration": 220,
    "position": 140,
    "url":
        "/Coherence/OD/Hahn-eLectures/OD_20.html",
    "weight": 0.5,
    "author": "hahn"
} ]
},
{ "_id": "00AD eLectures
    b1229d72-97cf-4b26-b2db-970891ab4dba",
    "type": "ContentType",
    "name": "Gleiche Eigenschaften - aber keine
        Generalisierung",
    "weight": 0.5,
    "treeItemChildren":
    [ { "_id": "00AD eLectures
        a3dfb672-e082-40da-95c6-fd28e735a9dd",
        "type": "ContentSection",
```

```
    "name": "Hahn eL 141 Gleiche Eigenschaften  
      - aber keine Generalisierung",  
    "avgDuration": 226,  
    "minDuration": 200,  
    "maxDuration": 250,  
    "position": 141,  
    "url":  
      "/Coherence/OD/Hahn-eLectures/OD_21.html",  
    "weight": 0.5,  
    "author": "hahn"  
  } ]  
},  
{ "_id": "00AD eLectures  
  2354ce14-03be-4aef-a424-1a358532ef0b",  
  "type": "ContentType",  
  "name": "Vererbung Darstellung",  
  "weight": 0.5,  
  "treeItemChildren":  
  [ { "_id": "00AD eLectures  
    40d0c5c7-ea0f-445b-b602-b0b8bb7ce069",  
    "type": "ContentSection",  
    "name": "del Pino 4.28 Eigenschaften von  
      Generalisierungsmengen 2",  
    "avgDuration": 355,  
    "minDuration": 227,  
    "maxDuration": 283,  
    "position": 4028,  
    "url": "/Coherence/OD/delPino/OD_28.svg",
```

```
    "weight": 0.5,
    "author": "delPino"
  },
  { "_id": "00AD eLectures
    d4266715-f3fe-4a8b-8c62-a0702a90215c",
    "type": "ContentSection",
    "name": "Bühler 2-16 Vererbung 2",
    "avgDuration": 314,
    "minDuration": 279,
    "maxDuration": 348,
    "position": 2016,
    "url": "/Coherence/OD/Buehler/OD_16.svg",
    "weight": 0.5,
    "author": "buehler"
  },
  { "_id": "00AD eLectures
    5b495a98-221f-4be1-bd1f-ed03d83d8bb7",
    "type": "ContentSection",
    "name": "Hahn eL 142 Darstellung von
      Randbedingungen für Vererbung",
    "avgDuration": 354,
    "minDuration": 310,
    "maxDuration": 390,
    "position": 142,
    "url":
      "/Coherence/OD/Hahn-eLectures/OD_22.html",
    "weight": 0.5,
    "author": "hahn"
  }
```

```

    } ]
  },
  { "_id": "00AD eLectures
    897c08d7-48ee-4c06-b316-bac4436b4849",
    "type": "ContentType",
    "name": "Vererbung Anwendung 3",
    "weight": 0.5,
    "treeItemChildren":
  [ { "_id": "00AD eLectures
    e45ae0a5-6240-432e-9503-6a5e9a4f2f93",
    "type": "ContentSection",
    "name": "del Pino 4.29 Eigenschaften von
      Generalisierungsmengen 3",
    "avgDuration": 255,
    "minDuration": 227,
    "maxDuration": 283,
    "position": 4029,
    "url": "/Coherence/OD/delPino/OD_29.svg",
    "weight": 0.5,
    "author": "delPino"
  } ]
},
{ "_id": "00AD eLectures
  3c8f0f69-2387-45be-89bf-528080020654",
  "type": "ContentType",
  "name": "Vererbung Anwendung 4",
  "weight": 0.5,
  "treeItemChildren":

```

```
[ { "_id": "00AD eLectures
5a224e96-a8ca-49dd-8e8a-736fa1f23969",
"type": "ContentSection",
"name": "del Pino 4.30 Eigenschaften von
Generalisierungsmengen 4",
"avgDuration": 255,
"minDuration": 227,
"maxDuration": 283,
"position": 4030,
"url": "/Coherence/OD/delPino/OD_30.svg",
"weight": 0.5,
"author": "delPino"
} ]
},
{ "_id": "00AD eLectures
9ff29faa-8f6d-454d-a52e-68bf1a11dc8f",
"type": "ContentType",
"name": "Vererbung Anwendung 5",
"weight": 0.5,
"treeItemChildren":
[ { "_id": "00AD eLectures
94aabdb7-0a65-424b-802b-877300eae0e3",
"type": "ContentSection",
"name": "del Pino 4.31 Eigenschaften von
Generalisierungsmengen 5",
"avgDuration": 255,
"minDuration": 227,
"maxDuration": 283,
```

```

        "position": 4031,
        "url": "/Coherence/OD/delPino/OD_31.svg",
        "weight": 0.5,
        "author": "delPino"
    } ]
},
{ "_id": "00AD eLectures
    8927a85f-8618-42f0-8dca-1a2b44f2a64d",
    "type": "Condition"
} ]
},
{ "_id": "00AD eLectures
    d62766af-2e34-4842-af04-bf5643847252",
    "type": "ContentType",
    "name": "Ende",
    "weight": 1,
    "treeItemChildren":
    [ { "_id": "00AD eLectures
        abc7a531-2c82-48ab-a11a-d184306693a5",
        "type": "ContentSection",
        "name": "Bühler 2-17 Schluss Kapitel 2: UML 2 -
            Teil 1",
        "avgDuration": 0,
        "minDuration": 0,
        "maxDuration": 0,
        "position": 2017,
        "url": "/Coherence/OD/Buehler/OD_17.svg",
        "weight": 0.5,

```

```
        "author": "buehler"  
    } ]  
} ]  
}
```

C.4 Miscellaneous Preparations

Beside the prototype, the content, and the interview questions, some additional preparations have been accomplished. These are a presentation that supports the explanation of the concept, its background and the prototype. Taking audio recordings has been set up with the internal notebook microphone for face to face sessions. Interviews by video conferences or Voice over IP needed some additional routing, because they cannot be recorded right away: The system extension Soundflower in conjunction with the applications Soundflowerbed [39] and LineIn [100] did that job. Further, the experts got the chance to run Röll's learner preferences test [104] beforehand, so that they could test the prototype with their own user and therefore their own preferences. They also got a link to further remarks on the preference's purport [103].

Appendix D

Expert Interview Slide Set

The following slide set has been used for the expert interviews as an introduction to this PhD research project.

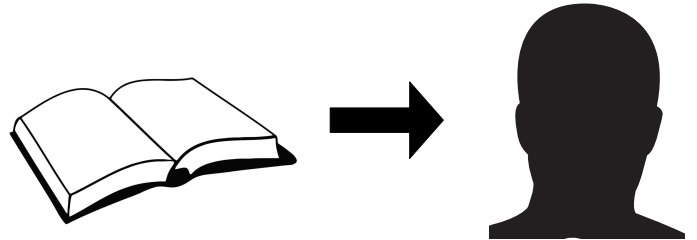
Appendix D. Expert Interview Slide Set



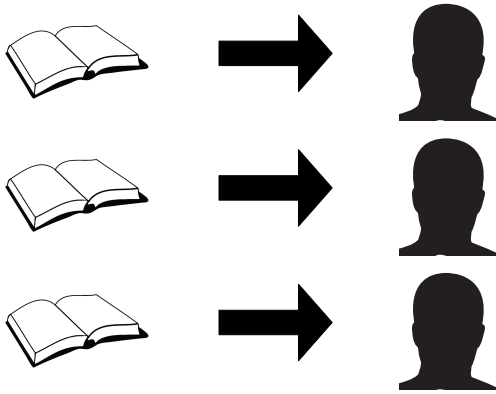
Adaptive eLearning Using Storytelling Approaches

Oliver Schneider
UoP, CSCAN

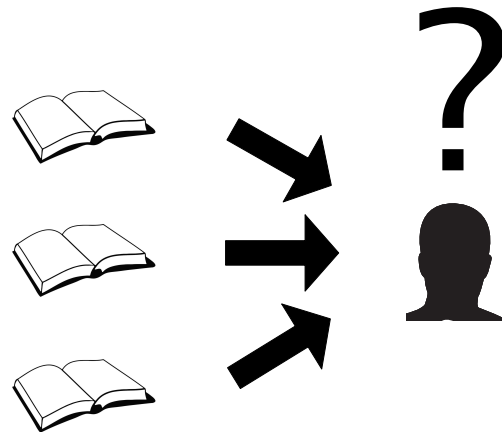
1



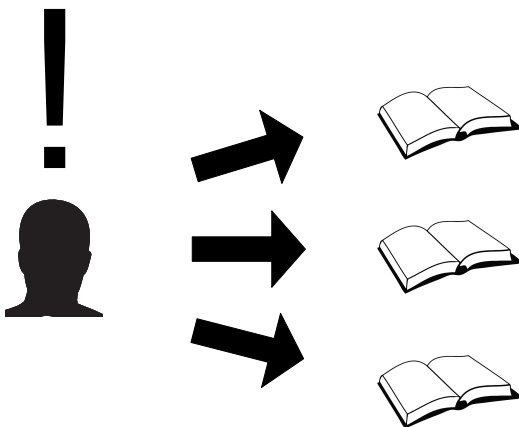
2



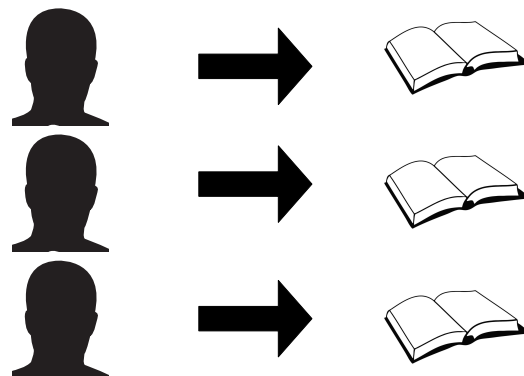
3



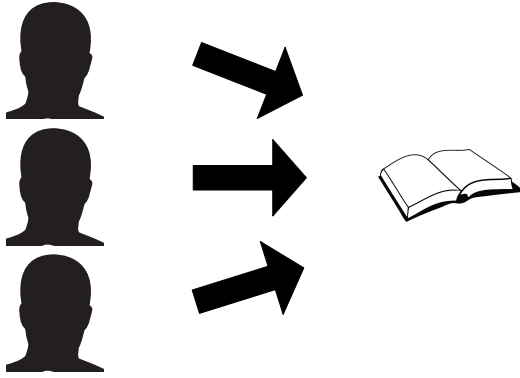
4



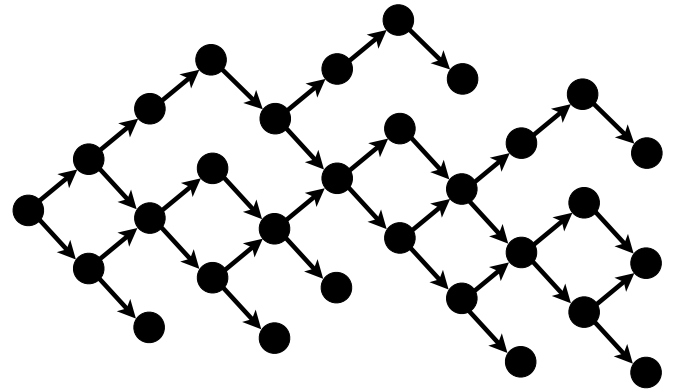
5



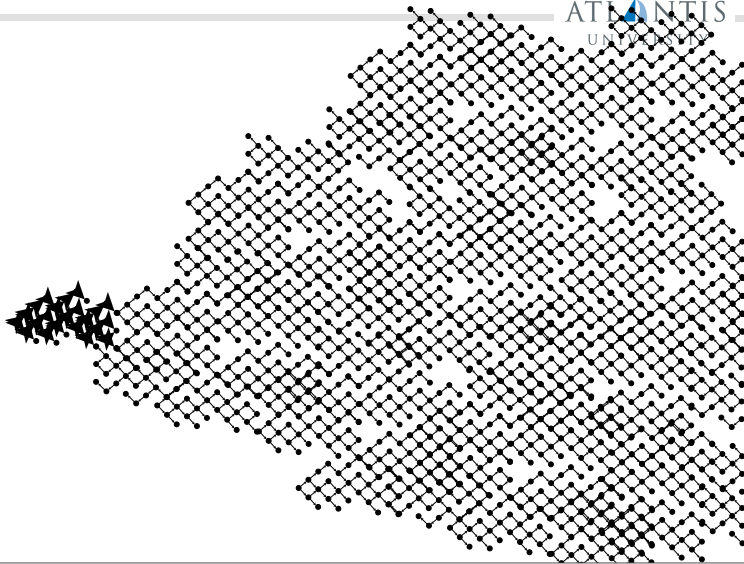
6



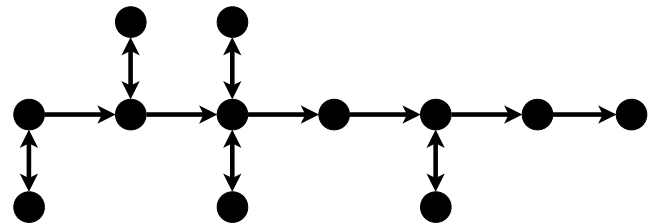
8



9



9



10

Students

- ▶ One size fits all
- ▶ No help to choose fitting content

11

Lecturers

- ▶ Too much
- ▶ Too complex
- ▶ Too trivial structures
- ▶ Only one structure

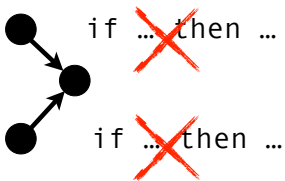
12

1

13

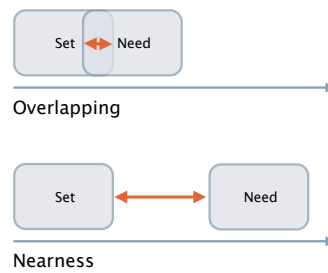
Binary to fuzzy

14



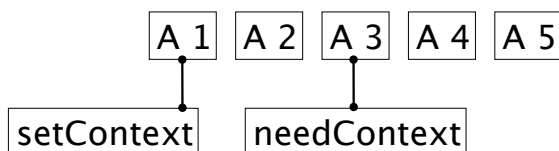
15

Contexts



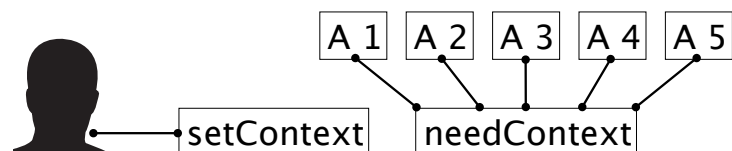
17

Preconditions



18

Golden Thread



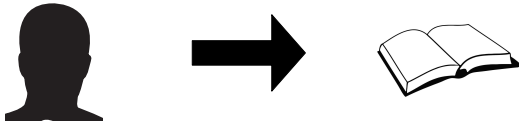
19

2

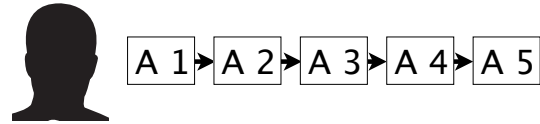
20

Use existing structures

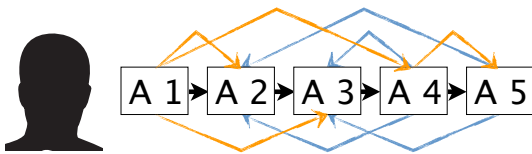
21



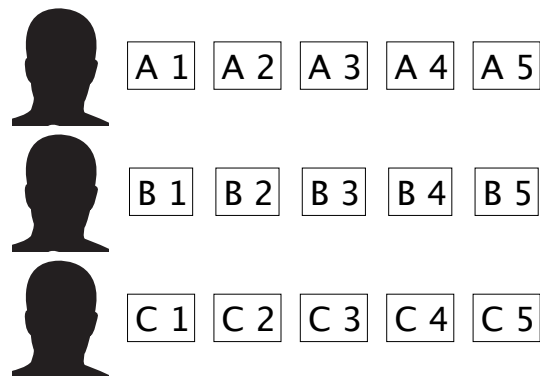
22



23

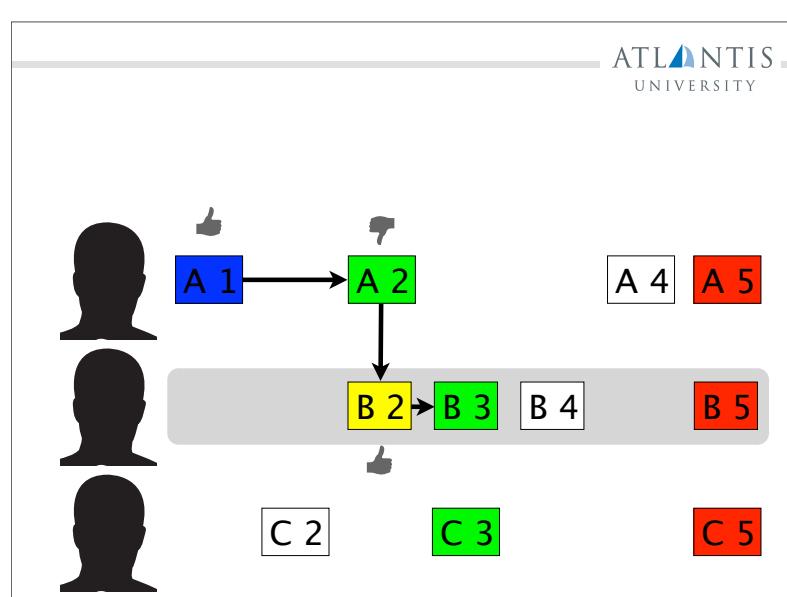
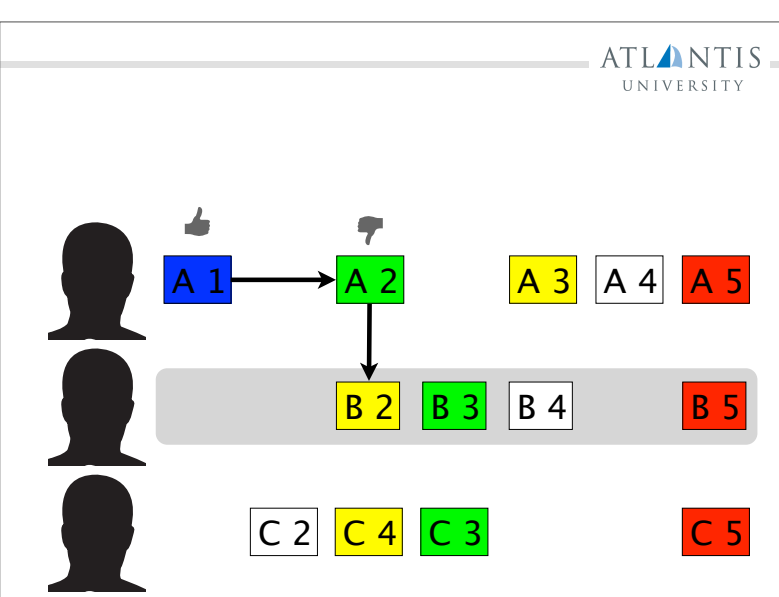
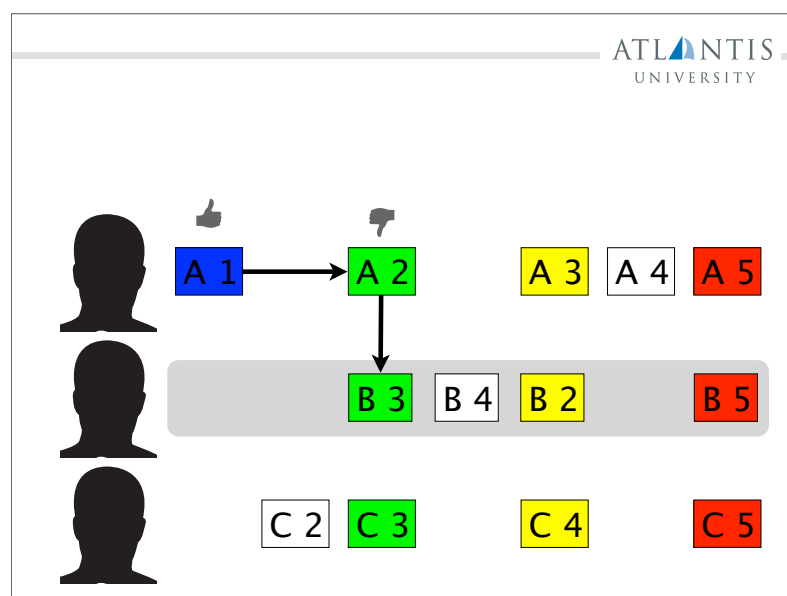
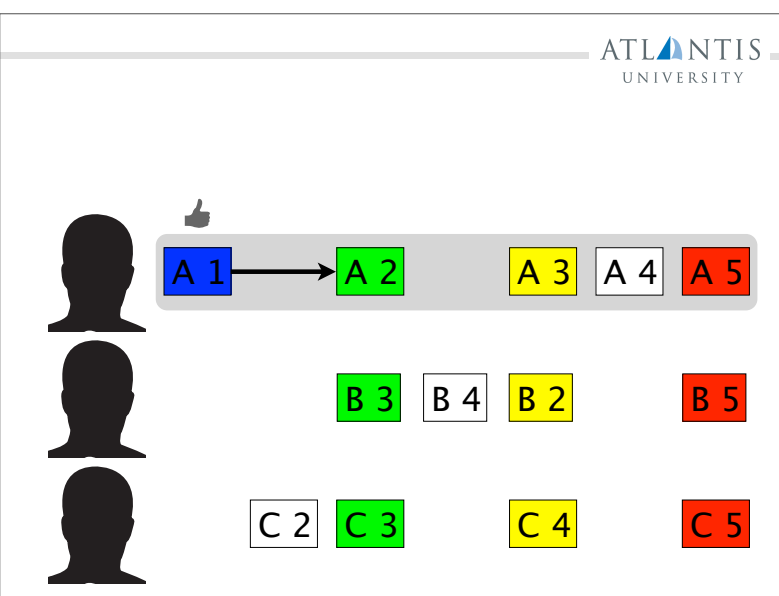
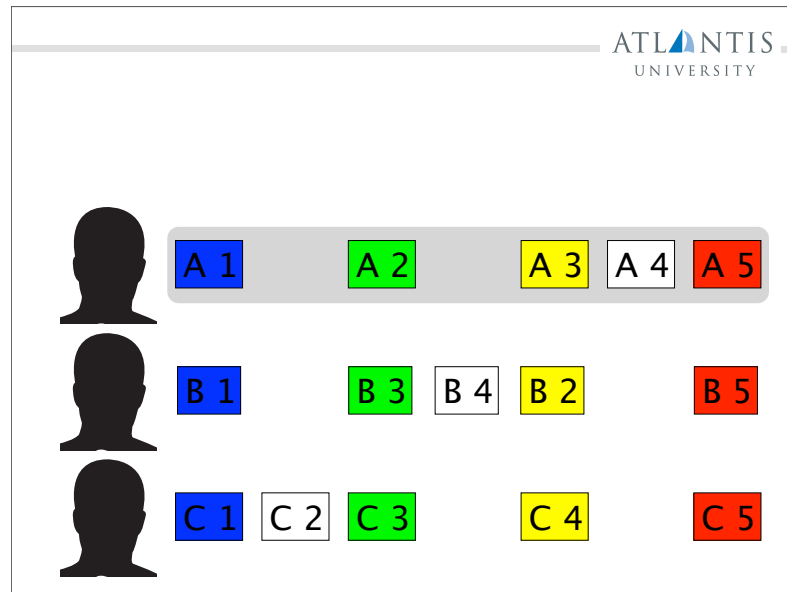
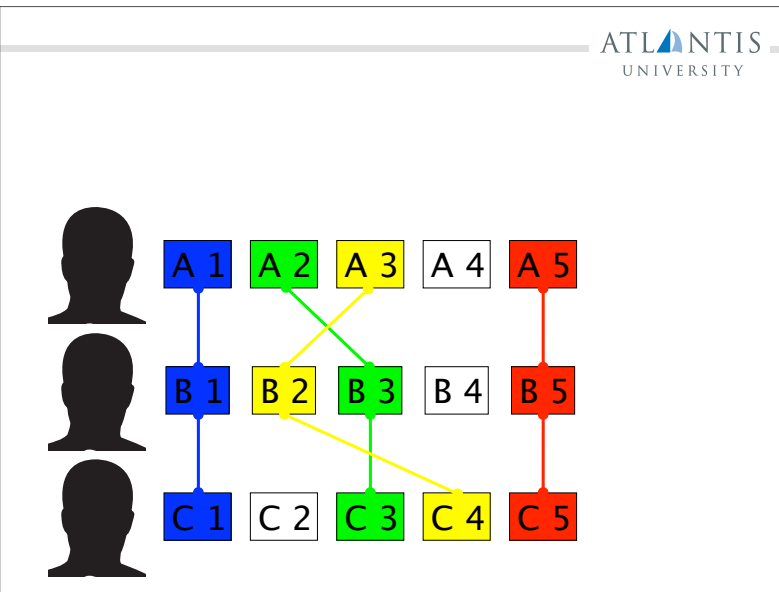


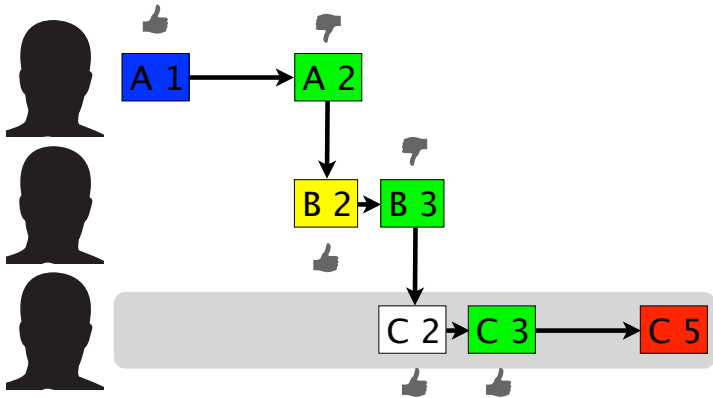
24



25

Appendix D. Expert Interview Slide Set





Todos for Authors

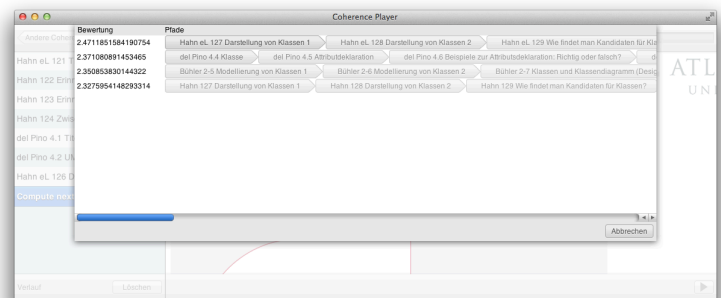
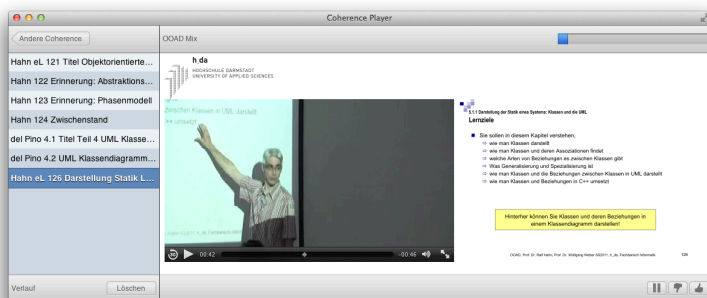
- ▶ Use existing content
 - Original order
 - Contexts added automatically
- ▶ Mark similar learning units
- ▶ Refinement
 - Preconditions
 - Weights
 - Repeats

Structure Creation

- ▶ Join existing content
- ▶ Enhance one existing content
- ▶ Student paths

Students

- ▶ Path suggestions
- ▶ Choose next step
- ▶ Choice influences path generation
- ▶ Content interaction may influence



Students

- ▶ Path suggestions
- ▶ Choose next step
- ▶ Choice influences path generation
- ▶ Content interaction may influence

36

Different styles
are merged
if needed

37



Adaptive eLearning Using Storytelling Approaches

Oliver Schneider
UoP, CSCAN
Oli.Schneider@me.com



38

Appendix E

Technical Details of the Coherence Model Components

This reference gives a brief description for all elements of the Coherence Model.

E.1 Coherence

The root element. Contains all content types and repeats. Defines necessary start parameters, start and end values as well as the overall presentation duration.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.
<code>name</code>	Unique name.
<code>minDuration</code>	Minimal overall duration in seconds.
<code>maxDuration</code>	Maximal overall duration in seconds.
<code>avgDuration</code>	Expected overall duration in seconds.

Table 7: Mandatory Coherence attributes

Children

Child	Description
<code>ContentType</code>	Typifies and bunches the content-sections.
<code>Repeat</code>	Repeats the enclosed content-types.

Table 8: Mandatory Coherence children

Child	Description
<code>SetContext</code>	Sets a context.
<code>NeedContext</code>	Queries a context for comparison.
<code>ReleaseContext</code>	Releases a context.
<code>ContextGroup</code>	Groups contexts.

Table 9: Optional Coherence children

Discussion

Optionally one or more `ContentType` and optionally one or more `Repeat` children (only one of them is needed necessarily). Their order is decisive for sequencing the content.

The duration values define the minimum, maximum, and the desired overall presentation-duration of the overall content. They might be overridden by start-parameters given by the user. The start-parameter values have to be within the values given here. For example, a start-parameter's minimal-duration must be greater than the minimal-duration defined here.

`SetContexts` at the beginning set the start-values. They maybe overridden by start-parameters given by the user. `SetContexts` at the end are ignored.

`NeedContext` at the beginning demands for start-parameters given by the user. `NeedContext` at the end defines the values that are needed to end the content.

`ReleaseContexts` at the beginning demands for start-parameters given by the user. They are released after that. Might be used to ask for values that are needed for content that might come later. Or, for example, for verification of the age in conjunction with a `NeedContext` child.

E.2 Condition

Defines the required contexts to exit the loop.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.

Table 10: Mandatory Condition attributes

Children

Child	Description
<code>NeedContext</code>	Queries a context for comparison.

Table 11: Mandatory Condition children

Child	Description
<code>ReleaseContext</code>	Releases a context.

Table 12: Optional Condition children

Discussion

More than one context might be needed and therefore appear as `NeedContexts`. To exit a loop, only the demanded contexts need to be set. There is no check for any value-comparison.

E.3 ContentSection

The meta-description of a content section.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.
<code>name</code>	Unique name.
<code>minDuration</code>	Minimal overall duration in seconds.
<code>maxDuration</code>	Maximal overall duration in seconds.
<code>avgDuration</code>	Expected overall duration in seconds.
<code>position</code>	Position within the linear content.
<code>url</code>	URL to the content.
<code>author</code>	The author of this content section.
<code>weight</code>	Weights the importance of the content section. The value's range is between -1 (must not be presented) and 1 (must be presented).

Table 13: Mandatory ContentSection attributes

Children

Child	Description
<code>SetContext</code>	Sets a context.
<code>NeedContext</code>	Queries a context for comparison.
<code>ReleaseContext</code>	Releases a context.
<code>ContextGroup</code>	Groups contexts.

Table 14: Optional ContentSection children

Discussion

`url` is used as a link to the content. It has the form `http://toplevel.domain.name/path/to/ContentSection`. Optionally one or more `SetContext`, `NeedContext`, `ReleaseContext`, and `ContextGroup` children.

E.4 ContentType

Typifies and relates the content-sections.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.
<code>name</code>	Unique name.
<code>weight</code>	Weights the importance of the content type. The value's range is between -1 (must not be presented) and 1 (must be presented).

Table 15: Mandatory ContentType attributes

Children

Child	Description
<code>ContentSection</code>	Content section to be related.
<code>SetContext</code>	Sets a context.
<code>NeedContext</code>	Queries a context for comparison.
<code>ReleaseContext</code>	Releases a context.
<code>ContextGroup</code>	Groups contexts.

Table 16: Optional ContentType children

Discussion

If there is not any `ContentSection` child within a `ContentType` block, this `ContentType` block is ignored. This is useful for defining a complete model, but filling it with content (and therefore with `ContentSections`) step by step.

`SetContexts` at the beginning set the contexts for that `ContentType` block. `SetContexts` at the end set contexts before proceeding to the next `ContentType` block.

`NeedContext` at the beginning demands for set context-values before presenting that `ContentType` block. `NeedContext` at the end defines the values that are needed to end that `ContentType` block.

`ReleaseContext` behaves the same as `SetContext`, except that it is releasing the given context.

E.5 ContextGroup

Groups related contexts.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.
<code>name</code>	Unique name.
<code>validationMode</code>	Defines the validation mode of the contexts and subgroups.
<code>weight</code>	Weights the importance of the context group. The value's range is between -1 (must not be presented) and 1 (must be presented).

Table 17: Mandatory `ContextGroup` attributes

Children

Child	Description
SetContext	Sets a context.
ContextGroup	Groups contexts.

Table 18: Mandatory ContextGroup children

Discussion

One or more `SetContext` and `ContextGroup` children elements. Groups can be nested. Contexts and subgroups inherit values of outer groups. **Comment: Groups are not implemented yet.**

E.6 EmergencyExitType

Typifies and bunches the content sections that are used as emergency exit content sections to leave a loop in a case that the conditions cannot be fulfilled.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.
<code>name</code>	Unique name.
<code>weight</code>	Weights the importance of the emergency exit type. The value's range is between -1 (must not be presented) and 1 (must be presented).

Table 19: Mandatory EmergencyExitType attributes

Children

Child	Description
<code>ContentSection</code>	Content section used as emergency exit.

Table 20: Mandatory `EmergencyExitType` children

Child	Description
<code>SetContext</code>	Sets a context.
<code>NeedContext</code>	Queries a context for comparison.
<code>ReleaseContext</code>	Releases a context.
<code>ContextGroup</code>	Groups contexts.

Table 21: Optional `EmergencyExitType` children

Discussion

`EmergencyExitType` is exactly the same as `ContentType`, but used for another purpose: It contains all the `ContentSections` that are used if the `Condition` cannot be fulfilled and therefore a content is needed that fulfils the condition. This might happen because of one or more of the following reasons:

- All the enclosed content sections have been presented without fulfilling the exit-condition.
- Not enough time left to present more content-sections that are included in this `Repeat` loop.

The enclosed content sections must ensure that all needed contexts are set properly. That means, the included `ContentSections` must set contexts that are marked as needed in the `Condition`.

There must be at least one `ContentSection` child within an `EmergencyExitType` block. It must be assured that all contexts needed by `Condition` are set. At least one `ContentSection` child or the `EmergencyExitType`'s `SetContexts` might do this.

It also must be assured that at least the `ContentSection` children that sets all needed contexts can be presented under all circumstances. All `NeedContexts` must be grantable by the content sections within the `Repeat` block. Hence, it is strongly recommended to not use any `NeedContext` within an `EmergencyExitType`!

`SetContexts` at the beginning set the contexts for that `ContentType` block. `SetContexts` at the end set contexts before proceeding to the next `ContentType`-block.

`NeedContext` at the beginning demands for set context-values before presenting that `ContentType` block. `NeedContext` at the end defines the values that are needed to end that `ContentType`-block.

`ReleaseContext` behaves the same as `SetContext`, except that it is releasing the given context.

E.7 NeedContext

Queries a needed context for comparison.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.
<code>name</code>	Path to the context that is needed and compared for this content section. If the path ends on a context-group, all enclosed contexts are needed and compared.
<code>min</code>	Minimum value of the context value range.
<code>max</code>	Maximum value of the context value range.

Attribute	Description
<code>needed</code>	Indicates how much this context is needed. The value's range is between -1 (must not be present) and 1 (must be present).
<code>weight</code>	Weights the influence of the context for path rating. The value's range is between -1 (must not) and 1 (must).
<code>comparisonMethod</code>	Defines the context comparison method. Valid arguments are <code>nearness</code> and <code>overlapping</code> . <code>overlapping</code> is the default value.

Table 22: Mandatory NeedContext attributes

Children

None.

Discussion

If the `needed` attribute is 1, the corresponding context has to be set before the content type (or whatever the context is used for) can be presented.

Contexts are used as meta description. They are defined with an initial value range. The attributes `min` and `max` stretch a value range for the comparison.

E.8 ReleaseContext

Releases a context.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.
<code>name</code>	Path to the context that is released. If the path ends on a context group, all enclosed contexts are released.

Table 23: Mandatory ReleaseContext attributes

Children

None.

Discussion

A released context is not available for any comparisons. It has to be set explicitly with `setContext` before it can be used again for `needContext` or `releaseContext`.

E.9 Repeat

Repeats the enclosed content-types.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.

