TABLE OF CONTENTS

	Pag
LIST OF ILLUSTRATIONS	xxv
LIST OF TABLES	xxvii
LIST OF ABBREVIATIONS	xxxv
1. INTRODUCTION: COMPUTERS IN EDUCATION AND TRAINING	1
1.1. Educational Technology and Computer-Assisted Learning (CAL)	1
1.2. A Brief Historical Review	2
1.3. CAL Today - Where Are We?	3
1.4. Statement of the Problem	5
1.5. Definition of Terms	9
1.6. Need for the Study	13
1.7. Research Approach	15
1.8. Limitations of the Study	17
1.9. Organization of the Remainder of the Study	18
2. LEARNING WITH COURSEWARE	19
2.1. Introduction	19
2.1.1. Courseware Is More Than Software	19
2.1.2. Definition of Terms	20
2.1.3. Research Approach	21

2.1.4. Methodological Aspects	:	22
2.1.5. Assumptions and Limitations	:	24
2.1.6. Remainder		24
2.2. Identification of a List of Basic Instructional F	Fac-	24
2.2.1. Introduction		24
2.2.2. Result of the Literature Rev Instructional Factors From Se		25
2.2.3. Identification of Basic Instr	cuctional Factors	41
2.2.4. Discussion of the Result		42
2.2.5. Validation of the Basic Instr	ructional Factors	43
2.2.6. Summary		46
2.3. Application of Instructional Factors in the Dev ment and the Summative Evaluation of CAL N		46
2.3.1. Introduction: What to Do Wittors?	ch Instructional Fac-	46
2.3.2. Application in the Summative Materials	ve Evaluation of CAL	46
2.3.3. Application in the Developmer	nt of CAL Materials	48
2.3.4. Summary		48
2.4. Summary		49
3. DEVELOPMENT OF QUALITY COURS	SEWARE	51
3.1. Introduction		51
3.1.1. Why Is Courseware Still Said	to Be Poor?	51
_	CO DE 1001.	53
3.1.2. Definition of Terms		54
3.1.3. Research Approach		54
3.1.4. Assumptions		55
3.1.5. Remainder		23

3.2. What the Literature Reveals: An introduction to the Design and Development of Software for Education and	
Training	55
3. 2. 1. Introduction	55
3. 2. 2. Instructional Systems Design and the Development of CAL Materials 3. 2. 2. 1. From Instructional Design and Development Theory	55 55
3.2.2.2. To Instructional Systems Design (ISD) Models 3.2.2.3. The Merits and Problems of ISD 3.2.2.4. Summary	56 58 61
3. 2. 3. Software Engineering and the Development of Courseware	62
3.2.3.1. Basic Principles of Software Engineering 3.2.3.2. Software Engineering as Link to Quality Assurance	62 65
3.2.3.3. Problems Encountered in Software System Devel- opment and Use 3.2.3.4. Summary	67 68
3. 2. 4. Courseware Development: Co-operation Between ISD and Software Engineering 3. 2. 4. 1. Comparison of ISD and Software Engineering 3. 2. 4. 2. Specific Principles and Models of Courseware Development 3. 2. 4. 3. Summary	68 68 70 74
3.2.5. Summary: A List of Suggested Quality Factors for the Development of CAL Materials, Identified from Literature	75
3.3. What Experience Shows: Reviewing the Investigation of Real Courseware Production Systems	77
3.3.1. Introduction	77
3. 3. 2. Results of a Follow-up Survey	77
3.3.3. Results of a Survey Focussing on the Development and Use of Courseware	78
3. 3. 4. Results of a Research Trip to the U.S.A.	80
3.3.5. Summary: A List of Suggested Quality Factors for the Development of CAL Materials, Identified from Experience	84
3.4. Discussion of Results: Identification of a List of Quality Factors	86
3.5. Summary	87

