Contents

Part I   Preliminaries to Cognitive Load Theory

1   Categories of Knowledge: An Evolutionary Approach .......................... 3
    Why Instructional Design Needs to Distinguish
    Between Biologically Primary and Secondary Knowledge .................. 4
    Biologically Primary Knowledge....................................................... 5
    Biologically Secondary Knowledge.................................................... 6
    Instructional Consequences .............................................................. 8
    Instructional Consequences Associated
    with Biologically Primary Knowledge.............................................. 8
    Instructional Consequences of Biologically
    Secondary Knowledge........................................................................ 11
    Conclusions........................................................................................ 13

Part II   Human Cognitive Architecture

2   Amassing Information: The Information Store Principle..................... 17
    How Natural Information Processing Systems Store Information ............ 17
    Evolutionary Biology ........................................................................ 17
    Human Cognition: Long-Term Memory .............................................. 18
    Instructional Implications ................................................................. 24
    Conclusions....................................................................................... 25

3   Acquiring Information: The Borrowing and Reorganising
    Principle and the Randomness as Genesis Principle ........................... 27
    The Borrowing and Reorganising Principle........................................ 27
    Biological Evolution ........................................................................ 27
    Human Cognition ............................................................................. 28
    Instructional Implications ................................................................. 31
    Conclusions....................................................................................... 31
    Randomness as Genesis Principle..................................................... 32
    Biological Evolution ........................................................................ 32
Human Cognition ............................................................. 33
Instructional Implications............................................ 36
Conclusions .................................................................. 37

4 Interacting with the External Environment: The Narrow
Limits of Change Principle and the Environmental
Organising and Linking Principle .............................. 39

Narrow Limits of Change Principle............................ 40
  Biological Evolution .................................................... 40
  Human Cognition ........................................................ 41
  Instructional Implications .......................................... 44
Conclusions ................................................................. 45

The Environmental Organising and Linking Principle 46
  Biological Evolution .................................................... 46
  Human Cognition ........................................................ 48
  Instructional Implications .......................................... 50
Conclusions ................................................................. 50

Summary of Structures and Functions
of Human Cognitive Architecture ............................... 51

Part III Categories of Cognitive Load

5 Intrinsic and Extrinsic Cognitive Load .................. 57

Additivity of Intrinsic and Extrinsic Cognitive Load .... 58
Element Interactivity ..................................................... 58
Element Interactivity and Intrinsic Cognitive Load .... 59
  Task Difficulty .......................................................... 61
  Understanding .......................................................... 62
  Altering Intrinsic Cognitive Load .............................. 64
  Relations of Intrinsic Cognitive Load to Human
  Cognitive Architecture ............................................. 65
Element Interactivity and Extrinsic Cognitive Load .... 66
Instructional Implications .......................................... 67
Conclusions ................................................................. 68