Table 24: Mandatory Repeat attributes

Children

Child	Description
Condition	Required contexts to exit the loop.
ContentType	Bunch of content-types that are looped.
EmergencyExitType	Typifies and bunches the content-sections that are used as emergency-exit content-sections to leave a loop in a case that the conditions cannot be fulfilled.

Table 25: Mandatory Repeat children

Child	Description
Repeat	Repeats the enclosed content-types.

Table 26: Optional Repeat children

Discussion

Repeats may contain further repeats.

The **Condition** contains the exit condition(s) as **Context(s)**. The **EmergencyExitType** is jumped to, if the condition may be never fulfilled. This might happen because of one or more of the following reasons:

- All the enclosed content sections have been presented without fulfilling the exit condition.
- Not enough time left to present more content-sections that are included in this **Repeat** loop.

The exit content section must ensure that all needed contexts are set properly.

E.10 SetContext

Sets a context or changes its value.

Attributes

Attribute	Description
<code>_id</code>	Unique identifier.
<code>name</code>	Unique name.
<code>min</code>	Minimum value of the context value range.
<code>max</code>	Maximum value of the context value range.

Table 27: Mandatory SetContext attributes

Children

None.

Discussion

If `SetContext` is used within a `ContentType`, it defines the context that is set after the content type has been successfully presented.

Contexts are used as meta-description. They are defined with an initial value range. The attributes `min` and `max` stretch a value range for the comparison.

Appendix F

Bibliography

- [1] Jeremy Allaire. Macromedia Flash MX – A next-generation rich client. White paper, Macromedia, Inc., San Francisco, CA, USA, 2002. <http://download.macromedia.com/pub/flash/whitepapers/richclient.pdf> (Accessed 25th February 2012).
- [2] J. Chris Anderson, Jan Lehnardt, and Noah Slater. *CouchDB: The Definitive Guide*. O'Reilly Media Inc., Sebastopol, CA, USA, January 2010. <http://guide.couchdb.org> (Accessed 25th February 2012).
- [3] The Apache Software Foundation. Apache License, Version 2.0. <http://www.apache.org/licenses/LICENSE-2.0> (Accessed 25th February 2012), January 2004.
- [4] The Apache Software Foundation. The Apache CouchDB. <http://couchdb.apache.org> (Accessed 25th February 2012), 2012.
- [5] The Apache Software Foundation. The Apache HTTP Server Project. <http://httpd.apache.org> (Accessed 9th May 2012), 2012.
- [6] Apple. Cocoa Bindings Programming Topics. Guide, Apple Inc., Cupertino, CA, USA, 2009. <http://developer.apple.com/library/mac/>

- documentation/Cocoa/Conceptual/CocoaBindings/CocoaBindings.pdf
(Accessed 25th February 2012).
- [7] Apple. Cocoa Fundamentals Guide. Guide, Apple Inc., Cupertino, CA, USA, 2010. <http://developer.apple.com/library/mac/documentation/Cocoa/Conceptual/CocoaFundamentals/CocoaFundamentals.pdf> (Accessed 25th February 2012).
- [8] Apple. Key-Value Observing Programming Guide. Guide, Apple Inc., Cupertino, CA, USA, 2011. <http://developer.apple.com/library/mac/documentation/Cocoa/Conceptual/KeyValueObserving/KeyValueObserving.pdf> (Accessed 25th February 2012).
- [9] Aristotélēs and Manfred Fuhrmann (German translation). *Poietike*. Philipp Reclam jun. GmbH & Co. KG, Stuttgart, Germany, 335 BC (German translation: 1994).
- [10] Phil Barker, Lorna M. Campbell, Anthony Roberts, and Colin Smythe. IMS Meta-data Best Practice Guide for IEEE 1484.12.1-2002 Standard for Learning Object Metadata. Specification 1.3, IMS Global Learning Consortium, Inc., Lake Mary, FL, USA, August 2006.
- [11] Roland Barthes. Introduction à l'analyse structurale des récits. In Susana Onega and José Angel García Landa, editors, *Communications*, volume 8, pages 1–27, Paris, République Française, 1966. Seuil.
- [12] David Barton. pdf2svg. <http://www.cityinthesky.co.uk/opensource/pdf2svg/>, 2013. (Accessed 10th December 2013).
- [13] Christiane Beinke, Melanie Brinkschulte, Lothar Bunn, and Stefan Thürmer. *Die Seminararbeit – Schreiben für den Leser*. UVK Verlagsgesellschaft mbH, Konstanz, Germany, 2nd edition, September 2011. ISBN 9783825284701.

-
- [14] Thomas Bernhardt and Marcel Kirchner. *E-Learning 2.0 im Einsatz: „Du bist der Autor!“ – Vom Nutzer zum WikiBlog-Caster*. Verlag Werner Hülsbusch, Boizenburg, Germany, 2007. ISBN 978-3-940317-16-2.
- [15] Udo Bleimann. Atlantis University – A New Pedagogical Approach beyond E-Learning. *Campus-Wide Information Systems*, 21(5):191–195, 2004.
- [16] Udo Bleimann. International project-based learning – Bologna 2.0. In Steve Wheeler, editor, *5th Plymouth e-Learning Conference – Learning without Limits: Facing the Challenges*, page 46, Plymouth, UK, April 2010. University of Plymouth.
- [17] Udo Bleimann and Franz Josef Röhl. Extended Blended Learning – Innovative Lernszenarien für die Hochschule. In *Querschnitt (Beiträge aus Forschung und Entwicklung der FH Darmstadt)*, volume 01/06, Darmstadt, Germany, 2006.
- [18] Home of the Blender project. <http://www.blender.org>, 2014. (Accessed 26th January 2014).
- [19] Paul De Bra, Geert-Jan Houbent, and Hongjing Wu. AHAM: A Dexter-based Reference Model for Adaptive Hypermedia. In Jörg Westbomke, Uffe K. Wiil, John J. Leggett, Klaus Tochtermann, and Jörg M. Haake, editors, *Proceedings of the tenth ACM Conference on Hypertext and hypermedia: returning to our diverse roots*, pages 147–156, New York, NY, USA, February 1999. GMD-IPSI, Darmstadt, Association for Computing Machinery. ISBN 1-58113-064-3, DOI 10.1145/294469.294508, <http://wwwis.win.tue.nl/~debra/ht99/ht99.ps>.
- [20] Paul De Bra, David Smits, Kees van der Sluijs, Alexandra Ioana Cristea, Jonathan Gregory Kenneth Foss, Christian Glahn, and Christina M. Steiner. GRAPPLE: Learning Management Systems Meet Adaptive Learning Environments. In Alejandro Peña-Ayala, editor, *Intelligent and Adaptive Educational-Learning Systems*, volume 17 of *Smart Innovation, Systems and*

- Technologies*, page 133–160, Heidelberg, September 2012. Springer-Verlag GmbH. ISBN 978-3-642-30170-4, http://www.dcs.warwick.ac.uk/people/academic/Alexandra.Cristea/Books/Chapter6_00170133.pdf.
- [21] Bertolt Brecht. Radiotheorie. In *Schriften zur Literatur und Kunst. Gesammelte Werke*. Suhrkamp Verlag, Frankfurt am Main, 1969.
- [22] Elizabeth Brown. *The Use of Learning Styles in Adaptive Hypermedia*. PhD thesis, University of Nottingham, School of Computer Science, Nottingham, UK, October 2007. <http://etheses.nottingham.ac.uk/577/1/ejb-thesis-for-ethesis-archive.pdf>.
- [23] Simon Brückner. *Structure Patterns Depending on Various Learner Types in an e-learning Context*. Diploma thesis, Fachhochschule Darmstadt, 2005.
- [24] Peter Brusilovsky. Developing Adaptive Educational Hypermedia Systems: From Design Models to Authoring Tools. In Tom Murray, Stephen B. Blessing, and Shaaron Ainsworth, editors, *Authoring Tools for Advanced Technology Learning Environments*, pages 377–409. Springer Science+Business Media B.V., Dordrecht, NL, 2004. DOI 10.1007/978-94-017-0819-7_13, ISBN 978-90-481-6499-8.
- [25] Peter Brusilovsky and Mark T. Maybury. From Adaptive Hypermedia to the Adaptive Web. volume 45, pages 30–33. Association for Computing Machinery, Inc., New York, NY, USA, May 2002. ISSN 0001-0782, DIO 10.1145/506218.506239.
- [26] Peter Brusilovsky, Vincent P. Wade, and Owen Conlan. From Learning Objects to Adaptive Content Services for E-Learning. In Claus Pahl, editor, *Architecture Solutions for E-Learning Systems*, pages 243–261, Hershey, Pennsylvania, USA, November 2007. IGI Global. ISBN 1599046334, DOI 10.4018/978-1-59904-633-4.

-
- [27] Canonical Group Limited. Server | Ubuntu. <http://www.ubuntu.com/server/>, 2012. (Accessed 9th May 2012).
- [28] Sherol Chen, Mark J. Nelson, Anne Sullivan, and Michael Mateas. Evaluating the Authorial Leverage of Drama Management. In Sandy Louchart, Manish Mehta, and David L. Roberts, editors, *Proceedings of the AAAI Spring Symposium on Intelligent Narrative Technologies II*, pages 20–23, Stanford, USA, March 2009. Association for the Advancement of Artificial Intelligence, AAAI Press. ISBN 978-1-57735-413-0, <http://www.aaai.org/Papers/Symposia/Spring/2009/SS-09-06/SS09-06-004.pdf>.
- [29] Alan Cooper, Robert Reimann, and David Cronin. *About Face 3: The Essentials of Interaction Design*. Wiley Publishing, Inc., Indianapolis, IN, 2007. ISBN 978-0-470-08411-3.
- [30] Linda J. Cowgill. *Writing Short Films: Structure and Content for Screenwriters*. Lone Eagle Publishing, Los Angeles, CA, 1997. ISBN 1-58065-063-5.
- [31] Chris Crawford. Assumptions underlying the Erasmatron interactive storytelling engine. In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA, 1999. AAAI Press.
- [32] Chris Crawford. *Chris Crawford on Interactive Storytelling*. New Riders Games, June 2004. ISBN 0-321-27890-9.
- [33] Chris Crawford. Storytron: Plans for the Future. <http://www.storytron.com/PlansForFuture.html>, 2011. (Accessed 20th September 2012).
- [34] Chris Crawford. Storytron: Tutorial. <http://www.storytron.com/Tutorial/>, 2011. (Accessed 22nd September 2012).

- [35] Chris Crawford. Storytron: What Went Wrong With the Previous Effort. <http://www.storytron.com/WhatWentWrong.html>, 2011. (Accessed 20th September 2012).
- [36] Alexandra Ioana Cristea and Lora Aroyo. Adaptive Authoring of Adaptive Educational Hypermedia. In Paul De Bra, Peter Brusilovsky, and Ricardo Conejo, editors, *Adaptive Hypermedia and Adaptive Web-Based Systems, Second International Conference Proceedings*, volume 2347 of *Lecture Notes in Computer Science*, pages 122–132, Málaga, España, May 2002. Universidad de Málaga, Springer-Verlag GmbH. DOI 10.1007/3-540-47952-X, <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.18.5131&rep=rep1&type=pdf>.
- [37] Alexandra Ioana Cristea and Arnout de Mooij. LAOS: Layered WWW AHS Authoring Model and their corresponding Algebraic Operators. In Paul De Bra and Wolfgang Nejdl, editors, *The Twelfth International World Wide Web Conference WWW2003 – Alternate Tracks: Education*, Budapest, Hungary, May 2003. International World Wide Web Conference Committee (IW3C2), Computer and Automation Research Institute of the Hungarian Academy of Sciences (MTA SZTAKI). <http://www2003.org/cdrom/papers/alternate/P301/p301-cristea.pdf>.
- [38] Alexandra Ioana Cristea and Craig Stewart. Automatic Authoring of Adaptive Educational Hypermedia. In Zongmin Ma, editor, *Web-based Intelligent E-Learning Systems: Technologies and Applications*, chapter 2, pages 24–55. IGI Global, Hershey, PA, October 2005. ISBN 1-59140-729-X, DOI: 10.4018/978-1-59140-729-4, <http://www.dcs.warwick.ac.uk/~acristea/Books/chapter-cristea-stewart27.pdf> (Accessed 31st May 2014).
- [39] Cycling '74. Soundflower. <http://cycling74.com/products/soundflower/>, 2012. (Accessed 9th May 2012).

-
- [40] Hochschule Darmstadt. Lernplattform Moodle der Hochschule Darmstadt. <http://lernen.h-da.de>, 2012. (Accessed 25th February 2012).
- [41] Thorsten Dresing, Thorsten Pehl, and Christian Schmieder. Manual (on) transcription. transcription conventions, software guides and practical hints for qualitative researchers. <http://www.audiotranskription.de/english/transcription-practicalguide.htm> (Accessed 1st January 2014), Marburg, February 2013. ISBN 978-3-8185-0497-7.
- [42] Ecma. ECMAScript Language Specification. Specification ECMA-262, Ecma International, Geneva, Switzerland, June 2011. <http://www.ecma-international.org/publications/files/ECMA-ST/Ecma-262.pdf> (Accessed 25th February 2012).
- [43] Daniel Eichelsbacher. *Entwurf und Realisierung eines Benutzermodellierungsmoduls zur Adaption eines E-Learning-Systems*. Nauguraldissertation, Ruprecht-Karls-Universität, Heidelberg, Germany, March 2006.
- [44] f4analyse – QDA-Software. <http://www.audiotranskription.de/f4-analyse>, 2013. (Accessed 16th January 2014).
- [45] F5 – Transkriptionssoftware für Mac. <http://www.audiotranskription.de/f5.htm>, 2013. (Accessed 1st January 2014).
- [46] Syd Field. *Das Handbuch zum Drehbuch: Übungen und Anleitungen zu einem guten Drehbuch*. Zweitausendeins, Frankfurt am Main, 1992.
- [47] Eddy N. Forte, Majunia Wentland Forte, and Erik J. Duval. ARIADNE: A Supporting Framework for Technology-Based Open & Distance Lifelong Education. In Francesco Maffioli, Manfred Horvat, and Franz Reichl, editors, *Educating the Engineer for Lifelong Learning: SEFI Annual Conference '96 Proceedings*, pages 137–142, Wien, Österreich, September 1996. Technische Universität Wien. <http://info.tuwien.ac.at/hsk/sefi/papers/forte.htm>.

- [48] Jonathan Gregory Kenneth Foss. *Manual and Automatic Authoring for Adaptive Hypermedia*. PhD thesis, University of Warwick, Department of Computer Science, Warwick, UK, September 2012. http://wrap.warwick.ac.uk/56270/1/WRAP_THESIS_Foss_2012.pdf (Accessed 18th February 2014).
- [49] Fawaz Ghali and Alexandra Ioana Cristea. Authoring for E-Learning 2.0: a Case Study. In *2009 Ninth IEEE International Conference on Advanced Learning Technologies (ICALT 2009)*, pages 170–174, Rīga, Latvia, July 2009. Rīgas Tehniskā universitāte, Latvia; Centre for Research & Technology Hellas (CERTH), Greece, IEEE Computer Society Press. ISBN 978-0-7695-3711-5, DOI 10.1109/ICALT.2009.71.
- [50] Ulrich Gojny, Ingo Stengel, Horst Friedrich Röder, Daniel Eichelsbacher, and Christian Vejrazka. 2MN – Module für die multimediale netzbasierte Hochschullehre. Schlussbericht, Fachhochschule Darmstadt, Institut für graphische Datenverarbeitung (IgDV), Darmstadt, Germany, June 2004. http://forschung.eichelsbacher.de/files/paper_2004-06-01_BMBF.pdf.
- [51] Frank Graf, Rolf Lindner, and Michael Schnaider. IDEALS – Aufbau und Einsatz eines internet- basierten Lernsystems. In José Luis Moreira da Encarnação, editor, *Forschungs- und Arbeitsbericht des Fachgebietes „Graphisch-Interaktive Systeme“*, number GRIS-97-6, pages 15–20, Darmstadt, Germany, 1997. Technische Universität Darmstadt, Fachgebiet Graphisch-Interaktive Systeme.
- [52] Evin Grano. Sproutcore-Universal Data Source (SCUDS) Library. <http://github.com/etgryphon/sproutcore-uds>, 2012. (Accessed 25th February 2012).
- [53] Grapple project website. <http://www.grapple-project.org>, 2011. (Accessed 4th August 2012).

-
- [54] Dieter Grasbon. *Konzeption und prototypische Implementation einer Storyengine: Dynamisch-reaktives System zum Erzählen nichtlinear-interaktiver Geschichten bei größtmöglicher Spannung, gedanklicher Immersion, Identifikation und Motivation des Spielers*. Diploma thesis, Technische Universität Darmstadt, Darmstadt, Germany, 2001.
- [55] Dieter Grasbon and Norbert Braun. A Morphological Approach to Interactive Storytelling. In Monika Fleischmann and Wolfgang Strauss, editors, *Cast'01 // Living in Mixed Realities*, volume special issue of *netzspannung.org/journal*, pages 337–340, Birlinghoven, 2001. FhG – Institut Medienkommunikation (IMK) and Bundesministerium für Bildung und Forschung – bmb+f (German Federal Ministry of Education and Research).
- [56] Clemens Gull. *Web-Applikationen entwickeln mit NoSQL*. Franzis Verlag GmbH, Haar, Germany, July 2011. ISBN 978-3-645-60104-7.
- [57] Frank Halasz and Mayer Schwartz. The Dexter Hypertext Reference Model. In Kaj Grønbaek and Randall H. Trigg, editors, *Communications of the ACM*, volume 37, pages 30–39, New York, NY, USA, February 1994. Association for Computing Machinery, Inc. ISSN 0001-0782, DOI 10.1145/175235.175237.
- [58] David Harel. Statecharts: A Visual Formalism for Complex Systems. *Science of Computer Programming*, 8(3):231–274, June 1987. DOI 10.1007/978-3-642-03364-3_30, <http://www.wisdom.weizmann.ac.il/~dharel/SCANNED.PAPERS/Statecharts.pdf>.
- [59] H. Rex Hartson, Terence Scott Andre, and Robert C. Williges. Criteria For Evaluating Usability Evaluation Methods. *International Journal of Human-computer Interaction*, 15:145–181, 2003. DOI 10.1207/S15327590IJHC1501_13, <http://people.cs.vt.edu/~hartson/publications/hartsonIJHCS2003v15n1.pdf>.

- [60] David Hauger and Mirjam Köck. State of the Art of Adaptivity in E-Learning Platforms. In *15th Workshop on Adaptivity and User Modelling in Interactive Systems – ABIS 2007*, Halle, Germany, September 2007. SIG ABIS of the Gesellschaft für Informatik e.V. <http://users.informatik.uni-halle.de/~lwa07/abis07/Hauger.pdf>.
- [61] Maurice Hendrix. *Supporting Authoring of Adaptive Hypermedia*. PhD thesis, University of Warwick, Department of Computer Science, Warwick, UK, March 2010. <http://www.computing.northampton.ac.uk/~maurice/files/cs-rr-446.pdf> (Accessed 18th February 2014).
- [62] Wayne Hodgins and Erik Duva. Learning Object Metadata. Standard 1484.12.1-2002, Institute of Electrical and Electronics Engineers, Piscataway, NJ, USA, July 2002. http://ltsc.ieee.org/wg12/files/LOM_1484_12_1_v1_Final_Draft.pdf (Accessed 20th July 2012).
- [63] Steve Hoffmann, Ulrike Spierling, and Hans-Georg Struck. A Practical Approach To Introduce Story Designers to Planning. In *Proceedings of GET 2011, IADIS International Conference Game and Entertainment Technologies*, Rome, Italy, July 2011.
- [64] Wonil Hwang and Gavriel Salvendy. Number of People Required for Usability Evaluation: The 10 ± 2 Rule. *Commun. ACM*, 53(5):130–133, May 2010. ISSN 0001-0782, DOI 10.1145/1735223.1735255.
- [65] Vocabulary Definition Exchange. <http://www.imsglobal.org/vdex/>, February 2004. (Accessed 6th June 2012).
- [66] IMS Global Learning Consortium. <http://www.imsglobal.org>, 2012. (Accessed 19th July 2012).
- [67] IRIS (Integrating Research in Interactive Storytelling). <http://iris.scm.tees.ac.uk/>, 2011. (Accessed 17th July 2012).

-
- [68] Jeff Kahn. IMS GLC Common Cartridge Profile: Overview. Specification 1.2, IMS Global Learning Consortium, Inc., October 2011.
- [69] Bonnie Kaplan and Dennis Duchon. Combining Qualitative and Quantitative Methods in Information Systems Research: A Case Study. *Management Information Systems Quarterly*, 12(4):571–586, December 1988. DOI 10.2307/249133, ISSN 02767783, http://staff.blog.ui.ac.id/r-suti/files/2010/03/qualquant_in_is.pdf.
- [70] Evgeny Knutov, Paul De Bra, and Mykola Pechenizkiy. AH 12 Years Later: a Comprehensive Survey of Adaptive Hypermedia Methods and Techniques. In Paul De Bra and Peter Brusilovsky, editors, *Special Issue: Adaptive Hypermedia*, volume 15 of *New Review of Hypermedia and Multimedia*, pages 5–38, Bristol, PA, USA, April 2009. Technische Universiteit Eindhoven, Taylor & Francis, Inc. ISSN 1361-4568, DOI 10.1080/13614560902801608.
- [71] Rob Koper. Modelling units of study from a pedagogical perspective – The pedagogical metamodel behind EML. <http://hdl.handle.net/1820/36>, June 2001. Accessed 22nd December 2012.
- [72] Rob Koper, Bill Olivier, and Thor Anderson. IMS Learning Design Best Practice and Implementation Guide. Specification 1.0, IMS Global Learning Consortium, Inc., Lake Mary, FL, USA, January 2003. http://www.imsglobal.org/learningdesign/ldv1p0/imsld_bestv1p0.html (Accessed 22nd July 2012).
- [73] Rob Koper and Colin Tattersall, editors. *Learning Design – A Handbook on Modelling and Delivering Networked Education and Training*. Springer-Verlag GmbH, Heidelberg, Germany, 2005. ISBN 978-3-540-22814-1.
- [74] Siegfried Lamnek. *Qualitative Sozialforschung*. Beltz, Psychologie Verlags Union, Weinheim, Germany, 1993. ISBN 3-621-27177-5.

- [75] LAMS 2 – LAMS Foundation Wiki. <http://wiki.lamsfoundation.org/display/lams/Home>, April 2012. (Accessed 23rd December 2012).
- [76] LAMS: Learning Activity Management System. <http://www.lamsinternational.com>, 2011. (Accessed 23rd December 2012).
- [77] Steve Lay. IMS Question and Test Interoperability Implementation Guide. Specification 2.0, IMS Global Learning Consortium, Inc., January 2005.
- [78] Janis Lesinskis. Applications of Vladimir Propp’s formalist paradigm in the production of cinematic narrative, August 2010. <http://researchbank.rmit.edu.au/eserv/rmit:7520/Lesinskis.pdf> (Accessed 20th January 2014).
- [79] Jakub Majewski. *Theorising Video Game Narrative*. Minor thesis, Centre for Film, Television & Interactive Media, School of Humanities & Social Sciences, Bond University, Robina, Australia, 2003. http://mirek.majewscy.net/jakub/downloads/mthesis_jakub.pdf, (Accessed 1st September 2012).
- [80] David Massart, Nick Nicholas, and Nigel Ward. IMS GLC Learning Object Discovery Exchange (LODE). Specification 1.0, IMS Global Learning Consortium, Inc., March 2010. <http://www.imsglobal.org/LODE/spec/imsLODEv1p0bd.html>.
- [81] Greg McFall, Mark McKell, Lance Neumann, and Stephen Vickers. IMS Global Learning Tools Interoperability Implementation Guide. Specification 1.1.1, IMS Global Learning Consortium, Inc., June 2012.
- [82] Maram Meccawy, Peter Blanchfield, Helen Ashman, Tim Brailsford, and Adam Moore. WHURLE 2.0: Adaptive Learning Meets Web 2.0. In Pierre Dillenbourg and Marcus Specht, editors, *Times of Convergence. Technologies Across Learning Contexts – Third European Conference on Technology Enhanced Learning, EC-TEL 2008*, volume 5192 of *Lecture Notes in Computer*

-
- Science*, pages 274–279, Heidelberg, Germany, September 2008. Springer-Verlag GmbH. ISBN 978-3-540-87604-5, DOI 10.1007/978-3-540-87605-2.
- [83] Moodle Course Management System. <http://moodle.org>, 2012. (Accessed 25th February 2012).
- [84] Conditional Activities. http://docs.moodle.org/22/en/Conditional_activities, 2012. (Accessed 25th February 2012).
- [85] Using Conditional activities. http://docs.moodle.org/22/en/Using_Conditional_activities, 2012. (Accessed 25th February 2012).
- [86] Catherine Mulwa, Seamus Lawless, Mary Sharp, Inmaculada Arnedillo-Sanchez, and Vincent Wade. Adaptive Educational Hypermedia Systems in Technology Enhanced Learning: A Literature Review. In *Proceedings of the 2010 ACM conference on Information technology education*, pages 73–84, Central Michigan University, Midland, MI, USA, October 2010. ACM Special Interest Group for Information Technology Education Conference (SIGITE). ISBN 978-1-4503-0343-9, DOI 10.1145/1867651.1867672, <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.188.3673&rep=rep1&type=pdf>.
- [87] Rowena Murray. *How to Write a Thesis*. Open University Press, Berkshire, UK, 3rd edition, 2011. ISBN: 0-33-524428-9.
- [88] Jakob Nielsen and Rolf Molich. Heuristic Evaluation of User Interfaces. In *Proceedings of the SIGCHI conference on Human factors in computing systems: Empowering people*, CHI '90, pages 249–256, New York, NY, USA, 1990. ACM. ISBN 0-201-50932-6, <http://hci.cs.ait.ac.th/course/archives/nielsen-heuristic-chi90.pdf>.
- [89] Mark Norton, Claude Ostyn, Angelo Panar, and Brendon Towle. IMS Simple Sequencing Best Practice and Implementation Guide. Specification 1.0, IMS Global Learning Consortium, Inc., Lake Mary, FL, USA, March 2003.

- [90] CEN WS-LT Learning Technology Standards Observatory. A Common Evolution for IMS Simple Sequencing? <http://www.cen-ltso.net/main.aspx?put=220&n=1>, July 2009. (Accessed 22nd July 2012).
- [91] Reinhard Oppermann, Rossen Rashev, and Kinshuk. Adaptability and Adaptivity in Learning Systems. In Ali Behrooz, editor, *Proceedings on Knowledge Transfer*, volume 2 of *Knowledge Transfer*, pages 173–179, London, UK, July 1997. School of Oriental and African Studies, University of London, pAce. ISBN 1-900427-15-X, http://www.uni-koblenz-landau.de/koblenz/fb4/institute/icv/agoppermann/PublikationenPDFs/kt97_gmd.
- [92] Rune Pettersson. *Information Design: An Introduction (Studies in Discourse and Grammar)*. John Benjamins Publishing Co, Amsterdam, 2002. ISBN 90 272 3203 2.
- [93] Manuel Pieke, Christopher Russell, and Udo Bleimann. Collaborative Content Manipulation – an e-Learning Approach. In *Internet Research*, volume 17, page 49–60, Bradford, England, 2007. Hochschule Darmstadt, Emerald Group Publishing Limited.
- [94] David Pizzi and Marc Cavazza. From Debugging to Authoring: Adapting Productivity Tools to Narrative Content Description. In Ulrich Spierling and Nicolas Szilas, editors, *Proceedings of First Joint Conference on Interactive Digital Storytelling, ICIDS 2008*, volume 5334 of *Lecture Notes in Computer Science*, pages 285–296, Heidelberg, Germany, November 2008. Fachhochschule Erfurt, Springer-Verlag GmbH. ISBN 3-540-89424-1, DOI 10.1007/978-3-540-89454-4_36.
- [95] Elvira Popescu. A Unified Learning Style Model for Technology-Enhanced Learning: What, Why and How? In Fuhua Lin, editor, *International Journal of Distance Education Technologies (IJDET)*, volume 8, pages 65–81. IGI

-
- Global, Hershey, Pennsylvania, USA, 2010. DOI 10.4018/jdet.2010070105, ISSN 1539-3100, EISSN 1539-3119.
- [96] Wladimir Jakowlewitsch Propp. Morphology of the Folktale. In *International Journal of American Linguistics*, volume 24. Indiana University of Research Center in Anthropology, Folklore, and Linguistics, Bloomington, IN, 1958.
- [97] Leena Razzaq and Neil T. Heffernan. Open Content Authoring Tools. In Roger Nkambou, Jacqueline Bourdeau, and Riichiro Mizoguchi, editors, *Advances in Intelligent Tutoring Systems*, volume 308 of *Studies in Computational Intelligence*, pages 407–420, Heidelberg, Germany, 2010. Springer-Verlag GmbH. ISBN 978-3-642-14362-5, DOI 10.1007/978-3-642-14363-2.
- [98] RELOAD Project: Learning Design Editor. <http://www.reload.ac.uk/1deditor.html>, June 2006. (Accessed 4th August 2012).
- [99] Leonard Richardson and Sam Ruby. *Web Services mit REST*. O'Reilly, Köln, 2007.
- [100] Rogue Amoeba Software, LLC. Freebies. <http://rogueamoeba.com/freebies/> (Accessed 9th May 2012), 2011.
- [101] Franz Josef Röhl. Computermedien, Bildungsmedien. Vom pädagogischen Nadelöhr zur selbstbestimmten Bildung. In Wolfgang Schindler, editor, *MaC*_Reloaded: Perspektiven aus der Skepsis für *Menschen am Computer*, pages 37–58. RabenStück Verlag für Kinder- und Jugendhilfe, Chemnitz, Germany, 2005.
- [102] Franz Josef Röhl. Lerno-Project Documentation. <http://www.lerno.de>, 2005. (Accessed 14th February 2010).
- [103] Franz Josef Röhl. Entdecken Sie Ihren persönlichen Lernstil. http://www.lerno.de/lerno/MPX_rubrik.php@PHPSESSID=

- b3dcb5fa5b17632bceeb2b24000825ed&pos=0&rubrik_id=289.html, April 2006. (Accessed 9th May 2012).
- [104] Franz Josef Röhl. Learning preference test. <http://lerntest.h-da.de>, 2010. (Accessed 9th May 2012).
- [105] Martin Schmettow. Sample Size in Usability Studies. *Communications of the ACM*, 55(4):64–70, April 2012. DOI 10.1145/2133806.2133824, ISSN 0001-0782, EISSN 1557-7317.
- [106] Oliver Schneider, Udo Bleimann, Andrew D. Phippen, and Bettina Harriehausen-Mühlbauer. Non-Linear Extended Blended Learning. In Steven M. Furnell and Paul S. Dowland, editors, *Proceedings of the Sixth International Network Conference (INC2006)*, pages 377–384, Plymouth, UK, July 2006. Network Research Group, University of Plymouth. ISBN 1-84102-157-1.
- [107] Oliver Schneider, Udo Bleimann, and Ingo Stengel. Atlantis University: Learn Your Own Way. *Int. J. Mobile Learning and Organisation*, 3(2):184–201, 2009.
- [108] Joshua Scotton. *Supporting Delivery of Adaptive Hypermedia*. PhD thesis, University of Warwick, Department of Computer Science, Warwick, UK, March 2013. http://wrap.warwick.ac.uk/57728/1/WRAP_THESIS_Scotton_2013.pdf (Accessed 18th February 2014).
- [109] Colin Smythe. IMS GLC Learning Information Services Best Practice and Implementation Guide. Specification 2.0, IMS Global Learning Consortium, Inc., December 2011.
- [110] Marcus Specht and Reinhard Oppermann. ACE – Adaptive Courseware Environment. In Douglas Tudhope and Daniel Cunliffe, editors, *New Review of Hypermedia and Multimedia*, volume 4, pages 141–161. Taylor & Francis Group Ltd, Oxford, UK, Special Issue: Adaptivity and User Modelling

-
- in Hypermedia Systems; Hypermedia for Museums and Cultural Heritage edition, 1998. ISSN 1361-4568, http://www.researchgate.net/profile/Marcus_Specht/publication/220590235_ACE_-_Adaptive_Courseware_Environment/file/9c960518b8badd7ade.pdf (Accessed 18th February 2014).
- [111] Ulrike Spierling. *'Implicit Creation' – Non-Programmer Conceptual Models for Authoring in Interactive Digital Storytelling*. PhD thesis, University of Plymouth, Plymouth, GB, August 2012.
- [112] Ulrike Spierling, Steve Hoffmann, and Nicolas Szilas. Report on Prescriptive Narrative Formalisms and Creation Methods in Interactive Storytelling (Non-Digital and Digital). Deliverable D 3.1, Fachhochschule Erfurt, Université de Genève, January 2010. <http://www.scm.tees.ac.uk/f.charles/fp7-iris/deliverables/IRIS-FP7-ICT-231824-Deliverable-3.1.pdf>.
- [113] Ulrike Spierling and Nicolas Szilas. Authoring Issues beyond Tools. In Ido Iurgel, Nelson Zagalo, and Paolo Petta, editors, *Proceedings of the 2nd Joint International Conference on Interactive Digital Storytelling: Interactive Storytelling*, volume 5915 of *ICIDS '09*, pages 50–61, Berlin, Heidelberg, 2009. Springer-Verlag GmbH. ISBN 978-3-642-10642-2, DOI 10.1007/978-3-642-10643-9_9, http://www.ai.fh-erfurt.de/fileadmin/AI_Dokumente/Dokumente_der_Mitarbeiter/Mitarbeiter/Spierling/2009-ICIDS09___AuthoringIssuesBeyondTools.pdf.
- [114] Ulrike Spierling, Sebastian A. Weiß, and Wolfgang Müller. Towards Accessible Authoring Tools for Interactive Storytelling. In Stefan Göbel, Rainer Malkewitz, and Ido Iurgel, editors, *Proceedings of the Third international conference on Technologies for Interactive Digital Storytelling and Entertainment*, volume 4326 of *TIDSE'06*, pages 169–180, Berlin, Heidelberg, 2006. Springer-Verlag GmbH. ISBN 3-540-49934-2, 978-3-540-49934-3,

DOI 10.1007/11944577_17, http://www.ai.fh-erfurt.de/fileadmin/AI_Dokumente/Dokumente_der_Mitarbeiter/Mitarbeiter/Spierling/2006-TIDSE06___TowardsAccessibleAuthoringTools_01.pdf.

- [115] Ingo Stengel, Oliver Schneider, and Udo Bleimann. Exploration of Learner Preferences and their Impact Within a Media Module. In Udo Bleimann, Paul S. Dowland, Steven M. Furnell, and Oliver Schneider, editors, *Proceedings of the Eighth International Network Conference (INC 2010)*, page 279–288, Heidelberg, Germany, July 2010. ISBN 978-1-84102-259-8.
- [116] Andrew Stern. Deeper Conversations with Interactive Art: Or Why Artists Must Program. In Julia Knight, Jeanette Steemers, and Alexis Weedon, editors, *Convergence: The International Journal of Research into New Media Technologies*, volume 7, pages 17–24, Thousand Oaks, CA, March 2001. SAGE Publications. DOI 10.1177/135485650100700102, ISBN 1354-8565.
- [117] Martin Stingelin. *Das Netzwerk von Gilles Deleuze: Immanenz im Internet und auf Video*. Merve Verlag, Berlin, 2000.
- [118] Daniela Stoecker. *eLearning – Konzept und Drehbuch*. X.media.press. Springer-Verlag GmbH, Berlin, Heidelberg, 2nd edition, 2013. ISBN 978-3-642-17205-2.
- [119] Strobe Inc. SproutCore. <http://sproutcore.com>, 2012. (Accessed 25th February 2012).
- [120] Ivo Swartjes and Mariët Theune. Iterative Authoring Using Story Generation Feedback: Debugging or Co-creation? In Ido Aharon Iurgel, Nelson Zagalo, and Paolo Petta, editors, *Second Joint International Conference on Interactive Digital Storytelling, ICIDS 2009*, volume 5915 of *Lecture Notes in Computer Science*, pages 62–73, Heidelberg, Germany, December 2009. Universidade do Minho, DSI – Departamento de Sistemas de Informação, Guimarães, República

-
- Portuguesa, Springer-Verlag GmbH. ISBN 3-642-10642-0, DOI 10.1007/978-3-642-10643-9_10.
- [121] Ronald B. Tobias. *20 Masterplots: Woraus Geschichten gemacht sind*. Zweitausendeins, Frankfurt am Main, 1999.
- [122] Lex van Velsen, Thea van der Geest, Rob Klaassen, and Michaël Steehouder. User-Centered Evaluation of Adaptive and Adaptable Systems: A Literature Review. In *The Knowledge Engineering Review*, volume 23, pages 261–281. Cambridge University Press, Cambridge, UK, September 2008. DOI 10.1017/S0269888908001379.
- [123] Robert A. Virzi. Refining the Test Phase of Usability Evaluation: How Many Subjects is Enough? *Hum. Factors*, 34(4):457–468, August 1992. ISSN 0018-7208, <http://coursesite.uhcl.edu/hsh/PeresSC/Classes/PSYC6419seminar/Refining%20the%20test%20phase.pdf>.