4. EMPIRICAL STUDY	89
4.1. Introduction	89
4.2. Rationale: The Reason for an Empirical Study in Swiss Schools	89
4.3. Statement of the Research Question	92
4.4. Methodological Aspects	92
4.4.1. Identification of Variables and Study Design	92
4.4.2. Description of the Overall Procedures	95
4.4.3. Sampling Method and the Composition of Sample Groups	95
4.4.4. Selection of CAL Materials	96
4.4.5. Instruments	99
4.4.6. Organization of the Empirical Test	103
4.4.7. Selection of Data Analysis Methods	104
4.4.8. Presentation of Results	106
4.4.9. General Assumptions and Limitations 4.4.9.1. In Regard to CAL Materials and Learning 4.4.9.2. In Regard to the Measurement of Variables	106 106 107
4.4.10. Summary	107
4.5. Statement of Hypotheses	108
4.6. Results	114
4.6.1. Starting Point: Internal Validity and Design As- signment Differences	114
4.6.2. Effects of the Quality of Instruction (= CAL Materials and Their Evaluation)	120
4.6.3. Effects of Student Characteristics 4.6.3.1. Related to General Personal Characteristics 4.6.3.2. Related to the Learning Style 4.6.3.3. Related to the Computer Attitudes	128 128 141 152
4 6.4 Miscellaneous Effects	162

4.7. Discussion of Results	165
4.8. Summary	171
5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS 5.1. Summary	173 173
5.2. Conclusions	177
5.3. Recommendations	178
REFERENCES	181
APPENDICES:	189
A: Courseware Preselection Evaluation Form	189
B: Identification of Personal Characteristics C: Ermittlung von persönlichen Charakteristika	193 194
D: Identification of the Learning Style (by D.A. Kolb) E: Ermittlung des Lernstiles (nach D.A. Kolb)	195 199
F: Identification of Computer Attitudes (by C.P. Gressard/B.H. Loyd) G: Ermittlung von Einstellungen gegenüber Computern (nach C.P. Gressard/B.H. Loyd)	203 206
d: Courseware Evaluation Form for Students d: Lernprogramm-Evaluationsform für Studenten	209 212
CURRICULUM VITAE	215

LIST OF ILLUSTRATIONS

			Page
Ill.	1. 1:	The Student and the Learning Environment (Simplified View)	5
Ill.	1. 2:	The Developers of CAL Materials Within the Production System and Environment (Simplified View)	6
Ill.	1. 3:	The Quality Assurance Base and the Production System for the Development of CAL Materials (Simplified View)	6
Ill.	1. 4:	Disciplines, Bodies of Theories, and Models Relevant to the Complete Reference Model of the Development and Use of CAL Materials	7
Ill.	1. 5:	Outcomes and Results of the Disciplines, Models, and the Bodies of Knowledge for the Development and Use of Courseware	8
I11.	1. 6:	Possible Uses of Computers in Education and Training	10
I11.	1. 7:	Software Used in Education and Training	10
I11.	2. 1:	Constituents of Software per se and Courseware	20
I11.	2. 2:	Ideal Flow of Information on Instructional Factors	49
Ill.	3. 1:	Relationship Between Instructional Design and Instructional Development	56
111.	3. 2:	The Main Components of a Production System for Software Development (Software Production Cube)	66
111.	3. 3:	Comparison of ISD with the Life-cycle Concept	69
I11.	4.1;	Major Variables in Bloom's Theory of School Learning	93
I11.	4. 2:	Main Procedures and Treatment Conditions of a Quasi-Experimental Design	94
111.	4. 3:	Evaluation and Test Instruments Used Through out the Empirical Study	100

- List of Illustrations -

I11.	4.4:	Overview of Variables Encompassed by the Empirical Study	102
Ill.	4. 5:	Scheduling of the Empirical Tests	103
111.	4.6:	Graphic Synopsis of Research Questions	113

