Ergonomie: Mensch – Produkt – Arbeit – Systeme
Band 11

Sissel Guttormsen Schär

Multimedia Didactics

Studies on the learning effects of dynamic visual media, based on analyses of cognitive models and learning content characteristics

Shaker Verlag
Aachen 2006

For Natalie, Valerie and Marius, – showing that independence is a precius outcome of learning.

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Acknowledgments

This work is a collection of my research experience in the field of Multimedia didactics from my time at the Institute of Hygiene and Applied Physiology (IHA) at the Swiss Federal Institute of Technology Zurich (ETHZ). My gratitude goes to all those with whom I worked and cooperated over the past years. Without them, this work would not have been possible.

First of all my gratitude goes to Prof. Helmut Krueger who provided an inspiring working environment and gave me enough autonomy to build up my own research activities. His consistent support throughout the years built the vital basis of my work.

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Last but not least my husband Heinz Schär has provided the constant support and tolerance for my commitment to research, which is a vital contribution when combining family life with active professional work.

Foreword

Although we would expect human learning processes to be well known and well investigated, it continues to be a research field with many unknown areas. The emergence of new technology, 'multimedia', to support learning has not only opened for new forms of learning, but has also made deficits of existing learning theories more clear.

Countless factors contribute to the overall picture of multimedia in teaching. It is a challenge to try to encompass the dynamics of learning processes. Multimedia didactics is the synergy of at least the following aspects:

- new ways of presenting information with various media through recent technological development,
- cognitive theories of learning, describing human preconditions for information processing and other influencing individual characteristics like motivation, intelligence, aptitude,
- analysis and descriptions of the learning content and the learning task,
- modalities of knowledge and knowledge testing

Based on many years of theoretical research and practical experience in multimedia didactics during her activity at the Swiss Federal Institute of Technology, and partly in tele-cooperation with the Technical University of Karlsruhe Sissel Guttormsen goes one-step beyond a most common one-dimensional point of view in scientific papers. She considers the learning process in different contexts of multimedia. She tackles the problem in a thoroughly scientific way. The general introduction gives a comprehensive classification and exhaustive definitions of the variables. She proposes a mapping between the dynamics of cognitive concepts and the dynamics of multimedia means. The process of learning does not drive this mapping exclusively, as is so often seen in intelligent tutoring systems. Content drives this mapping. Form follows content.

Going into new grounds in sciences is like an adventure. Sissel Guttormsen's approach to multimedia didactics is on the edge of new insights in didactics for a number of reasons.

Sissel Guttormsen advocates a cognitive approach for investigating the effects of multimedia presentations on human learning. Different theories for human learning in a multimedia environment are presented and their strengths and weaknesses are discussed. Her work particularly points out the theoretical deficits in explaining the cognitive processes involved when perceiving dynamic media presentations (e.g. animation or film). Continued empirical research is needed for model building in this area.

Dynamics in teaching means and methods is a relatively new subject in the human sciences. For years, linear and static concepts were preferred because they are easier to operationalize and control. The last decade or so showed us the failure of the latter approach with respect to computer supported learning. That is why this work is so promising for future research. It demonstrates the possibility and offers a methodology for the research on dynamical factors in learning, more specifically in the context of computer enhanced learning systems.

The use of ergonomics in the context of learning is original. Two factors drive the design of visual material: human cognitive competencies, their underlying processes, and the content, what is to be learned.

The problem is approached from a very broad perspective. By this fact, the results should be applicable, or at least inspirational, to other fields of research. For example, the concept of mapping spatial layout and behavioural skills including cognition and emotion is essential to open up the functionality of products to a user by minimizing the learning effort.

This book shows the close relation between multimedia didactics, cognitive aspects, learning content, and knowledge testing. New technology offers unlimited possibilities for how to design learning situations. The bottleneck continues to be the human learner, for whom the whole effort of designing good instructions with multimedia should be worth the expense. Within the frame of the complex context for research and development in this field, the author aims at nothing else than advocating the necessity to understand the interplay between the conditions of the learner and the learning content and thereby providing the most optimal support with the given technological possibilities.

