MENTAL MODELS

Edited by DEDRE GENTNER ALBERT L. STEVENS Bolt Beranek and Newman Inc.

Technische Hochschule Darmstadt Fachbereich 3 Institut für Psychologie Steubenplatz 12, 6100 Darmstadt

Inv. - Nr. 9/07678



Contents

Introduction 1 Albert L. Stevens and Dedre Gentner

1. Some Observations on Mental Models 7 Donald A. Norman References 14

2. Phenomenology and the Evolution of Intuition

15

Andrea A. diSessa

- 55

Introduction 15 Springiness 17 Ohm's P-Prim 23 Rolling and Pivoting 26 A Note on Abstraction 29 Persistent False Intuitions 30 Summary and Conclusion 32 References 33

3. Surrogates and Mappings: Two Kinds of Conceptual Models for Interactive Devices 35 Richard M. Young
Different Kinds of Mental Models 37 Surrogate Models 40 Task/Action Mapping Models 44
Discussion 50 References 52 VI CONTENTS

4. Qualitative Reasoning About Space and Motion 53 Kenneth D. Forbus

Introduction 53 Spatial Descriptions 55 Describing a Particular Motion 59 Describing Possible Motions 62 Answering Questions 66 Discussion 68 References 72

5. The Role of Problem Representation in Physics 75

Jill H. Larkin Problem Representations 76 Empirical Studies 84 Possibilities for Instruction 93 Summary 96 References 97

6. Flowing Waters or Teeming Crowds: Mental Models of Electricity 99

Dedre Gentner and Donald R. Gentner

A Structure-Mapping Theory of Analogical Thinking 101 Two Analogies for Electricity 107 Electricity and Water—An Analogy . 108 Experiments on Analogies for Electricity 111 Experiment 1 117 Experiment 2 119 Discussion 124 References 127

7. Human Reasoning About a Simple Physical System 131

Michael D. Williams, James D. Hollan, and Albert L. Stevens

Introduction 131 An Example of the Phenomenology 132 Defining Mental Model 133 An Analysis of a Protocol 135 A Critique 150 Conclusions 152 Appendix 1: Questions 153 References 153

8. Assumptions and Ambiguities in Mechanistic Mental Models 155

Johan de Kleer and John Seely Brown Introduction 155 Qualitative Simulations 156 Ambiguities, Assumptions and Mechanisms 172 Implications of the Theory 180 References 190

9. Understanding Micronesian Navigation 191

Edwin Hutchins

Caroline Island Navigation 192 Some Anomalous Interpretations 200 An Alternative Model 210 Discussion 223 References 225

🛛 10. Conceptual Entities 227

James G. Greeno

Analogies Between Domains229Reasoning with General Methods239Computational Efficiency247Planning249Conclusions250References251

11. Using the Method of Fibres in Mecho to Calculate Radii of Gyration 253

Alan Bundy and Lawrence Byrd

Introduction 253 Continuous Measure Systems 254 Choosing Continuous Measure Systems 256 Uniformity 259 A Worked Example 261 Conclusion 264 References 266

viii CONTENTS

12. When Heat and Temperature Were One 267 Marianne Wiser and Susan Carev

The Experimenters' Enterprise 271 Source-Recipient Model 274 Evidence for the Source-Recipient Model 276 Studies of Artificial Freezing 276 The Experimenters' Thermal Concepts 289 Were Heat and Temperature Differentiated? 290 What Next? 294 History of Science and the Novice-Expert Shift 294 References 296

13. Naive Theories of Motion 299

Michael McCloskey

Misconceptions about Motion 300 A Naive Theory of Motion 305 Individual Differences 311 Historical Parallels: The Medieval Impetus Theory 315 Naive Theories and Physics Instruction 318 A Brief Review of Related Research 319 Concluding Remarks 321 References 322

14. A Conceptual Model Discussed by Galileo and Used Intuitively by Physics Students 325 John Clement

The "Motion Implies a Force" Preconception 326 Discussion of Similar Arguments in Galileo's Writinas 331 Summary of Characteristics for the "Motion Implies a Force" Preconception 333 Post Course Results 334 Implications for Instruction 335 Theoretical Implications 337 References 338 Appendix 1: Example of a Transcript from the Rocket Problem 340

Author Index341Subject Index345