1. Record Nr. UNINA9910574063703321

Fostering understanding of complex systems in biology education: Titolo

pedagogies, guidelines and insights from classroom-based research //

edited by Orit Ben Zvi Assaraf and Marie-Christine P. J. Knippels

Cham, Switzerland: ,: Springer, , [2022] Pubbl/distr/stampa

©2022

ISBN 3-030-98144-4

Descrizione fisica 1 online resource (283 pages)

Collana Contributions from Biology Education Research

Disciplina 570.71

Soggetti Teacher orientation

> Educational technology Biologia de sistemes

Ensenyament de les ciències naturals

Llibres electrònics

Lingua di pubblicazione Inglese

Formato Materiale a stampa

Livello bibliografico Monografia

Nota di bibliografia Includes bibliographical references and index.

Nota di contenuto Intro -- Preface -- Contents -- Chapter 1: Theoretical Perspectives

on Complex Systems in Biology Education -- 1.1 Introduction -- 1.2 Systems Dynamics and Systems Thinking -- 1.3 From Structure, Behavior, Function to Phenomena-Mechanisms-Components -- 1.4 Agent-Based Modeling -- 1.5 Thinking in Levels -- 1.6 Conclusion --References -- Chapter 2: Long Term Ecological Research as a Learning Environment: Evaluating Its Impact in Developing the Understanding of Ecological Systems Thinking - A Case Study -- 2.1 Introduction --2.2 Literature Review -- 2.2.1 The Ecosystem as Complex System --2.2.2 The Difficulties Associated with Understanding Complex

Ecological Systems -- 2.2.3 Developing and Assessing System Thinking -- 2.3 Methods -- 2.3.1 Setting and Population -- 2.3.2 Research

Tools and Data Analysis -- 2.4 Results -- 2.4.1 Analysis Level -- 2.4.2 Synthesis Level -- 2.4.3 Implementation Level -- 2.4.4 Students'

Understanding of the Content and the Value of LTER -- 2.5 Discussion

-- References -- Chapter 3: Involving Teachers in the Design Process of a Teaching and Learning Trajectory to Foster Students' Systems

Thinking -- 3.1 Introduction -- 3.1.1 Definitions of Systems Thinking -- 3.1.2 Teaching Systems Thinking -- 3.1.3 Focus of the Research -- 3.2 Method -- 3.2.1 Participants -- 3.2.2 LS Meetings -- 3.2.3 Designed Lessons -- 3.2.3.1 Lesson 1 -- 3.2.3.2 Lesson 2 -- 3.2.4 Pre- and Post-interviews -- 3.3 Results -- 3.3.1 RQ1: Contributions of the Teachers -- 3.3.2 RQ2: Learning Experiences -- 3.4 Conclusion -- References -- Chapter 4: Supporting University Student Learning of Complex Systems: An Example of Teaching the Interactive Processes That Constitute Photosynthesis -- 4.1 Introduction -- 4.1.1 What Makes Biological Systems Complex? -- 4.1.2 How Students Learn About Complexity.

