**Outline**

- Review of learning principles
  - Constructivism, Transfer, ZPD, Meta-cognition
- Systems:
  - Constructivist learning
  - Collaborative learning
  - Meta-cognition
  - Inquiry-based environments
  - Tutors

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**Learning and existing knowledge**

- Learning is a process of building new knowledge using existing knowledge.
- Knowledge is not acquired but constructed out of existing "materials".
- The process of applying existing knowledge in new settings is called Transfer.

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**ZPD**

- Learning is layered and incremental.
- In real societies, learners are helped by others.
- In fact learners have a "zone" of concepts they can acquire with help.
- This is the Zone of Proximal Development (ZPD).

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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 form those experiences serves as a foundation for knew knowledge.

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**Transfer and understanding**

- Transfer depends on thorough learning in the first situation (learning with understanding*).
- The more thorough the understanding in the first situation, the more easily knowledge will transfer.
Transfer and Generality

- Generality of existing knowledge: has the learner already seen it applied in several contexts?

Transfer and Motivation

- Motivation: is the new knowledge useful or valuable?
- 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 to everyday situations.

Transfer and Abstraction

- Is the existing knowledge abstract or specific?
- Abstract knowledge is packaged for portability. It's built with virtual objects and rules that can model many real situations.
- E.g. clipart

Metacognition

- Metacognition is the learner's conscious awareness of their learning process.

Metacognition

- 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.

Learning systems

- Constructivist Systems
  * Logo, Microworlds, Boxer
- Group-learning Systems
  * CoVis, TVI, Livenotes
- Meta-Cognitive Systems
  * SMART, CSILE/Knowledge Forum
- Inquiry-Based Systems
  * ThoughtTools
- Automatic Tutors
  * Inquiry Island
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.


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.

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).

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.

Boxer is a new 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.
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.

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.

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.

CoVis

- CoVis included a "Mentor database" of volunteer experts that teachers could tap to talk about advanced topics.
- It also included a collaboratory 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.

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.
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).

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?).

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 whiteboard. The whiteboard overlays PowerPoint lecture slides, so that note-taking and conversation are integrated.

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.

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

1. Reinforcing/rejecting a bullet:
   - Face-to-Face: the ultimate?
     - Easier to read
     - Possible to ask questions
     - Requires more effort
   - E-mail:
     - Easier to read
     - Possible to ask questions
     - Requires less effort

2. Answering a question in a bullet:
   - Personal:
     - A wiki paradigm of a character
     -: None
     -: Cognitivist
     -: Constructor
     -: Editor
     -: Dip Nurse
   - Why do we do this?
     - Students construct specific instances by designing a recipe in order to create a new type of instrument, often with extremely limited time.

Collaborative Systems

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

Meta-Cognitive Systems

1. The SMART project (Vanderbilt, 1994-) gave students science activities with meta-cognitive scaffolds.
2. Students choose appropriate instruments to test their hypothesis - requiring them to understand the kind of information an instrument can give.
3. The case study was an environmental science course called the "Stones River Mystery".

Inquiry-Based Systems

1. A development of Piaget based on similarities between child learning and the scientific method.
2. In this approach, learners construct explicit theories of how things behave, and then test them through experiment.
3. The "ThinkerTools" system (White 1993) realized this approach for "force and motion" studies.
ThinkerTools uses an explicit inquiry cycle, shown below. Students are scaffolded through the cycle by carefully-designed exercises.

The Inquiry Cycle

Question → Predict

→ Apply

→ Experiment

→ Model

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

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

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

Agents: Inquiry Island

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

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.
Question

How portable (across different courses) are these systems (SMART, ThinkerTools, Inquiry Island)?

Summary

We reviewed some learning principles from lec 5.
We gave some systems that roughly track the frontier of learning technology:
* Constructivist systems
* Collaborative systems
* Meta-cognitive scaffolding systems
* Inquiry systems
* Automatic tutoring systems