Wisdom is not the product of schooling but the lifelong attempt to acquire it.
- Albert Einstein

Overview of Learning

Gerhard Fischer and Hal Eden
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A Chinese Saying

I hear and I forget,

I see and I remember,

I do and I understand.

Discovery Learning Initiative (DLI)
and
Discovery Learning Center (DLC)

- a new, unique facility of the College of Engineering, CU Boulder

- opinions about discovery learning
  - Hirsch, E. D. (1996) The Schools We Need And Why We Don't Have Them, Doubleday, New York.
  - Mayer, R. E. (2004) "Should There Be a Three-Strikes Rule Against Pure Discovery Learning? — The Case for Guided Methods of Instruction," American Psychologist, 59(1), pp. 14-19.

"Discovery Learning" — Characterized by E.D. Hirsch

- The phrase refers to the teaching method which sets up projects or problems so that students can discover knowledge for themselves through hands-on experience and problem solving rather than through textbooks and lectures. Progressivists made discovery learning the chief or exclusive form of teaching starting with the "project method".

- The premise is true that knowledge acquired on one's own, with difficulty and by expending lots of time and effort, is more likely to he retained than knowledge presented verbally. It is also true that knowledge gained in a realistic context as part of an effort to solve a problem is likely to be knowledge that is well understood and integrated.

- Unquestionably, then, discovery learning is an effective method—when it works. But there are two serious drawbacks to preponderant or exclusive reliance on discovery learning.
  - First, students do not always make on their own the discoveries they are supposed to make; in fact, they sometimes make "discoveries" that aren't true. Hence, it is essential to monitor students to probe whether the desired learning goal has been achieved, and if not, to reach the goal by direct means.

  - Second, discovery learning has proved to be very inefficient. Not only do students sometimes fail to gain the knowledge and know-how they are supposed to gain, but they do not gain it very fast. Research into teaching methods has consistently shown that discovery learning is the least effective method of instruction in the teacher's repertory.

“Basic” Skills in the Age of Computational Media

- question: if most job-relevant knowledge must be learned on demand what is the role of “basic” education?

- what is the critical background knowledge which makes learning on demand feasible?

- question: do “basic skills” change their meaning under the influence of technology?

Example: Changes by Hand-Held Calculators

YOU are the expert consultant for the BVSD

- **step 1:** ignore the existence of the gadget
- **step 2:** make people learn arithmetic, multiplication tables, long division, drawing square root by hands → and after they have it all mastered, they can use hand-held calculators
- **step 3:** create / invent new calculators, which makes learning these skills more fun and creates a deeper understanding
- **step 4:** find new ways to distribute responsibilities between humans and machines
  - humans do the qualitative reasoning, use estimation skills
  - machines do the detailed quantitative computations

Some Claims about Learning

- people learn best when engrossed in the topic, motivated to seek out new knowledge and skills because they need them in order to solve the problem at hand