The clear structure will lead also readers who are not yet familiar with the topic to a deeper knowledge of multimedia didactics.

Karlsruhe,
June 2006

(PD Dr. Peter Haubner)

Zürich,
June 2006

(Prof. Dr. Dr. Helmut Krueger)

Abstract

This work examines actual issues related to *Multimedia Didactics* from three perspectives. The first part presents an overview of relevant cognitive theories and their employment in empirical multimedia research on the one hand and theoretical and applied framework for instructional design on the other hand. The selective synthesis of these two theoretical sections is a major contribution of this work.

The second part presents a selection of the author's own empirical research on multimedia didactics. Five experiments are presented in depth. Four experiments were designed to investigate the didactical conditions required for establishing a learning effect of dynamic visual media. In order to explore and test this issue the experiments also incorporated various static and dynamic media and their combinations (e.g. text, picture, voice, animation).

The fifth experiment applies to both instructional design and multimedia design in the following way: It is necessary to analyse the learning content before applying an instructional strategy. Hence, learning content analysis could proceed by identifying a given set of learning content categories, for which favorable instructional strategies are already known. Furthermore, we suggest that multimedia design to some extent relies on characteristics of the learning content. Hence, learning content categories for this purpose must be identified. Consequently, experiment five represents basic research related to the learning content analysis issue, as it aims at identifying reliable learning content categories for the mentioned purposes.

The third part of this work presents a synthesis of the theoretical state of the art, the implications for further research and multimedia design guidelines that are consistently supported in the literature.

Kurzfassung

Ein erster Teil gibt eine Einführung über Theorien des Lernens mit multimedialer Unterstützung. Dieser Teil zeigt vor allem den aktuellen Wissensstand der Theorie der Kognition auf diesem Wissensgebiet. Kritisch werden Stärken und Schwächen der Theorien diskutiert. Besonderes Schwergewicht wird auf den Effekt einer doppelten Kodierung gelegt. Dazu ist eine genaue Betrachtung der Verarbeitung und Speicherung notwendig. Menschen sind nicht einfach passive Informationsempfänger, sondern interpretieren, bewerten, ordnen und

handhaben jede Information. Ein eigenes Kapitel ist den Lehrtheorien (Computer supported instructional Design, CSID) gewidmet, die sich mit dem Design einer E-Learning-Umgebung beschäftigen. Auf die Struktur von Lernobjekten (Learning objects) wird vertieft eingegangen. Diese stellen im Hinblick auf die Erstellung von E-Learning-Material ein besonderes Problemfeld dar.

Im zweiten Teil präsentiert die Autorin einen Teil der Ergebnisse ihres eigenen empirischen Beitrags zum Thema. Es sind empirische Studien zu den Randbedingungen des Einsatzes statischer Medien im Hinblick auf Lernerfolg und kognitive Beanspruchung, zur Effektivität dynamischer Medien und der Konsistenz des Effektes im Hinblick auf verschiedene Wissenskategorien und Lerninhalte, die Auswirkung der Medien und eines vom Benutzer kontrollierten Informationsflusses sowie auch vordefinierter Grössen von Lerneinheiten (Chunks) auf verschiedene Lernparameter. Die letzte Studie beschäftigt sich mit Lerninhalten und didaktischen Metadaten. Speziell die Ergebnisse dieser letzten Studie geben Hinweise, dass eine Verallgemeinerung von Metadaten möglich ist.

In einem abschliessenden dritten Teil werden Folgerungen aus den beiden ersten Teilen gezogen und Perspektiven für die weitere Forschung und Entwicklung aufgezeigt.

Transfer to Practice

This work is a theoretical and empirical contribution to research on new technology in didactical multimedia design. It applies to researchers, in the first place, as well as interested instructional designers, in the second place.

Theoretical contribution

The work presents an overview of relatively early and new theories relevant for research and implementation of multimedia didactics. Our view on multimedia didactics intends to integrate both cognitive theory and didactical models for learning design. Hence, the integration of classical cognitive models for *information processing* together with instructional models focusing on *structures of the learning environment* is a major contribution of this work.