- [124] Sarah Voß. *LernBar 3.0 – Ein Autorentool für das Wesentliche*. studiumdigitale – Zentrale eLearning-Einrichtung der Goethe-Universität Frankfurt, Frankfurt am Main, Germany, 2012. <http://www.studiumdigitale.uni-frankfurt.de/Service/medientechnik/LernBar.pdf>.
- [125] W3C. HTML5 – A vocabulary and associated APIs for HTML and XHTML. Specification (working draft), World Wide Web Consortium, June 2012. <http://dev.w3.org/html5/spec/Overview.html> (Accessed 8th June 2012).
- [126] Wibke Weber, editor. *Kompendium Informationsdesign*. X.media.press. Springer-Verlag GmbH, Berlin, Heidelberg, 2008. ISBN 378-3-540-69187-3.
- [127] Christa Weßel. Semi-strukturierte Interviews im Software-Engineering: Indikationsstellung, Vorbereitung, Durchführung und Auswertung – Ein Fall-basiertes Tutorium. In Klaus-Peter Fähnrich and Bogdan Franczyk, editors, *Informatik*

2010: *Service Science – Neue Perspektiven für die Informatik*, volume P176 of *Lecture Notes in Informatics (LNI) – Proceedings Series of the Gesellschaft für Informatik (GI)*, pages 927–937, Bonn, Germany, September 2010. Universität Leipzig, Gesellschaft für Informatik e.V. (GI). ISBN 978-3-88579-270-3, ISSN 1617-5468 http://www.christa-wessel.de/files/Publikationen/wessel2010_inf10_int_paper.pdf (Accessed 11th November 2013).

[128] Carsten Wiegrefe. *Das Moodle 2 Praxisbuch*. Addison-Wesley, München, Germany, 2011. ISBN 978-3-8273-2744-4, <http://www.moodle-praxisbuch.de/>.

[129] Wikibooks.org. *Blender 3D: 3D Content Creation – Noob to Pro*, 2014. http://en.wikibooks.org/wiki/Blender_3D:_Noob_to_Pro (Accessed 26th January 2014).

Appendix G

Copies of Own Publications

G.1 Non-Linear Extended Blended Learning

Schneider, O., Bleimann, U., Harriehausen, B., and Phippen, A.D.: *Non-Linear Extended Blended Learning*, Proceedings of the Sixth International Network Conference (INC2006), Plymouth, UK, 11–14 July, pp 377–384 (2006)

© 2006 University of Plymouth

Permission to reproduce this paper in this thesis has been granted by University of Plymouth.

Proceedings may be obtained at:

<http://www.lulu.com/shop/steven-furnell-and-paul-dowland/proceedings-of-the-sixth-international-network-conference-inc2006/paperback/product-12037441.html>

Non-Linear Extended Blended Learning

Oliver Schneider^{1,2}, Udo Bleimann¹, Bettina Harriehausen¹ and Andrew D. Phippen²

¹Institute of Applied Informatics Darmstadt (aida),

University of Applied Sciences Darmstadt, Darmstadt, Germany

²Network Research Group, University of Plymouth, Plymouth, United Kingdom

OliFFM@web.de

Abstract

The *extended blended learning* approach combines three different types of learning and teaching: face-to-face learning, e-learning and project based learning. This conceptual position paper discusses techniques for a new content-coherent, non-linear interactive extension to the existing e-learning part of extended blended learning including an authoring environment. Based on Digital Storytelling concepts, this extension will enable adaptive e-learning, increase collaboration and integrate the different types of learning and teaching. Additionally, Interactive Storytelling authoring concepts facilitates the creation of Units of Learning for authors, who are not used to the creation of non-linear content.

Keywords

e-Learning, Blended Learning, Digital Storytelling, Authoring, User-Adaptation, Interaction

1 Introduction

Extended blended learning (Bleimann and Röhl, 2006) is an attempt to address the growing demands of modern learning environments. In order to optimise integration of learners, lecturers and the learning-environment, this concept adds project-based learning to blended learning, that comprehends face-to-face learning and e-learning.

1.1 Usage of the Term “Non-Linearity”

Within this paper, “non-linearity” is used to distinguish between linear and non-linear content presentation. This paper is not about “non-linearity” as it is used in the mathematical-context.

Nowadays, everybody is used to linear forms of presentations, in most cases books, motion-pictures and radio-plays are all linear media. Even though some stories are non-linear (for example Pulp Fiction), the presentation itself is linear – from the beginning of the motion-picture to its end. Hyperlinked-stories or computer-games are typical examples for non-linearity – by stepping in the user influences the progression.

Within this context, non-linear presentation means neither action-driven learning nor that learners even take notice of non-linearity. It’s more comparable to a lecture or, as another example, parents narrating a fairy-tale to their children: there is only one Cinderella, but it has been told

in many different ways. Sometimes it is presented as short story, because the children are tired and the narration has to come to its end fast, whereas at other times the children are curious and ask questions, so parts of the fairy-tale are told with greater depth, or the narration sequence is changed.

In the digital world content-presentation's progression is changed at decision points. But from the user's point of view there is a major disadvantage in non-linear presentations: He might think that he has missed something and becomes unsatisfied (Ryan, 2001). Hence, mostly there is a need to hide decision points (Mateas and Stern, 2000). Therefore, taking care of content's coherence is the most important aspect. In addition, most decisions have to be implicitly carried out.

1.2 Benefits of Non-Linear Extended Blended Learning

There are several benefits in applying the principle of non-linearity to extended blended learning. Firstly, non-linearity enables the creation of adaptive learning environments, enabling the accommodation of the different learning styles of students. While some learners are comfortable with streaming text, while other learners need illustrations for understanding. Some learners prefer practical examples before learning the theoretical background, while other learners need to learn the theory before they may understand the practical examples. Tests have shown that adaptation and personalisation may increase learning performances. For example, using suggestopedical practices could nearly double the performance of learners in tests (französisch intensiv seminar, 2003).

Non-linear extended blended learning enables the personalisation of instructions in respect to the learner type. This might be accomplished by exchanging the course's content (for example, authored by another lecturer), by changing the way of content presentation (for example, text, illustrations or film), by adapting the environment as possible interactions, or by diversifying the order of the Units of Learning.

With non-linearity the inclusion of explicit interactive Units of Learning is possible. This includes practical experiments and assessments. Furthermore, their results may influence the ongoing course's direction. In an advanced level of development, students may ask questions that might be answered context-based by the system.

Collaboration may be encouraged by the redirection of questions to other students. The student with the best fitting profile and/or knowledge may be preferred by the learning system.

Finally, non-linearity enables the consolidation of the different types of learning and teaching: face-to-face learning and project based learning supported by e-learning. This simplifies the inclusion of the outcomes of the different types of teaching.

2 Related Work

The international project *Atlantis University* (Bleimann, 2004) is the first development of the extended blended learning concept. It is an ongoing project, so parts are missing but it already demonstrates direction in the area. Some goals proposed in this paper have been realised within the e-learning project *Environment for Learning and Teaching* (ELAT) (Gojny et al., 2003). However, due to the lack of interactivity and effective authoring environment, further developments and concepts are required.

At present, existing learning environment's authoring tools are limited to the e-learning part of extended blended learning and do not address important learning tasks such as face-to-face learning and project based learning. Further examination of e-learning systems shows most of them (for example *Blackboard* (Blackboard Inc., 2005), *TopClass* (WBT Systems Ltd., 2005) and *WebCT* (WebCT, Inc.)) don't clearly indicate the supported didactical methods and models. Additionally, the possibilities for adaptation are limited (van Rosmalen and Boticario, 2005). The impression with many of those e-learning systems is, that they "are more or less technically focused solutions created by technically oriented individuals, who have not taken pedagogical nor didactic considerations into account. [...] I [...] spoke with two of the programmers, who admitted to not having done any user nor pedagogical research, but 'had made some assumptions'" (Brückner, 2005).

movii (movii, 2005) is a very interesting concept for a hypermedia learn- and design-system. Firstly, it features interaction and user adaptation. By providing various *cores* and *scenes* inside of *acts*, learners may view the content in different styles, with a variety of media and different depths. However, because it's comparable to adventure games' *string of pearls* (Laird, 2003), *movii* doesn't provide the facility to change the order of the learning path's scenes.

3 Supporting Concepts

The authors of this paper propose an *Interactive Digital Storytelling* approach for *Non-Linear Extended Blended Learning*, because the demands of Digital Storytelling and e-learning are comparable (Koper, 2005). In both domains content has to be presented in a coherent and user centred manner. Time constraints are important to manage time limited situations as lectures or semesters. "Game over" situations should generally be avoided, except for tests. Additionally immersion and suspense can be exploited to learn more effectively.

3.1 Digital Storytelling

Storytelling is the most universal form of human conversation. Regardless of whether there is something to narrate or to explain – humans do this by telling each other stories. Many years ago, there was only a small percentage of people with access to books – therefore, the storyteller often was a real person telling news, stories, etc., interacting with his audience. When books became popular and people developed the ability to read, the storytelling job began to get more sophisticated. Since there is usually no possibility for the reader of a book to inquire

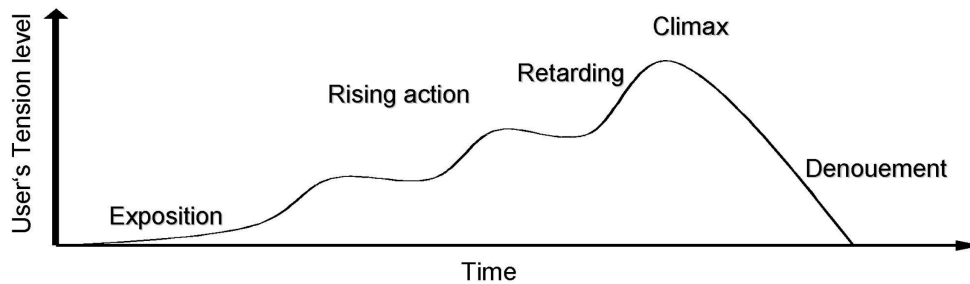


Figure 1: Suspense-arc according to Aristotle.

about certain inferred aspects of the story, artistic rules for telling a story through a book were developed over time. The same holds true when examining the movie or TV sector. Today, authors can make use of a whole new world of possibilities to tell their stories, ranging from direct worldwide access of content and 3D visualisation of content to interactive possibilities for the audience.

Digital Storytelling is the research area based on narrative structures (Braun, 2002). Because every human is used to stories and therefore understands them well – much better than the normally used point-and-click and desktop metaphors of present day graphical user interfaces – the goal are everyday applications with storytelling based human computer interfaces.

Digital Storytelling applications motivate users to carry on by giving him an experience of *immersion* in the content presented. This immersion is enabled by the feeling of *suspense*. Aristotle described the well-known suspense-arc with a five act structure: Exposition, rising action, retarding, climax and denouement (figure 3.1).

Beside immersion and suspense further fundamentals of Digital Storytelling are:

- The content presentation comes always to an end over a specific period, regardless of the user's behaviour.
- Unlike games, “game over” situations have generally to be avoided as these frustrate users (Kelso et al., 1992).
- The coherence of content presentation has to be assured.

The core technology of a narration engine (figure 3.1) consists of a story engine and a scene engine. The story engine loads a story model – a global description of the narration type (for example novella or fairy tail) or even the description of a module. Second, the content description for a specific narration is loaded. The content description describes the scenes and their coherence. In conjunction with the general runtime set-up information like an user-description and the specific period, the story engine is able to pick out scenes in the accurate order at the right time to gain suspense.

At start-up, the scene engine loads the content description as well. The story engine tells the scene engine which scene has to played in which context. With a scene script and additional environment information, it plays the scene interactively. Thus it controls the renderer and the input/output management.

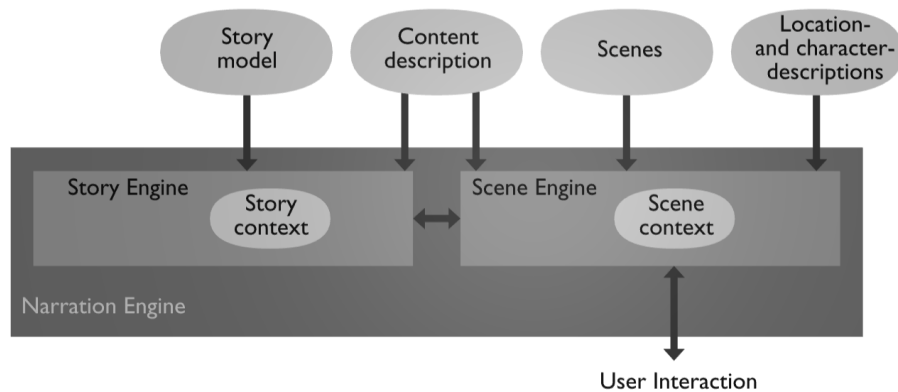


Figure 2: Diagrammatic plan of a narration engine.

Various edutainment projects have been realised with Digital Storytelling concepts, for example *Geist* (Kretschmer et al., 2001) and *EduTeCH* (Schneider, 2004). Within the first scenario of *Virtual Human* (Göbel et al., 2004), a story engine has been used to manage the content of a course in a mixed reality class room, where a real pupil (the user) learns with virtual teachers and virtual pupils.

3.2 Authoring

Most lecturers prepare their courses in a linear way as lecture notes and -slides. Fortunately they are also experienced in the use of non-linear presentations during the lessons – for example when discussing and answering the students’ questions. Hence, an authoring environment should be designed with this fact in mind. To let lecturers feel comfortable with the authoring environment, the courses should be authored linear-like, but the environment should push the authors smoothly to non-linearity (Schneider, 2002).

Of course, there will be the demand of changing a published Unit of Learning. Some topics may have changed because of further developments or to optimise the manner of presentation.

Interactive Digital Storytelling provides user friendly authoring concepts (Schneider et al., 2003). These concepts are a good basis for the development for a non-linear extended blended learning authoring suite, but they have to be adapted to the learning environment as well as to the intended users. These are lecturers and students, both acting on par as authors.

4 Non-Linearity and Extended Blended Learning

As mentioned above, non-linearity should not be apparent to the user. This can be accomplished in various ways:

- **Time Management**
If there is a given time for a module, say, 90 minutes, the system should present the most important Units of Learning. If the learner is fast enough, the learning system may present additional content such as more in depth explanations or practical examples.
- **Assessments**
The learning system might be influenced by the correctness of the learner's answers to assessment questions. For example in the case of wrong answers the topic should be explained once more (in a different way) instead of only complaining about the wrong answer.
- **User Tracking**
The learning environment should track and interpret each user (inter-) action. If the user pushes a "next" button, of course he wants to read further on. But it's also interesting, *when* he wants to continue. If he needed a long time for a page, he might had some problems in understanding it – or he just went to the kitchen to get a cup of coffee.

The integration of this work with the existing extended blended learning platform of Atlantis University is a major goal. Therefore, its ideas and technologies have to be used and integrated from the very beginning. This demands a *Moodle course management system* (Moodle, 2005) compliant and therefore a *Sharable Content Object Reference Model* (Alexandria ADL Co-Laboratory, 2005) compliant development, because Atlantis University is based on these technologies. Since version 1.3, SCORM provides sequencing and navigation in combination with its runtime environment.

As an overall content management system, the *Learning Design* specifications (Olivier and Tattersall, 2005) match very well with the proposed concept. It is very flexible, tested in a wide area of e-learning applications and projects and is related to some aspects of Digital Storytelling. Its design enables the implementation and adaptation of fundamental Digital Storytelling features, like easy-to-use time constraints and role-behaviour. It facilitates the integration of face-to-face learning, e-learning and project based learning, because the Learning Design specifications were developed to describe an unlimited number of pedagogical approaches by abstracting from those described in the literature (Reigeluth, 1999).

However, Learning Design does not provide any interaction-logic or render functionality. Therefore, there is a requirement for support from other applications. One solution might be accomplished via XSLT for transforming Learning Design's XML-output to HTML and ECMA-Script for programming the user-interaction, but a more flexible solution could provide a richer learning environment. Commercial applications like Flash or Director have high costs and are not available for all platforms. This is not acceptable for distributed and collaboration environments. Examples of free available user interaction environments are *Blender* (Roosendaal et al., 2004) for 3D purposes and *Scalable Vector Graphics* (World Wide Web Consortium, 2005a) using the *Synchronized Multimedia Integration Language* (World Wide Web Consortium, 2005b) for 2D environments.

5 Conclusion and Future Work

This paper shows the benefit of a non-linear interactive extension to the Extended Blended Learning platform. It proposes an Interactive Storytelling approach for runtime and authoring purposes and discusses a possible way of realisation. The next steps of research are intensive talks with the intended users to determine their needs in detail (for example favoured usage and required functionality). Following this analysis, the platform will be specified. At each subsequent stage of development users' feedback will decide further progression within the iterative development process.

References

- Alexandria ADL Co-Laboratory (2005). "Sharable Content Object Reference Model SCORM". <http://www.adlnet.org/scorm>. (Accessed 9 November 2005).
- Blackboard Inc. (2005). "Blackboard e-Education Enterprise suite". <http://www.blackboard.com>. (Accessed 17 November 2005).
- Bleimann, U. (2004). "Atlantis University – A New Pedagogical Approach beyond E-Learning". *Campus-Wide Information Systems*, 21(5):191–195.
- Bleimann, U. and Röhl, F. J. (2006). "Extended Blended Learning – Innovative Lernszenarien für die Hochschule". In *Querschnitt (Beiträge aus Forschung und Entwicklung der FH Darmstadt)*, volume 01/06, Darmstadt, Germany.
- Braun, N. (2002). "Automated Narration – the Path to Interactive Storytelling". In *NILE*, Edinburgh, Scotland.
- Brückner, S. (2005). *Structure Patterns Depending on Various Learner Types in an e-learning Context*. Diploma Thesis, Fachhochschule Darmstadt.
- Göbel, S., Schneider, O., Iurgel, I., Feix, A., Knöpfle, C., and Rettig, A. (2004). "Virtual Human: Storytelling and Computer Graphics for a Virtual Human Platform". In Göbel, S., Spierling, U., Hoffmann, A., Iurgel, I., Schneider, O., Dechau, J., and Feix, A., editors, *Technologies for Interactive Digital Storytelling and Entertainment: TIDSE 2004*, pages 79–88, Berlin, Heidelberg, New York. Springer Verlag. Lecture Notes in Computer Science 3105.
- Gojny, U., Vejrazka, C., Leichtweiß, A., Trebing, C., Röder, H., Knorz, G., Bleimann, U., and Li, G. (2003). "ELATnet – E-Learning Entwicklung im Hochschulbereich". In *Querschnitt (Beiträge aus Forschung und Entwicklung der FH Darmstadt)*, number 17, pages 90–104, Darmstadt, Germany.
- Kelso, M. T., Weyhrauch, P., and Bates, J. (1992). "Dramatic Presence". Technical Report CMU-CS-92-195, Carnegie-Mellon-University, Pittsburgh, PA.
- Koper, R. (2005). "An Introduction to Learning Design". In Koper, R. and Tattersall, C., editors, *Learning Design*, pages 3–20, Berlin Heidelberg. Springer Verlag.
- Kretschmer, U., Coors, V., Spierling, U., Grasbon, D., Schneider, K., Rojas, I., and Malaka, R. (2001). "Meeting the Spirit of History". In *Virtual Reality, Archaeology, and Cultural Heritage*, pages 141–152, Glyfada, Spain.
- Laird, J. E. (2003). "Agitating for Dramatic Change". http://www.gamasutra.com/features/20031029/littlejohn_pfv.htm.
- Mateas, M. and Stern, A. (2000). "Towards Integrating Plot and Character for Interactive Drama". In Dautenhahn, K., editor, *Proceedings of the 2000 Fall Symposium: Socially Intelligent Agents: The Human in the Loop*, pages 113–118, Menlo Park, CA. AAAI Press.
- Moodle (2005). "Moodle course management system". <http://moodle.org>. (Accessed 9 November 2005).
- Olivier, B. and Tattersall, C. (2005). "The Learning Design Specification". In Koper, R. and Tattersall, C., editors, *Learning Design*, pages 21–40, Berlin Heidelberg. Springer Verlag.

- Reigeluth, C. (1999). *Instructional Design Theories and Models Volume II: A New Paradigm of Instructional Theory*. Erlbaum. Hillsdale, NJ.
- Roosendaal, T., Selleri, S., and e.a. (2004). *Blender 2.3 Guide*. Stichting Blender Foundation, Amsterdam, The Netherlands.
- Ryan, M. L. (2001). *Narrative as Virtual Reality: Immersion and Interactivity in Literature and Electronic Media*. The John Hopkins University Press, Baltimore, MD.
- Schneider, O. (2002). "Storyworld creation: Authoring for Interactive Storytelling". *Journal of the WSCG*. Plzeň, Česká republika.
- Schneider, O. (2004). "EduTeCH: Edutainment Technologies for Cultural Heritage in Asia". Jahresbericht 2004, Zentrum für Graphische Datenverarbeitung e.V., Darmstadt, Germany.
- Schneider, O., Braun, N., and Habinger, G. (2003). "Storylining Suspense: An Authoring Environment for Structuring Non-linear Interactive Narratives". *Journal of the WSCG*. Plzeň, Česká republika.
- WBT Systems Ltd. (2005). "TopClass E-learning Suite". <http://www.wbtsystems.com>. (Accessed 17 November 2005).
- WebCT, Inc. (2005). "WebCT integrated e-learning systems". <http://www.webct.com>. (Accessed 17 November 2005).
- World Wide Web Consortium (2005a). "Scalable Vector Graphics". <http://www.w3.org/Graphics/SVG>. (Accessed 19 November 2005).
- World Wide Web Consortium (2005b). "Synchronized Multimedia Integration Language". <http://www.w3.org/AudioVideo>. (Accessed 19 November 2005).
- französisch intensiv seminar (2003). "Was ist Suggestopädie?". <http://www.fis-seminar.de/franzoesisch-sprachkurs/suggestopaedie.html>. (Accessed 04 April 2006).
- movii (2005). "moving images & interfaces". <http://www.movii.de>. (Accessed 10 November 2005).
- van Rosmalen, P. and Boticario, J. (2005). "Using Learning Design to Support Design and Runtime Adaptation". In Koper, R. and Tattersall, C., editors, *Learning Design*, pages 291–302, Berlin Heidelberg. Springer Verlag.

G.2 Mobile Gaming Experience – Working on an Empirical Prototype

Grüter, B., Gröning, S., Milszus, W., Oks, M., and Schneider, O.: *Mobile Gaming Experience – Working on an Empirical Prototype*, NordiCHI'06 Workshop: User Experience – Towards a unified view. Oslo, Norway (2006)

Mobile Gaming Experience – Working on an Empirical Prototype

Barbara Grüter, Sonja Gröning, Wolfgang
Milszus, Miriam Oks, Oliver Schneider
University of Applied Sciences in Bremen
Flughafenallee 10, 28213 Bremen
grueter@informatik.hs-bremen.de
0049-421-5905 5486

ABSTRACT

In the following article we tackle the theoretical and methodological issue revolving around the unification of experience with reference to an elementary prototype of mobile gaming experience we gained by means of playtesting the mobile game *On the Streets* in June 2006. We propose to dissolve the contradiction between the uniqueness of an experience and its unification by scientific concepts and methods by looking for a form of motion for both sides within the framework of the activity theory.

Author Keywords

Experience, mobile games, gaming experience, activity, uniqueness and generalization, social behavior.

ACM Classification Keywords

H.1.2 [Information Systems]: User/Machine Systems—Software Psychology

INTRODUCTION

Experience is at the core a sensation of a person. Experience is unique for the person, the situation, the space and time, in which it comes into being within and by the person's activity. Experience is constantly changing. Experience is ephemeral. Why are we interested in this phenomenon? Experience is what happens, when we touch, hurt, move a person directly or by means of the results of our work. Understanding experience means we understand the effect of our own activity as a computer scientist, a designer or a psychologist on others. But those questions for a scientific understanding of experience lead into the risk to destroy the phenomenon we are looking for. If experience is unique, how it is possible to unify experience, to quantify and to measure experience. How is it even

possible to talk about experience? Everybody knows what can happen to a feeling if we put it into words. It is changing. Experience may be defined and structured by a concept, but experience is always more than the concept. Experience has a different quality, a quality without a name (Alexander 1979). If these assumptions are valid how can we dare to work on experience, experience design and evaluation?

The research project *Gangs of Bremen*¹ focuses on mobile gaming experiences and their conceptual, aesthetic and technological foundations by exploring, developing, and playtesting mobile games. In this summer we playtested the mobile game *On the Streets* we are still developing.

In the following we tackle the theoretical and methodological issue revolving around the unification of experience with reference to an elementary prototype of mobile gaming experience. We (1) address the problem, the contradiction between generalization and uniqueness of experience and propose an approach. We (2) introduce our empirical field, a first playtest of our mobile game. We (3) define mobile gaming experience within the framework of a particular version of activity theory and present an empirical prototype of mobile gaming experience. And we demonstrate our approach with reference to the empirical prototype.

THE PROBLEM OF UNIFYING EXPERIENCE (1)

Within the last years digital media move more and more beyond the desktop and enter everyday life. The space of possibilities for human-computer interaction at the desktop was clear defined. Now this space is changing constantly. The borders become permeable for influences from the outside and the inside. Humans use media within shifting roles in shifting contexts. Their spontaneous action and

¹ The project *Gangs of Bremen* lead by Barbara Grüter started in spring 2003 and is funded by the Hochschul- und Wissenschaftsprogramm Phase II (HWPII) in Bremen for a duration of three years with two positions for PhD students since January 2004.

reaction, within a particular situation becomes an issue of design.

Usability, design and evaluation of human-computer interaction at the desk could focus on task-orientation and performance. The experience of a person in a certain situations becomes important now. Feelings and emotions guiding the concrete use of media come to the fore.

We don't have problems with the scientific understanding and the measuring of task-orientation and performance. And we don't have a problem to define explicit knowledge. But as soon as we try to define implicit knowledge we do have problems because we enter the realm of experience. Implicit or tacit knowledge is not formalized. You cannot explain it, but demonstrate it. We do have problems to define and to measure experiences. What is happiness and joy, what is attraction? By definition we make experience comparable. We abstract from that particular context within which an experience gets its particular quality, its meaning for a person. But on the other hand we cannot forgo unification. We need to talk about our experiences in experience design. We need a direction, we need guidelines and we need standards.

Within this article we propose to dissolve the contradiction between the uniqueness of an experience and its unification by scientific concepts and methods by looking for a form of motion for both sides. The form of motion for the generalized dimension and the uniqueness of experience can be provided in our view within and by activity. We define experience as an internal moment of activity, an internal moment of that process, within which a person² produces and reproduces her relationships to the world.

PLAYTEST OF THE GAME ON THE STREETS (2)

Mobile games are based on the bodily movement of the players in their environment, which is enriched by virtual dimensions.

The elementary prototype of an experience we present here results from the playtest of the core mechanic of the mobile game *On the Streets* at the 13th of June 2006.

The Mobile Game On the Streets

The game *On the Streets* is played in a part of a city that is divided into squares, we call fields in the following. Players are organized in gangs. One gang consists of one to five runners and a boss who is located in the home base. The goal of the game for each gang is to gain power and influence in the city by capturing as much territory as possible, fields, or even the home bases of the other gangs. A conquered home base field has a higher value than a normal field. The value of that home base field is for example ten times of the value of a normal field.

² The actor can also be a group or an organization.

All players have a virtual map of the game territory displayed on their PDAs where they can retrieve detailed information about the field they are currently in and the eight surrounding fields.

In the game area there are also neutral, non-conquerable fields. They contain hospital buildings that can be used by all gangs. Other fields contain bank buildings. These fields can be conquered and the gang who owns it will get money on their gang account in periodical intervals. The boss can buy virtual robots with this money, so called Bots, place them on the map and let them defend conquered fields for him.

When players enter an empty field it is automatically passed into their holdings. If one player enters an occupied field both attacker and defender can choose whether to fight for it by virtual means or to flee quickly. Players fighting and being hit will lose life energy, which can be recharged in hospitals. If a player misses to recharge his energy soon enough he will become deactivated and can only reactivate himself in his home base, as long as it is in the holding of his gang.

A conquered field can be searched for items like medpacks or stroke-proof waistcoats.

In the summer 2006 we playtested *On the Streets* under varying conditions and within different environments.

The Core Mechanic of On the Streets

A core mechanic is the most reduced version of a game. Within the playtest at the 13th of June 2006 the game *On the Streets* has been reduced to four fields, two gangs each with one runner and one boss - no items, no Bots, no bank, no hospital.

The home base of gang Red has been placed in the field A1 and the home base of gang Blue has been placed at the field B2.

The runner June and the boss Paul belonged to gang Red and the runner Hank and the boss Hodi belonged to gang Blue. We organized the game around the building of the ZIMT, the Center for Informatics and Media Technologies, the location of our research project.

Thus, the general play activity of a runner consisted of two main actions

- Running, change fields and conquer them if they are empty
- Fighting against the enemy to conquering occupied fields respectively the home base of the other gang

The general play activity of a boss consisted of two main actions

- Observing the map, the movements, the fights, the status of the own runner
- Fighting against the enemy to defend the own home base.

A further important play action of both members of a gang is the communication with each other by means of Walkie-Talkies.

The game process on June 13th 2006

The game lasted 7 minutes and 50 seconds (7:50). Gang Blue won the game. The runners used only three of four fields throughout the whole game: the fields A1, A2 und B2. The fourth field has never been conquered³.

For providing a coarse overview over the whole game we divide the game process into phases taking into account the score changing during the game and the activities needed to change the score. The game process consists of five phases (see Table 1). The column “Time” indicates the relative duration of each phase.

	Game Phase	Score	Time m:ss
	The game starts.	1:1	0:00
1	Red conquers the field A2	2:1	0:21
2	Red and Blue fight against each. Red wins and keeps hold of the field A2	2:1	1:51
3	Blue conquers the field A2	1:2	2:48
4	Blue and Red fight against each other. Blue wins the fight.	1:2	3:49
5	Blue and Red fight against each other. Blue wins the fight again and wins the game.	1:12	7:50

Table 1. Game phases On the Streets, June 13th 2006.

Data collection

We organized the data collection within this playtest as follows

- A visualization of all players’ movements throughout the game;
- Recordings of the communication⁴;

³ We ascribe this fact mainly to the reduced game format and the particular architecture of the game world. You could win only by conquering the other home base and the field A2 consisted of a street directly connecting the hostile home bases at field A1 and field B2.

⁴ The recordings of communication functioned only partly because of technical reasons.

- Participating film observation of the red runner and the red boss
- The capture of the PC screen of the red boss;
- Film observation from the perspective of the blue runner by means of a head camera.

A PROTOTYPE OF A MOBILE GAMING EXPERIENCE (3)

Trying to understand experience in the context of the mobile game On the Streets we take a next step. We identify the activity of the players throughout the game. Within this article we present the activity of the red runner June (see Table 2).

June’s play activity

June is a member of gang Red. We analyze her play activity on the basis of the film observation and the recording of her communication. We identify phases of her play activity by taking into account obvious changes in the conduct of her activity (see Table 2). As soon as the game starts, June moves from her home base in field A1 into the direction of the home base of gang Blue. She enters the field A2, conquers it by that movement and moves further. June starts running and then slows down and stops in front of the blue runner Hank. They communicate with each other and start fighting. June wins and keeps hold of the field A2 ... and so on. We stop at this point. For a demonstration of a prototype of mobile gaming experience this section of June’s play activity is sufficient.

	June'Play actions	Result	Time m:ss
	The game starts.		0:00
1.	June moves from A1 over A2 into the direction of B2.		0:21
2.	Entering A2	June conquers A2.	0:21
3.	June starts running		0:21
4.	June slows down		0:28
5.	June stops in front of the Blue Runner Hank		0:36
6.	June communicates with Hank		0:39
7.	Hank and June fight with each other.	June wins and keeps hold of A2	1:51

Table 2. June’s play activity as a sequence of actions

Experience and activity

For further understanding of activity and experience I stepwise introduce first a theoretical definition and then the reference to the empirical material.

Human information processing is an inseparable dimension of activity. Experiencing, sensing is the most basic form of human information processing. Our understanding of a particular experience begins with the (re)construction of the particular activity.

Each activity is defined by subjective (Person), objective (Goal) and mediating conditions (Medium) and by other persons (Others), the actor is referring to (See Figure 1).

In this case we have June (Person), her concept of the game and the empirical instances of her activity in this situation she is aware of playing the game including the PDA (Medium), the objective of her play activity - she wants to win the game (Goal), the other players and the surrounding observers (Others).

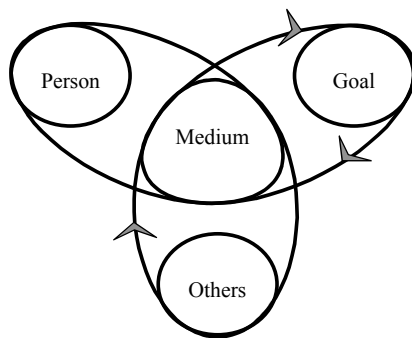


Figure 1. Activity - reproduction of the person-world relations.

Each activity has in our understanding a *double character*, a structural, cognitive as well as a contextual, intuitive dimension. The *structure* of an activity resembles an algorithm. It is an answer to the question, what do I want to do and what do I have to do to achieve that goal under the present conditions. The structure is an implication of the actor's game concept and the thereby foreseeable and generalizable properties of the activity. The structure is thus defined by the accordance of subjective and objective conditions with respect to the actor's objective.

Our conclusions about the structure of June's activity are based on our observations of her activity. June wants to win the game and therefore she is heading into the direction of the other home base. Because of the architecture of the game world, a mediating condition, she has to cross the field A2. The street connects the fields, A1 and B2 and leads through A2.

The *context* of an activity is given by the difference of subjective and objective conditions, by that what we don't

foresee, what comes into being within and by the interaction of all conditions.

The context in our case is the interaction of all activity conditions so far it is not foreseen within the game concept and the structure. Unforeseen aspects of the interaction between June, the game technology, the game goal and the blue runner Hank. Our conclusions about the context of June's activity are also based on our observations of her activity particular on the observation of unexpected aspects of her activity. For example June meets Hank. From the perspective of the game logic a fight is indicated, but they start communicating.

Against this background we define experience theoretically. Experience in a nuclear form is sensation as

- an internal moment of activity and the thereby initiated and/or maintained relations to something and somebody;
- an immediate awareness of the here and now;
- a unit of identity and conflict of different (even logical incompatible) qualities.

With the definition of experience as the awareness of the here and now, we emphasize that experience is inseparable from the person and the context. Separate experience from the context and you will gain knowledge and lose the particular quality of the experience.

With the definition of experience as a unit of identity and conflict of different (even logical incompatible) qualities we return to the problem of unifying experience at the theoretical level. The definition of experience provided here reflects on both dimensions: the generalization and the uniqueness at the same time. What we want to do now is to demonstrate the meaning of this definition for supporting an empirical understanding of experience.

Experience as a unit of identity and conflict of different qualities reflects on experience as a time-based phenomenon. Experience is a phenomenon unfolding in time within the activity cycle. There is a difference between desire and fulfillment, between the goal and the result. And we try to grasp this difference and to understand the particular form of motion (the Identity) for the conflict of the different qualities.

June's mobile gaming experience

Of particular interest for the understanding of mobile gaming experience are the transitions between the actions of June's play activity (see Table 2). Actions are goal-oriented and are therefore mainly defined by the structure of an activity. The change of the mode of an action is in difference to that often context motivated.

The transition from 1 to 2 is only a structural implication of the game logic. The following transitions are different: June changes in these cases the mode of her action (see Table 3).

Within the transition from 2 to 3 we are looking for now she changes from walking speed to running speed.

The structure of her whole activity is mainly defined by the basics of the game logic, as she understands it: for winning you have to gain fields, particular the other home base. The first two actions are defined by the sub goal: move into the direction of the other home base. The mode of her movement – walking speed is not structural defined. Why is she speeding up?

We find the answer in the context of her activity – she suddenly sees Hank in the far distance running towards her

	June's play actions	Context	Time m:ss
	The game starts.		0:00
1.	June moves from A1 into the direction of B2		0:21
2.	June enters A2 and moves on	June sees far away Hank running	0:21
3.	June starts running		0:21
4.	June slows down	June and Hank approach each other. Hank stops	0:28
5.	June stops in front of the Blue Runner Hank	The game system reacts unexpected	0:36
6.	June communicates with Hank		0:39
7.	Hank and June fight with each other.	As soon as the fight dialog is displayed	1:51

Table 3. June's play activity – actions and context

and changes her mode. The context in this situation is defined by the particular quality of her encounter with Hank. Within their encounter (transition 3 to 4) both runners adapt to the movement of the other. She slows down. He also slows down and stops to look at the display of the PDA. She approaches him and stops too (transition 4 to 5).