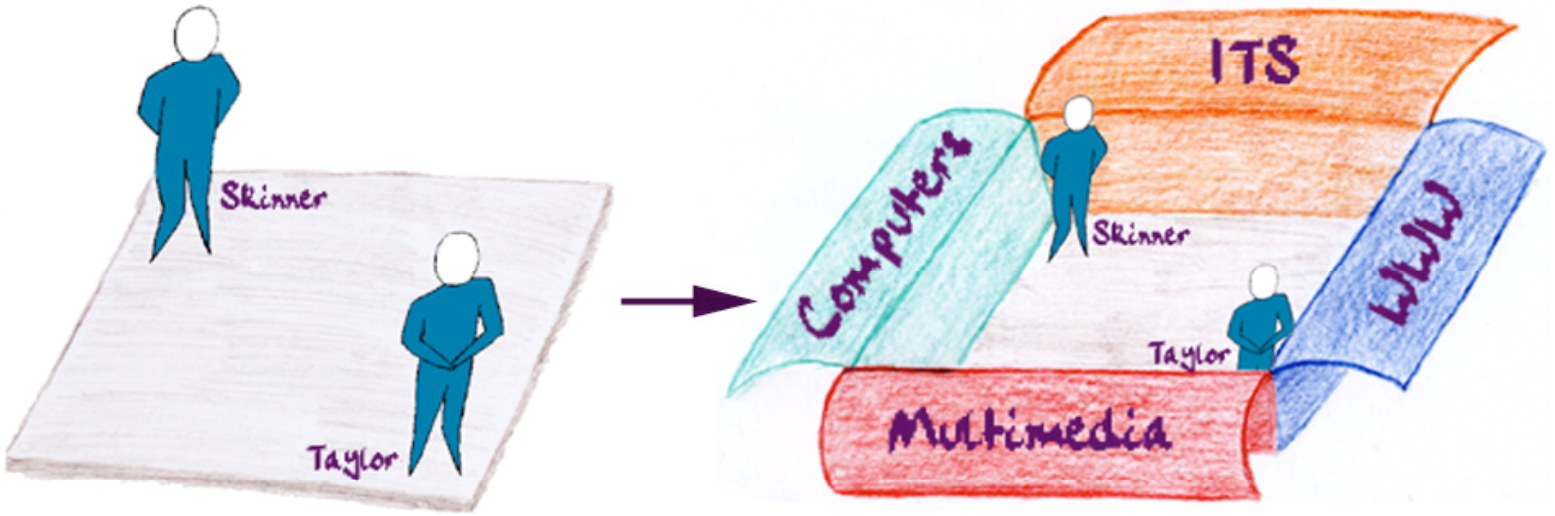
- real learning — the way we learn is trying something, doing it and getting stuck. In order to learn, we really have to be stuck, and when we're stuck we are ready for the critical piece of information. The same piece of information that made no impact at a lecture makes a dramatic impact when we're ready for it.

- "*A major illusion on which the school system rests is that most learning is the result of teaching*" — Ivan Illich (in "Deschooling Society")

- learning and teaching are not inherently linked:
  - much learning takes place without teaching
  - much teaching takes place without learning

Learning and Media

Adding Technology to Existing Educational Practice

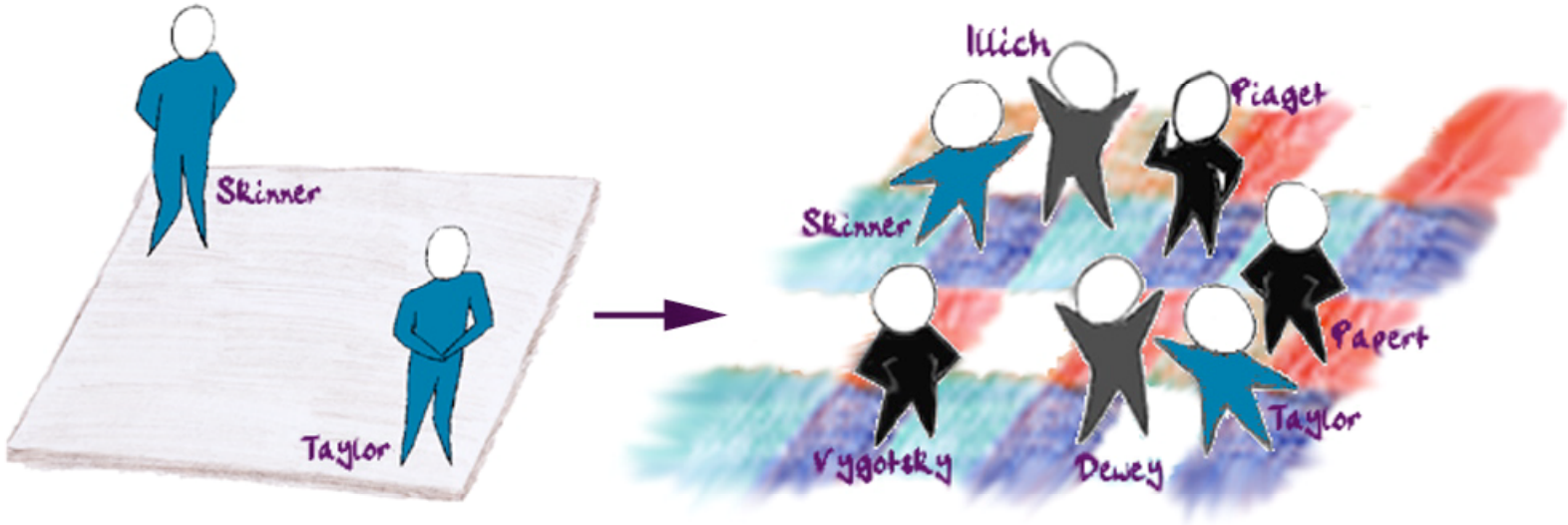


Current Education

Current Education
wrapped in Technology

Learning and Media

Rethinking, Reinventing and Reengineering Educational Theory and Educational Practice