Iterative process

Theories contribute in two important ways in this context: First, they offer a frame for structured observation, which is crucial in experimental research. Systematic research is difficult without a model. Second, deep insight in the way humans process information is a prerequisite for designing learning environments that have constructive impact on learning. Purposeful change without this insight is not

possible. In this context research both aims at applying existing models, which are still limited, and at the same time extending them. Hence, focused research and the generation of theoretical models are two factors of an ongoing iterative process in this field.

Integration

Cognitive models hold that learning will occur when information is presented according to how our cognitive system processes information. Instructional design models advocate that an important key to successful learning is to create learning environments that are based on thorough insight into the structural aspects of didactical design, e.g. analysis of the subject matter content, specification of the learning objectives, selection of the suitable presentations forms, and of the suitable test methods. In order to design complete learning environments, we pronounce that both approaches are essential and suggest how they can be integrated.

Empirical research

We have given the presentation and discussion of empirical research much space in this work. We have presented a review of relevant empirical research and derived guidelines for design from existing research (chapter 3). The presentation of Rieber's experiments (chapter 3.3) states an example of excellent focused experimental research in this field. Rieber's research also demonstrates the key problems of research in this context, i.e. the identification of consistent factors resulting in a learning effect with dynamic media. Based on the reviewed empirical research and on our own research, this work conclusively suggests some factors that are related to and possibly responsible for a learning effect with dynamic media.

Recommendations

The last part of this work (chapter 7) presents a synopsis of the theoretical and practical conclusions of our work. We suggest concrete research questions for further research. The problem related to this kind of research is not so much to design experiments, but to design experiments addressing the crucial questions. Last but not least, we present an outline of design guidelines that have shown to be consistently supported in the empirical research.

About the Author

Sissel Guttormsen Schär (1965) from Norway studied philosophy, psychology and statistics at the University of Oslo (1985–1992). She was a scientific assistant at the Institute of Hygiene and Applied Physiology (IHA), Swiss Federal Institute of Technology (ETHZ) from 1992–1997. Her doctoral thesis published in 1997 dealt with cognitive theory and the influence of the user interface on learning computerised tasks. Mrs. Guttormsen lead the research group Man Machine Interaction (MMI) from 1998–2005. MMI run interdisciplinary applied research within the fields of human factors & technology, e.g. interaction design, communication technology and e-learning. She received the Venia Legendi (habilitation) for the field cognitiv ergonomics at the ETHZ in 2004. The habilitation thesis covered her scientific work on multimedia didactics. Since 2005 Mrs. Guttormsen is professor for medical education and the director of the Institute of Medical Education at the University of Bern.

Table of Content

Acknowledgments III
Foreword IV
Abstract VI
Kurzfassung VI
Transfer to Practice VII
About the Author IX

1.1 Contextual Definitions 15
1.1.1 Multimedia Definitions 15
Media as technical or physical medium 15 / *Media as information representation codes* 16 / *Media as modality of communication* 16 / *Media as implication for cognitive information processing* 17
1.1.2 Learning & Instruction in Context 18
The role of multimedia in instructional design 20
1.1.3 Basic Classification of Information 20
1.2 Multimedia Learning – an Issue of Cognitive Ergonomics 22
1.2.1 What is Software Ergonomics? 23
1.2.2 New Aims for the Next Generation of Software Ergonomics Research 25
1 The priorities for the software ergonomics need to be reformulated. 26 / *2 Knowledge & models for information processing (cognition) need continuous reevaluation.* 28 / *3 A shift from technology-driven to human factors-driven HCI design is due.* 28 / *4 New methods for measurement of usability and accessibility are necessary.* 30
1.2.3 Conclusions 32

Part I: Theoretical Review

2.0 Theories of Multimedia Learning 35
2.1 Paivio's Dual Coding Theory 38
2.1.1 Assumptions About the Dual Coding System 39
2.1.2 The Picture Superiority Effect 43
2.1.3 Summary 44
2.1.4 Discussion 45
2.2 Sweller's Cognitive Load Theory 47
2.2.1 Cognitive Architecture 47
Schemas 48 / *Automation* 48 / *Understanding and working memory load* 49
2.2.2 Theoretical Assumptions 50
Some sources of extraneous cognitive load 52