We can summarize June's mobile gaming experience in this situation. It encompasses:

- The old structure of activity: striving for the game goal 'attack the other home base', consequently her movement towards the other home base from field A1 to field A2 in

the direction of field B2; movement in walking speed seems sufficient from her perspective;

- The new structure of activity: striving for the game goal 'attack the other home base', consequently her movement towards the other home base from field A1 to field A2 in the direction of field B2; movement in running speed seems to be indicated;
- The context: Seeing the other runner Hank running towards her from far away

The old and the new structure have different qualities. Both qualities are mediated within and by June's experience at the transition point.

Further transitions happen from 5 to 6 and from 6 to 7. The encounter of both gamers is defined first by a communication about the game. This seems to be induced by the retarded and for the players unexpected reaction of the game system. Hank is looking at her PDA and together they try to make sense of the situation. But suddenly they change their behavior - they concentrate now on fighting. The structure of June's action in this situation is given by the sub goal to understand the real and the virtual situation displayed. Also this transition from 6 to 7 is motivated by the context. The start of the fight dialog by the system induces the change of her dominant focus from communicating to fighting.

What we see in these small events here is the particular value the direct social encounters and interactions have for the emergence of game tension and for the framing of the magic circle (Salen and Zimmerman, 2004) within player communication.

The acceleration of June's speed indicates a new quality of game tension. Obviously June feels animated by Hanks behavior.

The magic circle separates the game world from the surrounding environment. It is defined not only by the game system but also by the players' activity. In this situation the system disturbs the gaming experience and the player compensate for that by mutually understanding of the current situation.

Form of Motion

The basis for unifying and generalization of experience is in our view the structure of an activity. We have worked so far only with generalization by definition. Further forms are quantitative analyses. But a quantitative analysis of experiences makes sense in our view only if the relationship to the data source and thereby to the context is maintained. The reconstruction of the concrete meaning of an experience is the basis for interpreting the quantitative results.

The form of motion between the generalization and uniqueness of a singular case is provided within and by the activity cycle.

What is, what happens with the experience during the activity cycle? The experience is changing. We perceive something as relevant in whatever respect and pay attention. Experience at this point may be structured and/or spontaneous and mainly context motivated.

We analyze the situation, use standards and control our feelings to getting a clear understanding. Experience at this point is structured and controlled.

We act according to our goal and the results of orientation with respect to the varying situational conditions. Experience at this point is a movement within a given structure, a space of possibilities.

We experience the difference between goal and effect of our action and reflect on that (Piaget 1975). Experience at this point may become a boundary experience accompanied by insecurity and ambivalence.

We use the results of the foregoing steps for reproduction and risk the achieved status of our relationships. Within and by reproduction novel possibilities may emerge, but this is never certain. Experience at this point may be a crossing boundary experience. The feeling in this situation may be joy but can also be mourning because of the loss of the old.

METHODOLOGICAL ISSUES

For studying time-based phenomena we follow a process-oriented approach.

Concept and Use⁵

A core issue of a process-oriented method can be described if we take into account the double character of activity and work with the difference of concept and use applied to the person-world-relation in the case of a player. The concept level is given then, if you study the process by reducing meaning to the player's goal definition and look for specifications of that within the process. The use level is given, if you study the same process with reference to the player's use of her goal definition and look for the interaction of the goal definition and situational conditions, the player is referring to within the process.

The difference of concept and use can also be applied to the researcher-case-relation. Both levels of the case A Mobile Gaming Experience can also be studied on the concept level of the researcher, that means within the limitations of a theoretically pre given definition, and they can be studied on the use level of the researcher. On the *concept level* the researcher is representing the process as a sequence of stills, datasets, which are empirical representatives of the pre given definition. On the *use level* the forming impact of the concept on the research process and the modifying impact of the research situation or the presentation situation on the meaning of the concept are focused.

⁵ A first version of this paragraph has been published in Grüter & Valsiner 1997

Subjects are using definitions all the time, but they are seldom fully aware of all the implications of that use. Both applications can and must be separated analytically, but in practice they are combined and inseparable. We concentrate in the beginning of our empirical studies on both forms of application for developing our own understanding.

The distributed game event and the clapboard

A mobile game like On the Streets is a distributed event. The game starts as soon as each gang arrived at the own home base field. Each gang consists of some runners moving around and a boss sitting at a PC. There is the system administrator, there is the game master and there is the game audience. Everybody has some insight in the game, but nobody has an overview over the whole game. The methodological problems to identify the game process, to get access to the process and maintain the relation of the data to the original source are immense.

For the data collection we worked with different data streams (see above). As within motion picture and videotape production we encountered the problem of synchronizing the different data streams. Our idea was to start the data recording at a common location with the clapboard.

CONCLUSION

Starting with the project in Spring 2003 we never imagined the difficulties we are facing on the conceptual, technical, theoretical, methodological and the aesthetical level. At the core of all those levels we find experience as a time-based phenomenon. We proposed a form of motion for the contradiction between generalization and uniqueness of an experience within the framework of the activity theory and demonstrated this with reference to a prototype of a mobile gaming experience.

ACKNOWLEDGMENTS

We thank The Hochschul- und Wissenschaftsprogramm Phase II (HWPII) in Bremen for funding the project and the Management of The University of Applied Sciences in Bremen for funding the playtest in summer 2006. We also thank all the students and former members participating in the project over the years particularly Hans Hamm, Janos Kovic, Anna Mielke, Florian Schaper, Patrick Tangemann and Christoph von Tycowicz.

REFERENCES

1. Alexander, C. The Timeless Way of Building. Oxford University Press, Oxford, 1979.
2. Grüter, B., & Valsiner, J. Concept, Meaning and Use - A Single Case Study of developmental Change. Paper presented at the 13. Tagung Entwicklungspsychologie in Vienna, Austria, Sept. 21 - 24, 1997
3. Salen, K. & Zimmerman, E. Rules of Play. Game Design Fundamentals. The MIT Press, Cambridge, Massachusetts, 2004

G.3 Learn Your Own Way:

Decision Way through Narrative Approaches, Methods, and Paradigms for Learning Purposes

Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen, B.: *Learn Your Own Way: Decision Way through Narrative Approaches, Methods and Paradigms for Learning Purposes*, in Bleimann, U. et.al: Proceedings of the Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007), Plymouth, UK, 14–15 June, pp 99–114, ISBN: 978-1-84102-173-7 (2007)

© 2007 Information Security & Network Research Group, University of Plymouth
Permission to reproduce this paper in this thesis has been granted by University of Plymouth.

Proceedings may be obtained at:

<http://www.lulu.com/shop/steven-furnell-and-paul-dowland-and-udo-bleimann/sein-2007-proceedings-of-the-third-collaborative-research-symposium-on-security-e-learning-internet-and-networking/paperback/product-1073723.html>

Learn Your Own Way: Decision Way through Narrative Approaches, Methods and Paradigms for Learning Purposes

Oliver Schneider^{1,2}, Udo Bleimann¹,
Andrew D. Phippen² and Bettina Harriehausen-Mühlbauer¹

¹Institute of Applied Informatics Darmstadt (aida),
University of Applied Sciences Darmstadt, Darmstadt, Germany

²Network Research Group, University of Plymouth, Plymouth, United Kingdom

OliFFM@web.de

Abstract

This paper give reasons for the chosen Digital Storytelling approach for Non-Linear Extended Blended Learning. Hence, umpteen levels of Digital Storytelling are looked at from different point of view. Thus, important background information is given. The result is a well grounded decision for the principles of the aimed coherence engine, that will be the realisation of these concepts. Finally, further steps for finalising and integrating an usable engine are addressed.

Keywords

e-Learning, Blended Learning, Digital Storytelling, User-Adaptation, Interaction

1 Introduction

Extended Blended Learning is the successor of Blended Learning. Its approach of integrating face to face learning, eLearning and project based learning is a promising solution to overcome the obstacles of earlier (pure) eLearning attempts (Bleimann and Röhl, 2006).

Atlantis University is the first learning project, that realises the principles of Extended Blended Learning (Bleimann, 2004). Because of its narrative structures, storytelling is a possible for a better way of learning (Niegemann et al., 2004, p 30), and an approach for author-friendly handling of complex interactive content (Schneider, 2002). One main reason for this is, that humans live with stories from their beginning:

“Narrative is present in every age, in every place, in every society; it begins with the very history of mankind and there nowhere is nor has been a people without narrative.” (Barthes, 1996)

Hence, it had been decided to implement a Digital Storytelling based coherence engine for the Atlantis University project (Schneider et al., 2006). This paper shows the decision way to the chosen Digital Storytelling approach.

2 Motivation

Dan Norman states: “For teaching to be effective, cognition and emotion must work together.” (Currin, 2004) This statement gets confirmed by studies in neuronal sciences, that aver the importance of emotional engagement for learning efforts and motivation (Spitzer, 2002). The key for this can be found in stories: Stories foster emotional engagement, because of having content structured in a suspenseful way. Total immersion of in the imaginary world can be caused for the recipient, because of experiencing a good story.

Stories and their structures provide essential functionalities for learning environments: Focussing the teacher’s attention, provision of information and feedback about the learner’s efforts (Gagné et al., 1992). Stories are not limited to a certain topic. With narrative structures complex dependencies can be explained in a human understandable way. Stories are fundamental to culture and human understanding. They have familiar structures which are recognisable and can easily be understood. In human tradition stories were means for information transmission and knowledge acquisition, e.g. within families and cultural communities. “Much true understanding is achieved through storytelling. Stories are how we communicate events and thought processes.” (Schell, 2002)

This can be summarised as: The pedagogical dimensions of stories span are humanistic, cross-disciplinary, cross-cultural, multi-sensory, multi-modal, constructivist and learning directed (Springer et al., 2004).

3 Decision Way

To find the right approach for integrating Digital Storytelling concepts in Atlantis University, this paper looks from different points of view onto this field of research. Therefore, it starts with a survey of the most important story models – concerning their relevance to Digital Storytelling. This gives an overview of general storytelling methods and the relating narrative principles. To get deeper into the subject, a technical view onto the different technical approaches of Digital Storytelling follows. Last, existing Digital Storytelling projects are benchmarked regarding their utility for Extended Blended Learning.

The specific requirements for a Digital Storytelling based coherence engine – thus, for all underlying approaches, methods and paradigms – are as follows: For the Atlantis University project a storyteller for presenting the content is needed, but not a story writer. The focus of the research is on when and which content is presented, but it’s not about how. Thus, the realised coherence engine has to organise content on the basis of the users’ interaction and his previous history, but there’s no need of anthropomorphic mimic presentation. The creation and annotation of the content should be done by human authors.

3.1 Modern Story Models

In general a story integrates structure, content, context and its progression as a unit (Linane-Mallon and Webb, 1997). During the narrative spatial relations between are originated characters, properties and objects (Herman, 1999). Narratives themselves can be categorised into discourse and story (Chatman, 1978), whereas the story represents the narrative and the discourse is responsible for the presentation (Meech, 1999). Only the relevant information is presented in a story (Boella et al., 1999), because it otherwise would become boring (Sengers, 2000).

Because these general explanations are not very helpful for the realisation of an engine, more detailed models are looked at in the following.

3.1.1 Syd Field Paradigm

Syd Field's paradigm (Field, 1992) is considered as the basic structure of the Hollywood cinema. It is geared to the mythical heroic stories, that is described by Campbell as follows (Campbell, 1999, p 13):

“The hero leaves the world of the common day and visits an area of supernatural miracles, passes there fable-like powers and gains a determining victory, then he returns with the strength to stock his person with blessings, from his secret-full journey.”

Like Aristotle, Syd Field divides a story into three acts: Exposition, confrontation and resolution, whereas the narrative should emerge permanently – at least every 10 to 15 minutes something significant should happen in the motion picture.

The leading character is introduced in the exposition. It is explained what the story is about and what is the dramatic situation. This notion of the basic structure and point of departure of the story should last approximately 25 minutes. After this, the first plot point follows. This is a turn, that wakes a need which must be satisfied. In the second act the hero starts his search for the fulfilment of his needs. Hence, because of obstacles suspense and action arises respectively. These obstacles culminate into the second plot point – the climax – that pushes the story into the third act to the resolution.

A film has several plots to Field. However, the two plot points at the end of the first both acts are the most important ones, because these propel the narrative forward and explain the further progression. Only after the first plot point the hero has the motivation to accomplish something and to look for the confrontation. And only after the second plot point all obstacles are overcome, thus his way is free to achieve his purpose that leads to the resolution of the story.

It is interesting that Field applies the second plot Point with approximately 85 to 90 minutes. Because this corresponds to the length of most Hollywood films, it can be derived, that the confrontation is the main element of a story according to Syd Field and implies therefore the emotional immersion with the viewer. The resolution of the story is important to achieve a unity and a consistency of the story, however, it doesn't bear a film and it is in an unequal relation to

the first and second act. Good stories arise from misfortune, but not because of luck, like it is said in journalistic circles: “Only bad news are good news” (Wilder, 1951).

3.1.2 The Propp Model

The Russian formalist Wladimir Jakowlewitsch Propp established a model for the structural analysis of Russian fairy tales (Propp, 1958). He concluded, that all Russian fairy tales show the same structure irrespective of the mode of content. A story is divided into individual functions which act on the course of the story. This is irrespective of the concrete action that happens within a function and the person that carries it out.

Propp calls them morphological functions. The functions’ impact onto the course of the story are unalterable, however, the content itself may differ. Their figure is changeable and therefore “morphologically”. These functions are constant basic units of the story. Their quantity is limited and they are always in the same order. However, not all functions need to happen during a concrete story (Grasbon, 2001).

Propp introduced a system for the notation of this structure of the fairy tales, while he assigned a symbol to each function. Basically he distinguishes two categories of stories: On the one hand defeating an enemy in a fight (1), on the other hand, solving a difficult assignment (2). The structures of both stories look as follows:

$$\begin{aligned} & ABC\uparrow DEFG\ H\ \text{JI}\ K\downarrow PrRs^\circ LQExTUW* \text{ (1)} \\ & ABC\uparrow DEFG^\circ\ LMJ\ NK\downarrow PrRs^\circ\ ExTUW* \text{ (2)} \end{aligned}$$

Some functions may be left out, however, there are some dependencies. For example, the misfortune A must be made good in K. A fight against the enemy H leads necessarily to the victory I, a difficult assignment M for their coping N and the pursuit of the hero Pr to his rescue Rs (Grasbon, 2001, p 64). This can be noted as follows:

$$\begin{aligned} A & \rightarrow K \\ H & \rightarrow I \\ M & \rightarrow N \\ Pr & \rightarrow Rs \end{aligned}$$

3.1.3 20 Masterplots

Ronald B. Tobias has described twenty returning narrative structures which he refers as *20 master plots* (Tobias, 1999). However, the choice and the underlying reason seems questionable. For instance, the reason for the classification of the plots *rivalry* and *love* is the relation between the central characters. However, the source motive is decisive with *search* and *escape*.

Already in 1928 a similar approach has been criticised by Vladimir Propp for same reasons (Propp, 1958, p 7). Even Tobias grants that an action can fall back on several categories, thus,

the plots are combinable with each other. However, an action thread has to remain recognisably as a main plot (Tobias, 1999, pp 317).

3.1.4 Barthes' Model

Barthes proposes to study narratives on different levels of description (Barthes, 1996). He describes three levels of instances: functions, actions, and narration.

narration (top level)

narrative communication

narrative situation

actions (middle level)

functions (bottom level)

functions (relate to the same level)

cardinal functions (nuclei) (important for the narrative)

catalysers (complementary)

indices (relate across levels)

indices (relate to character, feeling, atmosphere,
philosophy)

informants (identifies, locates in space and time)

Functions are the smallest unit of narrative, something that may not have meaning directly but which acquire meaning in combination with other units, on the same level or on a higher level. Functions can in some cases be shorter than the sentence, even parts of a word.

Actions is the level of characters. Characters in the narrative are classified according to their participation in actions. Actions often have two sides. For instance *Giving* has a Donor and a Receiver. Example of actions are desire, communication, struggle.

The narrational level include narrative communication between author, narrator and recipient and narrative situation as a set of protocols according to which the narrative is consumed. Here is included different styles of representation, the point of view and codalities.

3.1.5 Appraisal

At first, Vladimir Propp's model was intended only to formally describe Russian fairy tales. The Russian formalism is certainly an especially extreme approach to dispose of all aesthetic aspects of a story. Nevertheless, this approach is not new – Aristoteles already divided the drama into the three elements prologue, episode and exodos (Komerell, 1988, p 9).

Because of its huge quantity of functions and its very precise formulation, Propp's model seems to be very restrictive and less applicable in contrast to Syd Field's paradigm. However, there are a lot of parallels: Both see a misfortune at the beginning of the story (that is needed to begin the

story). Syd Field defines this misfortune as the first plot point. Before this, the first act describes the pre-story. Propp's model says the same: The first act is equivalent to the function α , the first plot point is defined as A , the misfortune. According to Syd Field the hero undertakes everything to end the misfortune in the second act. After a huge number of adventures the second act accumulates to a climax (the second plot Point) in which the misfortune is finished. Propp's paradigm is correspondent, the hero starts to finish the misfortune after an amount of adventures experiences (function C), and stops, in the end, the misfortune in K . Hence, all points of the Syd Field paradigm are defined by Propp's model.

Compared with Vladimir Propp's classification Tobias' 20 master plots falls back clearly. This inherently applies for linear stories, for computer based non-linear stories Tobias' model may just serve as a provider of additional ideas. With the application of one of his 20 master plots the scenario decreases to one story with the very chosen plot – a linear story would result, that prevents every interactive impact on the events. In contrast, Propp's model merges all variations in one single model and at every time of the story alternatives for other courses through the storyline are available.

Barthes' approach is of interest for the overall system and corresponds to a large extend with the hierarchical approach – see section 3.2.5) (Aylett, 1999). However, for one single engine it seems be too complex.

3.2 Technical Approaches to Digital Storytelling

1990 the research topic *Narrative Intelligence* has been established at the MIT by the *Narrative Intelligence Reading Group* (Davis and Travers, 2002). It has been discussed how people organise her experiences in the form of stories – as a central issue of the Narrative Intelligence (Mateas and Sengers, 1999). To give consideration to this complicated and interdisciplinary question, the discussion group has been based on knowledge of the areas artificial intelligence, literature, human computer interaction, philosophy, media theory, psychology and cognitive science.

The approaches to the automation of the linear narrative are also of interest to Interactive Storytelling. These can be differentiated in three categories (Bailey, 1999): Author-based systems try to model the human author tasks, stories-based systems use abstract descriptions like a story grammar (Lang, 1999) and world-based systems create a world with autonomous characters.

Strictly speaking there are no interactive stories, because stories hold a complete structure that can't be changed any more (Crawford, 2000, p 240). However, the *presentation* of a story may be interactive.

Especially the effect on the audience is of particular importance for Interactive Digital Storytelling (Mateas and Sengers, 1999). It is a matter of presenting to the recipients an interesting and exciting story, but not about modelling of the author's or the audience's tasks. The following attempts take into consideration the requirements of presenting interactive stories.

3.2.1 Character-Based Approach

This approach assumes, that exciting stories arise automatically by the interaction between the recipients and autonomous agents. Hence, the agents feature modules for the perception, for a knowledge base, for their state as well as aim(s) and planning algorithms. Based on this, they make decisions independently (Russell and Norvig, 1995).

With these systems the stories originate by the moment of interaction. Hence, they are generative in the highest degree. The player has the greatest possible leverage on the course of the story. Such systems are also called *Emergent Narrative*.

3.2.2 Action-Based Approach

The basis of the action-based approaches lies in the abstraction of personal motivations, experiences and the destinations of the characters, that are involved in the action (Propp, 1958). The actions of the persons are motivated less by their own interests, but even more by the narrator's interests. Therefore the action might (and should) contradict the characters interests.

3.2.3 Rule-Based Approach

The rule-based approach tries to formalise dramatic structures and to conceptualise them in rules. Concrete actions are generated by a given set of rules.

However, it seems very unlikely that the creative and artistic essence of a drama can be reduced to a set of machine-understandable rules (Bringsjord and Ferrucci, 1999). If the story exists out of known parts and these have been rated by an author, a set of rules may be used for the presentation (Crawford, 1999).

3.2.4 World-Based Approach

World-based approaches combine Emergent Narrative with simulation – and exactly this raises a problem: A simulation is such complex that it requires the description of needlessly many details. Thus, the concentration on the essential dramaturgical elements is hindered (Braun, 2003, p 63).

3.2.5 Hierarchical Approach

Hierarchical approaches tries to avoid the established disadvantages by the combination of the existing attempts. They introduce four abstraction levels (Aylett, 1999): The superior action (e.g., Propp's functions), the action sequences at character level for the different action variations of the particular functions, as well as the cognitive and the reactively physical behaviour.

Because of this partitioning this approach is extremely adaptable. The more levels are not influenced by the author, the more autonomous the overall system is. A consideration of both possible extreme cases shows this impressively: If every level is given by the author, a linear story results. If, however, every level can freely improvise, the story is constructed completely at run time – it concerns Emergent Narrative.

3.2.6 Appraisal

Unfortunately, the character-based approaches don not have any knowledge about exciting and presentation-worthy actions. Completely dull details are told in full length. It is very difficult to achieve coherence of the action and suspense.

Rule-based approaches retire because of their difficult or even impossible implementation. Even if a realisation would be possible, the author-unfriendly abstraction might complicate the usability needlessly.

Not being author-friendly excludes the world-based approaches, too. Beside the disadvantages of the character-based approaches, the vast amount of details to be described are an additional obstacle.

The concepts of the present engine are based on the action-based attempts, because action is pushing the achievement of suspense (Field, 1992). However, the overall system should correspond to the hierarchical approach in which the coherence engine is embedded.

3.3 Storytelling Projects

Often computer games are regarded as interactive stories. The following distinguishing features can be made (Murray, 1998, p 140):

- Games provide *one* form of activity.
- Games often require learning a skill.
- Games use language instrumentally without describing nuances of emotions.
- Games contain a diminished and schematised world view.
- Games are organised in moves and destination-based.

Especially adventure games are treated as equal with Digitally Storytelling or Interactive Fiction. Nevertheless, the main attention of adventure games are solving of riddles, while Digital Storytelling requires a story-line as well as a characterisation of the characters (Goetz, 1994). However, both are developed too briefly in adventure games (Crawford, 2000, p 240): The immediate connection between the background story and the actions of the player doesn't exist, the players' actions are only rudimentary expressed in the body language of their characters, and the players don't implicate other characters of the story (Aylett, 1999). In addition, the player

cannot fully unfold his abilities for linguistic communication and social interaction (Aarseth, 1997).

Shooter games point out action, animation, spatial thinking, resource management and special effects, however, neglect action and characters (Crawford, 2000, p 240). Immediate physical behaviour exceeding action sequences are missing. The ability of saving scores is absolutely problematic, because coming back to the point that has been left before may degrade the coherence of the story (Aylett, 1999).

3.3.1 Oz

The research project Oz of the Carnegie Mellon University (Bates, 1992) is a typical representative for Emergent Narrative and, has performed pioneering work for the research of the interactive drama (Mateas, 1999). The project has concentrated upon the development of believable agents to let interoperate them with the players as authentic characters. Hence, a suspenseful story should be created autonomously.

Because this assumption has not been confirmed, a concept for a drama manager has been developed (Mateas and Stern, 2000). Unfortunately, this has never been implemented completely (Weyhrauch, 1997). The concept consisted in determining a choice and sequence of plot points with the introduction of corresponding transitional scenes by unidirectional brief commands, that should advance the story-line. The drama manager should intervene in the course of the story only every now and then, otherwise the agents should remain widely autonomous.

An additional stage manager should take over the control of the story-line. At last this has admitted no autonomy of the agents any more, any independent action mechanisms had to be avoided.

3.3.2 Erasmatron

In this world-based project a microeconomic model allows the characters to palter among each other. The lowest abstraction level provides the realistic behaviour of the characters, as the movement of the characters on the right stage. The purposeful behaviour of the characters is predefined by a clause-based approach.

As in natural languages, a clause exists of subject, property, verb and other elements like indirect and prepositional properties as well as adverbial clauses and subordinate clauses. Characters may adopt the role from subjects as well as from properties. As a basis component of the operation, verbs express actions. The author defines corresponding roles for every verb. These roles are adopted by the actors as a subject or property. For instance, `hide` may be associated with the role of the pursuer. For each role dramaturgical sensible reactions are defined by verbs. Following behaviours have been implemented in Erasmatron: Reactions, planning, plan performing by the characters, lies, sniffing out secrets, deferment of deliberate action because of observation of wrong persons as well as anticipation of likely reactions to a action taken into consideration. However, the system is not laid out on a superior timing. This happens indirectly by the verb `PlotPoint`, however, the system is unfitted to this purpose.

Erasmatron is one of few projects which bear up against an implementing. However, the problem is the complexity of the production of a story for the system, so up to now no author had been able to implement a story world (Crawford, 1999).

3.3.3 DEFACTO

DEFACTO adopts the Aristotle's concept of conflict and resolution with a rule-based system (Sgouros, 1999). The characters come in conflict with each other while tuning in to their aims (Sgouros, 2000). These conflicts are increased up to the climax in which the decision on the denouement of the story is made and all conflicts are resolved successively. The most dramatically effective possibilities are chosen out of all available actions. The player adopts a role and is involved into the action very often.

DEFACTO consists of a story engine, a module for natural-speaking output and a multimedia interface. However, no published results are to be found and the demonstrator (DEFACTO, 2006) is too smallish to be meaningful.

3.3.4 Façade

The *Interactive Storyworld Façade* is a simulation including a drama manager. It integrates interaction at story level (drama management), believable agents and an uncomplex natural language processing in the context of a graphic interactive first-person drama on a real-time basis. The discourse is not turn-based, but continuously and real time.

Façade is based on so-called *beats* as a basis for interaction and plot – they propel, so to speak, like a heartbeat the story. The beats are a collection of behaviour, linked with a certain situation or a certain context. Beats are annotated by the author with preconditions and their impact on the history. The player has in turn impact on the outcome of generally held beats and can influence thus the course of the story-line.

For the production of interactive stories four authoring languages have been developed:

- A Behaviour Language (ABL):
A reactive planning language
- Natural Language Understanding (NLU):
On pattern-matching based template language for the language input.
- Reaction Decider Language:
Selects reactions from discourses and suggests reactions.
- Beat Sequencing Language:
Language specialised on drama management.

Façade is one of the few and far realisations of an Interactive Storytelling environment that has been implemented completely and for that at least one interactive history has been realised. With a free downloadable demonstrator (Mateas and Stern, 2006) this can be evaluated by everyone.

3.3.5 IDtension

IDtension consists out of the following central components (Szilas, 2003): The *World of Story* to manage the basic elements and their states, the *Narrative Logic* computes all possible operations of the characters, *Narrative Sequencer* selects the operations with the most interesting narrative effect, the *user model* regulates the state of the user and his impact on the story, finally, the *Theatre* shows the story. While the system IDtension itself is very promising, it also has to fight with the usability for authors: The production of stories happens very abstractly and does not correspond therefore to the creative process authors are used to (Szilas et al., 2003).

3.3.6 alVRed

alVRed is, actually, an authoring environment for “Non-Linear Dramaturgy in Virtual Reality” environments (Wages and Grützmaker, 2004). It offers a lot of interesting modules for authors for the production and presentation of non-linear content with narrative metaphors. However, the major disadvantage of the used story engine is that it is based on branching. Because, however, many other portions for interactively visual presentations have been realised, it may be used in the presentation level including the first processing of user’s operations.

3.3.7 StoryEngine

The primality Propp model based StoryEngine had been realised by Norbert Braun and Dieter Grasbon at the Zentrum für Graphische Datenverarbeitung e.V. (Computer Graphics Centre) in Darmstadt, Germany (Grasbon and Braun, 2001). Basically the StoryEngine has a knowledge about the story model and the dependence between the morphological functions introduced by Propp. The author has to fill a database with a huge number of scenes. A function must be assigned to each of these scenes. Depending on context, the scene and the play time the story engine chooses an appropriate scene out of the functions. The context indicates which variables are important for this scene or for the story-line. There are six characteristics for the context:

- Actor: Only dramatic persons in the context appear . Fifty persons on the stage can stay, speak, trade and interoperate with the player. As long as they are no dramatic person, they are not described.
- Magical Assistant: The Magical Assistant can have different occurrences. It is important that the Magical Assistant helps the hero to defeat the enemy and to undo the misfortune later.
- Misfortune: The misfortune the initiates the story.
- Background: The background knowledge. The events which have happened or occurrences which has to be reminded – knowledge of the general public.
- Sign: Hints to occurrences, thus the hero’s knowledge.
- Risk: The risk that a misfortune happens.

Each of these six context kinds has three characteristics: The context can be anew in the story, it is required in the scene or it disappears from the story. Hence, scenes can be described at an abstract level, and the StoryEngine can generate thus stories according to the Propp model, without inconsistencies appear. Furthermore the StoryEngine attends that scenes are played properly at the current place and that the overall play time complies to the pre-setting.

3.3.8 Appraisal

Most of the projects introduced here try either to leave the generation of the story to the computer (Oz, Erasmatron, DEFACTO and IDtension), or they fall back on the branching approach (alVRed) which is not suited for the production of contents with bigger complexity. Façade uses another approach which leaves the regulation of the progression at several levels sometimes more to the author, sometimes to the engines in co-operation with the user's interactions.

The implementation of the coherence engine for Atlantis University will be based on the StoryEngine. This is, because the underlying Propp Model fits best the project's needs of modelling and organising the (pre-) authored content. The action based approach is realised using contexts as the coherence parameter. The flexibility of its structures enables the creation of stories that are completely linear, non-linear with the guaranty of coherence up to random content presentation. Hence, this gives the authors the possibility of creating a linear content at the beginning and de-linear it step by step (Schneider et al., 2003). The content-model based structuring enables mixing of related content of different authors and the adaptive presentation to fit the different learner types.

4 Conclusion and Future Work

The decision way presented in this paper results in using the StoryEngine as a basis for implementing non-linear Extended Blended Learning. Beside its appropriate methodical and technical background it has already shown that it's applicable for edutainment purposes in various projects (Göbel et al., 2003).

However, the existing StoryEngine can't be adopted as is. First of all, the original StoryEngine is confined to Propp's model. Of course, the Atlantis University project needs the flexibility to build pedagogical based models. Second, its architecture has to fit into the SOA-based Atlantis University environment. Furthermore, it has to be robust for long term usage, because it may be intended to plan whole courses.

The prototypical implementation of the "Coherentor" named coherence engine is nearly finished. After some technical tests the engine will be evaluated with pedagogical models as Anchored Instruction (Bransford et al., 1990), Cognitive Apprenticeship (Brown et al., 1989), Goal Based Scenarios (Schank, 1995) or 4C/ID (van Merriënboer and Kester, 2005). Therefore, models will be realised in co-operation with pedagogues. Additionally, further integration for real live usage has to be done. And, of course, an authoring environment has to be developed, because a presentation without content is useless. At least, an evaluation of the environment with students within a real lecture scenario is planned.

References

- Aarseth, E. (1997). *Cybertext: Perspectives on Ergodic Literature*. The Johns Hopkins University Press, Baltimore & London.
- Aylett, R. (1999). "Narrative in Virtual Environments – Towards Emergent Narrative". In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA. AAAI Press.
- Bailey, P. (1999). "Searching for Storiness: Story-Generation from a Reader's Perspective". In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA. AAAI Press.
- Barthes, R. (1996). "Introduction to the Structural Analysis of Narratives". In Onega, S. and Landa, J. A. G., editors, *Narratology*, pages 45–60, New York, NY. Longman.
- Bates, J. (1992). "The Nature of Characters in Interactive Worlds and The Oz Project". Technical Report CMU-CS-92-200, Carnegie Mellon University, Pittsburgh, PA. School of Computer Science.
- Bleimann, U. (2004). "Atlantis University – A New Pedagogical Approach beyond E-Learning". *Campus-Wide Information Systems*, 21(5):191–195.
- Bleimann, U. and Röhl, F. J. (2006). "Extended Blended Learning – Innovative Lernszenarien für die Hochschule". In *Querschnitt (Beiträge aus Forschung und Entwicklung der FH Darmstadt)*, volume 01/06, Darmstadt, Germany.
- Boella, G., Damiano, R., and Lesmo, L. (1999). "Understanding Narrative is Like Observing Agents". In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA. AAAI Press.
- Bransford, J. D., Sherwood, R. D., Hasselbring, T. S., Kinzer, C. K., and Williams, S. M. (1990). "Anchored Instruction: Why We Need It and How Technology Can Help". In Nix, D. and Spiro, R., editors, *Cognition, Education, and Multimedia: Exploring Ideas in High Technology*, pages 115–141. Lawrence Erlbaum Associates, Hillsdale, New Jersey Hove and London.
- Braun, N. (2003). *Nonlinear Storytelling: Programmierter, interaktiver Narrationsansatz für kontinuierliche Medien*. PhD thesis, Technische Universität, Darmstadt.
- Bringsjord, S. and Ferrucci, D. A. (1999). "Artificial Intelligence and Literary Creativity: Inside the Mind of Bbrutus, a Storytelling Machine". In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA. AAAI Press.
- Brown, J. S., Collins, A., and Duguid, P. (1989). "Situated Cognition and the Culture of Learning". *Educational Researcher*, 18(1):32–42.
- Campbell, J. (1999). *Der Heros in tausend Gestalten*. Insel Verlag, Frankfurt am Main.
- Chatman, S. (1978). *Story and Discourse. Narrative Structure in Fiction and Film*. Cornell University Press, Ithaca, NY.
- Crawford, C. (1999). "Assumptions underlying the Erasmatron interactive storytelling engine". In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA. AAAI Press.
- Crawford, C. (2000). *Understanding Interactivity*. Chris Crawford. www.erasmatazz.com/book, not available at the moment (Accessed 15th April 2007).
- Curran, L. (2004). "Feelin' Groovy". <http://www.elearnmag.org/subpage.cfm?section=articlesarticle=10-1>. (Accessed 23rd May 2007).
- DEFACTO (2006). "DEFACTO Demonstrator". www.cslab.ece.ntua.gr/~defacto/demo/DefactoDemo.htm. (Accessed 11th April 2007).
- Davis, M. and Travers, M. (2002). "A Brief Overview of the Narrative Intelligence Reading Group". In Mateas, M. and Sengers, P., editors, *Narrative Intelligence*, Amsterdam. John Benjamins Company.

- Field, S. (1992). *Das Handbuch zum Drehbuch: Übungen und Anleitungen zu einem guten Drehbuch*. Zweitausendeins, Frankfurt am Main.
- Gagné, R. M., Briggs, L. J., and Wager, W. W. (1992). *Principles of Instructional Design*. Harcourt Brace Jovanovich College, Fort Worth.
- Goetz, P. (1994). *Interactive Fantasy I*, chapter Interactive Fiction and Computers, pages 98–115. Crashing Boar Books.
- Grasbon, D. (2001). “Konzeption und prototypische Implementation einer Storyengine: Dynamisch-reaktives System zum Erzählen nichtlinear-interaktiver Geschichten bei größtmöglicher Spannung, gedanklicher Immersion, Identifikation und Motivation des Spielers”. diploma thesis, Technische Universität, Darmstadt.
- Grasbon, D. and Braun, N. (2001). “A Morphological Approach to Interactive Storytelling”. In Fleischmann, M. and Strauss, W., editors, *Cast’01 // Living in Mixed Realities*, volume special issue of *netzspannung.org/journal*, pages 337–340, Birlinghoven. FhG – Institut Medienkommunikation (IMK) and German Federal Ministry of Education and Research (bmb+f).
- Göbel, S., Schneider, O., Wichert, R., Hoffmann, A., Dechau, J., Lohde, U., Iurgel, I., and Feix, A. (2003). “Storytelling based Edutainment Applications”. In *Computer Graphic Topics*, volume 15 of *Reports of the INIGraphicsNet*, pages 16–19, Darmstadt. Technische Universität Darmstadt – Fachgebiet Graphisch-Interaktive Systeme, Zentrum für Graphische Datenverarbeitung e.V., Fraunhofer-Institut für Graphische Datenverarbeitung, INIGraphicsNet.
- Herman, D. (1999). “Spatial Cognition in Natural-Language Narratives”. In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA. AAAI Press.
- Komerell, M. (1988). *Lessing und Aristoteles – Untersuchung über die Theorie der Tragödie*. Klostermann, Frankfurt am Main.
- Lang, R. R. (1999). “A Declarative Model for Simple Narratives”. In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA. AAAI Press.
- Linane-Mallon, B. and Webb, B. (1997). “Evaluating narrative in multimedia.”. In *DSV-IS’97, 4th International Eurographics Workshop*, pages 77–92, Granada, Spain.
- Mateas, M. (1999). “An Oz-Centric Review of Interactive Drama and Believable Agents”. In Wooldridge, M. and Veloso, M. M., editors, *AI Today: Recent Trends and Developments*, volume 1600 of *Lecture Notes in Computer Science*, Berlin/Heidelberg. Springer.
- Mateas, M. and Sengers, P. (1999). “Introduction to the Narrative Intelligence Symposium”. In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA. AAAI Press.