6 Measuring Cognitive Load ................................. 71

Indirect Measures of Cognitive Load ..................... 71
  Computational Models ............................................. 71
  Performance During Acquisition ......................... 72
  Error Profiles Between Problems ....................... 72
Subjective Measures of Cognitive Load ................ 73
  A Subjective Measure of Mental Effort ............... 73
  A Subjective Measure of Difficulty ....................... 73
<table>
<thead>
<tr>
<th>Contents</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Variations in Subjective Ratings</td>
<td>74</td>
</tr>
<tr>
<td>Consistency of the Subjective Measures</td>
<td>74</td>
</tr>
<tr>
<td>Efficiency Measures</td>
<td>75</td>
</tr>
<tr>
<td>Issues with Calculating Efficiency</td>
<td>77</td>
</tr>
<tr>
<td>Measuring Cognitive Load Through a Secondary Task</td>
<td>77</td>
</tr>
<tr>
<td>Physiological Measures of Cognitive Load</td>
<td>80</td>
</tr>
<tr>
<td>Measuring the Different Types of Cognitive Load</td>
<td>81</td>
</tr>
<tr>
<td>Summary</td>
<td>85</td>
</tr>
<tr>
<td>Part IV Cognitive Load Effects</td>
<td></td>
</tr>
<tr>
<td>7 The Goal-Free Effect</td>
<td>89</td>
</tr>
<tr>
<td>Empirical Evidence for the Goal-Free Effect</td>
<td>91</td>
</tr>
<tr>
<td>Alternative Explanations of the Goal-Free Effect</td>
<td>93</td>
</tr>
<tr>
<td>A Dual-Space Explanation</td>
<td>93</td>
</tr>
<tr>
<td>An Attentional Focus Explanation</td>
<td>96</td>
</tr>
<tr>
<td>A Subjective Measure of Cognitive Load and the Goal-Free Effect</td>
<td>97</td>
</tr>
<tr>
<td>Conditions of Applicability</td>
<td>97</td>
</tr>
<tr>
<td>Instructional Implications</td>
<td>98</td>
</tr>
<tr>
<td>Conclusions</td>
<td>98</td>
</tr>
<tr>
<td>8 The Worked Example and Problem Completion Effects</td>
<td>99</td>
</tr>
<tr>
<td>Basic Empirical Evidence</td>
<td>100</td>
</tr>
<tr>
<td>Worked Examples in Mathematics and Related Domains</td>
<td>100</td>
</tr>
<tr>
<td>Worked Examples and Ill-Structured Learning Domains</td>
<td>102</td>
</tr>
<tr>
<td>Worked Examples in Non-Laboratory-Based Experiments</td>
<td>104</td>
</tr>
<tr>
<td>Worked Examples and the Alternation Strategy</td>
<td>104</td>
</tr>
<tr>
<td>The Problem Completion Effect</td>
<td>105</td>
</tr>
<tr>
<td>Critiques of the Use of Worked Examples</td>
<td>106</td>
</tr>
<tr>
<td>Conditions of Applicability</td>
<td>107</td>
</tr>
<tr>
<td>Instructional Implications</td>
<td>108</td>
</tr>
<tr>
<td>Conclusions</td>
<td>108</td>
</tr>
<tr>
<td>9 The Split-Attention Effect</td>
<td>111</td>
</tr>
<tr>
<td>Various Categories of the Split-Attention Effect</td>
<td>113</td>
</tr>
<tr>
<td>Worked Examples and the Split-Attention Effect</td>
<td>114</td>
</tr>
<tr>
<td>Diagrams and Written Explanations</td>
<td>116</td>
</tr>
<tr>
<td>Multiple Sources of Text</td>
<td>119</td>
</tr>
<tr>
<td>More Than Two Sources of Information</td>
<td>119</td>
</tr>
<tr>
<td>Split-Attention While Learning to Use a Computer</td>
<td>120</td>
</tr>
<tr>
<td>Split-Attention and Other Cognitive Load Theory Effects</td>
<td>122</td>
</tr>
<tr>
<td>Temporal Split-Attention</td>
<td>122</td>
</tr>
<tr>
<td>Alternative Methods to Overcome Split-Attention</td>
<td>124</td>
</tr>
</tbody>
</table>
Directing Attention and the Split-Attention Effect ............................... 124
The Pop-Up Alternative to Text Integration ......................................... 125
Procedural Information and the Split-Attention Effect .......................... 126
Learner Integration of Split-Source Materials ....................................... 126
A Meta-Analysis of the Split-Attention Effect ...................................... 127
Conditions of Applicability ................................................................... 127
Instructional Implications ..................................................................... 128
Conclusions ......................................................................................... 128

10 The Modality Effect ......................................................................... 129
The Effect of Replacing Written with Spoken Text ............................... 130
The Modality Effect in Interactive Learning Environments ................... 132
Factors Moderating the Modality Effect ............................................. 134
Levels of Element Interactivity ......................................................... 135
Pacing of Presentations ...................................................................... 135
An Alternative Explanation for the Reverse Modality Effect .................. 136
Reducing Visual Search ...................................................................... 137
Summary of Conditions of Applicability ............................................. 138
Instructional Implications ................................................................... 139
Conclusion .......................................................................................... 140

11 The Redundancy Effect ................................................................... 141
Some Empirical Evidence for the Redundancy Effect ........................... 142
The Effect of Simultaneously Presented Written and Spoken Text .......... 144
The Redundancy Effect in Second/Foreign Language Learning ............. 146
Evidence for the Redundancy Effect in Pre-Cognitive Load Theory Research .......................................................... 148
Factors Moderating the Redundancy Effect ........................................ 149
Independence of Information Sources .............................................. 149
Levels of Element Interactivity ......................................................... 150
Pacing of Presentations ...................................................................... 150
The Length of Instructional Segments .............................................. 151
Summary of Conditions of Applicability ............................................. 152
Instructional Implications ................................................................. 153
Conclusions ....................................................................................... 154

