

Computer-Assisted Learning Environments

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Outline

- Review of learning principles
 - * Constructivism, Transfer, ZPD, Meta-cognition
- Constructivist Learning Systems:
 - * Construction Toolkits
 - * Collaborative learning
 - * Meta-cognition
 - * Inquiry-based environments
 - * Agent-based Tutors
- Design Patterns for Education

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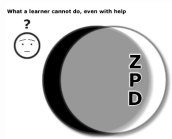
Building Understanding

- Learning is a *process* of building new knowledge using existing knowledge.
- Knowledge is not acquired in the abstract, but constructed out of existing materials.
- Like any other human process, HCI researchers/practitioners seek to mediate learning via technology.

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Learning and Experience

- Learning is most effective when it connects with the learner's *real-world* experiences.
- The knowledge that the learner already has from those experiences serves as a foundation for new knowledge.
- In real societies, learners are helped by others.
- Zone of Proximal Development (ZPD): "zone" of concepts one can acquire with help.



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Motivation and Abstraction

- Motivation encourages the user to visualize use of the new knowledge, and to try it out in new situations.
- Students are usually motivated when the knowledge can be applied directly.
- Abstract knowledge is packaged for portability. It's built with virtual objects and rules that can model many real situations.
- Our goal is students that are motivated to collect abstract knowledge and build general understanding

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Metacognition

- Metacognition is the learner's conscious awareness of their learning process.
- Strong learners carefully manage their learning.
- For instance, strong learners reading a textbook will pause regularly, check understanding, and go back to difficult passages.
- Weak learners tend to plough through the entire text, then realize they don't understand and start again.
- We want to turn weak learners into strong learners.
 - * Or, at least, make them act like strong learners.

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Constructivist Learning Systems

- Construction Kits
 - * Logo, Microworlds, Boxer
- Group-learning Systems
 - * CoVis, TVI, Livenotes
- Meta-Cognitive Systems
 - * SMART, CSILE/Knowledge Forum
- Inquiry-Based Systems
 - * ThinkerTools
- Automatic Tutors
 - * Inquiry Island
- Integrated Learning Environments
 - * WISE, UC-WISE

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Logo

- The Logo project began in 1967 at MIT.
- Seymour Papert had studied with Piaget in Geneva. He arrived at MIT in the mid-60s.
- Logo often involved control of a physical robot called a turtle.
- The turtle was equipped with a pen that turned it into a simple plotter - ideal for drawing math shapes or seeing the trace of a simulation.

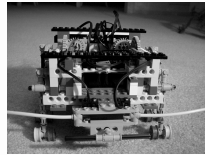


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Logo

- Early deployments of Logo in the 1970s happened in NYC and Dallas.
- In 1980, Papert published "Mindstorms" outlining a constructivist curriculum that leveraged Logo.
- Logo for Lego began in the mid-1980s under Mitch Resnick at MIT.



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Logo

- The "Microworlds" programming environment was created by Logo's founders in 1993. It made better use of GUI features in Macs and PCs than Logo.
- In 1998, Lego introduced Mindstorms which had a Logo programming language with a visual "brick-based" interface.



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Logo

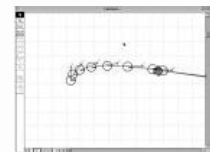
- Logo was widely deployed in schools in the 1990s.
- Logo is primarily a programming environment, and assignments need to be programmed in Logo.
- Unfortunately, curricula were not always carefully planned, nor were teachers well-prepared to use the new technology.
- This led to a reaction against Logo from some educators in the US. It remains very strong overseas (e.g. England, South America).

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Uses of Logo

- Logo is designed to create "Microworlds" that students can explore.
- The Microworld allows exploration and is "safe," like a sandbox.
- Children "discover" new principles by exploring a Microworld.
- e.g. they may repeat some physics experiments to learn one of Newton's laws.