Current Education

Computer-supported & Computer-mediated Education of the Future

How the World Has Changed

dimension	old paradigm	new paradigm
information	scarce	plentiful
reproduction of documents	expensive and restricted	cheap
specialization	low	high
change within a human life time	slow	fast
interaction / collaboration	physical proximity	shared professional interests
economy	rigid, hierarchical organizations long-term personal identity	dynamic economy, flexibility, networking no long-term

Learning in Humans and Machines

- **machine learning** = subfield of AI concerned with programs that learn from experience
  - **applied learning systems — a practical necessity?**
    - to overcome the tedious work of programming
    - the ultimate form of knowledge acquisition in knowledge-based systems
  - **machine learning as a science**
    - understand human learning well enough to reproduce aspects of that learning behavior in computer systems
    - computer enforces a commitment to fine-structure process-level detail
    - exploration of alternative learning mechanism complementing human learning methods

- **in this course:** we are interested in computational media and environments in support of **human learning** (specifically in the context of design and collaboration)

Global Theories about Learning

- **B. F. Skinner (1904 – 1990)—** behavior is affected by its consequences. We reward and punish people, for example, so that they will behave in different ways. → programmed instruction, multiple choice questions

- **Jean Piaget (1896-1980) —** developmental psychology and genetic epistemology: how does knowledge grow? → children's logic and modes of thinking are initially entirely different from those of adults

- **Lev Vygotsky (1896-1934)** — social interaction plays a fundamental role in the development of cognition → computer-supported collaborative learning (CSCL)

- **John Dewey (1859-1952) —** application of his theory of knowledge to education: informal education, passion for democracy (public versus private schools) → self-directed learning, exploration of thinking and reflection, environments for learning

Jerome Bruner (1915 -): Education and Learning

- It is surely the case that schooling is only one small part of how a culture inducts the young into its canonical ways. Indeed, schooling may even be at odds with a culture's other ways of inducting the young into the requirements of communal living.

- What has become increasingly clear is that education is not just about conventional school matters like curriculum or standards or testing. What we resolve to do in school only makes sense when considered in the broader context of what the society intends to accomplish through its educational investment in the young.

- How one conceives of education, we have finally come to recognize, is a function of how one conceives of culture and its aims, professed and otherwise.

Global Theories about Learning

- **Ivan Illich** — convivial tools, deschooling society → learning webs
- **Seymour Papert** — constructionism → LOGO, Turtle Geometry
- **Frederick W. Taylor (1856-1915)** — scientific management: the study of relationships between people and tasks for the purpose of redesigning the work process to increase efficiency

Transcending Skinner and Taylor

Skinner/Taylor		Beyond Skinner and Taylor
there is a "scientific," best way to learn and to work (programmed instruction, computer-assisted instruction, production lines, waterfall models)	→	real problems are ill-defined and wicked; design is argumentative, characterized by a symmetry of ignorance among stakeholders
separation of thinking, doing, and learning	→	integration of thinking, doing, and learning
task domains can be completely understood	→	understanding is partial; coverage is impossible
objective ways to decompose problems into standardizable actions	→	subjective, situated personal interests; need for iterative explorations
all relevant knowledge can be explicitly articulated	→	much knowledge is tacit and relies on tacit skills
teacher / manager as oracle	→	teacher / manager as facilitator or coach
operational environment: mass markets, simple products and processes, slow change, certainty	→	customer orientation, complex products and processes, rapid and substantial change, uncertainty and conflicts

Learning: Current Theories

- learning is a process of **knowledge construction**, not of knowledge recording or absorption
- learning is **knowledge-dependent**; people use their existing knowledge to construct new knowledge
- learning is highly **tuned to the situation** in which it takes place
- learning needs to account for **distributed cognition** requiring to combine knowledge in the head with knowledge in the world
- learning is affected as much by **motivational issues** as by cognitive issues
- **learning and teaching are not inherently linked** ("much learning takes place without teaching" — but: "much teaching takes place without learning")

