Learning about Learning with Computers

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Structure

1. Personal Motivation
2. Personal History
3. Taxonomy of Models
4. Taxonomy of Enhancements
5. Tradeoffs & Tensions
6. Machine Learning
7. Research Agenda

Personal Motivation

1. Enhance Learning
2. Enjoy Computers
3. Respect Psychology
4. Follow Technology
5. Science Desirable
6. Intuition Acceptable
7. Educational Technology Works!

Personal History

1. 1965-67 Maze Learning
2. 1967-70 Graph Learning
3. 1970-74 ML Based Tutors
4. 1974-78 Learning by Programming
5. 1978-82 Machine in Machine
6. 1982-87 Smalltalk Learnability
7. 1987-92 Distributed Learning
8. 1992- Descent into Management

Taxonomy of Models

1. Reinforcement
2. Association
3. Feedback
4. Procedural
5. Developmental
6. Symbolic
7. Collaborative
8. Environmental

Reinforcement

1. Skinner - Psychology
2. Suppes - Technology
3. Repetition
4. Partial Reinforcement
5. Memory & Motivation
6. Focus on Basic Skills
7. Delivers Test Scores

Association

1. Bush - Rhetoric
2. Crowder - Pioneer
3. Programmed Learning
4. Smallwood Optimised
5. Nelson Popularised
6. Facts Retained
7. Web Facilitates

Feedback

1. Wiener Pioneer
2. Pask Inventor
3. Cybernetic Approach
4. Some Successes
5. Much Confusion
6. Serialists & Holists
7. Learning Styles

Procedural/Declarative

1. Dartmouth BASIC
2. Learner as Programmer
3. Explicit Representation
4. Sequencing
5. Debugging
6. Goto Harmful?
7. Prolog & Databases

Developmental

1. Piaget - Psychologist
2. Papert - Pioneer
3. LOGO Learner’s LISP
4. Learner as Program
5. Procedural Decomposition
6. Powerful Ideas
7. Smalltalk & Lego

Symbolic

1. Kimball Pioneer
2. Reinforcement & Expert Systems
3. Student Models
4. J Self Pioneer
5. Subtraction Model
6. Peaked with SOPHIE
7. Scaffolding
8. Expensive but Possible

Games

1. Lunar Lander
2. Battleships
3. Theoretician – Malone
4. Intrinsic Motivation
5. Extrinsic Motivation
6. Simcity, MOO & MUP
7. Technology & Market

Collaborative

1. Vygotsky Psychologist
2. Situated Learning
3. Synchronous & Asynchronous
4. Smith & Scanlon
5. New Topologies
6. Peer Learning
7. Activity Theory/HCI

Environmental

1. Hiltz Virtual Classrooms
2. PLATO & TICCIT
3. VLEs inclusive ragbag
4. Interoperability essential
5. Learning Management
6. Chronology & Peers
7. Assessment Support

Enhancements to Learning

Special properties used to enhance learning on orthogonal dimensions

Visualisation

By augmenting simulation engines, symbolic calculators and other software with graphical output it becomes possible to support student visualisation of highly abstract processes and procedures.

Diagnosis

By tracking student work on related tasks it becomes possible to distinguish ‘accidental’ errors from those which provide statistical evidence for failure to understand key concepts or to master critical skills.

Remediation

By systematically giving students greater access to relevant information or rehearsing them on weak skills it becomes possible to focus remediation on areas that the student, tutor or software has diagnosed as requiring attention.

Reflection

By giving the student access to records of their past working, the responses of the peers, tutors and systems they were working with and by providing them with tools with which to annotate and file such work it becomes possible to support systematic reflection on what they have learnt and on their own learning processes.

Memory Prostheses

By giving students comprehensive access to their past computer mediated work and by providing them with appropriate search engines it becomes possible for students to have the self confidence to be very selective and focused about what they chose to attempt to memorise at any point in time, thus supporting much greater cognitive economy on the part of the learner.

Scaffolding

By tracking student learning gains and by human or system dialogue with the learner it becomes possible to dynamically vary the level of scaffolding provided for learners.

Tackling the Hypothetical

By making it possible for students to set up counterfactual situations in simulations or to break laws in symbolic reasoning systems it becomes possible for students to investigate the fundamental principles which underpin formal scientific, mathematical and other models.