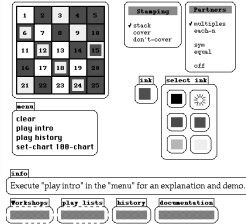


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Boxer

- Boxer is a system developed at Berkeley by Andy diSessa (one of the creators of Logo).
- Boxer uses geometry (nested boxes) to represent nested procedure calls.
- It has a faster learning curve in most cases than pure Logo.



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Strengths of Logo

- Very versatile.
- Can create animations and simulations quickly.
- Avoids irrelevant detail.
- Tries to create "experiences" for students (from simulations).
- Provides immediate feedback - students can change parameters and see the results right away.
- Representations are rather abstract - which helps knowledge transfer.

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Weaknesses of Logo

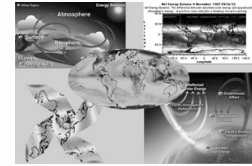
- Someone else has to program the simulations etc - their design may make the "principle" hard to discover. Usability becomes an issue.
- The "experience" with Logo/Mindstorms is not real-world, which can weaken motivation and learning.
- The "discovery" model de-emphasizes the role of peers and teachers.
- It does not address meta-cognition.

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Collaborative Software

- CoVis (Northwestern, SRI) was a system for collaborative visualization of data for science learning, primarily in geo-science, 1994-...
- Students work online with each other, and with remote experts.
- They take virtual field trips, or work with shared simulations.



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CoVis

- CoVis included a "Mentor database" of volunteer experts that teachers could tap to talk about advanced topics.
- It also included a collaboration notebook. The notebook included typed links to guide the student through their inquiry process.
- Video-conferencing and screen-sharing were used to facilitate remote collaboration.

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TVI

- TVI (Tutored Video Instruction) was invented by James Gibbons, a Stanford EE Prof, in 1972.
- Students view a recorded lecture in small groups (5-7) with a Tutor. They can pause, replay, and talk over the video.
- The method works with a live student group, but also with a distributed group, as per the figure at right.




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DTVI

- ☐ Sun Microsystems conducted a large study of distributed TVI in 1999.
- ☐ More than 1100 students participated.
- ☐ The study showed significant improvements in learning for TVI students, compared to students in the live lecture (about 0.3 sdev).



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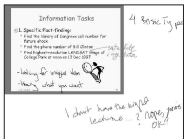
DTVI

- ☐ The DTVI study produced a wealth of interesting results:
- ☐ Active participation was high (more than 50% of students participated in > 50% of discussions).
- ☐ Amount of discussion in the group correlated with outcomes (exam scores).
- ☐ Salience of discussion did not *significantly* correlate with outcome (*any* conversation is helpful??).

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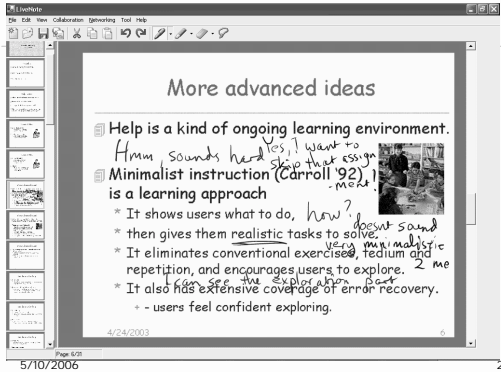
Livenotes

- ☐ TVI requires a small-group environment (small tutoring rooms).
- ☐ **Livenotes** attempts to recreate the small-group experience in a large lecture classroom.
- ☐ Students work in small *virtual* groups, sharing a common workspace with wireless Tablet-PCs.
- ☐ The workspace overlays PowerPoint lecture slides, so that note-taking and conversation are integrated.



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Livenotes Interface



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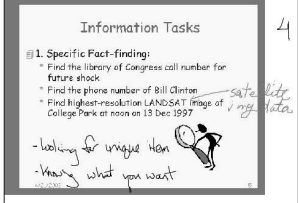
Livenotes Findings

- ☐ The dialog between students happens spontaneously in graduate courses - where student discussion is common anyway.
- ☐ It was much less common in undergraduate courses.
- ☐ Students have different models of the lecture - something to be "captured" vs. some that is collaboratively created.