2.2.3 Instructional Designs; Solutions as Suggested by Sweller 53
2.2.4 Summary 55
2.2.5 Conclusions 55
2.3 Mayer's Cognitive Theory of Multimedia Learning 57
2.3.1 Theoretical Premises 57
Definitions and experimental context 57 / *Different qualities of learning* 58
2.3.2 Theoretical Assumptions 59
Elaborating on the dual channels assumption 59 / *Elaborating on the limited capacity assumption* 60 / *Elaboration on the active learning assumption* 61 / *Five steps of multimedia learning* 61 / *Creating mental representations* 63
2.3.3 Examples of How Three Kinds of Presented Material are Processed 64
2.3.4 Summary 64
2.3.5 Discussion 66
2.4 Engelkamp's Multimodal Memory Theory 69
2.4.1 Architecture of the Multimodal Memory Theory 70
2.4.2 The Structure of the Sensory-motor System 74
2.4.3 The Structure of the Conceptual System 74
2.4.4 Discussion 75
3.0 Visualisation in Education: An Overview 78
Concluding remarks 81
3.1 Mayer's Principles for Multimedia Design 82
3.1.1 Multimedia Principle 82
3.1.2 Spatial Contiguity Principle 83
3.1.3 Temporal Contiguity Principle 83
3.1.4 Coherence Principle 84
3.1.5 Individual Difference Principle 85
3.1.6 Modality Principle 85
3.1.7 Redundancy Principle 86
3.2 Reviews of Research on the Learning Effect of Animation 88
3.2.1 Conceptual definitions 88
3.2.2 Overview of empirical evidence for the effectiveness of animations 90
3.2.3 Reasons for varying results 90
The influence of the research paradigm 91 / *Research objective, methods and conceptualisation* 92 / *Individual characteristics* 94 / *Possible evaluation flaws* 94
3.2.4 Growing evidence for the relevance of the learning content for instructional design with animations 95
3.2.5 Cognitive effects of animations 97

3.2.6 Guidelines for instructional design with animations, derived from state-of-the-art research 98
3.2.7 Conclusions 101
3.3 Rieber's Research on Animation in Computer-Based Instruction, an Empirical Review and a Case Study 102
3.3.1 Experiment I (Rieber & Hannafin, 1988) 103
Method 103 / *Results* 104 / *Retrospective discussion* 104
3.3.2 Experiment II (Rieber, 1989) 105
Method 106 / *Results* 106 / *Retrospective discussion* 107
3.3.3 Experiment III (Rieber, Boyce, & Assad, 1990) 108
Method 108 / *Results* 109 / *Retrospective discussion* 110
3.3.4 Experiment IV (Rieber, 1991a) 110
Method 112 / *Results* 113 / *Retrospective discussion* 114
3.3.5 Experiment V (Rieber, 1991b) 115
Method 116 / *Results* 117 / *Retrospective discussion* 117
3.3.6 General discussion 117
4.0 Computer Supported Instructional Design (CSID) 120
4.1 Merrill's Component Display Theory (CDT) 123
4.1.1 Performance – Content Classification 124
Specifying objectives 124 / *Performance-content matrix (P/C matrix)* 124 / *Content* 125 / *Performance* 126 / *Specifying test items* 127
4.1.2 A Taxonomy of Presentation Forms 128
Generalities and instances 128
4.1.3 Prescriptions Related to Classification System and Presentation Forms 129
Merrill's instructional theory: Performance and PPF consistency 130 / *Secondary Presentation forms* 130 / *Interdisplay relationships* 132
4.1.4 Discussion 133
4.2 Merrill's Instructional Transaction Theory 135
4.2.1 Defining a Knowledge Object 135
4.2.2 Instructional Transaction Theory and the Computer Programme assumption 136
4.2.3 Architecture of the Instructional Transaction Theory 137
4.2.4 Component Design Theory 139
Mental models in CDT_2 139 / *Knowledge components* 140 / *Instructional strategy components* 142 / *Parts-of instructional transactions* 143 / *Kinds-of transactions* 143 / *How-to or what-happens transactions* 145
4.2.5 Discussion 146
4.3 Learning Objects in Computer-Supported Instructional Design 148
4.3.1 Towards Learning Object Models 148
4.3.2 Aspects of Reusability 150