Learning: Current Theories → Specific System Developments

- learning is a process of **knowledge construction**, not of knowledge recording or absorption → ***reflection-in-action, argumentation***

- learning is **knowledge-dependent**; people use their existing knowledge to construct new knowledge → ***differential descriptions, user models, personalization***

- learning is highly **tuned to the situation** in which it takes place → ***human problem-domain communication, domain-oriented design environments***

- learning needs to account for **distributed cognition** requiring to combine knowledge in the head with knowledge in the world → ***learning on demand, using on demand, Envisionment and Discovery Collaboratory***

- learning is affected as much by **motivational issues** as by cognitive issues → ***gift cultures, an interest is a terrible thing to waste***

- **learning and teaching are not inherently linked** → **learning when the answer is not known, informed participation**

An Example: Learning about Gravity

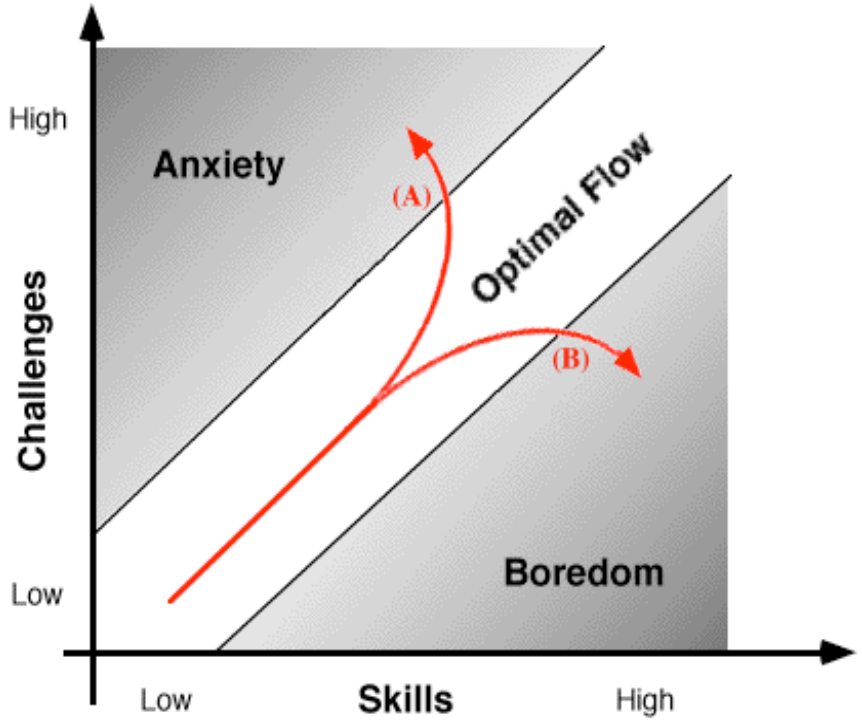
- teach about gravity ←→ letting people experience it
- use contradictions as a source for curiosity and insight
- ask interesting questions and let the students come up with answers
- use of new media (specifically Squeak = open source version of Smalltalk; used for Swikis and the Envisionment and Discovery Collaboratory)
- reinvent the classroom culture with new media

Motivation

- **claims:**
  - the chief impediments to learning are not cognitive but motivational
  - people can learn many things if they want to
  - motivation is a tricky problem in learning because while it plays a major role, it is not well understood

- **impact of our approach on motivation:**
  - make information relevant to the task at hand
  - create interesting products
  - provide multiple learning opportunities
  - provide challenges matched to skill levels
  - create communities (among peers, over the net)
  - provide access to real practitioners and experts

Optimal Flow as a Motivating and Driving Force in Learning



- **architectures and concepts for optimal flow:**
  - low threshold and high ceiling
  - increasingly complex micro-world
  - co-adaptive systems