4.1.3 How Instruction Can Support Student Learning of Complex Systems -- 4.1.4 Teaching and Learning the Complexity of Photosynthesis -- 4.2 Classroom Context and Methods -- 4.3 Results from Implementation -- 4.4 Conclusions and Implications --References -- Chapter 5: High School Students' Causal Reasoning and Molecular Mechanistic Reasoning About Gene-Environment Interplay After a Semester-Long Course in Genetics -- 5.1 Introduction -- 5.2 Background of the Study -- 5.3 Aims and Objectives -- 5.4 Method -- 5.4.1 Sample -- 5.4.2 Assessment of Students' Reasoning -- 5.4.3 The Interviews -- 5.4.4 Coding the Students' Responses to the Open-Response Task -- 5.5 Results -- 5.5.1 Findings for the First Question of the Task: What Does the Eye Color of Fruit Flies Depend on? -- 5.5.2 Findings for the Second Question of the Task: Tracing Trait Formation -- 5.5.3 Findings from the Interviews -- 5.6 Discussion and Educational Implications -- References -- Chapter 6: Systems Thinking in Ecological and Physiological Systems and the Role of Representations -- 6.1 Introduction -- 6.2 Similarities and Differences of Complex Systems -- 6.3 Systems Thinking -- 6.4 Representations of Complex Systems -- 6.5 Purpose and Methodology -- 6.6 Systems Thinking in Ecological Contexts -- 6.7 Systems Thinking in Physiological Contexts -- 6.7.1 Process Continuity -- 6.7.2 Self-Regulation -- 6.7.3 Causal-Mechanistic Relations -- 6.8 Discussion -- References -- Chapter 7: The Zoom Map: Explaining Complex Biological Phenomena by Drawing Connections Between and in Levels of Organization -- 7.1 Introduction -- 7.2 What Makes Biological Explanations Complex? The Perspective of Scientists -- 7.2.1 Characteristics of Biological Explanations -- 7.2.2 A Plethora of Biological Levels -- 7.2.3 Organizing the Levels of Biological Organization.

7.2.4 Comparing the Levels of Scientific Disciplines -- 7.3 What Makes Biological Explanations Complex? - The Students' Perspective -- 7.3.1 Students' Difficulties for Explaining Phenomena -- 7.3.2 Zooming in on the Construction of Explanations -- 7.4 Guiding the Process of Explaining with the Zoom Map-The Educators' Perspective -- 7.4.1 Theoretical Learning Principles for Teaching Complex Phenomena --7.4.2 The Zoom Map -- 7.5 Design of the Study and Materials -- 7.5.1 The Zoom Map Prepared for a Particular Explanation -- 7.5.2 Experience-Based Conceptions Are Needed to Construct an Explanation -- 7.5.3 External Representations Depict the Mechanism -- 7.5.4 Participants -- 7.5.5 Analysis -- 7.6 Results -- 7.6.1 A Zoom Map to Explain Upright and Wilted Leaves -- 7.6.2 A Zoom Map Demands Exhaustive Editing -- 7.6.3 Learners Drill Down to Lower Levels in Their Explanations -- 7.6.4 Direction of Explanation: Top-Down, Bottom-Up, or yo-yo -- 7.7 Discussion -- 7.8 Implications for Biology Teaching --References -- Chapter 8: Pre-service Teachers' Conceptual Schemata and System Reasoning About the Carbon Cycle and Climate Change: An Exploratory Study of a Learning Framework for Understanding