LIST OF TABLES

		Page
Table 1.1:	Frequency of Stated Benefits of CAL	3
Table 1.2:	Main Instruments and Methods Used Throughout the Study	16
Table 2.1:	Overview of Authors, Their Research Interests and the Related Fields of Knowledge	40
Table 2.2:	Rating of Instructional Factors by Respondents	45
Table 3.1:	Key Problems Encountered in ISD For Small, Medium, and Large-scale Projects	60
Table 3.2:	Synopsis of the Basic Ideas Presented by the Models and Recommendations for Courseware Development	73
Table 3.3:	Synopsis of Quality Factors Identified from Literature for the Development of Quality Courseware	76
Table 3.4:	Synopsis of Suggested Quality Factors Ident- ified from Empirical Studies for the Develop- ment of Quality Courseware	85
Table 3.5:	Comparison of Quality Factors Stated in Literature and Identified by Empirical Studies	86
Table 4.1:	Overview of the Composition of the Systematic Samples	96
Table 4.2:	Subjective Assessment of the CAL Materials Concerning the Learning Approach	111
Table 4.3:	Arithmetical Means of All Subject Matter Achievement Variables, for the Subjects of the Control One and the Experimental Conditions, for Hypothesis Number 1.1	115
Table 4.4:	Mann-Whitney U Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 1.1 With Grouping Variable "Treatment Condition", Including the Subjects of the Control One and the Experimental Conditions	116

Table 4.5:	Arithmetical Means of the Posttest Subject Matter Achievement, for the Subjects of the Control Two and the Experimental Conditions, for Hypothesis Number 1.2	117
Table 4.6:	Mann-Whitney U Test Statistic of the Subject Matter Achievement Variable POST, for Hypothesis Number 1.2, With Grouping Variable "Treatment Condition", Including the Subjects of the Control Two and the Experimental Conditions	118
Table 4.7:	Arithmetical Means of the Subject Matter Achievement Variables, for the Subjects of the Control One and the Experimental Conditions, for Hypothesis Number 2	119
Table 4.8:	Mann-Whitney U Test Statistic of the Subject Matter Achievement Variable POST, for Hypothesis Number 2, With Grouping Variable "Treatment Condition", Including the Subjects of the Control One and Two Conditions	119
Table 4.9:	Arithmetical Means of the Subject Matter Achievement Variables, for the Subjects of the Control Two and the Experimental Conditions, for Hypothesis Number 3	121
Table 4.10:	Kruskal-Wallis H Test Statistic of the Subject Matter Achievement Variables POST and DifPrPo, for Hypothesis Number 3, With Grouping Variable "Courseware Strategy", Including the Subjects of the Control Two and the Experimental Conditions	122
Table 4.11:	Extract from the Pearson Correlation Matrix of the Evaluation and the Subject Matter Achieve- ment Variables, for the Subjects of the Con- trol Two and the Experimental Conditions, for Hypothesis Number 4.1	123
Table 4.12:	Bonferroni-Adjusted Probabilities of the Evaluation Subscale and the Subject Matter Achievement Variables, for Hypothesis Number 4.1, Including the Subjects of the Control Two and the Experimental Conditions	124
Table 4.13:	Bartlett's Chi-Square Test Statistic of the Evaluation Subscales and the Subject Matter Achievement Variables, for Hypothesis Number 4.1, Including the Subjects of the Control Two and the Experimental Conditions	125
Table 4.14:	Arithmetical Means of the Evaluation Variables, for the Subjects of the Control Two and the Experimental Conditions, for Hypothesis Number 4.2	126

Table 4.15:	Kruskal-Wallis H Test Statistic of the Evaluation (Sub-) Scale Variables, for Hypothesis Number 4.2, With Grouping Variables "Courseware" and "Class", Including the Subjects of the Control Two and the Experimental Condi-	407
Table 4.16:	Number of Cases of the Variable AGE in All	127
Table 4.17:	Treatment Conditions, for Hypothesis Number 5 Arithmetical Means of the Subject Matter	120
	Achievement Variables, for the Subjects of the Control Two and the Experimental Conditions, for Hypothesis Number 5	129
Table 4.18:	Number of Subjects in Control Two and Experimental Conditions by Courseware and Age, for Hypothesis Number 5	129
Table 4.19:	Kruskal-Wallis H Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 5, With Grouping Variable "Age", Including the Subjects of the Control Two and	
	the Experimental Conditions	130
Table 4.20:	Number of Subjects in All Treatment Conditions by Categories of Computer Experience, for Hy- pothesis Number 8	131
Table 4.21:	Number of Subjects of the Control Two and Experimental Conditions Classified By the Categories of Computer Experience and Courseware Strategies, for Hypothesis Number 8	131
Table 4.22:	Arithmetical Means of the Subject Matter Achievement Variables, for the Subjects of the Control Two and the Experimental Conditions, for Hypothesis Number 8	132
Table 4.23:	Kruskal-Wallis H Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 8, With the Grouping Variable "Computer Experience", Including the Subjects of the Control Two and the Experimental Conditions	132
Table 4.24:	Kruskal-Wallis H Test Statistic of the Subject	132
	Matter Variables POST and DifPrPo, for Hypothesis Number 8, Without the Grouping Category "LEISURE" of ExpComp, Including the Subjects of the Control Two and the Experimental Condi-	
	tions	133
Table 4.25:	Arithmetical Means of the Subject Matter Achievement Variables, for the Subjects of the Control Two and the Experimental Conditions of Sample 3, for Hypothesis Number 9	133