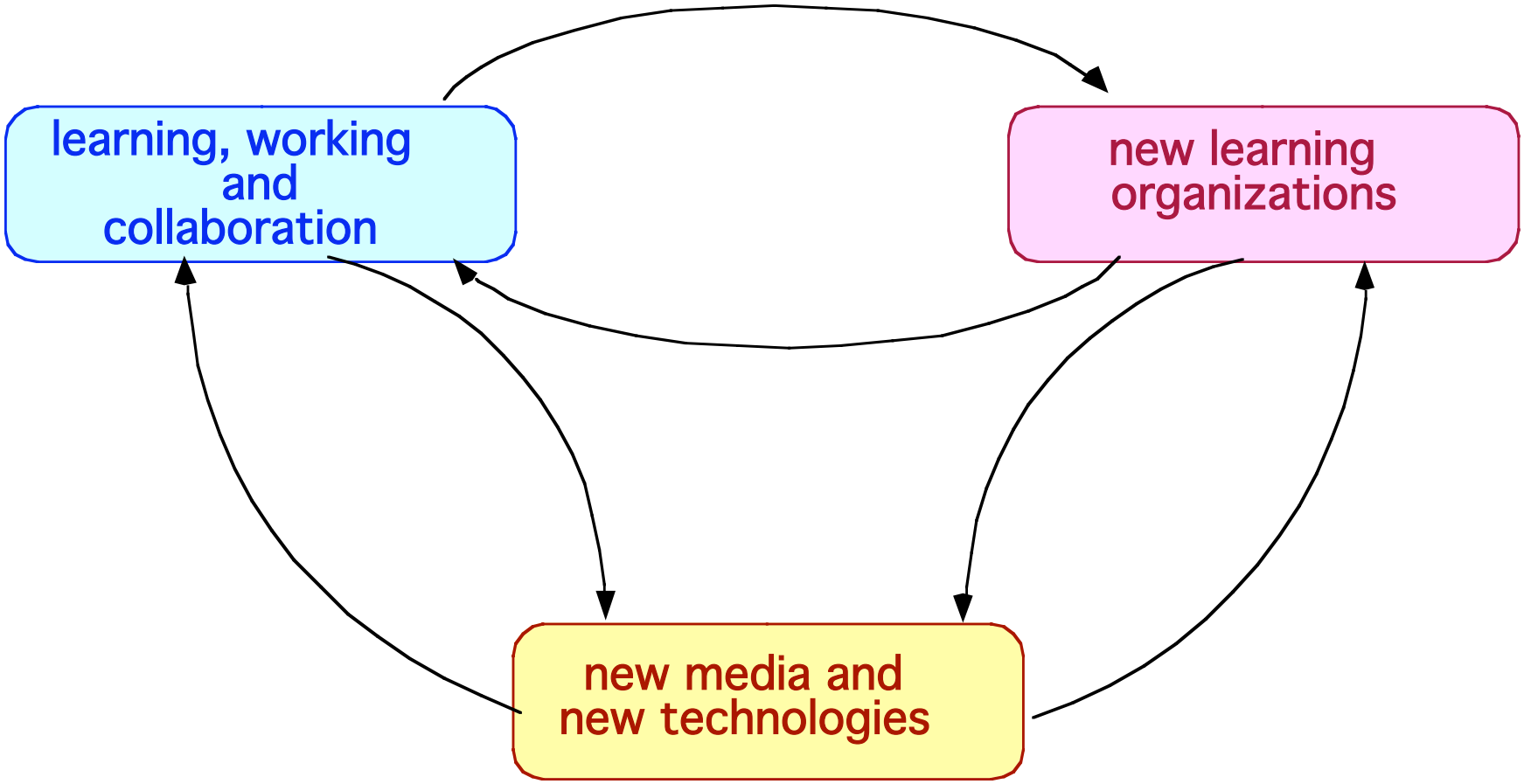
Different Approaches to Learning

concept	definition	strengths	weaknesses	media support
learning by being told				
just-in-time learning				
learning on demand				
integration of working and learning				
self-directed learning				
discovery learning				
problem-based learning				
collaborative learning				
organizational learning				
lifelong learning				

Myths and Misconceptions

- Computers by themselves will change education
- Information is a scarce resource
- “Ease of use” is the greatest challenge or the most desirable goal for new technologies
- The content, value, and quality of information and knowledge is improved just because it is offered in multi-media or over the WWW
- The “Nobel Prize winner” myth: Every school child will have access to a Nobel Prize winner
- The single or most important objective of computational media is reducing the cost of education

Co-Evolution: Beyond "Technology-Driven Developments" and "Gift-Wrapping"



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