- Mateas, M. and Stern, A. (2000). “Towards Integrating Plot and Character for Interactive Drama”. In Dautenhahn, K., editor, *Proceedings of the 2000 Fall Symposium: Socially Intelligent Agents: The Human in the Loop*, pages 113–118, Menlo Park, CA. AAAI Press.
- Mateas, M. and Stern, A. (2006). “Façade Download”. www.interactivestory.net/download. (Accessed 12th April 2007).
- Meech, J. F. (1999). “Narrative Theories as Contextual Constraints for Agent Interaction”. In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA. AAAI Press.
- Murray, J. H. (1998). *Hamlet on the Holodeck: The Future of Narrative in Cyberspace*. MIT Press, Cambridge, MA.
- Niegemann, H. M., Hessel, S., Hochscheid-Mauel, D., Aslanski, K., Deimann, M., and Kreuzberger, G. (2004). *Kompodium E-Learning*. X.media.press. Springer-Verlag, Berlin Heidelberg New York.
- Propp, W. J. (1958). “Morphology of the Folktale”. In *International Journal of American Linguistics*, volume 24. Indiana University of Research Center in Anthropology, Folklore, and Linguistics, Bloomington, IN.

- Russell, S. and Norvig, P. (1995). *Artificial Intelligence: A Modern Approach*. Prentice-Hall, Englewood Cliffs, NJ.
- Schank, R. C. (1995). *Tell Me a Story: Narrative and Intelligence (Rethinking Theory)*. Northwestern University Press, Evanston, IL.
- Schell, J. (2002). "Understanding Entertainment: Story And Gameplay Are One". In Jacko, J. A. and Sears, A., editors, *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications*, chapter 43. Lawrence Erlbaum Associates, Florence, Kentucky.
- Schneider, O. (2002). "Storyworld Creation: Authoring for Interactive Storytelling". *Journal of the WSCG*. Plzeň, Česká republika.
- Schneider, O., Bleimann, U., Phippen, A. D., and Harriehausen-Mühlbauer, B. (2006). "Non-Linear Extended Blended Learning,". In *Proceedings of the Sixth International Network Conference (INC2006)*, pages 377–384, Plymouth, UK. Network Research Group, University of Plymouth.
- Schneider, O., Braun, N., and Habinger, G. (2003). "Storylining Suspense: An Authoring Environment for Structuring Non-linear Interactive Narratives". *Journal of the WSCG*. Plzeň, Česká republika.
- Sengers, P. (2000). "Narrative Intelligence". In Dautenhahn, K., editor, *Human Cognition and Social Agent Technology*, Advances in Consciousness, Philadelphia, PA. John Benjamins Publishing Company.
- Sgouros, N. M. (1999). "Dynamic Generation, Management and Resolution of Interactive Plots". *Artificial Intelligence*, 107(1):29–62.
- Sgouros, N. M. (2000). "Using Character Motives to Drive Plot Resolution in Interactive Stories". *Applied Intelligence*, 12(3):239–250.
- Spitzer, M. (2002). *Lernen. Gehirn-Forschung und die Schule des Lebens*. Elsevier, Spektrum, Akademischer Verlag, München, Heidelberg.
- Springer, J., Kajder, S., and Brazas, J. B. (2004). "Digital Storytelling at the National Gallery of Art". In Bearman, D. and Trant, J., editors, *Museums and the Web*, Toronto. Archives Museum Informatics.
- Szilas, N. (2003). "IDtension: A Narrative Engine for Interactive Drama". In Göbel, S., Braun, N., Spierling, U., Dechau, J., and Diener, H., editors, *Proceedings of the Technologies for interactive Digital Storytelling and Entertainment (TIDSE) Conference*, Darmstadt. Zentrum für Graphische Datenverarbeitung e.V., Fraunhofer IRB Verlag.
- Szilas, N., Marty, O., and Réty, J.-H. (2003). "Authoring highly generative Interactive Drama". In Balet, O., Subsol, G., and Torguet, P., editors, *Virtual Storytelling; Using Virtual Reality Technologies for Storytelling, Second International Conference, ICVS 2003, Proceedings*, Lecture Notes in Computer Science, Heidelberg. Springer-Verlag.
- Tobias, R. B. (1999). *20 Masterplots: Woraus Geschichten gemacht sind*. Zweitausendeins, Frankfurt am Main.
- Wages, R. and Grützmaker, B. (2004). "Schlussbericht BMBF-Projekt alVRed: Nichtlineare Dramaturgie in VR-Umgebungen 2001 - 2004". Technical Report 01IRA06A, Institut LMR – Gesellschaft zur Förderung künstlerischer Informatik e.V., Köln.
- Weyhrauch, P. W. (1997). *Guiding Interactive Drama*. PhD thesis, Carnegie Mellon University, Pittsburgh, PA. CMU-CS-97-109.
- Wilder, B. (1951). *The Big Carnival (Reporter des Satans)*. Paramount Pictures.
- van Merriënboer, J. J. G. and Kester, L. (2005). "The Four-Component Instructional Design Model: Multimedia Principles in Environments for Complex Learning". In Mayer, R. E., editor, *The Cambridge handbook of multimedia learning*, pages 71–93. Cambridge University Press, Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo.

G.4 Inside Coherence: Concept for a Non-Linear eLearning Solution

Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen, B.: *Inside Coherence: Concept for a Non-Linear eLearning Solution*, Proceedings of the Seventh International Network Conference (INC2008), Plymouth, UK, 8–10 July, pp 223–233, ISBN: 978-1-84102-188-1 (2008)

© 2008 University of Plymouth

Permission to reproduce this paper in this thesis has been granted by University of Plymouth.

Proceedings may be obtained at:

<http://www.lulu.com/shop/steven-furnell-and-paul-dowland/proceedings-of-the-seventh-international-network-conference-inc-2008/paperback/product-2831552.html>

Inside Coherence: Concept for a Non-Linear eLearning Solution

Oliver Schneider^{1,2,3}, Udo Bleimann^{1,2}, Andrew D. Phippen³
and Bettina Harriehausen-Mühlbauer²

¹Centre for Advanced Learning, Media and Simulation (igdv),
²Institute for Applied Informatics Darmstadt (aiDa),
University of Applied Sciences Darmstadt, Germany
³Information Security and Network Research Group, University of Plymouth,
United Kingdom
eMail: OliFFM@web.de

Abstract

This paper describes a system that selects and presents non-linear learning content and shows how such a system has to be designed. Hence, this paper describes what functionality the non-linear eLearning system must provide. An Interactive Digital Storytelling based approach has been chosen. It is shown how this concept has been adapted and extended for the purpose of non-linear Extended Blended Learning. Furthermore a general concept for an extremely adaptable engine has been designed, implemented and tested.

Keywords

eLearning, non-linear extended blended learning, interactive digital storytelling

1. Introduction

As the successor of Blended Learning, Extended Blended Learning overcomes the pure eLearning obstacles by integrating eLearning with face-to-face learning and project-based learning (Bleimann and Röhl, 2006). The first project realising this approach is Atlantis University (Bleimann, 2004). Within the scope of this project a system has been designed that provides methods for presenting non-linear content.

Such a system should present non-linear content in coherent way. To fit into the Extended Blended Learning environment it also should be user-adaptive and independent of any content (Schneider *et al.* 2006). The system should be able to provide coherence, so that module content is not lined up pointlessly or contradictory. For example a student should not be able to complete an assessment for object-oriented content prior to encountering and learning the corresponding material. In any case, consistency must be guaranteed. The module must be able to lead to a successful end in any situation and with any chosen path, except in the event of failed exams or missed necessary exercises.

The learner's personal learning types (Brückner, 2005) should decisively influence the path through the module's interactive content. Also conceivable are content-sections that question knowledge. All these results should influence the module. The

eLearning environment should work completely regardless of any concrete content. This signifies that it is not only independent from the media type, whether the content is a video or a set of slides, but also that the system should be usable for each kind of learning content and learning styles.

2. Related Work

Most of the present learning environments (Baumgartner *et al.* 2002, Niegemann *et al.* 2004) such as Blackboard (Blackboard Inc., 2008) and TopClass (WBT Systems Ltd., 2008) do not support adapting content to the users' actions, behaviours or learning styles (van Rosmalen and Boticario, 2005). Systems like ELAT (Gojny, 2003), Moodle (Gertsch, 2007) and, ILIAS (Ilias, 2008) that are based on newer specifications such as SCORM 2004 (Alexandria ADL Co-Laboratory, 2008), EML (LearningNetworks, 2008) and its successor Learning-Design (Koper and Tattersall, 2005) fulfil the demands of interaction and adaptation, but neither support time management nor provide the means to author more complex content, because these features are based on branching (Schneider *et al.* 2006) in this systems.

A modified storytelling-system fits best to the demands of Extended Blended Learning (Schneider *et al.* 2006); for this research, the *StoryEngine* based on Propp's story model (Grasbon, 2001) is most suitable for Atlantis University (Schneider *et al.* 2007).

3. An Interactive-Storytelling Approach

Propp analysed Russian fairy tales and could verify a subset of a total of 31 action functions in every story (Propp, 1968). These functions are arranged in a generally static order, but may be repeated individually or in groups (Grasbon, 2001 p 63). Several variations (scenes) of a function can exist and all these functions are linked by dependencies (Grasbon, 2001 p 64).

The principle of the summarisation of scenes into functions and relations, to repeat and to apply conditions, can be transferred to the needs of Extended Blended Learning. However, Propp's functions do not fit directly to the Extended Blended Learning scenario.

Because of the mixture between the three pillars, the execution of various Extended Blended Learning modules differ. Thus, one single model with firmly prescribed functions is not adaptable enough to describe those variations. The *StoryEngine* (Grasbon, 2001) must be advanced in this respect so that it can process different models and that each of these models is able to define its own functions.

The Propp-model is originated in the fairy-tale world and therefore did not consider interaction (Grasbon, 2001 p 70). The functions are not polymorphic; all variations always return the same result. Grasbon has extended the Propp-model by splitting some functions into two part-functions, so that interaction becomes possible. Within the scope of Extended Blended Learning all functions should be polymorphic, so that they can influence the action.

4. Components and Design of a Corresponding System

In spite of the necessary extensions to the model of Grasbon's engine its top level-design can be presented. Figure 1 shows the design of this engine.

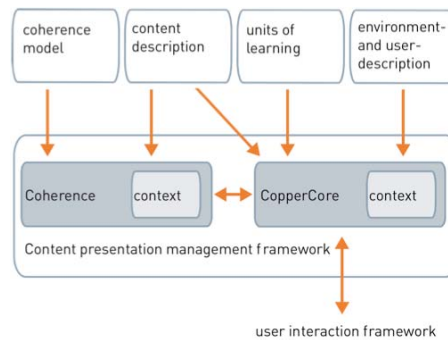


Figure 1: System's overall architecture

The core is the so-called Coherence-Engine that corresponds to Grasbon's StoryEngine. In order to operate, this engine needs the data of the top-level modules. It also may manipulate this data to change, for example, the contexts. It works closely with CopperCore (Martens and Vogten, 2005), which is used as the content-engine and therefore is the interface to the user interaction framework.

4.1. Scenes vs. eLearningContent-Sections

Many characteristic features of the scenes of interactive stories are transferable to this context. In the Atlantis University Project a scene can be compared with a learning content-section or a learning unit. For example, the subjects Addition and Subtraction could correspond to a scene within a mathematics-story. Scenes are small parts of the story, but are coherent and are self-contained, so the scene's unity is guaranteed (Field, 1992). The temporal unity should arise by the organisation of the subjects in scenes, so that a subject can be graduated by a session (e.g., lesson) and is not interrupted by other subjects.

In this respect the local unity is interesting because the concept of Extended Blended Learning intentionally jumps between the learning styles. A content-section should refer only to a subject within a learning style accordingly to the learning content-section's corresponding characteristics. Even if addition is explained within an eLearning-scene followed by a face-to-face lecture also explaining the top addition, they are still different scenes.

While not directly applicable to the concept of the story, all scenes of Atlantis University should be dramatic scenes, and should propel the content by either itself or by user's interaction (Field 1992). For this purpose every scene should be able to find out at least whether it was finished successfully or not.

Because this paper is not about storytelling but learning environments, scenes are called *content-sections*.

4.2. Content-Types

To be able to automatically tie single scenes with each other, they are categorised like Propp's concept of functions. In the scope of Atlantis University the user can define these functions and because the functions typify scenes and design relations between the groups of content-sections, they are called *content-types*. Figure 2 shows some examples of content-types.

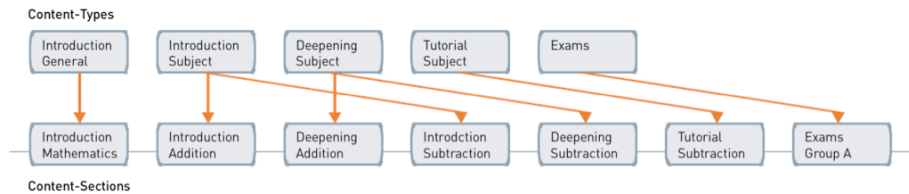


Figure 2: Mathematics module composed of content-types

For example, the content-type *Introduction General* characterises the content-sections that are needed at start of a lecture. The following three content-types refer in special subjects within the lecture. The content-type *Deepening Subject* could characterise content-sections for deepening addition and deepening subtraction. The example lecture repeats the content-types, but not the content-sections. The content-type *Exams* at the end characterises different assessment sheets as content-sections to avoid plagiarism.

The example already points clearly why some content-types have to be repeatable and why relations can exist between them. If content-types are defined for all subjects and only have a linear relationship, all non-linearity would be lost and offer no benefit over the usual eLearning-system approach. It would also be rather pointless to begin with an introduction about addition, then to continue with deepening subtraction and to carry on with a practise for multiplication. The deepening of a subject should always follow an introduction on the same subject.

4.3. Contexts

Contexts provide coherences and dependencies between the content-sections. They serve as variables for the communication between content-sections, module-contents and systems. The engine differs between three different types:

- **Private** contexts are set while presenting content-sections exclusively by the coherence-engine. Having completely presented a content sequence, these kinds of contexts are no longer valid. Their purpose is tying together the single content-sections coherently while presenting them.
- **Public** contexts are likewise set and maintained by the engine. However, this type of contexts can be used by each of the learning-environment's content.
- **External** contexts can be used by the engine as well as by any components of the overall system.

Contexts can be organised in groups that may be further nested in sub-groups. Thus, a context tree can be developed. Several contexts can be checked in an interrelated manner by calling a context-group.

In contrast to usual computer languages every context has two values stretching a value range. For example, the context *acceptedAge* could be set with the minimum value *18* and the maximum value *30*. The content-sections needing these contexts likewise define a value range that is compared to the set range. The comparison delivers a standardised return value between *0* and *1* that is multiplied by a weighting value that is likewise defined in the context query. This value's range is defined between *-1* and *1* and serves to evaluate the result of the corresponding query. The effect reaches fluently from “must not” (*-1*) through “should not” and “should” until “must” (*1*). Hence, the limit values *-1* and *1* signify compelling requirements.



Figure 3: Context comparison modes

The concept provides two different query-modes, illustrated Figure 3. The first mode is overlapping. In this mode the system investigates how much the set context and the needed area overlap. Using overlapping the result is more than *0* as soon as the set context overlaps with the needed one. *1* is returned only if both value ranges are identical. For example, a student could state that he likes to be presented with learning content-sections that are designed for students aged between *20* and *30* years. If this context is defined to *18 – 30*, the comparison result is a value near to *1*. However, if the learner-type should be checked, the second query mode is used. In this case the nearness between the set and the requested values is checked. *1* is returned if the values touch. With increasing distance the value becomes smaller and smaller and approaches *0*.

4.4. Coherence-Model

To order the content-types in a sensible sequence and to present coherent stories, the StoryEngine needs a story-model that defines the story-process (Grasbon, 2001 p 62). In the introduced concept this is the coherence-model's task. An XML-dialect is used to put content-types in orders and loops. The model is not related to the content; it only defines the process in relation to the content-types. Arbitrarily many modules can define content-sections for the content-types of a model. For example, a model called *standardLecture-linear* could be deposited in the system, so that every lecturer can provide his own content based on this model.

A model orders weighted content-types coarsely. The weighting defines the necessity of the presentation with a span from *-1* to *1*. Only the limit values force or deny a presentation. If the weight of a context-type is smaller than *1* (for example *0.99*), paths through a model lacking this content-type would be also possible. However, a rating algorithm would value these paths rather badly, because the necessity of *0.99* is still very high.

Loops iterate their enclosed content-types, until one of the following three exit conditions is fulfilled:

- Within the loop a context has been set that is used as exit condition.
- The content-types within the loop have no more content-sections that can be appended to a sensible path. This can happen either because all available content-sections have been already presented, or because every remaining content-section cannot be presented due to the lack of fulfilled preconditions. If the loop exits because of this condition, it looks for an exit-content-section that must be defined in the loop condition, and presents it.
- Presenting any further content would make the total duration too long, so the coherence-model could not be presented completely. Also in this case an exit content-type must be determined.

To define dependence between two content-types, a *dependencies* block is used in the tail of the coherence-model. Again, the limit values -1 and 1 are exclusive criteria. A dependency weighted -1 means that a content-type must not have been presented as a precondition for presenting the dependent type.

4.5. Content-Description

Whereas the coherence-model regulates only the general processing of content-types and can therefore be used for many course-modules, the content-description describes the real content of the respective modules. Therefore, every module needs a content-description that states which content-sections may be presented in a lecture, how important the single content-sections are, which conditions are tied to present a concrete content-section and which conditions are created by it. Also a minimum, a maximum and an average presentation duration is defined. This is used by the coherence-system to determine the total duration and take over the time management.

Although the content-description documents refer to concrete content, for example a small set of slides or a video, they contain only meta-data relevant to the coherence-system. For example, it may only describe that the content-section *DeepeningAddition* takes between 30 and 90 minutes and that before this content-section an *IntroductionAddition* should have been already presented. In this manner the coherence-system remains independently of real content.

This context description references all needed content-types of the model and fills them with content-sections. Each of these content-sections represents a concrete learning content – a video, a set of slide or the similar. If the coherence-model wants to present a content-section of the content-type *Introduction*, it is searched in the content-description.

Each content-section is weighted within a range of -1 to 1 , so that the coherence-system can recognise the importance of a content-section: The greater the value, the more important is the content-section. The duration a content-section takes is also

given minimally, at most and on an average. With the help of these values the coherence-system can carry out the time management

Internal dependencies are needed for a sensible content. It is not a matter only of simply lining up content-sections out of predefined content-types, it must be also possible that dependencies can be defined between the content-sections. Therefore contexts can be set if the content-section has been completed successfully and defined as needed as a prerequisite for presenting a content-section. Indeed, context-conditions are not compelling and not binary. Relations can be also defined by corresponding weightings that could be described best as “would be nice if “or” the closer to the desired value the better.

5. Learning Path Construction

The interaction of the components introduced in the previous section allows the production of paths through the content-space. Originating from the meta-data all possible content-sections for a module are selected and combined to all possible paths corresponding to the coherence-model.

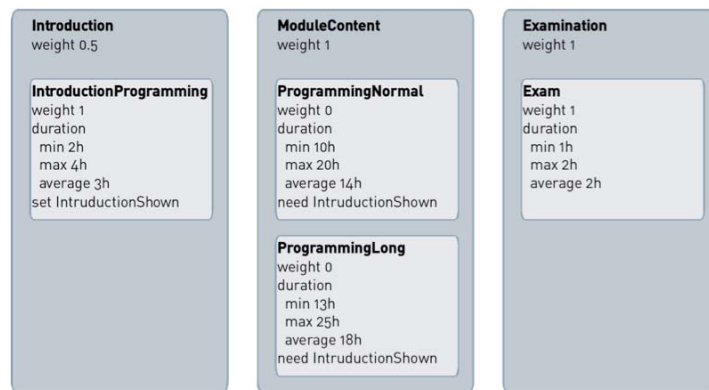


Figure 4: Simple model with content-sections

Figure 4 sketches a simple *Content-Description* with few content-sections and the corresponding *CoherenceModel*.

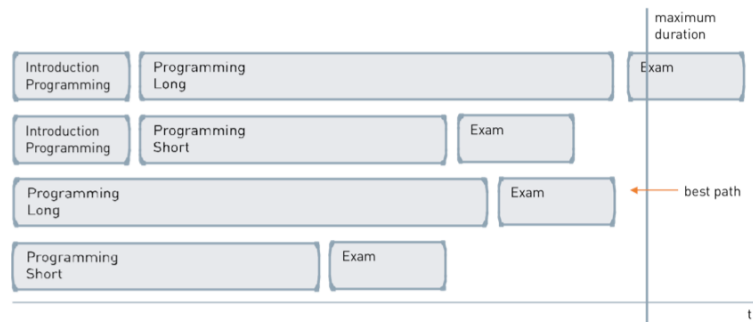


Figure 5: Best fitting path (duration)

Figure 5 illustrates the four possible paths. At first there originate two paths because of the two different content-sections of the type *ModuleContent*. As the model defines a weight of 1 for the content-types *ModuleContent* and *Examination*, both can be considered to be inevitable and therefore have to be combined in all paths and in this order. The *Introduction* is optional because it is weighted 0.5. Thereby two alternative paths arise beside the first two paths. These additional paths lack the introduction.

The vertical line marks the time limit and shows that the first path retires because it is simply too long. Not all content-sections can be presented within the maximum possible duration. The remaining three paths are within the duration, hence they are theoretically presentable. The best possible one must be selected out of these.

For the example in Figure 5 the defined context *IntroductionShown* is ignored. Because neither model nor content-description define or require contexts, the time is the only evaluation criterion for the choice of the best path in this example. The duration should be used optimally, so the system chooses the path that comes up very near to the at most available duration without being longer. Hence, the third path is selected in the figure.

If contexts are defined in the coherence-model, the content-description or both, time is not the only factor to determine the choice of a path. Instead, content-sections can define which contexts have to be set within the path, so that they can be presented. Therefore, the generator will reject paths that have not set these contexts to the appropriate weighting.

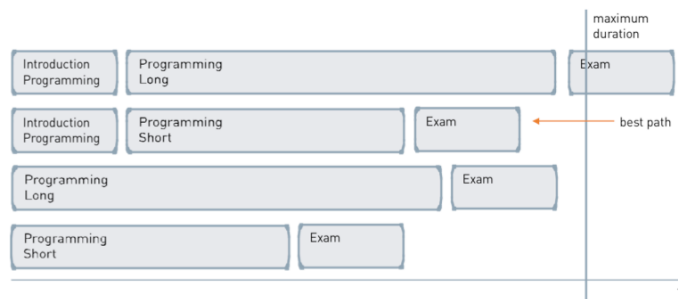


Figure 6: Best fitting path (context)

Figure 6 shows the same coherence-model as the preceding figure. Indeed, this time the defined contexts are taken into account. The *Introduction* sets the context *introductionShown* if it has been presented successfully. Presenting the *moduleContent*-content-sections requires that the context *introductionShown* is set, because it is marked as needed.

Although the model permits further paths by its *contentType*-weights lacking in the content-section *IntroductionProgramming*, the construction algorithm finds out that the paths three and four are not allowed, because the context-conditions are not fulfilled for certain content-sections. Therefore, only path one and two remain as valid paths. Because the first path needs more time than allowed, the second path is selec-

ted as the best one: it remains within the time limits and it fulfils all context-conditions.

6. Conclusion and Outlook

This paper describes a multi-level approach to present non-linear content that avoids the obstacles of other approaches such as *branching* and *string of pearls* (Schneider, 2006). The implementation has been tested successfully with several simple test models and different content-descriptions; hence it fulfils the demands of presenting non-linear content from a technical point of view.

However, the tests have also shown that this realisation has serious performance implications. Even simple models result in billions possible paths. For example, if a lecturer provides fifteen different learning content-sections for each learner-type, this results in up to 6^{15} (470.184.984.576) possible paths. Hence, further research is needed to develop a path-algorithm that reduces the number of the paths to be valued drastically. For example, limiting the search deepness severely could mitigate the situation. The algorithm would have to give up putatively bad paths quite early, even if as a consequence good paths may be lost. Another approach would be an algorithm that is based on depth-first search and only saves the best-rated path instead of all possible paths. Similar applications, such as chess computer or navigation systems, could deliver determining tips.

The application is prepared for integration into the Atlantis University Platform by using web-services. But a Portlet has still to be developed as well as the real connections to the other services (that are also under construction at the time of writing).

For creating real content of course an authoring environment is needed, because lecturers will not feel comfortable in writing XML-code. Furthermore an evaluation for lecturers and students with real models and real content is an essential development.

7. References

- Alexandria ADL Co-Laboratory (2005). "Sharable Content Object Reference Model SCORM". <http://www.adlnet.org/scorm>. (Accessed 28th January 2008).
- Baumgartner, P., Häfele, H., and Maier-Häfele, K. (2002), *E-Learning Praxishandbuch – Auswahl von Lernplattformen*, Studienverlag, Innsbruck, Wien, München, Bozen, Germany
- Blackboard Inc. (2008). "Blackboard » Educate. Innovate. Everywhere". <http://www.blackboard.com>. (Accessed 28th January 2008).
- Bleimann, U. (2004), "Atlantis University – A New Pedagogical Approach beyond E-Learning", *Campus-Wide Information Systems*, 21(5) pages 191–195.
- Bleimann, U. and Röll, F. J. (2006), "Extended Blended Learning – Innovative Learning Scenarios for universities", in Steven Furnell and Paul Dowland (eds.) *INC 2006 Conference Proceedings*, Plymouth 2006, 385–392.
- Brückner, S. (2005), "Structure Patterns Depending on Various Learner Types in an e-learning Context", diploma thesis, Fachhochschule Darmstadt, Germany

- Field, S. (1992), *Das Handbuch zum Drehbuch: Übungen und Anleitungen zu einem guten Drehbuch*, Zweitausendeins, Frankfurt am Main, Germany
- Gertsch, F. (2007), *Das Moodle 1.8 Praxisbuch*, Addison-Wesley Verlag, München, Germany, ISBN 978-3-8273-2514-3
- Gojny, U., Vejrazka, C., Leichtweiß, A., Trebing, C., Röder, H., Knorz, G., Bleimann, U., and Li, G. (2003). "ELATnet – E-Learning Entwicklung im Hochschulbereich". In *Querschnitt (Beiträge aus Forschung und Entwicklung der FH Darmstadt)*, number 17, pages 90–104, Darmstadt, Germany.
- Grasbon, D. (2001), "Konzeption und prototypische Implementation einer Storyengine: Dynamisch-reaktives System zum Erzählen nichtlinear-interaktiver Geschichten bei größtmöglicher Spannung, gedanklicher Immersion, Identifikation und Motivation des Spielers", diploma thesis, Technische Universität, Darmstadt.
- ILIAS open source (2008). "ILIAS Open Source LMS". <http://www.ilias.de>. (Accessed 28th January 2008).
- Koper, R. and Tattersall, C. (2005), editors, *Learning Design*, Springer Verlag, Berlin Heidelberg.
- LearningNetworks (2008). "Educational Modelling Language". <http://www.learningnetworks.org/?q=EML>. (Accessed 28th January 2008).
- Martens, H. and Vogten, H. (2005), "A Reference Implementation of a Learning Design Engine", in Rob Koper and Colin Tattersall (Eds.) *Learning Design*, pages 91–108, Springer Verlag, Berlin, Heidelberg, Germany, ISBN 3-540-22814-4
- Niegemann, H. M., Hessel, S., Hochscheid-Mauel, D., and Aslanski, K., and Deimann, M., and Kreuzberger, G. (2004), *Kompendium E-Learning*, Springer-Verlag, X.media.press, Berlin Heidelberg New York
- Propp, W. J. (1958), "Morphology of the Folktale", in *International Journal of American Linguistics*, volume 24. Indiana University of Research Center in Anthropology, Folklore, and Linguistics, Bloomington, IN
- Schneider, O., Bleimann, U., Harriehausen-Mühlbauer, B., and Phippen, A. D. (2006), "Non-Linear Extended Blended Learning", in *Proceedings of the Sixth International Network Conference (INC2006)*, pages 377–384, Plymouth, UK. Network Research Group, University of Plymouth.
- Schneider, O., Bleimann, U., Phippen, A. D., and Harriehausen-Mühlbauer, B. (2007), "Learn Your Own Way: Decision Way through Narrative Approaches, Methods and Paradigms for Learning Purposes", in Bleimann U., Dowland P. S., Furnell S. M. (Eds.) *Proceedings of the Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007)*, pages 99–114, Plymouth, UK. Network Research Group, University of Plymouth, ISBN 978-1-8410-2173-7
- van Rosmalen, P. and Boticario, J. (2005). "Using Learning Design to Support Design and Runtime Adaptation". In Koper, R. and Tattersall, C., editors, *Learning Design*, pages 291–302, Berlin Heidelberg. Springer Verlag.
- WBT Systems Ltd. (2008). "TopClass E-learning Suite". <http://www.wbt systems.com>. (Accessed 28th January 2008).

G.5 Find Your Own Path: Path Construction Strategy for Atlantis University's Coherence Service

Schneider, O., Bleimann, U., Phippen, A.D., Harriehausen, B.: *Find Your Own Path: Path Construction Strategy for Atlantis University's Coherence Service*, in Bleimann, U. et. al: Proceedings of the Fourth Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2008), Glyndŵr, UK, 6–7 November, p. 46–55, ISBN: 978-1-84102-196-6 (2008)

© 2008 Centre for Information Security and Network Research, University of Plymouth

Permission to reproduce this paper in this thesis has been granted by University of Plymouth.

Proceedings may be obtained at:

<http://www.lulu.com/shop/steven-furnell-and-paul-dowland-and-udo-bleiman-and-vic-grout/sein-2008-proceedings-of-the-fourth-collaborative-research-symposium-on-security-e-learning-internet-and-networking/paperback/product-3654828.html>

Find Your Own Path: Path Construction Strategy for Atlantis University's Coherence Service

Oliver Schneider^{1,2,3}, Udo Bleimann^{1,2}, Andrew D. Phippen³
and Bettina Harriehausen-Mühlbauer²

¹Centre for Advanced Learning, Media and Simulation (igdv),

²Institute for Applied Informatics Darmstadt (aiDa),
University of Applied Sciences Darmstadt, Germany

³Information Security and Network Research Group, University of Plymouth,
United Kingdom
eMail: OliFFM@web.de

Abstract

The Atlantis University Project's focus of research is on improving learning. Therefore, new methodologies are developed as well as supporting technologies. One aim is coherent non-linear eLearning content presentation. Hence, a so-called *Coherence Service* has been developed by the authors. It provides the functionality of creating coherent paths through a pre-authored content space. In this paper, different path construction approaches are described and benchmarked. The chosen algorithm is optimised in many ways and works without faults, but still demands too much resources. Hence, possible solutions are proposed based on the Coherence Service's demands and the benchmark's results.

Keywords

eLearning, non-linear extended blended learning, interactive digital storytelling, path creation

1. Introduction

Since nations more and more begin to undertake the first steps into the direction of knowledge societies, collecting, holding, and transmitting of knowledge is more important than ever. Retrievable knowledge can be mentioned as well as learned abilities, experiences, and social competence.

Indeed, the classical face-to-face lessons in schools and universities have proved itself during centuries. However, they also show clear weaknesses in the changed basic conditions nowadays. Lifelong learning is more and more important, however, solid lecture times normally cannot comply with an occupation. In addition, skills like team ability are only badly trained. Hence, many researchers are continuously seeking for new learning methods.

Already in the middle of the twentieth century the first learning machines had been developed that presented lessons disassembled in statements and questions to the learners. With the help of their responses different learning ways led to the learning

aim. In the fifties this idea contains central eLearning aspects (Schwicker et al. 2005, p 9). It took into consideration the user's individual learning speed as well as the individual learning paths.

With the wide spreading of home computers in the 1980s and the Internet in the 1990s eLearning got an immense hype because of its theoretical possibilities. Although the term eLearning encloses basically all forms of electronically supported learning, only the narrower definition is relevant for this work: “computer-aided, net-connected and web-based teaching and learning” (Schwicker et al. 2005, p 12).

Partly successful and partly disappointing experiences with eLearning (Douglis, 2008) lead to the combination of eLearning and classical face-to-face lessons, bringing together the advantages of both worlds. Blended Learning is a flexible approach for the creation of modules that support different learning times and places. It offers the comfort of some online modules without losing the face-to-face contact completely (Rovai and Jordan 2004).

Although project-based learning often registers a big learning success, it is taken only moderately or even not into consideration within the Blended Learning concept. In theoretical and practical terms great importance is assigned to project-based learning since it improves “communicating skills” – a major objective in education (see Bruffee, 1999; Batatia et al., 2002; Neo, 2005). Not any other learning form is suited this well for the requirements of professional life (Mills and Treagust, 2003, p 13), because within the scope of a project the project members gather not only the necessary specialist knowledge, but also strengthen their team ability, communication skills, and project management experience (Bleimann, 2004, p 4). If the projects are carried out together with companies, the students can already connect valuable contacts and the universities and companies can profit from the knowledge transfer. Therefore, *Extended Blended Learning* has been developed to integrate eLearning with face-to-face learning and project-based learning (Bleimann and Röhl, 2006). The *Atlantis University Project* is the first project that realises Extended Blended Learning (Bleimann, 2004).

The personal learning types of learners (Brückner, 2005) also decisively influence the path through the module's content. Also conceivable are content-sections that question knowledge. All these results influence the way a learning-module's content is presented.

Because Extended Blended Learning demands non-linear and adaptive learning content presentation, a so-called *Coherence Service* has been designed that provides methods for presenting non-linear content adaptively (Schneider *et al.* 2006). The service is able to provide coherence, so that module content is not lined up pointlessly or contradictory. It leads to a successful end in any situation and with any chosen path, except in the event of failed exams or missed necessary exercises.

Most of the present learning environments (Baumgartner *et al.* 2002, Niegemann *et al.* 2004) such as Blackboard (Blackboard Inc., 2008) and TopClass (WBT Systems Ltd., 2008) do not support adapting content to the users' actions, behaviours or learning styles (van Rosmalen and Boticario, 2005). Systems like ELAT (Gojny *et al.*

2003), Moodle (Gertsch, 2007) and, ILIAS (Ilias, 2008) that are based on newer specifications such as SCORM 2004 (Alexandria ADL Co-Laboratory, 2008), EML (LearningNetworks, 2008) and its successor Learning-Design (Koper and Tattersall, 2005) fulfil the demands of interaction and adaptation, but support neither time management nor authoring of more complex content, because these specifications are based on branching (Schneider *et al.* 2006).

A modified storytelling-system fits best to the demands of Extended Blended Learning (Schneider *et al.* 2006). For this research, the *StoryEngine* based on Propp's story model (Grasbon, 2001) is most suitable for Atlantis University (Schneider *et al.* 2007). Its functionality (Schneider *et al.* 2008) is based on path creation that has to handle all the possibilities that might occur during a learning-module.

2. Design of a Construction Algorithm

Each time a new content is requested, the Coherence Service constructs all possible and entire paths. The first approach is to traverse through the model again and again. Every traversing step a new path is constructed and saved in a list. Indeed, the following problems would occur:

- It would be very difficult to assure that every path is constructed only once. Coherence-models can contain many loops and any complexity of nesting. The possibly originating amount of paths cannot be generated any more with a simple algorithm. Hence, it also cannot be simply assured that paths are erected only once. The algorithm would have to analyse all already created paths every iteration. Loops are even more problematic.
- The difficult ascertainment if a path has been already created and repeated processing of the path would have negative impact on the system's speed.
- If every path is filed individually, in the worst case each new alternative doubles the demand of memory. The exponentially growing amount of path variations would encounter the system's limitations very fast.

A data structure has to be found, that is very memory efficient and admits a sophisticated path-creation. After several tests the idea originated to not construct a whole path with every iteration, but to develop all paths in parallel. As soon as a content-Type-element is found within the model, all paths that have been already originated become advanced with the new content-section. Instead of creating the paths branch by branch, they are created step by step. Hence, within a model free of loops, the amount of iterations is the same as the model's number of contentType-tags.