Table 4.26:	Mann-Whitney U Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 9, With Grouping Variable "Preference Course", Including the Subjects of the Control Two and the Experimental Conditions of Sample 3	134
Table 4.27:	Number of Cases of Female and Male Subjects of All Treatment Conditions, for Hypothesis Number 10.1	135
Table 4.28:	Descriptive Statistics of the Computer Attitude Scale Variables, for the Subjects of the Control One and the Experimental Conditions, for Hypothesis Number 10.1	135
Table 4.29:	Mann-Whitney U Test Statistic of the Computer Attitude Scale (CAS) Variables, for Hypothesis Number 10.1, With Grouping Variable "Gender", Including the Subjects of the Control One and the Experimental Conditions	136
Table 4.30:	Arithmetical Means of the Subject Matter Achievement Variables, for the Subjects of the Control Two and the Experimental Conditions, for Hypothesis Number 10.2	136
Table 4.31:	Mann-Whitney U Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 10.2, With Grouping Variable "Gender", Including the Subjects of the Control Two and the Experimental Conditions	137
Table 4.32:	Arithmetical Means of the Subject Matter Achievement Variables, for the Subjects of the Experimental Condition of Samples 1 and 5, for Hypothesis Number 11	138
Table 4.33:	Number of Subjects of the Experimental Condition Classified by the Level of Pretest Achievement, for Hypothesis Number 11	138
Table 4.34:	Mann-Whitney U Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 11, With Grouping Variable "Class", Including the Experimental Subjects of Samples 1 and 5	139
Table 4.35:	Mann-Whitney U Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 11, With Grouping Variable "Class", Including the Experimental Subjects of Samples 01 and 05 with Category PreLev =	139
	"medium"	139

Table	4.36:	Mann-Whitney U Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 11, With Grouping Variable "Pretest Achievement Level", Including the Subjects of the Experimental Condition	140
Table	4.37:	Number of Subjects of the Control One and the Experimental Condition, Grouped by the Learning Style Categories, for Hypothesis Number 12.1	142
Table	4.38:	Arithmetical Means of All Subject Matter Achievement Variables, for the Subjects of the Experimental Condition, for Hypothesis Number 12.1	143
Table	4.39:	Kruskal-Wallis H Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 12.1, With Grouping Variable "Learning Style", Including the Subjects of the Experimental Conditions and All Seven Learning Style Categories	143
Table	4.40:	Kruskal-Wallis H Test Statistic of the Subject Matter Achievement Variables POST and DifPrPo, for Hypothesis Number 12.1, With Grouping Variable "Learning Style", Including the Subjects of the Experimental Condition Belonging to the Four Main Learning Style Categories	144
Table	4, 41:	Descriptive Measures of the CAS Variables for the Subjects of the Control One and the Ex- perimental Conditions Belonging to the Four Main Learning Style Categories	145
Table	4. 42:	Kruskal-Wallis H Test Statistic of the CAS Variables, for Hypothesis Number 12.2, With Grouping Variable "Learning Style", Including the Subjects of the Control One and the Experimental Conditions	146
Table	4. 43:	Measures of Location of the Learning Mode Variables, for the Subjects of the Control One and the Experimental Conditions, for Hypoth- esis Number 13	148
Table	4. 44:	Descriptive Measures of the Combination Score and the Percentile Score Variables, for the Subjects of the Control One and the Experimen- tal Conditions, for Hypothesis Number 13	149
Table	4. 45:	Extract from the Pearson Correlation Matrix of the Combination Score and the Subject Achieve- ment Variables, for Hypothesis Number 13, In- cluding the Subjects of the Experimental Con- dition	150