Time Travel

By facilitating ‘time travel’ as a matter of routine in simulations and databases it becomes possible to help learners augment their understanding by focusing on the key issues of chronology and causality.

Autonomy

By taking the learner’s viewpoint when designing instructional software it becomes possible to give the learner greater control over the degree to which there are external interventions in their learning processes.

Pacing

By providing a ‘clock’ based on the planned work of a cohort of learners or on an appropriate instructional design it becomes possible for learners to increase their motivation when engaged in sequences of learning activity over longer time periods such as terms and years.

Redundancy

By encoding the same learning material using different media elements it becomes possible for heterogeneous groups of learners with different learning styles and media preferences to study the same curriculum content.

Motivation

By addressing issues of intrinsic and extrinsic learner motivation explicitly in the design of learning sequences supported by instructional software and in the design of educational interfaces it becomes possible to enhance motivation in ways that depend on the characteristics of the individual learner.

Group Working

By supporting synchronous or asynchronous group working modes and by appropriate choice of design to support competitive, collaborative or complementary activity it becomes possible for learners to work in teams and to acquire higher order learning skills from each other.

Knowledge Integration

By taking a chronological view when designing instructional software, by deliberately incorporating appropriate elements of media redundancy and by planning for student use of memory prosthetics it becomes more possible for the learner to integrate diverse knowledge acquired at different times.

Access

By incorporating diverse prosthetics in learner interfaces and by designing for learner autonomy and pacing, it becomes possible to extend access to learners who cannot take advantage of conventional modes of classroom delivery because of their special social or physical circumstances.

For Forgetting

1. To be more abstract
2. To remove clutter
3. To focus on reasoning
4. To build new patterns
5. To discover together
6. To make big leaps
7. To focus on understanding

For Surfing

1. Learning as exploration
2. Making new connections
3. Understanding knowledge topologies
4. Seeking puzzles and surprises
5. Continuous scepticism
6. Mapping boundary changes
7. Locates the learner

Key Issues

1. Improving navigation support
2. Reducing cognitive cost- especially fopr new learners
3. Ensuring approaches scale to 1000s of learners around the WWW
4. Maximising added value and incidental learning
5. Widening Access while Enhancing Constructive functionality

Navigation Support

1. Where am I in this information space?
2. Is it really a 2D space, tree, network lattice?
3. Who is also active in the space?
4. How can I plan net week’s route?
5. How can I travel between spaces?
6. How can I travel in parallel?

Cognitive Cost

1. Different metaphors – physical object, spatial, locational, computer – computer, etc
2. Broken metaphors – infinate desktops, etc
3. Mixed metaphors – disks into waste bins, etc
4. Different short cut conventions
5. Response time variation

Against Reductionism

1. It decontextualises
2. Topology can be lost
3. Construction can be inhibited
4. Morphology can be lost
5. Arbitrary limits are set
6. Teaching becomes trivialised
7. Assessment becomes trivialised

Virtuality

1. Value – reduces memory load, structures experience, easier to use and retrieve use
2. Key metaphor – ‘Direct manipulation’
3. Virtual Microscope
4. Virtual Summer School
5. Virtual University
6. Virtual Reality
7. Virtual Library
8. Virtual Computer – Computers!

Tradeoffs & Tensions

1. Understanding or Mastery
2. Reform or Revolution
3. Individual or Shared
4. Synoptic or Reductionist
5. Remembering or Forgetting
6. Virtual or Real
7. Autonomy or Direction

Machine Learning

1. Explicit – Rules
2. Explicit – Heuristic
3. Explicit – Decomposition
4. Implicit – Distributed
5. Implicit – Reinforcement
6. Implicit – Association
7. Both – Statistical

Surprise Wins

1. Key’s Dynabook Project
2. Asynchronous Collaboration
3. Virtual Machines
4. Subtraction Model
5. Suppes Drill & Practice
6. University of Phoenix
7. Blackboard

Research Agenda

1. Potential of Machine Learning
2. Fit to Psychology
3. Navigation Support
4. Learnability of Languages
5. Visual Metaphors
6. Promoting Autonomy
7. Goal – Reflective Inquiry