```
<coherenceModelML>
  <order>
    <contentType id="A" weight="0.5" />
    <contentType id="B" weight="1" />
    <contentType id="C" weight="1" />
  </order>
</coherenceModelML>
```

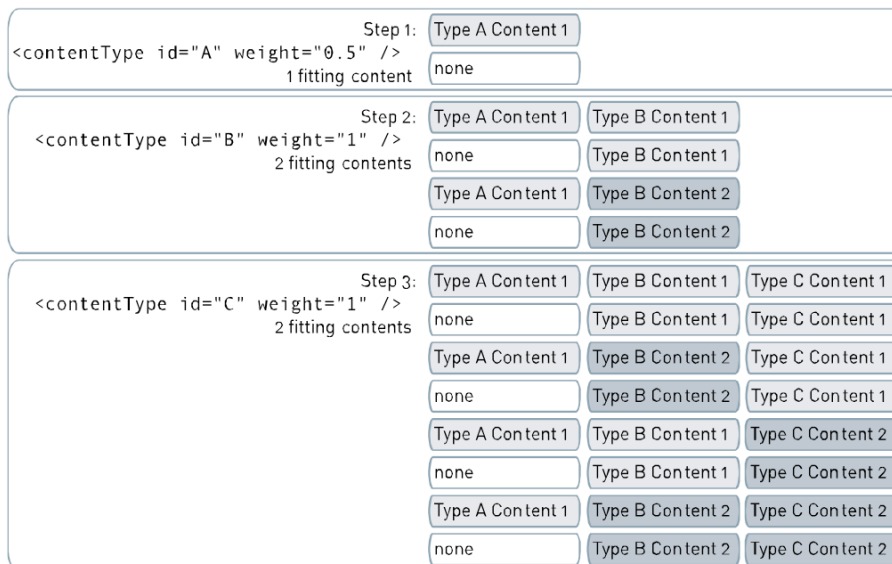


Figure 1: Stepwise construction of the paths

Two paths already originate in the first step because the weight of the first content-type is < 1 (0.5). Hence, branches with and without this content-type must be constructed. To enable the algorithm to work with omitted elements, it recognises the branches as alternatives. Instead of a content-section an empty node is used in the branch. Without this empty element in the next step it would be very difficult for the algorithm to take omitted content-types into consideration. But with this method the algorithm can simply append a new content-section to each existing branch.

In the second step the first content-section of type *B* is appended to both branches. Because this type provides two possible content-sections, the existing branches must be duplicated before. Then the second content-section is appended to both new branches. The result is four branches with all conceivable combinations of content-sections the model allows.

The content type *C* in the third step provides two possible content-sections, hence the action from the second step is repeated. The result is eight branches instead of four. All possible branches have been constructed with three steps. Now the available content-sections are rated to find the best fitting one.

In this manner all paths can be constructed elegantly in one pass. One list containing the paths would be enough as a data structure. Nevertheless, the problem of the memory consumption is not solved. In the example in Figure 1 a total of 24 objects are created by eight possible paths, which contain three content-section nodes each. In addition, all the path-nodes and all contained paths have to be copied with every new alternative. Beside memory consumption the creation of objects also needs time because of memory allocation and memory release (Hermann and Ebhart, 2008; Wilson and Kesselman, 2000, p 97). Thus, a list is rather unqualified as a data structure.

3. A Tree as a Data Structure for the Branches

The algorithm already suggests a better data structure for this approach, because it uses already created paths and branches them further out with new alternatives. This might be seen as a tree that branches further out with every new content-section. Such trees are already used in the graph theory for similar problem definitions (Turau, 2004, p 50). Figure 2 illustrates how a tree structure can handle the paths.

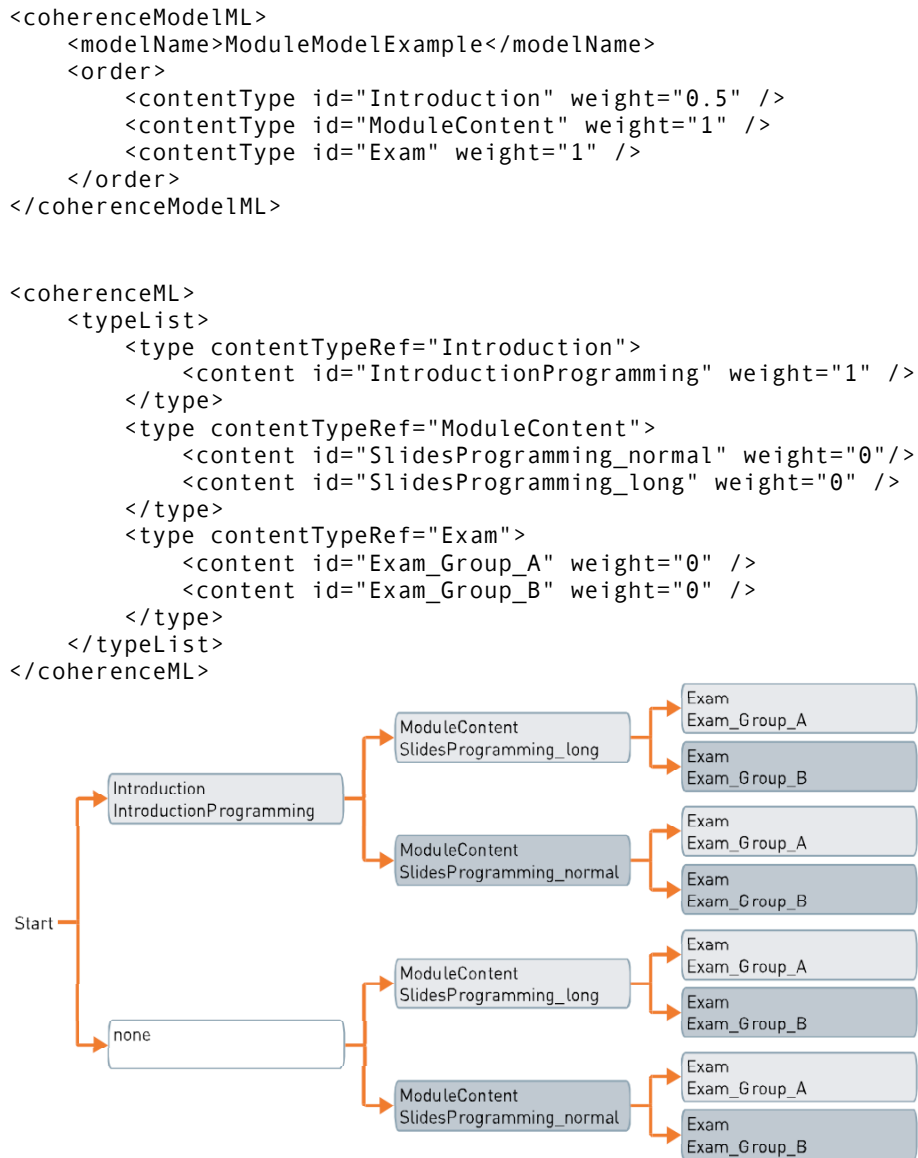


Figure 2: Example for a path-structure

The listings show the coherence-model and a content-description that refers to this model. The coherence-model presents three different content-types. The first content-type is weighted as optional, thus it can be left out. The content-description defines one content-section for the first content-type. For the second and third type in each case two content-sections are defined.

Figure 2 shows the corresponding tree. While the coherence-model is processed, each contentType-tag appends a new level containing the content-sections of that type to each tree's end-node (end-nodes are all nodes without any child-nodes). For appending "no content-type" an empty a node has to be appended. Thus, a new node is created without any content-section. In the next step the algorithm can search through all end-nodes and recursively append new content-sections. Without empty nodes, in this example no branches would be created for paths lacking the content-type Introduction.

Therefore, a tree as data structure solves many problems by itself. The path-generating algorithm does not need to take care of organising the paths, but hands over only the new content-sections to the tree that appends them as new nodes to all end-nodes. By this recursive traversing the tree can take care for itself: it deletes dead branches, thus paths and group of paths with dead-ends (for example because of duration limits) and saves memory.

The tree structures generate fewer objects than the lists. The more content-sections and content-types are used, the more effective the tree becomes compared to a list (Figure 3). The amount of generated objects is relatively close to the number of possible paths. Additionally, the tree-algorithm is more efficient.

Content-sections per content-type	With 3 content-types			With 4 content-types		
	Paths	List	Tree	Paths	List	Tree
2	8	24	14	16	64	30
4	64	195	84	256	1024	340
6	216	648	258	1296	5184	1554
8	512	1536	584	4096	16384	4680

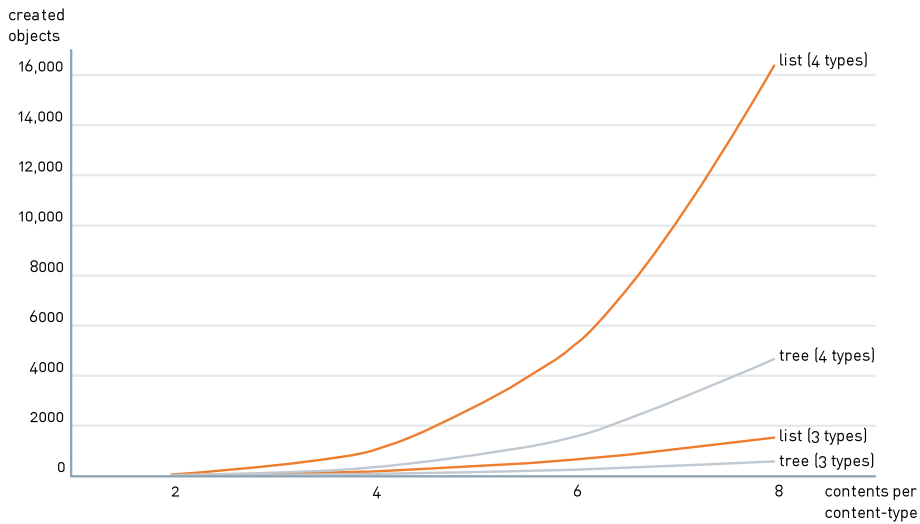


Figure 3: Comparison of the created objects' number in conjunction to the used storage type

Using four content-types and eight content-sections per type, 4680 nodes are originated in the tree. It is sensible to generate as few nodes as possible by previous audit of various parameters like duration and contexts, and to remove obsolete nodes and branches as early as possible.

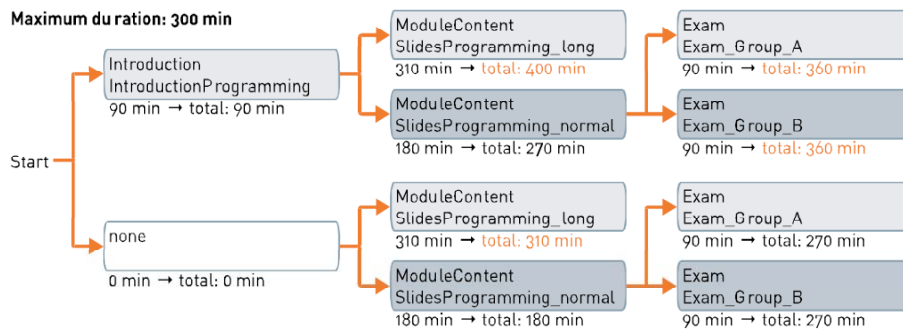


Figure 4: Time management during the tree-construction

During path-creation the path-generator already checks whether the originating path remains within the duration limit, or can be rejected immediately (see Figure 4). Therefore in each node the duration until this node is stored. If a new content-section should be appended, its duration is added to the overall duration. If the new overall duration is more than the maximum, the content-section won't be appended. In the figure's example all contents with orange (or grey) overall-values exceed the maximum duration. They are invalid and can be handled as dead ends.

Because appending new elements is done recursively, the superior node comes to know, whether adding new content-sections to one of its child-nodes was successful. If all child-nodes are dead-ends, it marks itself as a dead end and returns a corresponding value to its superior node. In Figure 4 the upper `SlidesProgramming_normal`-node recognises, that all child-nodes are dead ends. Although it is itself within the duration limit, however, it is useless to take it further into consideration, because it has likewise become a dead end. Hence, it informs the superior node `IntroductionProgramming` about this fact. Now also this node consists only of child nodes with dead ends and becomes likewise a dead end. In the example the complete upper branch deletes itself. In this manner the data structure is held automatically as small as possible what reduces the memory demand and accelerates traversing. The branches are also cut off, if a content needs a context that is not set.

4. Conclusion

Different approaches that fulfil the coherence service's demands for path construction have been described. A tree-based algorithm that is optimised for data usage but is still nice to handle and program has been chosen. Tests have shown, that this algorithm works without faults.

But there is still the problem of the huge amount of paths that have to be created. For example, a module discussing 15 subjects linearly (like addition and subtraction). If learner types are taken into consideration, so that for all six learner types every subject is processed accordingly, 6^{15} (470,184,984,576) possible paths must be constructed and rated. Taking loops into account (that have not been discussed in this paper), the possible number of possible paths might get significant bigger. Hence, the research is now focused on finding further optimisation possibilities or alternative approaches of path-finding algorithms.

Currently the Coherence Service uses propositional logic algorithms for the fuzzy task of finding the most suitable content-section. Hence, it has well-known problems associated with complete representation. In terms of memory and computing time this is too resource intensive, because of the so-called combinatorial explosion. Currently, other solutions are being explored. For example, the structured array-based logic (Davidrajuh, 2007) seems to be a promising approach.

An approach than can be implemented more easily is deleting potential badly rated paths. As soon as a predefined amount of paths is reached, the algorithms would scan for the worst rated paths so far and deletes them. Of course, sometimes this approach will not get the best possible paths. Hence, the best parameters have to be found and will be subject of further research.

5. References

Alexandria ADL Co-Laboratory (2005). "Sharable Content Object Reference Model SCORM". <http://www.adlnet.org/scorm>. (Accessed 28th January 2008).

Batatia, H., Ayache, A. and Markkanen, H. (2002), "Netpro: an innovative approach to network project based learning", *Proceedings of the International Conference on Computers in Education (ICCE'02)*.

- Baumgartner, P., Häfele, H., and Maier-Häfele, K. (2002), *E-Learning Praxishandbuch – Auswahl von Lernplattformen*, Studienverlag, Innsbruck, Wien, München, Bozen, Germany
- Blackboard Inc. (2008). “Blackboard » Educate. Innovate. Everywhere”. <http://www.blackboard.com>. (Accessed 28th January 2008).
- Bleimann, U. (2004), “Atlantis University – A New Pedagogical Approach beyond E-Learning”, *Campus-Wide Information Systems*, 21(5) pages 191–195.
- Bleimann, U. and Röhl, F. J. (2006), “Extended Blended Learning – Innovative Learning Scenarios for universities”, in Steven Furnell and Paul Dowland (eds.) *INC 2006 Conference Proceedings*, Plymouth 2006, pages 385–392.
- Brückner, S. (2005), “Structure Patterns Depending on Various Learner Types in an e-learning Context”, diploma thesis, Fachhochschule Darmstadt, Germany
- Bruffee, K.A. (1999), *Collaborative Learning: Higher Education, Interdependence, and the Authority of Knowledge*, Johns Hopkins University Press, Baltimore, MD.
- Davidrajuh, R. (2007) “Array-based logic for realising inference engine in mobile applications”, *Int. J. Mobile Learning and Organisation*, Vol. 1, No. 1, pages 41–57.
- Douglis, F. (2008), *Blended Learning: Choosing the Right Blend*. <http://coe.sdsu.edu/eet/articles/blendlearning>, accessed 12th September 2008
- Gertsch, F. (2007), *Das Moodle 1.8 Praxisbuch*, Addison-Wesley Verlag, München, Germany, ISBN 978-3-8273-2514-3
- Gojny, U., Vejrazka, C., Leichtweiß, A., Trebing, C., Röder, H., Knorz, G., Bleimann, U., and Li, G. (2003). “ELATnet – E-Learning Entwicklung im Hochschulbereich”. In *Querschnitt (Beiträge aus Forschung und Entwicklung der FH Darmstadt)*, number 17, pages 90–104, Darmstadt, Germany.
- Grasbon, D. (2001), “Konzeption und prototypische Implementation einer Storyengine: Dynamisch-reaktives System zum Erzählen nichtlinear-interaktiver Geschichten bei größtmöglicher Spannung, gedanklicher Immersion, Identifikation und Motivation des Spielers”, diploma thesis, Technische Universität, Darmstadt.
- Hermann, T. and Ebbart, D. (2003), “Performance von Javaanwendungen”, *Softwaretechnik-Trends*, 23(4), 11 2003. ISSN 0720-8928, http://pi.informatik.uni-siegen.de/stt/23_4/03_Technische_Beitraege/Java_Performance.ps.
- ILIAS open source (2008). “ILIAS Open Source LMS”. <http://www.ilias.de>. (Accessed 28th January 2008).
- Koper, R. and Tattersall, C. (2005), editors, *Learning Design*, Springer Verlag, Berlin Heidelberg.
- LearningNetworks (2008). “Educational Modelling Language”. <http://www.learningnetworks.org/?q=EML>. (Accessed 28th January 2008).
- Mills, J.E. and Treagust, D.F. (2003) “Engineering Education – is problem-based or project-based Learning the Answer?”, Scott, N.; Hadgraft, R., and Ilic, V. (Eds.) *Australasian Journal of Engineering Education*, The Australasian Association for Engineering Education Inc, ISSN 1324-5821, http://www.aee.com.au/journal/2003/mills_treagust03.pdf

- Neo, M. (2005), "Web-enhanced learning: engaging students in constructivist learning". *Campus-Wide Information systems*, Vol. 22 No. 1, Bradford, Emerald, pp 4–14, Emerald Group Publishing Limited, Bradford, England
- Rovai, A.P. and Jordan, H.P. (2004) "Blended Learning and Sense of Community: A comparative analysis with traditional and fully online graduate courses", *International Review of Research in Open and Distance Learning*, Number 2 Volume5, ISSN: 1492-3831
- Schneider, O., Bleimann, U., Harriehausen-Mühlbauer, B., and Phippen, A. D. (2006), "Non-Linear Extended Blended Learning", in *Proceedings of the Sixth International Network Conference (INC2006)*, pages 377–384, Plymouth, UK. Network Research Group, University of Plymouth
- Schneider, O., Bleimann, U., Phippen, A. D., and Harriehausen-Mühlbauer, B. (2007), "Learn Your Own Way: Decision Way through Narrative Approaches, Methods and Paradigms for Learning Purposes", in Bleimann U., Dowland P. S., Furnell S. M. (Eds.) *Proceedings of the Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007)*, pages 99–114, Plymouth, UK. Network Research Group, University of Plymouth, ISBN 978-1-8410-2173-7
- Schneider, O., Bleimann, U., Phippen, A. D., and Harriehausen-Mühlbauer, B. (2008), "Inside Coherence: Concept for a Non-Linear eLearning Solution", in Dowland P. S. and Furnell S. M. (Eds.) *Proceedings of the Seventh International Network Conference (INC2008)*, pages 223–233, Plymouth, UK. Network Research Group, University of Plymouth
- Schwickert, A. C., Hildmann, J., and Voß, C., (2005) "Blended Learning in der Universität – Eine Fallstudie zur Vorbereitung und Durchführung". *Arbeitspapiere WI 9/2005*, Gießen, Germany, ISSN 1613-6667
- Turau, V. (2004) *Algorithmische Graphentheorie*, Oldenbourg Verlag, ISBN 3486200380.
- van Rosmalen, P. and Boticario, J. (2005). "Using Learning Design to Support Design and Runtime Adaptation". In Koper, R. and Tattersall, C., editors, *Learning Design*, pages 291–302, Berlin Heidelberg. Springer Verlag.
- WBT Systems Ltd. (2008). "TopClass E-learning Suite". <http://www.wbt systems.com>. (Accessed 28th January 2008).
- Wilson, S. and Jeff Kesselman, J. (2000), *Java Platform Performance-Strategies and Tactics*, Addison Wesley, ISBN 020170969.

G.6 Atlantis University: Learn Your Own Way

Schneider, O., Bleimann, U., and Stengel, I.: *Atlantis University: Learn Your Own Way*, Int. J. Mobile Learning and Organisation, Vol. 3, No. 2, pp. 184 – 201 (2009)

© 2009 Inderscience Enterprises Ltd.

Permission to reproduce this paper in this thesis has been granted by Inderscience Publishers.

Atlantis University: Learn Your Own Way

Oliver Schneider*, Udo Bleimann,
and Ingo Stengel

igdv – Center for Advance Learning, Media, and Simulation
University of Applied Sciences Darmstadt
Schöfferstraße 1
64295 Darmstadt
Germany
Fax: +49 61 51 / 16 - 89 55
E-mail: O.Schneider@fbi.h-da.de
E-mail: U.Bleimann@fbi.h-da.de
E-mail: Ingo.Stengel@h-da.de
*Corresponding author

Abstract: Nowadays, capability development requires a flexible approach and needs to consider aspects such as internationalisation, effective teamwork, and learner mobility. A learning infrastructure has been developed which combines three different types of learning and teaching. It supports the adaptation of content-presentation to varying learning situations. It uses a storytelling-based framework that is influenced by parameters like current position of the learner, device used, learner-type, available timeframe, and prior actions. This system enables context sensitive and collaborative content contribution and thus helps to overcome some of the problems associated with this type of system.

Keywords: extended blended learning, eLearning, mLearning, learning management system, content adaptation, mobility, content manipulation, authoring, interactive digital storytelling

Reference to this paper should be made as follows: Schneider, O., Bleimann, U, and Stengel, I. (2008) 'Atlantis University: Learn Your Own Way' *Int. J. Mobile Learning and Organisation*, Special Issue on: Mobile Teaching/Learning and Authoring Tools; Accelerating Content Delivery, Vol. X, No. X, pp.XX–XX

Biographical notes: Oliver Schneider is Dipl.-Ing. for TV-engineering. 1991–2000 he worked as sound-engineer, camera assistance and application engineer. Then changed to science: 2000–2005 researcher at the Digital Storytelling department of the Centre for Computer Graphics, Darmstadt (2004–2005 as deputy). 2002–2005 lecturer for audio-engineering at the University of Applied Sciences Ulm. 2006–2007 researcher at the mobile-gaming department of the University of Applied Sciences Bremen. Since 2008 researcher at the Centre for Advanced Learning, Media and Simulation of the University of Applied Sciences Darmstadt. Since 2005 PhD-student at the University of Plymouth. Research topic: “Non-Linear eXtended Blended Learning”.

Udo Bleimann is Professor for business computing at the University of Applied Sciences Darmstadt. Chairman of many conferences and workshops including the topics eLearning,

Author

Web Applications, Workflow Systems, and Human Computer Interaction. Founder of the special-interest group Knowledge Media Design aiming at interdisciplinary projects with designers, psychologists, and computer scientists.

Director of aiDa – Institute of Applied Informatics Darmstadt, managing industry and research projects focusing on eLearning, Service Oriented Computing, Knowledge Media Design, and Human-Computer-Interaction.

Chairman of igdv – Center of Advanced Learning, Media and Simulation at University of Applied Sciences Darmstadt. Responsible for new learning, teaching strategies, and technologies.

Ingo Stengel is the co-founder and Executive Director of the igdv – Centre for Advanced Learning, Media and Simulation of the University of Applied Sciences Darmstadt, Germany. He received his PhD from the Department of Computing at the Cork Institute of Technology (CIT) Ireland. His research interests are in the area of advanced learning, multi-agent systems and simulation.

1 Introduction

As the successor of Blended Learning, eXtended Blended Learning overcomes the pure eLearning obstacles (e.g. Sheypak *et. al.*, 2007) by integrating face-to-face learning, eLearning and project-based learning (Bleimann and Röhl, 2006). This is one of the basic principles of the Atlantis University, an international partnership involving universities and companies from the European Union (EU) and USA. Its goal is to develop an innovative high-quality institution with common branding. The idea evolved from long-term experience in face-to-face and project-based teaching as well as several eLearning research projects (Bleimann *et al.*, 2004; Furnell *et al.*, 1998, 1999; Stengel *et al.*, 2003).

As current students develop into important contributors and decision makers, Atlantis University focuses on improving the teaching of students' capabilities necessary to succeed in today's societies. Capability goes beyond knowledge, skills and competence where it represents "an integration of knowledge, skills, personal qualities and understanding used *appropriately and effectively*" (Stephenson and Yorke, 1998). By contrast, competence is related to the ability to perform effectively in a specified location (e.g. in a known familiar setting) and at a specified time. Capability extends competence by implementing the capacity in an unknown or unfamiliar future context and by guaranteeing good performance at the current time.

As a result an enormous flexibility needs to be provided by the universities (Röhl, 2003). This includes aspects such as mobility, internationalisation, team performance, and more. Atlantis University meets those needs in various dimensions: It defines and implements eXtended Blended Learning methods that are used in modules of cooperating universities. Students work in international teams where most of the module tasks represent real life problems. This process is supported by a flexible platform that provides services for communication, data management as well as appropriate module/syllabus content.

This paper describes the concept, a partial implementation of the platform and its most significant services which provide flexible interfaces as well as content and version handling. It outlines how flexibility is achieved and handled in different scenarios.

Title

In this context a large amount of learning content within the system is necessary to offer material based on user adaptation. Creating good quality content is a time consuming task that individuals often fail to accomplish. The adaptation of the content itself is even more difficult. To present content from different perspectives, at different locations, and on various devices, many discussions and versions are needed to ensure that the content can be understood by the appropriate learner and can be presented in an accurate way. To solve this problem, many authors may create the content from their own point of view and use the appropriate input/output facilities. However, this raises the difficulty of interconnecting the content sections in a way that adaptive coherent non-linearity arises. This paper outlines a possibility to overcome this problem by merging the approaches of context-specific information (for example learner-types, position, device used), a storytelling based coherence service, and a content contribution system.

2 Changed Demands on Lectures

It is a current trend for nations to form international knowledge societies. This has resulted in the need to be able to effectively manage and store retrievable knowledge as well as learnable abilities, experiences and social competences. Universities need to prepare students to survive in a fast changing world, so that they are able to face the demands and to flexibly apply their capabilities.

This means that universities as a whole including lecturers and students need to be flexible. Changes from the inside and outside should be tackled by adaptable modules in a teaching network. Learning should not be restricted to the campus or home; it is a dynamic process where resources should be accessible at any time and location. Mobile technologies are one important step to fulfil those needs, because “Handheld technologies provide access to computing where student activities and learning occur, unlike desktop computers that are often segregated from other learning activities in the classroom.” (Uden, 2007) “mLearning is the acquisition of any knowledge and skill through using mobile technology, anywhere, anytime.” (Geddes, 2004)

The key for adaptive flexibility is context awareness; this also includes other forms of learning and not just mLearning. Lorna Uden (2007) uses the activity theory for mobile learning designs. This can be expanded by using interactive storytelling methods, as one main focus of Interactive Storytelling is the change of contexts during time towards a specific goal.

Dan Norman stated (Currin, 2004): “For teaching to be effective, cognition and emotion must work together.” Studies in neuronal sciences confirm this statement which stresses the importance of emotional engagement in learning efforts and motivation (Spitzer, 2002). The key for this can be found in stories: Stories foster emotional engagement, because content is structured in a suspenseful way. Reading or the viewing or by the experiencing of a good story can cause the reader to be totally immersed into an imaginary world. Beside the pure facts stories also provide a meaning that can be linked to the real world (Mateas and Sengers, 1999). This way can help for learned knowledge to be transferred to new situations for better understanding (McKillop, 2005). Several AR/MR-projects address the combination of Interactive Storytelling and mobile edutainment, for example Geist (Kretschmer et al., 2001) and EduTeCH (Schneider, 2004).

Author

3 Atlantis University Project

The Atlantis University project was founded in 2002 as an interdisciplinary project. Ten universities and companies from England, Ireland, Poland, Hungary, Germany and United States of America collaborate in order to research and implement new pedagogical concepts. Its focus is on innovative combination of different knowledge-transfer forms called *eXtended Blended Learning (XBL)*.

3.1 eXtended Blended Learning

eXtended Blended Learning combines blended learning with project-based learning, because it improves “communicating skills” – a major objective in education (see Bruffee, 1999; Batatia et al., 2002; Boud and Solomon, 2001; Neo, 2005). No other form of learning is suited to meet the requirements of professional life (Mills and Treagust, 2003, p 13), because project members gather not only the necessary specialist knowledge, but also strengthen their team ability, communication and project management experience within the scope of a project (Bleimann, 2004, p 4). Within eXtended Blended Learning teaching is based on three pillars (as shown in Figure 1).

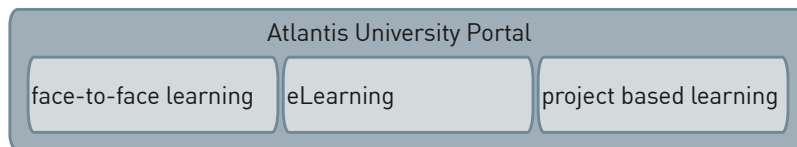


Figure 1: Three pillars of eXtended Blended Learning (Bleimann, 2004)

Atlantis University integrates all three columns of eXtended Blended Learning into a virtual university. The respective pillar's part is measured by the teaching contents as well as the learner's previous experience and general situation (Bleimann and Röll, 2006).

The real vision of *Atlantis University* is a smart mix of the three learning forms. A further goal is to internationally cooperate with other academic institutions in order to create an interdisciplinary and international study path for learners (this study path needs to be internationally approved) (Bleimann, 2004). The virtual university should offer online-content, modules and, personal details of all universities that are involved through a worldwide software portal. Students should be able to take part in lectures at one university but attend projects all over the world. This can be achieved by using content, exams and graduation ceremonies that have been approved internationally. *Atlantis University* will serve as a mediator, offering communication interfaces, filters, enabling the sorting and combining of international content as well as to provide facilities to enable local administration.

4 Supporting the Learning Process via Pedagogical and Technological Concepts

The Atlantis University learning environment is implemented using the following well known components:

Title

- Moodle, which is used as Learning Management System. It provides all the basic functionality that might be required such as enrolment, management of learning content, and communication facilities. It is used to create modules (content), to enrol students on courses, and provides basic information.
- Wiki, which is used intensively as a collaboration tool. Students describe their work in the Wiki system after completing a task. Some modules use the Wiki as documentation system – where each semester students describe some parts of a certain topic. Wiki-content is always up to date when compared to books that are only rarely updated.
- Moodle is optimised to handle learning content, but it is not intended to be used as Document Management System (DMS). Hence, for handling and versioning a large amount of revised documents a DMS was integrated into Atlantis University. It is used for document based project work and to submit results achieved by students during the semester.

In addition to these and other well-known components (such as calendar and a video conference system) the Atlantis University team has developed some special learning-tools that are described in the following sections.

4.1 Learner Types

To further improve the eXtended Blended Learning concept, individual learning characteristics of learners and teachers have been taken into consideration. The model developed by Franz Josef Röhl merges seven preference determination models out of 70 existing models (Brückner, 2005). It defines six different learner types (Röhl, 2005). A person does not only correspond to a single learner-type, but his strong and weak developed learning preferences are distributed through all six preferences, see Figure 2. Typically a learner develops two strong, two medium and two weak preferences.

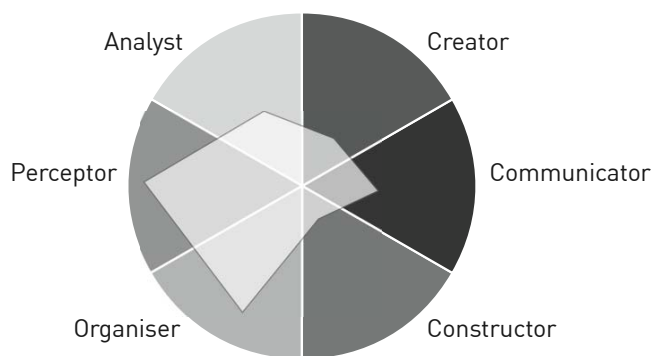


Figure 2: Example for the six learner-types

The illustration shows exemplarily strengths in the domains of a perceptor and organiser. A person of this learner type learns especially well if he is led step-by-step through clearly structured learning content (Brückner, 2005). In addition, the amplitude in the perceptor field shows that the learner should use audio-visually presented content to

Author

achieve the optimum learning success. Hence, the learning material prepared for this learner type stimulates his senses. These can be charts, animations or videos, but also kinetic stimulation like touch or audio based stimulations such as talks and discussions. However, constructors prefer experiments and are generally assessed in a pragmatic way. Engineers often represent this type. However, communicators need group work, while analysts use a rather analytical approach and achieve the best learning results only by using books. The creators learn best if they deal with something completely new. They often lose the interest if standard operations are involved during the process.

Atlantis University is not bound to use this special learner type theory. This is one possible way to put learners into categories. It is used intensively for typifying content-sections and to choose the best fitting learning path, because it fits well into the Atlantis University concepts.

4.2 Adjusting Content: Coherence

Stories and their structures provide the following essential functionality for learning environments: Focussing on the teacher's attention, provision of information and feedback about the learner's efforts (Gagné et al., 1992). Stories are not limited to a certain topic. With narrative structures complex dependencies can be explained in an understandable way (so that it can be understood by humans). Stories are fundamental to culture and human understanding. They have familiar structures that are recognisable and can be easily understood. In human tradition stories were means for information transmission and knowledge acquisition, e.g. within families and cultural communities. "Much true understanding is achieved through storytelling. Stories are how we communicate events and thought processes." (Schell, 2002)

Lectures are often presented in a uniform way (a lecturer might write a script and then uses it for several years). As a result eLearning modules are mainly used as lecture notes. In comparison to lectures, where students work step by step through the content, without making use of their individual strengths and without avoiding weaknesses. In contrast to this, the eXtended Blended Learning concept in the Atlantis University Portal supports learning using individual strengths of the students, being characterised by non-linearity in several dimensions. A new software approach is required in order to be able to control these processes.

Therefore, the *Coherence* service has been developed. Its design is based on interactive digital storytelling methods, that present non-linear content in a coherent way and is user-adaptive and independent of any concrete content (Schneider et al., 2006). It is based on the StoryEngine (Braun, 2003) that uses Propp's story model (Propp, 1958), because it is most suitable for the eXtended Blended Learning domain (Schneider et al., 2007).

The *Coherence* service provides coherence, so that module content-sections are not lined up pointlessly or contradictory. Students should not be allowed to process data until he has completed the theoretical part. In any case, conclusiveness is always guaranteed. In any situation and with any chosen path the service is able to lead to a successful end. Failed exams or missed exercises are excluded.

The performance of the learners and their personal learning types (Brückner, 2005) decisively influence the path through the learning-module by using interactive content. Content-sections that question knowledge are also conceivable. All these results influence the learning-module. The eLearning environment works completely independent of any concrete content. This signifies that it is not only media type independent (for exam-

Title

ple the content is a video or a set of slides), but also the system is usable with any kind of learning content and learning styles.

Therefore it divides content into three levels: The highest level is the coherence-model that describes the content-types and their relationship to each other. The medium level is an abstract content-description. It defines the content-sections, their relationship to each other and to the content-types they belong to. The lowest level includes the content and interactions itself. These descriptions are processed by *Coherence* and the Learning Design engine *CopperCore* (Martens and Vogten, 2005), see Figure 3.

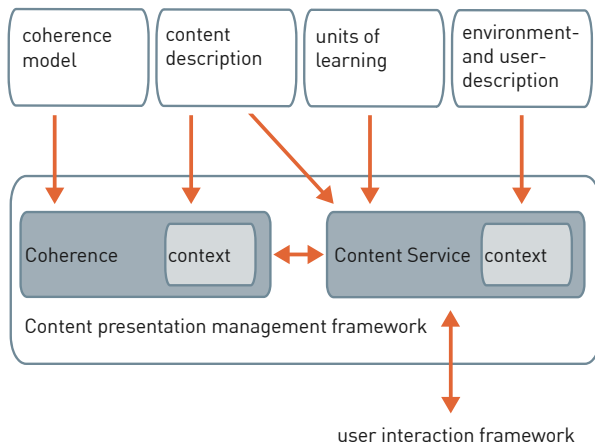


Figure 3: Coherence architecture

The model provides a timeline with a flexible duration. At this timeline the content-types are ordered. Although this order is not strictly enforced – it is a recommendation. It can be influenced by weights, contexts and loops. Each content type may typify several content-sections that refer to portions of concrete content. Figure 4 shows a simple example how content-types typify content-sections:

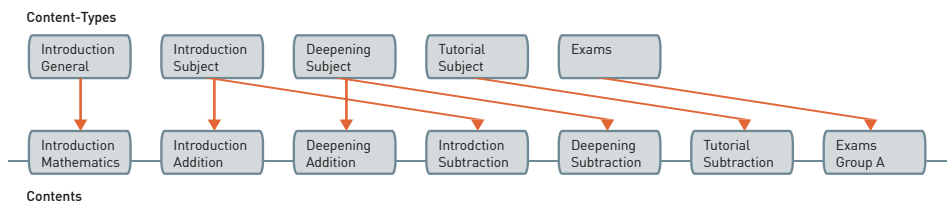


Figure 4: Mathematics module composed of content-types

During runtime, the following content-sections are selected depending on the history and the current context. Contexts provide coherences and dependencies between the content-sections. They describe the state of the content, the user and the environment and serve as variables for the communication between content-sections, module-contents and systems. In contrast to usual computer languages every context defines the range of two values. For example a context *acceptedAge* might have a minimum value of 18 and the

Author

maximum value of 30. Contexts can be organised in nested groups. Thus, a context tree can be formed. In this way several contexts can be checked logically interrelated by calling a context-group.

Currently the context *duration* and the context group *learnerType* are mandatory. With the help of these contexts it is guaranteed, that certain content is presented in a best fitting way to a learner type within a specific duration. Also coherence is assured as well since decisive content-sections have been presented.

Further contexts can be used to help to categorise the content. A content group is purposed for localisation data. Currently, this data can consist of coordinates that are streamed from a GPS-receiver, but also descriptions like lecture-room, laboratory, at home or maybe a specific university; combinations are also possible. Other context groups are prepared for internationalisation, including preferred (and provided) languages, measurement units and time zones. Other contexts specify input and output-devices. These enable the adaption of content-sections to concrete devices such as a PC with monitor and keyboard/mouse or mobile devices including a multi-touch screen.