4.3.3 Aspects of Representation 151
4.3.4 Metadata in Instructional Settings 152
4.3.5 Aspects of Knowledge 154
4.3.6 Conclusions 154
5.0 General Discussion 156
5.1 The Cognitive Approach to Multimedia Learning in Context 158
5.2 Learning Objects and Computer-Supported Instructional Design – a Critical Discussion 159
5.3 Conclusions 162

Part II: Empirical Research

6.0 Introduction to Our Empirical Research 165
6.1 Experiment I: Boundaries for Learning through Cognitive Load with Static Media 167
6.1.1 Introduction 167
6.1.2 Theoretically Supported Media Assumptions 169
6.1.3 Method 170
Design 170 / *Hypotheses* 171 / *Subjects* 171 / *Learning material and learning tasks* 171 / *Technical setup* 172 / *Test of learning & definitions of the knowledge categories* 172 / *Scoring of the inference knowledge task* 172 / *Control for third variables* 173 / *Procedure* 174
6.1.4 Results and discussion 174
Effect of the presentation forms on preference 177 / *Evaluation of the hypotheses* 178
6.1.5 Conclusion 179
6.2 Experiment II: Evaluation of the Learning Effects of Dynamic Media. Evaluating a framework of theoretical hypotheses for animation learning. 180
6.2.1 Introduction 180
Learning content for instructional design with animations 182
6.2.2 Method 186
Operational hypotheses 186 / *Design* 186 / *Subjects* 187 / *Experimental tasks and measures* 187 / *Production* 189 / *Experimental procedure* 190
6.2.3 Results and discussion 191
Evaluation of the hypotheses 192
6.2.4 Conclusions 194
6.3 Experiment III: Evaluating Learning Effects of Dynamic Media: Testing the Effect of Media and User-Controlled Information Flow on Different Knowledge Parameters 195

6.3.1 Introduction 195
6.3.2 Method 198
Hypotheses 198 / *Task* 199 / *Design and variables* 199 / *Subjects* 201 / *Production* 201 / *Procedure* 203
6.3.3 Results and discussion 203
6.3.4 Conclusions 206
6.4 Experiment IV: Investigating Learning Effects of Dynamic Media: The Effect of User-Controlled Information Flow and Predefined Information Chunks 209
6.4.1 Introduction 209
Hypotheses 211
6.4.2 Method 211
Subjects 212 / *Task* 212 / *Design & Variables* 213 / *Production* 214 / *Procedure* 216
6.4.3 Results and discussion 217
6.4.4 Conclusion 220
6.5 Experiment V: Didactical Metadata in E-Learning: Validating Theory-Based Learning Content Categories 222
6.5.1 Introduction 222
6.5.2 Impacts of and Needs for Validated Learning Categories 223
Multimedia design 223 / *Instructional design* 224 / *Learning content management and learning object repositories* 224
6.5.3 Research Process 226
The need for guidelines 227
6.5.4 Analysing learning content 227
Learning content main categories 227 / *Learning content sub-categories* 228 / *Limitations of other available taxonomies* 229
6.5.5 Method 229
Synthesis 230 / *Validation* 230 / *Hypotheses* 232 / *Design* 233 / Subjects 233 / *Experimental tasks and setting* 233
Procedure 234 / *Coding of the raw data* 234
6.5.6 Results and Discussion 235
6.5.7 Conclusions 237

Part III: Conclusions

7.0 Conclusions 240
7.1 Problems to be Addressed in Further Research 242
7.2 Propositions Derived from the Research Presented in this Work 246
7.3 Final Remarks 248
8.0 References 249