Complex Systems -- 8.1 Introduction -- 8.1.1 Knowledge About the Carbon Cycle and Climate Change -- 8.1.2 Climate Change Education -- 8.1.3 Systems Thinking and the Structure-Behavior-Function (SBF) Conceptual Framework -- 8.1.4 Research Objectives --8.2 Methods -- 8.2.1 Participants -- 8.2.2 Learning Intervention --8.2.2.1 Concept Maps -- 8.2.2.2 Lab Experiments -- 8.2.2.3 Computer Simulations -- 8.2.2.4 Concept Map Revision and Reflections -- 8.2.3 Data Collection and Analysis -- 8.2.3.1 Concept Map Analysis --8.2.3.2 Interview Analysis -- 8.3 Results -- 8.3.1 Group A: Slovenian Pre-service Lower-Secondary-School Biology Teachers. 8.3.2 Group B: Cyprus Pre-service Primary School Teachers -- 8.3.3 Group C: Cyprus Pre-service Preschool Teachers -- 8.4 Discussion --8.4.1 Educational Implications and Suggestions for Future Research --References -- Chapter 9: Teaching Students to Grasp Complexity in Biology Education Using a "Body of Evidence" Approach -- 9.1 Introduction -- 9.1.1 What Is a Body of Evidence Approach? -- 9.1.2 A BOE Approach for Middle School Science: Understanding Goals -- 9.2 Research Questions -- 9.3 Methods -- 9.3.1 Design -- 9.3.2 Participants -- 9.3.3 Curriculum -- 9.3.4 BOE Intervention Components -- 9.4 Data Sources and Analysis -- 9.4.1 Concept Maps -- 9.4.2 Postinterviews -- 9.5 Results -- 9.5.1 Concept Maps -- 9.5.2 Interviews --9.5.2.1 Confounding Causal Factors with Sources of Evidence --9.5.2.2 Expressing the Value of Multiple Possible Explanations/Models -- 9.5.2.3 Recognizing a Collection of Evidence Intended to Support a Claim -- 9.5.2.4 Making Connections to Other Learning about Evidence -- 9.5.2.5 Acknowledging Ecosystems Science Experimentation as Sensitive to Not Harming the Environment -- 9.6 Discussion -- Appendix -- Overview of the Plus BOE Curriculum --Experimentation Tools in EcoXPT -- EcoXPT Thinking Move Posters Including a Body of Evidence Approach -- Script for Body of Evidence Approach Thinking Move Video -- Body of Evidence Worksheet --Thinking About Different Types of Evidence Worksheet (Both Classes) -- Supporting Materials for Body of Evidence Thinking Move --Learning from Opportunistic Experiments -- Discussion Sheet --Uncertainty and Constructing a Best Explanation -- Discussion Sheet --References -- Chapter 10: Science Teachers' Construction of Knowledge About Simulations and Population Size Via Performing Inquiry with Simulations of Growing Vs. Descending Levels of Complexity -- 10.1 Introduction -- 10.1.1 Simulations. 10.1.2 Performing a Simulation-Based Scientific Inquiry -- 10.2 The Study and Its Context -- 10.2.1 Participants -- 10.2.2 Data Collection -- 10.2.3 Data Analysis -- 10.2.4 Procedure -- 10.3 What Did we Learn About Teachers' Knowledge and SBSI? -- 10.3.1 Teachers' Knowledge About Simulations and their Function -- 10.3.2 Teachers' Pedagogical Knowledge and Beliefs About Teaching with Simulations -- 10.3.3 Teachers' Knowledge and Understanding of Population Dynamics and Related Representations -- 10.3.4 Science Teachers' Inquiry Performance -- 10.3.5 SBSI Time Duration -- 10.3.6 Inquiry Phases --10.3.7 Teachers' Talk About Population Dynamics and SBSI Experiences -- 10.4 Promoting System Thinking through the Use of Simulations -Few Recommendations for a Pedagogy and a Learning Environment As Well As Implications for Instruction and Learning -- References --Chapter 11: Designing Complex Systems Curricula for High School Biology: A Decade of Work with the BioGraph Project -- 11.1 Developing a Coherent Understanding of Biological Systems -- 11.2 The BioGraph Curriculum and Instruction Framework -- 11.2.1 Curricular Relevance: What Is Being Learned? -- 11.2.2 Cognitively-Rich Pedagogies: How Does Learning Happen? -- 11.2.3 Tools for Teaching

and Learning: What Is Used to Support Instruction and Learning? -- 11.2.4 Content Expertise: What Is the Knowledge to Be Learned? -- 11.3 Designing for Teacher PD -- 11.3.1 Face-to-Face PD: Exploring Teacher Learning and Community Development -- 11.3.2 Online Asynchronous PD: Exploring How to Scale BioGraph Resources -- 11.4 Research Findings -- 11.4.1 Students Improve in Biology and Complex Systems Understanding -- 11.4.2 Students Understanding of Biology as a Coherent Set of Ideas Improves -- 11.4.3 Teachers Indicate High Usability in their Biology Courses -- 11.4.4 Developing Teacher's Social Capital Is Key.

11.5 Benefits of Computer-Supported Complex Systems Curricula and Lessons Learned.