Because of its flexibility this service is able to merge learning-modules of different lecturers to provide the optimal learning path for a specific learner-type. This includes modules from different universities. Beside the ability to choose the content that best fits the current circumstances (for example devices used and locations) by using context information in conjunction with the history and possible future paths, Uden's demand is fulfilled that it "is important not only to include current time but also past time (a history element of context) and future time" (Uden, 2007, p 93). This is either done during the initial planning stage carried out by the author or during the runtime stage by the coherence engine.

4.3 Merging Content

The coherence service provides the ability to merge content created by different persons during runtime. The key to this process is the context belonging to each content-section.

The coherence service creates coherent content out of many content-sections that is annotated by context. The context may be added explicitly, but most of the mandatory context can be set on the fly. For example, the author's learner-type is a context that must be set. But as it is known to the system because of preceding learner-type tests, no additional action is needed by the authors.

Lecturers might use content that suits their individual teaching style provided that everyone teaching the same module does agree upon the same coherence-model. Regarding to Röll's theory students learn best, if a lecturer has created the content whose learner type is close to theirs (Röll, 2006). Therefore the coherence service compares the content's learner-type (that is in fact the content creator's learner-type) with the learner-type of the actual content consumer and chooses content-section that is best suited.

Following example demonstrates this. In Figure 5 the student's learner type is split into fragments and lined up individually.

Title

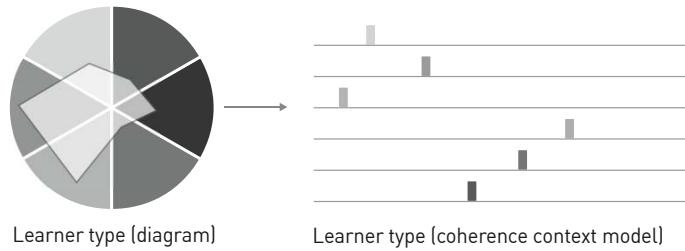


Figure 5: Splitting up the learner-type

Figure 6 illustrates the learner type for one content section created by three different authors (framed). The student's learner type (non-framed) is compared with them and the most akin (the third) is chosen.

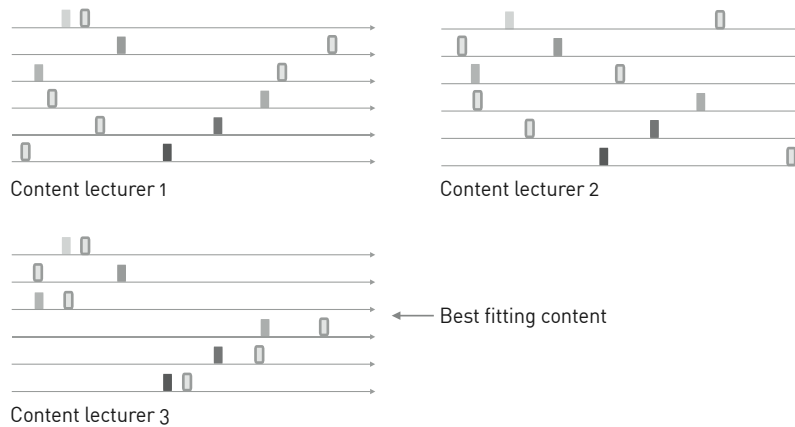


Figure 6: Evaluation of the best fitting content

This concept also enables the coherence service to explain the same topic from different point of views by looping the content-type. Doing this will not repeat the same content-section but presents the same topic that has been created by another lecturer. This increases the probability of the student understanding the topic, he learns about.

4.4 Mobile Aspects

The selection of content-sections is not limited to the context-group learner types. Location based services (LBS) are also context relevant. It is possible to bind locations to designated locations or movements by defining valid areas that are compared to incoming position data such as Gauß-Krüger coordinates. Instead of the exact position also the nearest location could be chosen as shown above.

The usage of LBS gives great possibilities in choosing the content and defining the path through the content. In the simplest case, the content specialises to different locations for example at home, at a laboratory, or a lecture room. The coherence service

Author

might choose the content that has been created by a lecturer working at this university in order to tailor the position of a university to the content.

Especially programmes that require fieldwork such as soil science and civil engineering but also typical indoor studies like mechanical engineers (Lipovszki and Molnar, 2007) have great advantage from LBS enriched modules. For example, standing at a bridge the content section might be able to explain facts about this special bridge. Or it might compare this bridge with others. Pedagogical reasons may require the explanation of the bridge at a certain moment, even though it is not possible to visit the bridge at that moment. The content can be fitted to new situations.

As an example the use during civil engineering lectures can be mentioned, see Figure 7: Presenting right learning content due to position tracking. The link between practical work and theory is done by integrating the forces that act within the building (Köhler, 2003). This can be used together with location based services that ensures that the right building is preselected based upon geographic coordinates.



Figure 7: Presenting right learning content due to position tracking (Köhler, 2003)

The devices used can be taken into account by assigning a context group that enhances mobility. Special content sections for PDAs or smart-phones can be created and used whenever they fit.

4.5 Weights and Path Creation

The content-section is not only chosen regarding to the current context, but also factors in the content's dependencies. The whole possible path to the content's end is taken into consideration. All the time paths through the content are created and adjusted depending on what has happened already and the possibilities (content-sections) remain for further content presentation. Each situation and action influences not only the present content-section, but also the whole path until its end. Hence, a content network is build up and adjusted during runtime. Therefore, the contexts normally do not force but propose a special action. Of course a specific content section can be explicitly bound to a concrete situation like a location, a language, a device or a learner type. But normally the content sections are weighted in a way that leaves freedom. For example, a content-section might be presented that does not fit very well to the location but is necessary from a pedagogical point of view.

Title

This flexible approach has a huge demand of content that has to be kept up-to-date. The storytelling-based approach provides a user-friendly approach for non-linear interactive content creation. Nevertheless, Atlantis University currently lacks of an integrated authoring environment (Schneider et al., 2003). But a first step in this direction has been done by developing CoCoMa.

4.6 Learning by Contribution: CoCoMa

When traditional teaching forms are used, the backward channel to the lecturer is limited and learners have little influence on the learning content, since knowledge in sciences as computer science continually loses relevance. In conditions of fast changing information a new approach to impart knowledge is necessary. This approach involves students more actively and increases their direct influence on the learning content.

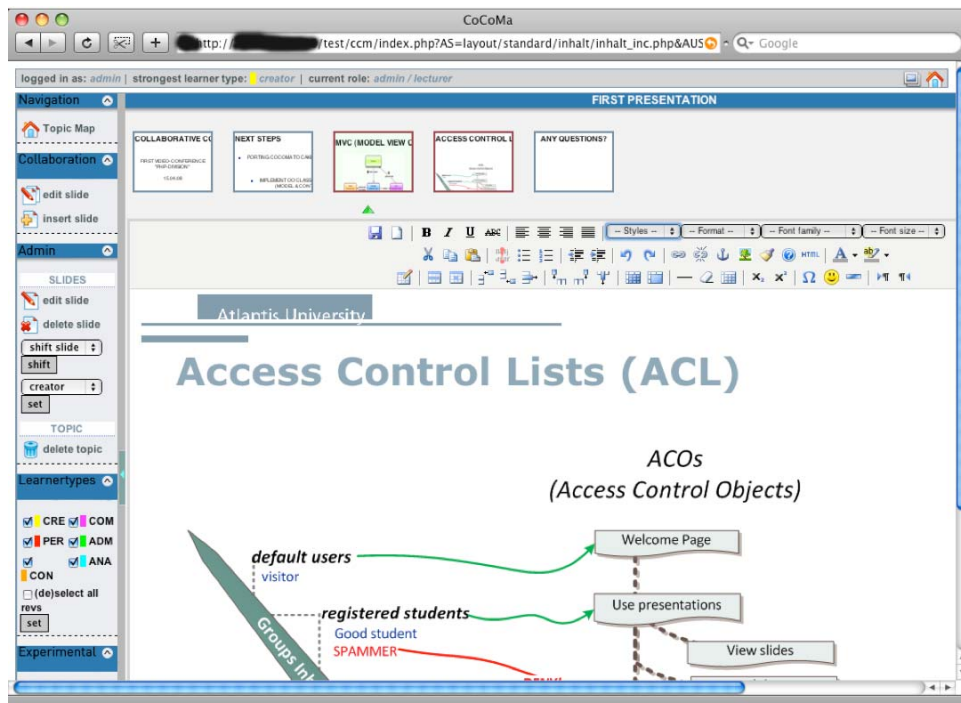


Figure 8: Screenshot of CoCoMa (edit mode)

The Atlantis University concept does this by allowing students to generate learning content using WIKI-systems and semantic networks. In addition, within the scope of the project a *Cooperative Content Manipulation* (CoCoMa) called system has been developed. With CoCoMa students are able to directly update learning content provided in an initial form by a lecturer. Lecturers do not lose the control of their content (Pieke et al., 2007). In contrast to normal versioning tools such as used by WIKI systems, the initial author must actively accept amendments to replace the original version. By this way the content is always kept up-to-date (see Figure 9).

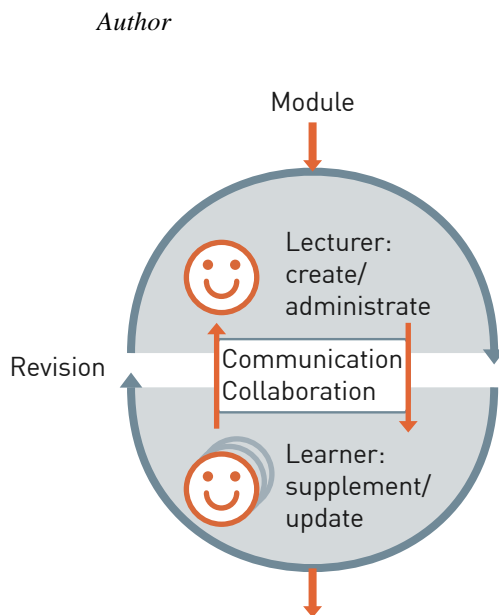


Figure 9: CoCoMa content updating circle

Currently development has started to expand CoCoMa with an *Alternative*-button in combination with recording all context information that is available at the moment of editing. This button graduates students from correctors to co-authors. Instead of accepting the revised version and dismissing all other revisions (including the original), the revised version becomes alternative content. Typically this will not be a different content but a different view onto the topic. Because the added content includes all needed contexts to build new path variants (for example position information, device used, and learner-type), the module becomes more and more adaptable on the fly. Hence, the *content update circle* would become a *content enrichment circle*.

CoCoMa gives great advantages to both, learners and lecturers. Learners may influence the learning content to their need. They are able to identify themselves with the content that consists of parts of their own work. This results in better learning abilities and results. This approach has been named “Learning by Contribution”.

On the other hand, for many lecturers CoCoMa is the enabler for eLearning-like on-line content presentation. Students are encouraged to cooperate while lecturers do not lose control. This decreases the shy and being anxious about putting content online in an editable manner. CoCoMa will have a positive impact on students and lecturers work with other eLearning components such as Wiki.

5 Experiencing the Atlantis Concept

Since the academic year 2004/05 the concept has been tested in several modules within the computing and social didactics faculty. One of these modules is *International Project-Based Learning* with its aim to develop the Atlantis University platform. Due to the enormous effort that is necessary for this challenging task, this can only be done in a network of universities like the Atlantis Network. This network unites students and lecturers of the faculties of pedagogy, computer science, engineering and design into a multi-national and interdisciplinary research team.

Title

As an eXtended Blended Learning module, International Project Based Learning is structured as follows:

1. The kick-off meeting at the beginning of each semester is held as a typical face-to-face event to prepare the following project phase: All participants meet at one university for four days. The first day is used for introductory purposes. New participants are introduced to the Atlantis University Project and to ongoing and future tasks. The following two days are normally used for social events. Each participant should become acquainted to the other participants. Teams are formed during the last day with a focus of one task for each team. First steps are discussed during the kick-off meeting.
2. During the longest phase the teams work collaboratively on their sub-project using the provided eLearning tools of the Atlantis University Portal, for example DMS, Wiki, calendar and chat. Once a month a videoconference is held to synchronise the teams. The topics processed are: The status of the project, the difficulties and the next steps.
3. At the end of each project phase again a meeting is held for presenting the results, face-to-face collaboration of the teams and brainstorming of the project's future tasks. After this project-end-meeting the teams summarise their work in reports that are due to be submitted to the project management team. The core project members rate these reports and the overall work of the individual student project members so that a mark for the students' study-module can be provided.

This eXtended Blended Learning approach has proved to be very successful for students and project, because of the following reasons:

- The students learn real-life international, interdisciplinary project work.
- Students are encouraged to design their own and other students' future of learning.
- Many ideas are contributions from postgraduate students, for example the Co-CoMa (Collaborative Content Manipulation) subproject and the Coherence subproject. Both projects have been implemented with the help student groups, researchers, and lecturers. The employers' feedback of the graduated students is very positive: They are impressed by the project itself, its processing and the results achieved by the students.
- Flexibility in this project requires mobility, which plays a decisive role in the learning process. Mobility has several aspects in the context of this project:
 - Mobility – as a requirement for meetings of students and lecturers from different countries. The contact to foreign countries and cultures is a very motivating component. Internationalisation opens the mind for new ideas, other cultures and different approaches. It enables social contacts between the project members and increases the commitment between them. This results in higher commitment to the project and improves the team ability (Bleimann and Roell, 2006). The students and their thinking become mobile.
 - mLearning – as a possibility to support learning in mobile contexts (Nyiri, 2002; Seppälä and Alamäki, 2002). An example for this is a traffic

Author

guidance system (TGS) whose representation is linked to a simulation. The data generated by the TGS is imported, evaluated and used in the simulation of the TGS. Parameters can be changed, so that the behaviour based on real data can be analysed. The selection of the object is done using geographical coordinates. In this way, the traffic light nearby to the learner has been chosen. More details can be found in (Tank, 2007).

- “Location based translation support” in a mLearning context. Since learning may take place at locations in different countries, technical terms may produce communication problems. This can be mitigated by offering a support for the translation of the technical terms or measurement units depending on the object and its geographical location (Köhler, 2003).

Mobile Learning plays a decisive role as shown during this international learning process.

6 Conclusions

The aim of this approach is to effectively support the development of student capabilities. This is a complex process that requires flexibility on both sides, students and the university. The suggested approach represents a comprehensive package which addresses the needs of this process this on various levels.

Based on the ideas of the Atlantis University project, modules like *International Project-Based Learning* have been introduced. They merge various learning forms in flexible combinations. Students work on their tasks in international teams and they are encouraged to contribute to the lecturer’s module content. Adopting this flexible approach to the delivery of modules leads to the development of skills associated with internationalisation, mobility, and effective team work.

A flexible learning system has been developed to support the students in this process. Its presentation of module content is influenced by a many adjustable factors that describe the current circumstances by using context-specific information such as location, learner-type, and input/output device. To minimise the need for explicit input, much of the information available is recorded in the background.

An interactive storytelling based service has been developed that manages different contexts (and associated variables) and their influence on the presentation of the content. It affects not only the current presentation but each context also influences the overall creation of learning paths. Furthermore, associated past and current actions as well as future possibilities all influence the creation of learning paths. The algorithms responsible for this task are based on interactive storytelling and their coherence and conclusiveness are assured.

Providing interactive and adaptable content requires a substantial amount of effort related to the organisation and structuring of such content and providing appropriate and sufficient content sections. The workload to create the appropriate amount of content and the difficulty to adapt this content to various situations means that it is nearly impossible for one person alone to fulfil these demands. The coherence service has been designed to build paths in a very flexible way. Hence, it is also possible to merge learning modules

Title

that have been created by different authors/lecturers. This includes modules from different universities.

A collaborative content contribution service called CoCoMa has been designed to enable students to propose revisions of content elements/sections. It is as easy as using a Wiki systems. But in contrast to Wikis the original author has to authorise the revised content. This way the content can easily be kept up-to-date.

By merging the suggested services and methods a solution is provided which overcomes the problems associated with creating and maintaining the amount of content necessary to provide an interactive and adaptive environment. Accepting such contributions as alternative content instead of the originator having to carry out revisions, means that content can quickly be developed and enriched. The concept is still under evaluation and needs refinement but first results are very promising.

Currently the Coherence Service uses propositional logic algorithms for the fuzzy task of finding the most suitable content-section. Hence, it has well-known problems associated with complete representation. This is, because of the so-called combinatorial explosion, too resource intensive in terms of memory and computing time. Currently, other solutions are being explored. The *structured array-based logic* (Davidrajuh, 2007) seems to be a promising approach.

Another problem relates to the use of all the context information which is recorded on the fly. Participants need to agree that individual contributions can be used and a way has to be found that satisfies the legal situation. This process is complicated because of the international nature of the project.

Although the initial ideas and concepts which led to the Atlantis University Project did not include aspects relating to mLearning, AUP's flexibility and inherent characteristics relating to internationalisation, team work and, mobility have been important considerations from the beginning. mLearning aspects have been incorporated as a matter of course, because they were also required in this context. Hence, the developed methods and services have always been designed in a way which will allow mLearning to be integrated.

References

- Batatia, H., Ayache, A. and Markkanen, H. (2002) "Netpro: an innovative approach to network project based learning", *Proceedings of the International Conference on Computers in Education (ICCE'02)*.
- Bleimann, U. (2004) "Atlantis University – A New Pedagogical Approach beyond E-Learning", in *Campus-Wide Information Systems* Volume 21 Number 2, Emerald Group Publishing Limited, Bradford, England.
- Bleimann, U.; Röder, H.; Gojny, U.; Stengel, I.; Leichtweiß, A.; and Knorz, G. (2004) "Von ELAT zu Atlantis University", *Querschnitt (Beiträge aus Forschung und Entwicklung der FH Darmstadt)* Nr. 18, Juli 2004, pp.8–15, Darmstadt, Germany.
- Bleimann, U. and Röll, F.J. (2006) "Extended Blended Learning – Innovative Learning Scenarios for Universities", in Furnell, S. and Dowland, P. (Hrsg): *INC 2006 Conference Proceedings*, pp.385–392, Plymouth, England.
- Boud, D. and Solomon, N. (Eds) (2001) *Work-based Learning: A New Higher Education?* Open University Press, Maidenhead.
- Braun, N. (2003) *Nonlinear Storytelling: Programmierter, interaktiver Narrationsansatz für kontinuierliche Medien*. PhD-thesis, Technical University, Darmstadt, Germany.

Author

- Brückner, S. (2005) *Structure Patterns Depending on Various Learner Types in an E-learning Context*. Diploma Thesis, University of Applied Sciences Darmstadt, Germany.
- Bruffee, K.A. (1999) *Collaborative Learning: Higher Education, Interdependence, and the Authority of Knowledge*, Johns Hopkins University Press, Baltimore, MD.
- Currin, L. (2004) *Feelin' Groovy*. <http://www.elearnmag.org/subpage.cfm?section=articles&article=10-1>, Accessed 23rd May 2007.
- Davidrajuh, R. (2007) "Array-based logic for realising inference engine in mobile applications", *Int. J. Mobile Learning and Organisation*, Vol. 1, No. 1, pp.41–57.
- Furnell, S., Bleimann, U., Girsang, J., Röder, H., Sanders, P. and Stengel, I. (1999) "Security considerations in online distance learning", paper presented at the *4th Euromedia Conference*, Munich, Germany.
- Furnell, S., Onions, P., Bleimann, U., Gojny, U., Knahl, M., Röder, H. and Sanders, P. (1998) "A security framework for online distance learning and training", *Internet Research*, Vol. 8 No. 3, pp.236–242.
- Gagné, R.M., Briggs, L.J., Wager, W.W. (1992) *Principles of Instructional Design*. Harcourt Brace Jovanovich College, Fort Worth.
- Geddes, S.J. (2004) *Mobile learning in the 21st century: benefit for learners*, <http://www.flexiblelearning.net.au/knowledgetree/edition06/download/geddes.doc>, Accessed 6th July 2008.
- Köhler, A. (2003) "Modules for civil engineering", in N. Gebbeken (Ed) *Digital proceedings of the International ELATnet Workshop 2003*, ISSN: 1431-5122.
- Kretschmer, U., Coors, V., Spierling, U., Grasbon, D., Schneider, K., Rojas, I., and Malaka, R. (2001) "Meeting the Spirit of History". *Virtual Reality, Archaeology, and Cultural Heritage*, pp.141–152, Glyfada, Spain.
- Lipovszki, G. and Molnar, I. (2007) "Mobile learning for mechanical engineers", *Int. J. Mobile Learning and Organisation*, Vol. 1, No. 3, pp.239–256.
- Martens, H. and Vogten, H. (2005) "A Reference Implementation of a Learning Design Engine", Koper, R. and Tattersall, C. (Eds.) *Learning Design*, pp.91–108, Springer Verlag, Berlin Heidelberg, Germany, ISBN 3-540-22814-4.
- Mateas, M. and Sengers, P. (1999) "Introduction to the Narrative Intelligence Symposium". In *Proceedings of the AAAI Fall Symposium on Narrative Intelligence*, Menlo Park, CA, AAAI Press.
- McKillop, C. (2005) "Storytelling grows up: using storytelling as a reflective tool in higher education". In Scotland Perth, editor, *Scottish Educational Research Association conference*.
- Mills, J.E. and Treagust, D.F. (2003) "Engineering Education – is problem-based or project-based Learning the Answer?", Scott, N.; Hadgraft, R., and Ilic, V. (Eds.) *Australasian Journal of Engineering Education*, The Australasian Association for Engineering Education Inc, ISSN 1324-5821, http://www.aee.com.au/journal/2003/mills_treagust03.pdf.
- Neo, M. (2005) "Web-enhanced learning: engaging students in constructivist learning". *Campus-Wide Information systems*, Vol. 22 No. 1, Bradford, Emerald, pp.4–14, Emerald Group Publishing Limited, Bradford, England.
- Nyiri, K. (2002) "Towards a philosophy of m-learning", *Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'02)*.
- Pieke, M.; Russell, C.; and Bleimann, U. (2007) "Collaborative content manipulation – an e-Learning approach", in *Internet Research*, Vol. 17 No.1, pp.49–60, Emerald Group Publishing Limited, Bradford, England.
- Propp, W.J. (1958) "Morphology of the Folktale", *International Journal of American Linguistics* Vol. 24, Indiana University of Research Center in Anthropology, Folklore, and Linguistics, Bloomington, IN, USA.
- Röll, F.J. (2003) *Pädagogik der Navigation. Selbstgesteuertes Lernen durch Neue Medien*. Kopaed verlagsgmbh, München, Germany, ISBN-10 3-935686-51-X.

Title

- Röll, F.J. (2005) "Computermedien, Bildungsmedien: vom pädagogischen Nadelöhr zur selbstbestimmten Bildung". In Schindler, W. (ed.): *MaC*_Reloaded: Perspektiven aus der Skepsis für Menschen am Computer*. pp.37–58, Chemnitz.
- Röll, F.J. (2006) *Entdecken Sie Ihren persönlichen Lernstil*. http://comas.offeneslernen.de/lerno/MPX_rubrik.php?rubrik_id=289, Accessed 30th June 2008.
- Schell, J. (2002) "Understanding Entertainment: Story And Gameplay Are One". In Jacko J. A. and Sears, A. (eds.): *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications*, chapter 43, Lawrence Erlbaum Associates, Florence, Kentucky, USA.
- Schneider, O.; Braun, N.; and Habinger, G. (2003) "Storylining Suspense: An Authoring Environment for Structuring Non-linear Interactive Narratives", *Journal of the WSCG*, Plzeň, Česká republika.
- Schneider, O. (2004) "EduTeCH: Edutainment Technologies for Cultural Heritage in Asia". Jahresbericht 2004, Zentrum für Graphische Datenverarbeitung e.V., Darmstadt, Germany.
- Schneider, O.; Bleimann, U.; Phippen, A.D.; and Harriehausen-Mühlbauer, B. (2006) "Non-Linear Extended Blended Learning", *Proceedings of the Sixth International Network Conference (INC2006)*, pp.377–384, Network Research Group, University of Plymouth, England.
- Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen-Mühlbauer, B. (2007) "Learn Your Own Way: Decision Way Through Narrative Approaches, Methods and Paradigms for Learning Purposes", *Proceedings of the Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007)*, pp.99–114 Network Research Group, University of Plymouth, Plymouth, England, ISBN 0978-1-8410-2173-7.
- Seppälä, P. and Alamäki, H. (2002) "Mobile learning and mobility in teacher training", *Proceedings of the IEEE International Workshop on Wireless and Mobile Technologies in Education (WMTE'02)*.
- Sheypak, O.A.; Artyushina, G.G.; Atryushina, A.O.; Sheypak, S.A. (2007) "Advantages and disadvantages of e-learning at the technical University", *Proceedings of the ICL2007 Conference*, Editor: Michael Auer, Villach, Austria, September 27–29, 2007.
- Spitzer, M. (2002) *Lernen. Gehirnforschung und die Schule des Lebens* Spektrum, Akademischer Verlag, München, Heidelberg, Germany, ISBN: 978-3-8274-1723-7.
- Stengel, I., Bleimann, U. and Stynes, J. (2003) "Social insects and mobile agents in a virtual university", *Campus-Wide Information Systems*, Vol. 20 No. 3, pp.84–9, Emerald Group Publishing Limited, Bradford, England.
- Stephenson, J. and Yorke, M. (1998) *Capability and Quality in Higher Education*, Kogan Page, London, England.
- Tank, R. (2007) *Integration of laboratory lessons into the Atlantis University Platform (AUP) shown by the example of a traffic simulation*, M.Sc. proposal, IT Tralee, 2007.
- Uden, L. (2007) "Activity theory for designing mobile learning", *Int. J. Mobile Learning and Organisation*, Vol. 1, No. 1, pp.81–102.

G.7 Simplified Creation and Presentation of Non-Linear Adaptive Content

Schneider, O., Bleimann, U., Phippen, A.D., and Harriehausen-Mühlbauer, B.: *Simplified Creation and Presentation of Non-linear Adaptive Content*, in M. Chang et al. (Eds.): “Learning by Playing. Game-based Education System Design and Development, Edutainment 2009, Banff, Canada, August 9–11, 2009. Proceedings”, Lecture Notes in Computer Science, Volume 5670, pp. 239 – 250, Springer Verlag, Berlin Heidelberg, ISBN 978-3-642-03363-6, DOI 10.1007/978-3-642-03364-3_30 (2009)

Reprint with kind permission from Springer Science and Business Media

Simplified Creation and Presentation of Non-Linear Adaptive Content

Oliver Schneider^{1,2,3}, Udo Bleimann^{1,2}, Andrew D. Phippen³, and
Bettina Harriehausen-Mühlbauer²

¹ Centre for Advanced Learning, Media and Simulation (igdv), Schöfferstraße 1,
64295 Darmstadt, Germany
Oli.Schneider@mac.com,

WWW home page: <http://www.igdv.h-da.de>

² Institute for Applied Informatics Darmstadt (aiDa), Birkenweg 7,
64295 Darmstadt, Germany

WWW home page: <http://www.aida.h-da.de>

³ Information Security and Network Research Group, University of Plymouth,
Drake Circus, Plymouth, PL4 8AA, United Kingdom

WWW home page: <http://www.plymouth.ac.uk>

Abstract. A interactive storytelling based service has been developed for the learning project Atlantis University. It provides methods for presenting user adaptive non-linear coherent content in the context of Extended Blended Learning. Like other non-linear projects, it has the problem that huge amount of content is needed.

First the Atlantis University Project including the most significant methods used are presented briefly. Then an approach to overcome the problem by merging learner-types, a storytelling based coherence service and a content contribution system is presented.

1 Introduction

As the successor of Blended Learning, Extended Blended Learning overcomes the pure eLearning obstacles by integrating eLearning with face-to-face learning and project-based learning [1]. The first project realising this approach is Atlantis University [2]. Within the scope of this project a storytelling based system has been developed that provides methods for presenting user adaptive non-linear coherent content [3].

A problem of these systems is the huge amount of content that is needed for real user adaptation. Normally one person cannot create it by his own. Even more difficult is the adaption itself. To present content from different point of views, lots of discussions are needed to ensure that the content is understandable by the addressed learners.

To solve this problem, many authors may create the content as each of them would understand it best by themselves. However, this raises the difficulty of interconnecting the content sections in a way that adaptive coherent non-linearity arises.

This paper sketches a possibility to overcome this problem by merging the approaches of learner-types, a storytelling based coherence service and a content contribution system.

2 Atlantis University Project

The interdisciplinary project Atlantis University started in 2002. Ten universities and companies from England, Ireland, Poland, Hungary, Germany and United States of America collaborate in research and implementation of new pedagogical concepts. It is focused on an innovative combination of different knowledge-transfer forms called Extended Blended Learning.

Extended Blended Learning (EBL) sets the teaching on three pillars, as shown in Figure 1. The first pillar consists of classical face-to-face learning. For example,

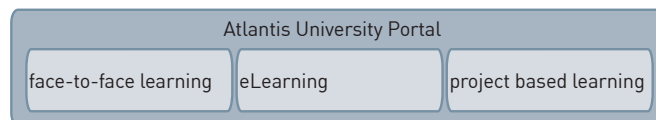


Fig. 1. Three pillars of Extended Blended Learning [2]

the learning topic's high-level dependencies and basics are communicated as well as questions and problems are clarified. The second pillar consists of the eLearning component used by learners to dynamically deepen knowledge and contribute with own information. This information can be interpreted generating knowledge and compiled results in, for instance, a Wiki system. In theoretical and practical terms great importance is assigned to project-based learning since it improves "communicating skills" – a major objective in education [4–6]. Not any other learning form is suited this well for the requirements of professional life [7, p 13], because within the scope of a project the project members gather not only the necessary knowledge, but also strengthen their team ability, communication and project management experience [2, p 4].

Atlantis University integrates all three columns of Extended Blended Learning into a virtual university. The respective pillar's part is measured depending on the teaching contents as well as the learner's previous experience and the learner's general situation [1]: A full-time student needs another mix than an employed person who needs specific skills.

The internationalisation of Atlantis does not end with its international project-partners: Of course, students may take modules at the partner universities. But there are also international modules like International Project Based Learning. In this way, the courses, modules and even lessons of the partner universities have been already merged. This enables the partners (and the lecturers) to focus on their own strengths. The students gain internationally accredited and recognised

qualifications by international cooperative, collaborative and interdisciplinary learning.

Because Atlantis University will bring together the contents of many existing universities, large amounts of learning content will be available. Especially students of small universities or departments would profit from this, because they could still select from a big offer. Although that is an immense advantage, the factor agony of choice also has to be taken into consideration: In today's universities the students know their lecturers from earlier lectures. Hence, usually they can estimate who provides the best content for them. However, in Atlantis University much more modules and lecturers as well as languages and individual student preferences have to be taken into consideration. Software has to be able to offer a suitable preselection.

3 Learner Types

For further improvement going beyond the Extended Blended Learning concept, individual learning characteristics of learners and teachers have been taken into consideration. The model developed by Franz Josef Röhl merges seven preference determination models out of 70 existing models [8]. It defines six different learner types [9]. A person does not correspond to only one learner-type, but his strong and weak developed learning preferences are averaged through all six preferences, see Figure 2. Typically two preferences are strong, two are medium and two are weak developed.

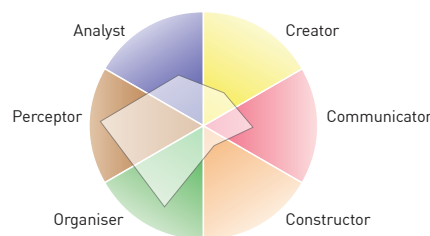


Fig. 2. Example for the six learner-types

The illustration shows exemplarily strengths in the domains of perceptor and organiser. A person of this learner type learns especially well and with pleasure if he is led step-by-step through clearly structured learning content [10]. In addition, the amplitude in the perceptor field shows that the learner should get these content audio-visually presented to achieve the optimum learning success. Hence, the learning material prepared for this learner type should stimulate his senses. These can be charts, animations or videos, but also kinetic stimulation like touch, or auditive for example talks and discussions. However, constructors

prefer experimentation and are generally very pragmatically assessed. Engineers often represent this type. Communicators need the group work, while analysts use a rather analytical approach and achieve the best learning results only using books. Creators learn best if they deal with something completely new. They lose often the interest if standard operations are involved in this process.

Atlantis University is not bound to the use of this special learner type theory. Hence, the discussion about the right learner characterisation is not scope within this paper. The learner type model can be replaced easily at any time.

4 Supporting the Learning Process via Technological Concepts

The basis of the Atlantis University learning environment consists of the following well-known components: Moodle is used as the Learning Management System. It provides all the needed basic functionality and is used to create modules, enrol the students to the courses, and provides basic information.

Wiki is used intensively as a collaboration tool. Students fulfil their tasks and describe their work in the Wiki system. Some modules use the Wiki as documentation system – each semester the students describe some parts of a certain topic. In contrast to books the Wiki-content is always up to date.

Moodle is optimised in handling learning content, but it is not intended to be used as Document Management System (DMS). Hence, for handling and versioning large amounts of revised documents a DMS has been integrated into Atlantis University. It is used for document based project work and for submitting the outcomes of a work that has been done by students during the semester.

In addition to these and other well known components (for example calendar, video conference system) some special learning-tools have been developed by the Atlantis University team.

4.1 Adjusting Content: Coherence

Dan Norman states [11]: “For teaching to be effective, cognition and emotion must work together.” This statement gets confirmed by studies in neuronal sciences that stress the importance of emotional engagement for learning efforts and motivation [12]. The key for this can be found in stories: Stories foster emotional engagement, because of having content structured in a suspenseful way. Total immersion into the imaginary world can be caused for the recipient, because of not only reading or viewing but also experiencing a good story.

Stories and their structures provide essential functionalities for learning environments: Focussing the teacher’s attention, provision of information and feedback about the learner’s efforts [13]. Stories are not limited to a certain topic. With narrative structures complex dependencies can be explained in a human understandable way. Stories are fundamental to culture and human understanding. They have familiar structures which are recognisable and can easily be understood. In human tradition stories were means for information transmission and

knowledge acquisition, e.g. within families and cultural communities. “Much true understanding is achieved through storytelling. Stories are how we communicate events and thought processes.” [14]

Lectures are often processed in an uniform way like a lecture script and then used for years. As a result eLearning modules are mainly used like lecture notes. Comparable to usual lectures the students work step by step through the content, without making use of their individual strengths and without avoiding their weaknesses. In contrast to this, the Extended Blended Learning concept of Atlantis University supports learning using the individual strength of the students. Thus it is characterised by non-linearity in several dimensions. To be able to control these processes, a new software approach is needed.

Therefore the Coherence service has been developed. Its design is based on interactive digital storytelling methods, which present non-linear content in a coherent way and is user-adaptive and independent of any concrete content [15]. The StoryEngine that is based on Propp’s story model [16] is most suitable for Extended Blended Learning [17]. Propp analysed Russian fairy tales and could verify a subset of a total of 31 action functions in every story [18]. These functions are arranged in a generally static order, but may be repeated individually or in groups [19, p 63]. Several variations (scenes) of a function can exist and all these functions are linked by dependencies [19, p 64].

The principle of the summarisation of scenes into functions and relations, to repeat and to apply conditions, can be transferred to the needs of Extended Blended Learning. However, Propp’s functions do not fit directly to the Extended Blended Learning scenario.

Because of the mixture between the three pillars, the execution of various Extended Blended Learning modules differ. Thus, one single model with firmly prescribed functions is not adaptable enough to describe those variations. The StoryEngine has been advanced in this respect so that it can process different models and that each of these models is able to define its own functions.

The Propp-model is originated in the fairy-tale world and therefore did not consider interaction [19, p 70]. The functions are not polymorphic; all variations always return the same result. Grasbon has extended the Propp-model by splitting some functions into two part-functions, so that interaction becomes possible. Within the scope of Extended Blended Learning all functions are polymorphic, so that they can influence the action. With the StoryEngine the course through the story is determined by predefined contexts, that may change to one of the following states: *not-set*, *demand*, *set*, and *on-stage*. Because this is too inflexible in the domain of Atlantis University, contexts can be defined freely, may be grouped, and they stretch value ranges instead of only supporting the four stages mentioned above.

With this extensions to Braun’s concept, this service is able to provide coherence, so that module content-sections are not lined up pointlessly or contradictory. The performance of the learners and their personal learning types [8] decisively influence the path through the learning-module by using interactive content.

The eLearning environment works completely regardless of any concrete content. This signifies that it is not only independent from the media type, whether the content is a video or a set of slides, but the system is usable for any kind of learning content and learning styles.

Therefore it divides content into three levels: The highest level is the coherence-model that describes the content-types and their relationship to each other. The medium level is an abstract content-description. It defines the content-sections, their relationship to each other and to which content-type they belong to. The lowest level includes the content itself and the interactions. These descriptions are processed by Coherence and a Content Service (Figure 3), for example the Learning Design engine CopperCore [20].