Table 4.46:	Bonferroni-Adjusted Probabilities of the Combination Score Variables and the Subject Matter Achievement Variables, for Hypothesis Number 13, Including the Subjects of the Experimental Condition	151
Table 4.47:	Bartlett's Chi-Square Test of the Combination Score and the Subject Matter Achievement Vari- ables, for Hypothesis Number 13, Including the Subjects of the Experimental Condition	151
Table 4.48:	Extract of the Pearson Correlation Matrix of the Computer Attitude (Sub-) Scale and the Subject Matter Achievement Variables, for Hy- pothesis Number 14.1, Including the Subjects of the Experimental Condition	153
Table 4.49:	Bonferroni-Adjusted Probabilities of the CAS Subscale Variables and the Subject Matter Achievement Variables, for Hypothesis Number 14.1, Including the Subjects of the Experimen- tal Condition	154
Table 4.50:	Bartlett's Chi-Square Test of the CAS Subscale and the Subject Matter Achievement Variables, for Hypothesis Number 14.1, Including the Sub- jects of the Experimental Condition	155
Table 4.51:	Descriptive Measures of the CAS Variables for the Subjects of the Experimental Condition, for Hypothesis Number 14.2	156
Table 4.52:	Arithmetical Means of the Subject Matter Achievement Variables, for the Subjects of the Experimental Condition, for Hypothesis Number 14.2, Grouped According to Computer Attitude Levels	157
Table 4.53:	Kruskal-Wallis H Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 14.2, With Grouping Variable "Attitude Levels", Including the Subjects of the Experimental Condition	157
Table 4.54:	Extracts from the Pearson Correlation Matrix of the CAS and the Evaluation Scale Variables, for Hypothesis Number 15.1, Including the Subjects of the Experimental Condition	158
Table 4.55:	Bonferroni-Adjusted Probabilities of the Computer Attitude and the Evaluation Subscale Variables, for Hypothesis Number 15.1, Including the Subjects of the Experimental Condition	159

Table	4.56:	Bartlett's Chi-Square Test of the Computer Attitude and the Evaluation Subscale Variables, for Hypothesis Number 15.1, Including the Subjects of the Experimental Condition	159
Table	4.57:	Arithmetical Means of the Evaluation Scale Variables Grouped by CAS Levels, for the Sub- jects of the Experimental Condition, for Hy- pothesis Number 15.2	160
Table	4.58:	Kruskal-Wallis H Test Statistic of the Evaluation Scale Variables for Hypothesis Number 15.2, With Grouping Variable "Attitude Levels", Including the Subjects of the Experimental Condition	161
Table	4.59:	Number of Treatments Throughout the Empirical Tests, for the Subjects of the Control Two and the Experimental Conditions, for Hypothesis Number 16	162
Table	4.60:	Duration of the Empirical Tests, for the Subjects of the Control Two and the Experimental Conditions, for Hypothesis Number 16	163
Table	4.61:	Arithmetical Mean of the Time Spent Using the Courseware, for the Subjects of the Control Two and the Experimental Conditions, for Hypothesis Number 16	163
Table	4.62:	Kruskal-Wallis H Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 16, With Grouping Variable "Duration", Including the Subjects of the Control Two and the Experimental Conditions	164
Table	4. 63:	Mann-Whitney U Test Statistic of the Subject Matter Variables POST and DifPrPo, for Hypothesis Number 16 With Grouping Variable "Duration" and "Class", Including the Subjects of the Control Two and the Experimental Conditions of Samples 2 and 3	164
Table	4.64:	Synopsis of Results for Investigated Hypotheses	165