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Livenotes Findings

- ☐ But what was very common in undergraduate transcripts was student "dialog" with the PowerPoint slides:
- ☐ Students often add their own bullets.



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Livenotes Findings

Reinforcing/rejecting a bullet:

Face-to-Face: the ultimate?


more private in email. status, physical appearance, has something to do with email. Face to face communication is a neutral communication that has more feedback. (but email is not a natural way to communicate)

Kiesler and Sproull findings:

- Participants talk more freely in email (than F2F).
- Participation is more equal in email.
- More propensities for action via email.
- Reduced effects of status/physical appearance.

But

- Longer decision times in email. (True, difficult to agree on meetings quickly this way)
- More extreme remarks and flaming in email.



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Livenotes Findings

Answering a question in a bullet:

Personae

A rich portrait of a character

- Name:
- Occupation:
- Values:
- Likes:
- Dislikes:



Why do we do this?

advantages - someone specific, audience to design for, design according to needs of target group, not what you think they need

As a generative process, the more details you have the more associations you can make with your own experiences, brings in more knowledge from your own experience and a more explicit personae stops you from intuitively imparting your own preferences onto the design

multiple personae expand the range of the user group

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Collaborative Systems

Given what you know about learning, list some advantages and disadvantages of the 3 systems (CoVis, TVI /DTVI, Livenotes).

What collaborative class features have you experienced in school?


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Meta-Cognitive Systems

The SMART project (Vanderbilt, 1994-) gave students science activities with meta-cognitive scaffolds.

Students choose appropriate instruments to test their hypothesis – requiring them to understand the kind of information an instrument can give.

The case study was an environmental science course called the “Stones River Mystery”.



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Meta-Cognitive Systems

The SMART lab required students to justify their choices – it encouraged them to reflect after their decisions, and hopefully while they are making them.

It also included several tools for collaboration between students. Explaining, asking questions, and reaching joint conclusions help improve meta-cognition.

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Inquiry-Based Systems

A development of Piaget based on similarities between child learning and the scientific method.

In this approach, learners construct explicit theories of how things behave, and then test them through experiment.

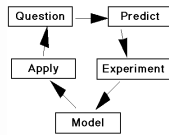
The “ThinkerTools” system (White 1993) realized this approach for “force and motion” studies.

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ThinkerTools

- ThinkerTools uses an explicit inquiry cycle, shown below.
- Students are scaffolded through the cycle by carefully-designed exercises.

THE INQUIRY CYCLE

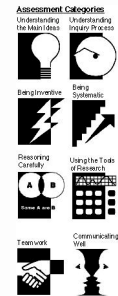


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ThinkerTools

- ThinkerTools uses "reflective assessment" to help students gauge their own performance and identify weaknesses.

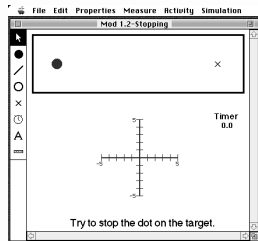


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ThinkerTools

- The tools include simulation (for doing experiments) and analysis, for interpreting the results.

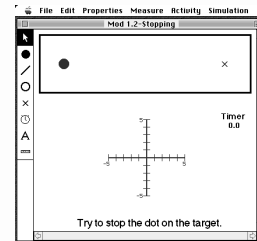


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ThinkerTools

- Students can modify the "laws of motion" in the system to see the results (e.g. $F=a/m$ instead of ma).



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Agents: Inquiry Island

- An evolution of the ThinkerTools project.
- Inquiry Island includes a notebook, which structures students inquiry, and personified (software agent) advisers.

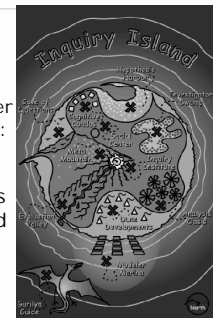


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Inquiry Island

- Task advisers:
 - Hypothesizer, investigator
- General purpose advisers:
 - Inventor, collaborator, planner
- System development advisers:
 - Modifier, Improver
- Inquiry Island allows students to extend the inquiry scaffold using the last set of agents.