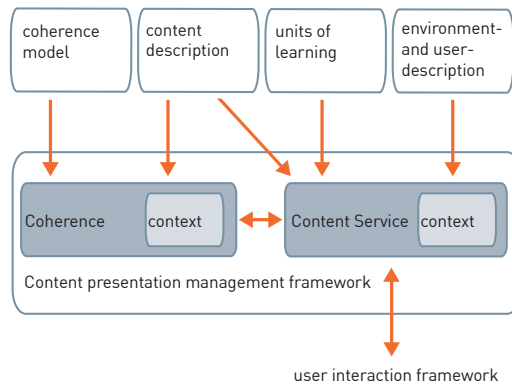


Fig. 3. System's overall architecture

The model has a timeline that provides a flexible duration. At this timeline the content-types are ordered. This order is not strict – it is more comparable to a proposal. It can be influenced by weights, contexts and loops. Each content type may typify several content-sections that refer to portions of concrete content. Figure 4 shows a very simple example for content-types typifying content-sections.

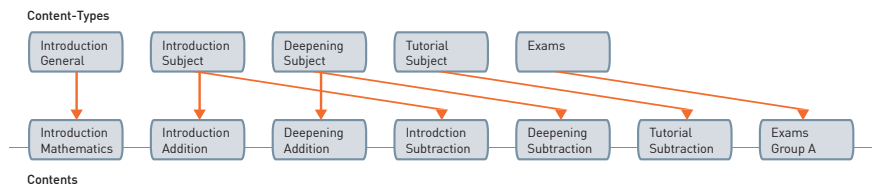


Fig. 4. Mathematics module composed of content-types

During runtime, the following content-section is selected depending on the history and the current context. Contexts provide coherence and dependencies between the content-sections. They serve as variables for the communication between content-sections, module-contents and systems. In contrast to usual computer languages every context has two values stretching a value range. For example, the context `acceptedAge` could be set with the minimum value 18 and the maximum value 30. The content-sections needing these contexts likewise define a value range that is compared to the set range. The comparison delivers a standardised return value between 0 and 1 that is multiplied by a weighting value that is likewise defined in the context query. This value's range is defined between -1 and 1 and serves to evaluate the result of the corresponding query. The effect reaches fluently from *must not* (-1) through *should not* and *should* until *must* (1). Hence, the limit values -1 and 1 signify compelling requirements.

The concept provides two different query-modes, illustrated in Figure 5. The first mode is overlapping. In this mode the system investigates how much the set context and the needed area overlap. Using overlapping the result is more than 0 as soon as the set context overlaps with the needed one. 1 is returned only if both value ranges are identical. using the second query mode, the nearness between the set and the requested values is checked. 1 is returned if the values touch. With increasing distance the value becomes smaller and smaller and approaches 0.



Fig. 5. Context comparison modes

Currently the context `duration` and the context group `learnerType` are mandatory. With the help of these contexts it is guaranteed, that a specific content is presented in a best fitting way to a learner type within a specific duration. Further contexts can be used to help to localise the content, for example the preferred (and provided) language, the needed locations, like lecture-room, laboratory, at home or maybe a specific university. Because of its flexibility this service is able to merge learning-modules of different lecturers to provide the optimal learning path for a specific learner-type. This includes modules of different universities.

This flexible approach has a huge demand of content that has to be kept up-to-date. The storytelling-based approach provides a user-friendly approach for non-linear interactive content creation. Nevertheless, currently Atlantis University lacks of an integrated authoring environment [21]. But a first step in this direction has been done with the development of CoCoMa.

4.2 Learning by Contribution: CoCoMa

When traditional teaching forms are used, the backward channel to the lecturer is limited and learners have little influence on the learning content, since knowledge in sciences as computer science loses its relevance rapidly. In conditions of fast changing information a new approach to impart knowledge is necessary. This approach will involve students more actively and increase their direct influence on the learning content.

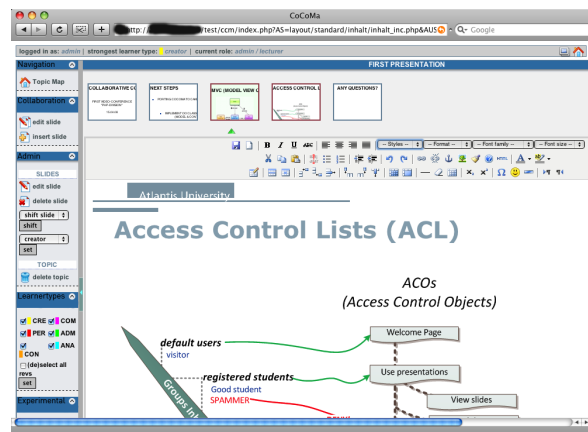


Fig. 6. CoCoMa screenshot

The Atlantis University concept does this by allowing students to generate learning content with WIKI-systems and semantic networks. In addition, within the scope of the project a system called Cooperative Content Manipulation (CoCoMa) has been developed. With CoCoMa students can update directly the learning content that has been initially provided by a lecturer. Lecturers don't lose the control of their content [22]. In contrast to normal versioning tools as used in WIKI systems, the initial author must actively accept amendments to replace the original version. By this way the content is always up-to-date without too much effort (see Figure 7).

CoCoMa gives great advantages to both, learners and lecturers. Learners may influence the learning content to their need. Hence, they identify themselves more with the content that consists of parts of their own work. This results in better learning abilities and results. This approach has been named "Learning by Contribution".

On the other hand, for many lecturers CoCoMa is the enabler for eLearning like on-line content presentation. They do not lose control, while students are encouraged to cooperate. This decreases the shy and being anxious about putting content online in an editable manner. CoCoMa will have a positive impact on students and lecturers work with other eLearning components like Wiki.

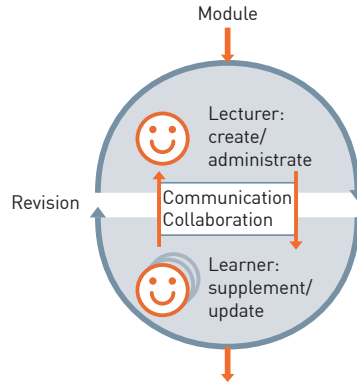


Fig. 7. CoCoMa content updating circle

5 Merging Content

The coherence service provides the ability to merge content created by different persons during runtime. The key to that is the context belonging to each content-section.

The coherence service creates coherent content out of many content-sections that are annotated by context. The context may be added explicitly, but most of the mandatory context can be set on the fly. For example, the author's learner-type is a context that must be set. But as it is known to the system because of preceding learner-type tests, no action is needed by the authors.

Provided that lecturers teaching the same module agree upon the same coherence-model, they fill it with content that fits best to their own type. Regarding to Röll's theory students learn best, if the content has been created by a lecturer whose learner type is close to theirs [10]. Therefore the coherence service compares the content's learner-type (that is in fact the content creator's learner-type) with the learner-type of the actual content consumer and chooses the best fitting content-section.

Following example demonstrates this. In Figure 8 the student's learner type is split into its fragments and lined up individually.

Figure 9 illustrates the learner type of one content section created by three different authors (framed). The student's learner type (non-framed) is compared with them and the most akin (the third) is chosen.

This concept also enables the coherence service to explain the same topic with different point of views by looping the content-type. Doing this, it will not repeat the same content-section but presents the same topic that has been created by another lecturer. This encourages the likeliness that the student will understand the topic he has to learn.

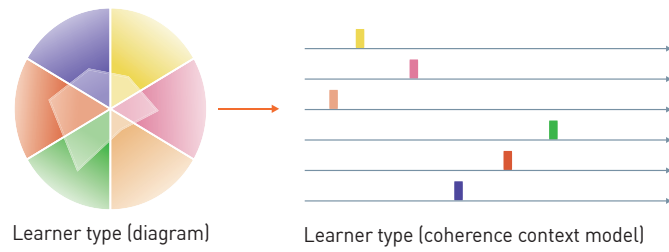


Fig. 8. Splitting up the learner-type

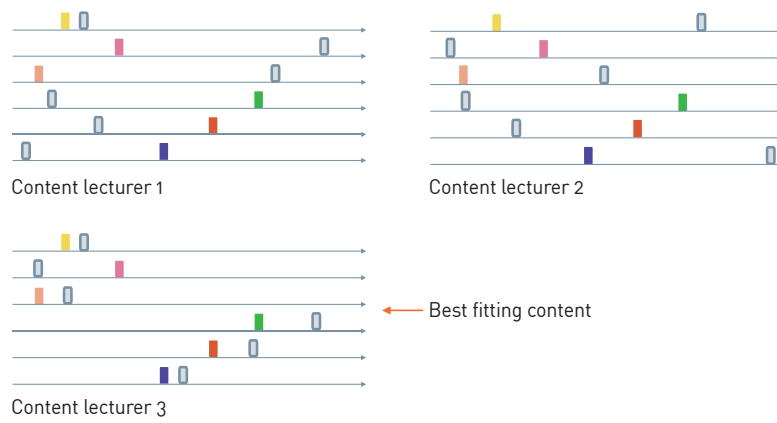


Fig. 9. Evaluation of the best fitting content

Of course, the coherence service does not only compare the learner types, but it also compares the other contexts as well as it factors in the content's dependencies. Hence, a content network is build up and adjusted during runtime.

6 Conclusion and Outlook

This paper presents a method that may overcome the difficulties of presenting adaptive non-linear content that has been created cooperatively in a learning context. Therefore the Atlantis University Project including the most significant methods used – Extended Blended Learning and learner types – are presented briefly. Two tools that have been developed in this context are explained: The storytelling based coherence service that ensures coherence of interactive presented content and CoCoMa that enables author guided contribution of students for content revision. These tools and approaches have been merged to gain support in creating and presenting the content. The concept is still under evaluation and needs refinement. But first results are very promising.

Further developments include expanding CoCoMa with an *Alternative*-button that graduates students from correctors to coauthors. Instead of accepting the revised version and dismissing all other revisions (including the original), the revised version becomes an alternative content. Typically this will not be a different content but a different view onto the topic. Hence, the *content update circle* would become a *content enrichment circle*.

References

1. Bleimann, U., Röhl, F.J.: Extended Blended Learning – Innovative Lernszenarien für die Hochschule. In: Querschnitt (Beiträge aus Forschung und Entwicklung der FH Darmstadt). Volume 01/06., Darmstadt, Germany (2006)
2. Bleimann, U.: Atlantis University – A New Pedagogical Approach beyond E-Learning. Campus-Wide Information Systems **21**(5) (2004) 191–195
3. Schneider, O., Bleimann, U., Phippen, A.D., Harriehausen-Mühlbauer, B.: Inside Coherence: Concept for a Non-Linear eLearning Solution. In: Proceedings of the Seventh International Network Conference (INC2008), Plymouth, UK, Network Research Group, University of Plymouth (7 2008)
4. Bruffee, K.A.: Collaborative Learning: Higher Education, Interdependence, and the Authority of Knowledge. Johns Hopkins University Press, Baltimore, MD (1999) ISBN-0-8018-5974-3.
5. Batatia, H., Ayache, A., Markkanen, H.: Netpro: An Innovative Approach to Network Project Based Learning. In: Proceedings of the International Conference on Computers in Education (ICCE'02), Auckland, New Zealand, College of Business, Massey University, IEEE Computer Society (December 2002) 382–386 ISBN 0-7695-1509-6.
6. Neo, M.: Web-Enhanced Learning: Engaging Students in Constructivist Learning. Campus-Wide Information Systems **22**(1) (2005) 4–14
7. Mills, J.E., Tregust, D.F.: Engineering Education – is Problem-Based or Project-Based Learning the Answer? In Scott, N., Hadgraft, R., Ilic, V.V., eds.: Australasian

- Journal of Engineering Education. The Australasian Association for Engineering Education Inc, http://www.aeee.com.au/journal/2003/mills_treagust03.pdf (Accessed 23rd January 2009) (2003) ISSN 1324-5821.
8. Brückner, S.: Structure Patterns Depending on Various Learner Types in an e-learning Context. Diploma thesis, Fachhochschule Darmstadt (2005)
 9. Röhl, F.J.: Computermedien, Bildungsmedien. Vom pädagogischen Nadelöhr zur selbstbestimmten Bildung. In Schindler, W., ed.: *MaC*_Reloaded: Perspektiven aus der Skepsis für *Menschen am Computer*. RabenStück Verlag für Kinder- und Jugendhilfe, Chemnitz, Germany (2005) 37–58 ISBN 3-935607-22-9.
 10. Röhl, F.J.: Entdecken Sie Ihren persönlichen Lernstil. http://comas.offeneslernen.de/lerno/MPX_rubrik.php?rubrik_id=289 (April 2006) (Accessed 30th January 2009).
 11. Currin, L.: Feelin' Groovy. <http://www.elearnmag.org/subpage.cfm?section=articles&article=10-1> (2004) (Accessed 6th February 2009).
 12. Spitzer, M.: *Lernen. Gehirn-Forschung und die Schule des Lebens*. Elsevier, Spektrum, Akademischer Verlag, München, Heidelberg (2002)
 13. Gagné, R.M., Briggs, L.J., Wager, W.W.: *Principles of Instructional Design*. Harcourt Brace Jovanovich College, Fort Worth (1992)
 14. Schell, J.: Understanding Entertainment: Story And Gameplay Are One. In Jacko, J.A., Sears, A., eds.: *The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications*. Lawrence Erlbaum Associates, Florence, Kentucky (2002)
 15. Schneider, O., Bleimann, U., Harriehausen-Mühlbauer, B., Phippen, A.D.: Non-Linear Extended Blended Learning. In: *Proceedings of the Sixth International Network Conference (INC2006)*, Plymouth, UK, Network Research Group, University of Plymouth (7 2006) 377–384
 16. Braun, N.: *Nonlinear Storytelling: Programmierter, interaktiver Narrationsansatz für kontinuierliche Medien*. Phd-thesis, Technische Universität, Darmstadt (December 2003)
 17. Schneider, O., Bleimann, U., Phippen, A.D., Harriehausen-Mühlbauer, B.: Learn Your Own Way: Decision Way Through Narrative Approaches, Methods and Paradigms for Learning Purposes. In: *Proceedings of the Third Collaborative Research Symposium on Security, E-learning, Internet and Networking (SEIN 2007)*, Plymouth, UK, Network Research Group, University of Plymouth (6 2007) 99–114 ISBN 0978-1-8410-2173-7.
 18. Propp, W.J.: Morphology of the Folktale. In: *International Journal of American Linguistics*. Volume 24. Indiana University of Research Center in Anthropology, Folklore, and Linguistics, Bloomington, IN (1958)
 19. Grasbon, D.: *Konzeption und prototypische Implementation einer Storyengine: Dynamisch-reaktives System zum Erzählen nichtlinear-interaktiver Geschichten bei größtmöglicher Spannung, gedanklicher Immersion, Identifikation und Motivation des Spielers*. diploma thesis, Technische Universität, Darmstadt (2001)
 20. Martens, H., Vogten, H.: A Reference Implementation of a Learning Design Engine. In Koper, R., Tattersall, C., eds.: *Learning Design*, Berlin Heidelberg, Springer Verlag (2005) 91–108 ISBN 3-540-22814-4.
 21. Schneider, O., Braun, N., Habinger, G.: Storylining Suspense: An Authoring Environment for Structuring Non-linear Interactive Narratives. *Journal of the WSCG* (2003) Plzeň, Česká republika.
 22. Pieke, M., Russell, C., Bleimann, U.: Collaborative content manipulation – an e-learning approach. In: *Internet Research*. Volume 17., Bradford, England, Hochschule Darmstadt, Emerald Group Publishing Limited (2007) 49–60

G.8 Exploration of Learner Preferences and their Impact Within a Media Module

Stengel, I., Schneider, O., Bleimann, U.: *Exploration of Learner Preferences and their Impact Within a Media Module*, in Bleimann, U., Dowland, P. S., Furnell, S.M., Schneider O. (Eds.): “Proceedings of the Eighth International Network Conference (INC 2010)”, pp. 279–288, ISBN: 978-1-84102-259-8 (2010)

© 2010 University of Plymouth

Permission to reproduce this paper in this thesis has been granted by University of Plymouth.

Proceedings may be obtained at:

<http://www.lulu.com/shop/steven-furnell-and-paul-dowland-and-udo-bleimann-and-oliver-schneider/proceedings-of-the-eighth-international-network-conference-inc-2010/paperback/product-12787113.html>

Exploration of Learner Preferences and their Impact Within a Media Module

Ingo Stengel, Oliver Schneider, and Udo Bleimann

igdv – Centre for Advanced Learning, Media, and Simulation
h_da – University of Applied Sciences Darmstadt
Ingo.Stengel@h-da.de

Abstract: Learner preferences of students have been analysed within two modules that have been given in the department of media using Röll's learner preference model. A qualitative analysis of the results of an online learner preference test based on this model has been conducted. This analysis showed that for the majority of the students the revealed results were valid.

Starting from current methods used by the different learners within the learning process, an aggregation helped to identify the methods and types of content that are predominantly used by students with certain learner preferences.

1 Introduction

In the Faculty of Media students work together to generate ideas and concepts for movies, products, print, as well as digital media and interactive applications. Some of them may have problems when they are confronted with the requirements of tasks in industry. They are able to produce interesting ideas, but they are not always able to address customers' needs.

The students involved in this elective were Bachelor and Master of Arts students. During this elective we address learner preferences in the process of content production for learning material, showing how different people are. This refers to the way they perceive, interact, and use different types of learning material. Students learn to identify correlations between certain learner preferences, and the methods and types of content used during the learning process.

2 Learner preferences

Students have certain preferences when learning. While some of them are more visually oriented, others might need auditive information, or even further types of stimuli to learn best.

Learning styles have been defined by Keefe [Kee79] as the “composite of characteristic

cognitive, affective, and physiological factors that serve as relatively stable indicators of how a learner perceives, interacts with, and responds to the learning environment”. All these are set in context with the learning process of students.

Over 70 models [CMHE04a] of learning preferences – sometimes also referred as “learning styles” – have been developed during the years. This is the expression of the fact that researchers do not agree on the ways how to measure learning preferences. Therefore, the existing learning preference models refer to specific abilities. A classification of the existing learning style models can be found in [CMHE04b].

During his work as a mentor of students from social sciences Röll noticed how different students approach problems. Since most of the existing models are addressing only certain abilities, Franz-Josef Röll designed a new learner preference model by analysing the existing models and aggregating them into a new model [Rö05a], pointing out that there also additional factors, e.g. educational background and learning environment, that have an influence.

His learner preference model identifies six different learner preference types [Rö05b]:

- The cognitive rational preference type (analyst) is lead by logic principles. He uses causal thinking and analytic procedures. The most specific abilities are related to abstract, theoretic models and to reflective watching. He needs structure and usually enjoys traditional lectures.
- The pragmatic-experimental preference type (constructor) prefers to active experiment instead of building theoretical models. His main principle is to act. Reflections on conducted actions are of secondary importance. He needs a plan and consequently a step-by-step procedure. Usually, he prefers project-based learning. By needing visual stimuli to learn better, he has good competencies in media.
- The organisational-structural preference type (administrator) needs data and facts. He is working systematically and thus is a good organiser. Sceptical to new ideas, he is always weighing the consequences before acting. While learning he needs instructions, thus he prefers to be supervised instead of self-driven learning.
- The sensory-kinaesthetic preference type (perceiver) is influenced by the perception of his senses. This makes him detail and fact oriented. Due to his imagination, he is able to see many perspectives of a problem. Impressions (audio, visual, kinaesthetic, etc.) support his learning process. He enjoys using case studies.
- The emotional-communicative preference type (communicator) is able to act only if he can recognise the benefit of the action. His actions are influenced by the need of appreciation, emotional preferences and relations. Communication is characterised by listening and talking. The best way of learning is through communication in groups or by dialogs.
- The intuitive-creative preference type (creator) is characterised by spontaneous ideas and visions that lead to intuitive problem solving. “Trial and error” procedures and intuitive comprehensions are used more often than rational thinking. As a learner,

the creator is an individualist who enjoys self-driven learning. Further, he questions established procedures by trying to find new solutions.

For this model a learner preference test has been developed in the lerno-project [Rö05a]. It uses crosschecks to ensure correctly evaluated data. Furthermore the results are referring to learning preferences and not to personality characteristics, although some conclusions on personality characteristics could be drawn.

This test gives, as most of the existing learner preference tests, only hints (positive, neutral, negative) about the characteristic of the learner preferences. For an example of a test please see figure 1.

The learner preference test is used to identify preferences that can be used to improve learning as well as preferences that need to be developed.

3 Activities and learning resources used

For the production of eLearning content the design of the overall module and application of different types of content were addressed.

The content of learning material was designed by using various methods. These methods can be traditional methods that are bound to certain learning theories, like the instructional design method from Gagne [GBW92]. Another possibility is given by methods that allow the use of different approaches belonging to different learning theories, e.g. the method from Kerres [Ker01].

To address a problem, the current tendency goes to the use of a proper methodology independently of its categorisation to a certain learning theory. This was also one of the results of an eLearning workshop at the University of Frankfurt in January 2010.

The methods used were face-2-face learning, eLearning, problem- and project-based learning as well as combinations of these known as blended learning.

The activities that have been taken into consideration include: brain storming, applying the 6 Thinking Hats, mind mapping, step by step approaches, moderation, storytelling, discussions, role play, teaching the group, flash cards, memory cards, tests, field trips, lab style sessions, exploration and experimentation, simulation activities, video training, writing own outlines, drawing concepts, using colour codes, making summaries, using sample assignments, categorising information, applying concepts, exercise and drills, and videoconferences.

The types of content used were: text, pictures, animations, video material, podcasts, screen-cast and recorded lectures. Therefore resources like the learning management platform Moodle including Wikis, Freemind, Camtasia, different Web 2.0 applications and the Adobe Software Package including Dreamweaver, Flash etc. have been used.

4 Outline of the course module and procedure

From the perspective of a trend towards individualisation and lifelong learning, there are two potential ways to improve learning: by taking into account the abilities of the learner and using them to accelerate the learning process on one side and by improving missing abilities on the other side.

In this module the focus lies on making students aware of their learner preferences and on the effects these have on the production of eLearning content.

The methodology used is based on experimental learning and qualitative interviews and group discussions. Produced content and opinions/preferences are gathered and questioned using open questions. The procedure is highly explorative. It is characterised by a qualitative study of theoretical aspects and the process of generation of hypotheses.

The module starts with the following experiment that outlines how different people visualise information. Then they are asked to describe how they learn best and write a short essay about it. To support this, predefined categories are handed out. Then they will proceed by doing the online learner preference test. The results, a learning profile together with the essay, are submitted and anonymised. They will be used to validate the learner preference test.

During the first content production task students will select a topic and produce content taking into account their own learning preferences. The samples of content produced are analysed and discussed in a group. In this step they will be able to identify the implications of learner preferences in the production of content.

After this step they are asked to analyse a set of information consisting of learner profile, essay containing a description of the preferences and the sample. This group work delivers a mapping between learner preference types and the activities performed.

Further, they will find out if the results delivered by the learner preference test show the same tendency as the essay is outlining.

After lectures about the production of content including the possibilities how to use different types of media within the learning content production process, they will have to produce a second sample for a predefined topic and learning profile.

In a final discussion the validity of the learner preference test used and the implications of learner profile in the production of learning content are discussed.

5 Results

5.1 Example of a learning profile and samples of content produced by a student

As an example the learning profile of one of the students involved and the content he produced is presented below.

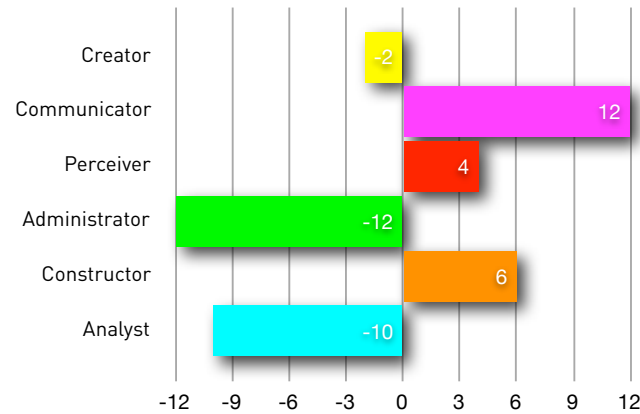


Figure 1: Learner preference profile of a student

This profile is characterised by positive tendencies in the learner preference types: communicator, perceiver and constructor and negative tendencies in the learner preference types: creator, administrator, and analyst.

From our experience:

- The learner preference creator is one of the preferences that is not “hard bound” to any other learner preference. A negative value characterises students that learn best by repeating learning material.
- The positive communicator value indicates toward a student that learns by interacting and communicating. Here a section from its essay: *“Taking a look at how I prepared myself for exams at university, the most important thing were several meetings with a learning group. We met and discussed all the topics that were relevant for the exam.”*
- The positive perceiver tendency is indicating the need of multi sensory experiences during the learning process. *“For my exams I learn with a conclusion of our professor’s slides. On these slides most is just text, but sometimes even visualised through pictures or graphics. If there are no graphics I paint little pictures by myself.”*
- The negative administrator tendency is usually giving a hint that the person is not using diagrams, tables or numbers during learning.
- The positive constructor value points at a learning process that uses exploration and experimentation in the context of a defined focus. *“Beginning a new task I always felt like this was ‘too high’ or ‘too complicated’ for me – but by just starting off [...] it was a thrilling experience.”*
- The negative analyst tendency indicates that the person is not using abstraction during the learning process.

The third element necessary for the analysis was the first content production task. This student developed a game that helps students to learn to identify the countries of Europe, see figure 2.

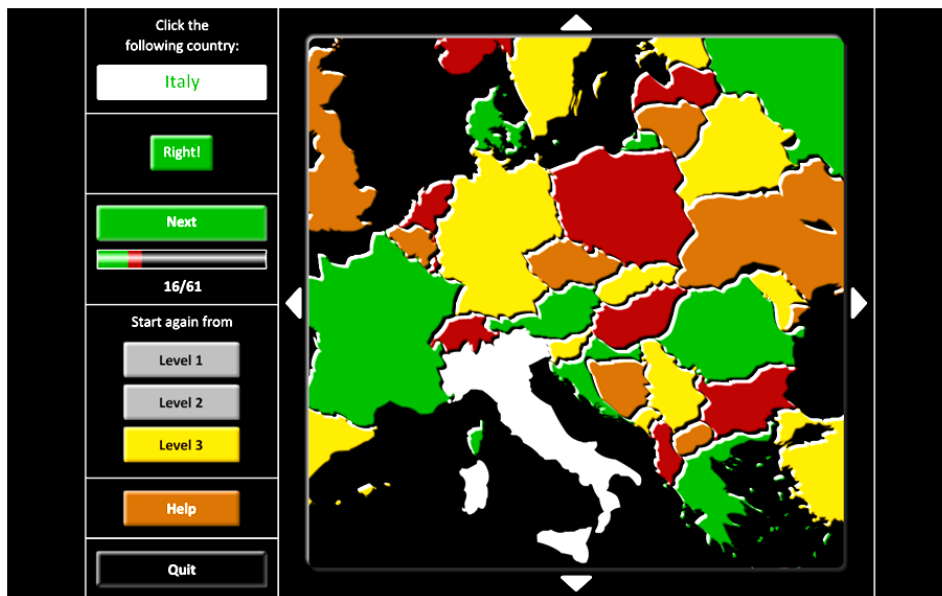


Figure 2: The Game: Countries of Europe

The game is characterised by continuous interaction through questions & answers – typical for a communicator. He needs continuous feedback, here implemented as a right or wrong statement to any action executed by the student.

The game reacts on mistakes questioning the countries that have been not recognised, addressing the need for learning through repetition (negative creator value).

The multiple details and facts as well as the multi sensory experiences (visual, colours) are typical for perceivers.

The learning by doing is characterised by practical experience, by learning through clicking on the countries. This is combined with a clear structure: starting with the basics, clear objectives, what is right or wrong, no grey areas, knowing your position through the progress bar shows the current position during the game, knowing clearly what is done. All these together with the rational, logical, practically oriented approach characterise constructors.

5.2 Findings

The total number of students involved was 30 within two modules given in the year 2008 and 2009. In each module 15 students have participated.

From the data collected using the learner preference test we can conclude:

- Some results of the same person varied since students may respond from different perspectives. One perspective was the current way they perceive learning, while alternatively they confounded it with the way how they would aim to learn.
- A couple of interesting cases have been identified, e.g. the communicator learning preference type also includes students that need to be involved passively in communication. They like to listen without being directly involved.
- The majority of students involved found the learner preference test as valid, since their profiles were fitting the way they learn. A quantitative analysis revealed the following distribution of the results, see figure 3. However, a readjustment of the learner preference analyst is recommended. In very seldom cases the value seems to be too low.

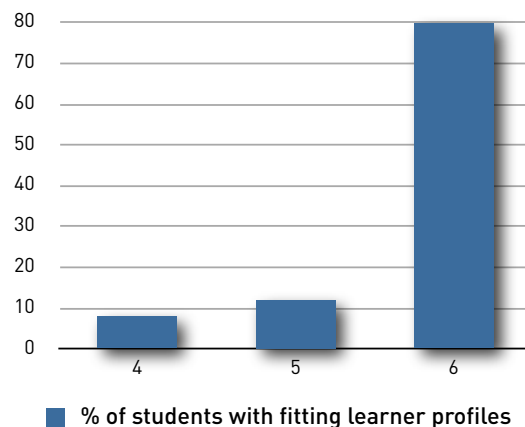


Figure 3: Percentage of students with 4–6 fitting learner preferences

- The results are statistical significant, since a Type I error characterised by the condition $P < 0.05$ was identified.
- The normal distribution of the tendencies in the learner profile contains usually two positive tendencies, two neutral values and two negative tendencies. This confirms the first observations in the lerno-project [Rö05a].
- We found that the isolation of only one learner preference type is possible] the creator. There are interdependencies between the rest of the learner preference types that lead to a restricted number of overall profile types.

- Usually, students are not aware of their learner preferences [Rö05b]. They use methods and contents sometimes instinctively and sometimes based on the results achieved.

As stated in [Pop09] “students with different learning styles have different needs and also different behaviours during the learning process”. During this module students found out that this has direct implications in the development and the production of learning contents and developed a simple mapping.

5.3 Related research

A high amount of learner style models exist. They can be very different, ranging from Neurolinguistic Programming (NLP) [DGBD80] to David Kolb’s model [Kol84] or even to personality based approaches like e.g. the Hausschild/Bambeck model [Hau02].

In [Aye96] it has been confirmed that when implementing learning environments the usage of learner styles leads to an improvement in the learning process.

Later in 2009 in [YG09] the authors affirm that “if the learning style features aren’t determined in the right way [...] the expected results cannot be reached.” In [YG09] a statistic evaluation was done using students from primary school. The learning environment was merely reduced to a class environment. This makes the implementation of learner styles compliant courses a big challenge. Some of the learner styles are hard to address in this environment.

A similar project that supports the use of own capabilities to learn more effectively is the Atlantis project [BSS09]. In this case students are encouraged to “learn their own way”.

6 Further developments

The learner-preferences can also be used to adapt the presentation of content to individual learners. The interactive digital storytelling based Coherence Service is being developed for that task. It provides the ability to merge content created by different persons during runtime. Therefore it uses content-sections that are annotated by context. This may be added explicitly, but most of the mandatory context can be set on the fly. For example, the author’s learner-preferences is a context that must be set. But as it is known to the system because of preceding learner-preferences tests, the authors don’t need to do any additional work [SBPHM09].

Regarding to Röll’s theory students learn best, if a lecturer has created the content whose learner preferences are close to theirs [Rö05b]. Therefore the coherence service measures the distance of each of the content creator’s learner-preferences with the current content consumer’s learner-preferences. The content section providing the overall nearest learner-preferences is the best fitting content regarding the learning style.

If more than one author has created the content for one topic, this concept also enables the coherence service to explain the same topic from different point of views. Doing this will not repeat the same content-section, but presents the same topic that has been created by another lecturer. This increases the probability of the student understanding the topic, he learns about.

Of course, the learner preferences are not the only criteria for choosing the right content section. Other dependencies and context information as LBS and language are also taken into account. This enables further applications, as location dependence [SBS09] or – for experienced authors – immersive and suspenseful storytelling oriented content presentation.

7 Conclusions

Learner preferences of the students have been analysed within two modules that have been given in the department of media using the Röll model. A qualitative analysis of the results of an online learner preference test based on Röll's learner preference model has been conducted and showed that about 80 % of the students confirmed that the generated learning profiles are fitting. The rest of the students had small divergences regarding their profile (1–2 preferences not fitting). This was due to answering questions from a wrong perspective (how they would like to be) or due to a too low analyst value. This showed that for the majority of the students the revealed results were valid.

Starting from current methods used within the learning process an aggregation helped to identify the methods and types of content that are predominantly used by students with certain learner preferences. A couple of interesting cases have been identified.

References

- [Aye96] David J. Ayersman. Reviewing the Research on Hypermedia-Based Learning. *Journal of Research on Computing in Education*, 28(4):500–576, 1996. ISSN-0888-6504.
- [BSS09] Udo Bleimann, Ingo Stengel, and Oliver Schneider. Atlantis University – The Future of Learning and Teaching. In Steve Wheeler, editor, *Conference Proceedings of the 4th Plymouth e-Learning Conference “Boundary Changes – Redefining Learning Spaces”*, Plymouth, 2009. University of Plymouth.
- [CMHE04a] Frank Coffield, David Moseley, Elaine Hall, and Kathryn Eccleston. *Learning Styles and Pedagogy in Post-16 Learning: A Systematic and Critical Review*. Learning and Skills Research Centre, London, 2004. ISBN: 185338918, www.LSRC.ac.uk, retrieved February 15th 2010.
- [CMHE04b] Frank Coffield, David Moseley, Elaine Hall, and Kathryn Eccleston. *Should we be Using Learning Styles? What Research Has to Say to Practice*. Learning and Skills Research Centre, University of Newcastle upon Tyne, London, 2004.
- [DGBD80] Robert Dilts, John Grinder, Richard Bandler, and Judith DeLozier. *Neuro-Linguistic Programming: Volume I – The Study of the Structure of Subjective Experience*. Meta Publications, Cupertino California, 1980.

- [GBW92] Robert M. Gagné, Leslie J. Briggs, and Walter W. Wager. *Principles of Instructional Design*. Wadsworth Publishing, 4 edition, 1992. ISBN: 0030347572.
- [Hau02] Harald Hauschildt. Modell 1: ALPHA PLUS® Profile. In Martina Schimmel-Schloo, Lothar J. Seiwert, and Hardy Wagner, editors, *Persönlichkeitsmodelle*, page 55–78. GABAL Verlag GmbH, Offenbach am Main, 2002.
- [Kee79] James W. Keefe. Learning style: An overview. In *NASSP's Student learning styles: Diagnosing and proscribing programs*, pages 1–17, Reston, 1979. National Association of Secondary School Principals.
- [Ker01] Michael Kerres. *Multimediale und telemediale Lernumgebungen. Konzeption und Entwicklung*. Oldenbourg Wissenschaftsverlag GmbH, München, 2001. ISBN 3-486-25055-8.
- [Kol84] David A. Kolb. *Experiential Learning: Experience as the Source of Learning and Development*. Prentice-Hall, Inc., Englewood Cliffs, N.J., 1984.
- [Pop09] Elvira Popescu. Learning Styles and Behavioral Differences. In *Web-based Learning Settings, Proceedings of the 9th IEEE International Conference on Advanced Learning Technologies*, pages 446–450, Riga, Latvia, July 2009.
- [Rö05a] Franz Josef Röhl. Lerno-project documentation. <http://www.lerno.de>, last accessed February 14th 2010, 2005.
- [Rö05b] Franz Josef Röhl. MaC* – Reloaded: Perspektiven aus der Skepsis. chapter Computermedien, Bildungsmedien – Vom pädagogischen Nadelöhr zur selbstbestimmten Bildung, page 37–58. RabenStück Verlag für Kinder- und Jugendhilfe, Chemnitz, 2005.
- [SBPHM09] Oliver Schneider, Udo Bleimann, Andrew D. Phippen, and Bettina Harriehausen-Mühlbauer. Simplified Creation and Presentation of Non-linear Adaptive Content. In Maiga Chang, Rita Kuo, Kinshuk, Gwo-Dong Chen, and Michitaka Hirose, editors, *Learning by Playing. Game-based Education System Design and Development*, volume 5670 of *Lecture Notes in Computer Science*, pages 239–250, Banff, Canada, August 2009. Athabasca University, Springer Verlag. DOI 10.1007/978-3-642-03364-3_30.
- [SBS09] Oliver Schneider, Udo Bleimann, and Ingo Stengel. Atlantis University: Learn Your Own Way. *Int. J. Mobile Learning and Organisation*, 3(2):184–201, 2009.
- [YG09] Özge Yazicilar and Bülent Güven. The Effects of Learning Style Activities on Academic Achievement, Attitudes and Recall Level. In *Proceedings of the World Conference on Educational Sciences 2009, Procedia Social and Behavioral Sciences 1*, volume 8, pages 2578–2583, Istanbul, 2009. Bahçeşehir Üniversitesi, İlköğretim Online.