12 The Expertise Reversal Effect ......................................................... 155
Some Empirical Evidence for the Expertise Reversal Effect ................. 156
Longitudinal Studies .......................................................................... 157
Cross-Sectional Studies Using Worked Examples and Other Forms of Guidance ................................................................. 159
Expertise Reversal and the Isolated Elements Effect ........................... 162
Expertise Reversal and the Variability Effect ..................................... 163
Pre-Training and the Expertise Reversal Effect .............................................. 164
Expertise Reversal for Multimedia and Hypermedia Representations ................ 165
The Expertise Reversal Effect and Aptitude-Treatment Interactions .......... 167
Conditions of Applicability of the Expertise Reversal Effect ...................... 167
Instructional Implications ............................................................................ 168
Conclusions ................................................................................................. 169

13 The Guidance Fading Effect ................................................................. 171
Empirical Evidence for the Guidance Fading Effect .................................... 172
Effects of Fading Worked-Out Solution Steps ......................................... 173
Knowledge-Dependent Dynamic Provision of Guidance .......................... 174
The Effect of a Gradual Change in Levels of Support Using Computer-Based Tutors ................................................................. 176
Applying Rapid Assessment Techniques to the Design of Adaptive Fading Procedures ................................................................. 177
Conditions of Applicability of the Fading Effect ........................................... 181
Instructional Implications ............................................................................ 182
Conclusions ................................................................................................. 182

14 Facilitating Effective Mental Processes: The Imagination and Self-Explanation Effects ................................................................. 183
The Imagination Effect ............................................................................... 183
The Imagination Effect Prior to Cognitive Load Theory Research .......... 185
Empirical Evidence for the Imagination Effect Within a Cognitive Load Theory Context ................................................................. 186
The Self-Explanation Effect........................................................................ 187
Conditions of Applicability ........................................................................ 190
Instructional Implications ............................................................................ 192
Conclusions ................................................................................................. 192

15 The Element Interactivity Effect ............................................................... 193
Empirical Evidence for the Element Interactivity Effect ............................ 194
Element Interactivity and the Split-Attention and Redundancy Effects ........ 194
Element Interactivity and Understanding Instructions .............................. 196
Element Interactivity and the Modality Effect .......................................... 197
Element Interactivity and the Expertise Reversal Effect ........................... 198
Element Interactivity and the Imagination Effect ...................................... 199
Conditions of Applicability ........................................................................ 199
Instructional Implications ............................................................................ 200
Conclusion .................................................................................................. 201
# 16 Altering Element Interactivity and Intrinsic Cognitive load

- Pre-training ................................................................. 204
- Focusing on Subgoals .................................................. 205
- Presenting Declarative and Procedural Information Separately ........................................ 206
- Reducing Intrinsic Load in Worked Examples ................................................................. 206
- Isolated Elements Effect ................................................ 208
- 4C/ID Model for Complex Learning .................................................. 211
- The Variability Effect ..................................................... 212
- Variability and Increased Intrinsic Cognitive Load ......................................................... 215
- Conditions of Applicability .................................................. 216
- Instructional Implications .................................................. 216
- Conclusions ....................................................................... 217

# 17 Emerging Themes in Cognitive Load Theory: The Transient Information and the Collective Working Memory Effects

- The Transient Information Effect ............................................. 219
- The Modality Effect and Transient Information ........................................... 220
- Instructional Animations and Transient Information ........................................ 222
- Animation Versus Static Presentations ........................................... 223
- Some Conditions Under Which Animations Can Be Effective ........................................... 224
- Learning Human Movement or Motor Skills: A Special Case ........................................ 226
- The Role of Biologically Primary Knowledge ....................................................... 227
- Conditions of Applicability ........................................................................ 229
- Instructional Implications ........................................................................ 229
- Conclusions ....................................................................... 229
- The Collective Working Memory Effect ......................................................... 230
- Conditions of Applicability ........................................................................ 232
- Instructional Implications ........................................................................ 233
- Conclusions ....................................................................... 233

# Part V Conclusions

# 18 Cognitive Load Theory in Perspective

- References ........................................................................ 243
- Index ................................................................................ 263
Cognitive Load Theory
Sweller, J.; Ayres, P.; Kalyuga, S.
2011, XVI, 274 p. 20 illus., Hardcover
ISBN: 978-1-4419-8125-7