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Integrated Learning Environments

Web-Based Inquiry Science Environment (WISE)

- * UC Berkeley TELS group
- * Middle School - High School science classes

UC-WISE

- * TELS group + CS Division
- * UC Berkeley & Merced lower division CS courses

Sakai

- * Multiple institutions
- * Called bSpace in the UC system

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UC-WISE - Question

- What components of UC-WISE are similar to the systems we've considered thus far?
- What components are noticeably different?

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UC-WISE Features

Learning Management System

- * Cohesive collection of lessons, tasks, assignments, assessments, and related info

Collaborative Tools

- * Brainstorms, discussion forums, collaborative reviews

Inquiry-Based Tools

- * Web-Scheme, Eclipse exercises

Meta-Cognitive Tools

- * Quick quizzes, "extra brain," peer assessment

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Question

- How portable (across different courses) are these systems (SMART, ThinkerTools, Inquiry Island) and their content (UCB CS3)?

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Design Patterns for Education

Recall Lecture 15:

- * Design patterns for architecture & software
- * Communicate design problems and solutions
- * Not too general, not too specific
 - + Use a solution "a million times over, without ever doing it the same way twice."

This concept can be applied to education!

- * Pedagogical Patterns

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Pedagogical Patterns Project

- "Attempt to capture expert knowledge of the practice of teaching and learning in a portable, salient format."

<http://www.pedagogicalpatterns.org/>

- E.g. "Expand the Known World"

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"Expand the Known World"

- ☞ Context:
 - * You have a new concept to introduce. Your students have some related knowledge and experience.
- ☞ Forces/Key Problem:
 - * A student's learning will be deeper if they associate a new concept to their existing knowledge and experience.
- ☞ Solution:
 - * Therefore introduce the concept by explicitly linking it to experiences that you know the students have already...
- ☞ Additional Information:
 - * Time consuming, works well with Larger than Life, etc...

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Problems in Practice

- ☞ Pedagogical patterns have a tendency to be too abstract to be useful.
 - * Difficult to apply to a new context
- ☞ Pattern-informed environments rarely reveal clues about the underlying patterns to the untrained observer
- ☞ Collaboration between content experts and pedagogical specialists is rare
 - * Individuals that can fill both roles are even more scarce.

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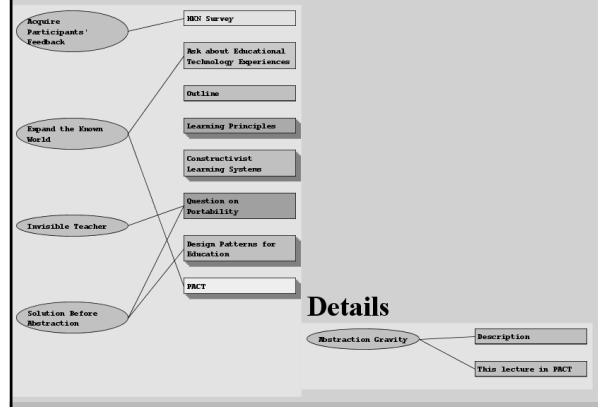
Pattern Annotated Course Tool

- ☞ Research project intended to bridge the gap between pedagogical patterns in theory and in practice
- ☞ Visual editor in which expert course designers can create representations of their own courses, complete with references to pedagogical patterns
- ☞ Novice instructors can see patterns instantiated in a context that they can relate to directly

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CAL Environments



Summary

- ☞ We reviewed some learning principles from lec 19.
- ☞ We gave some systems that roughly track the frontier of learning technology:
 - * Construction toolkits
 - * Collaborative systems
 - * Meta-cognitive scaffolding systems
 - * Inquiry systems
 - * Agent-based tutoring systems
 - * Integrated learning environments
- ☞ We considered the application of design patterns to pedagogy and a tool to facilitate this process

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