CS160: Lecture 6

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Human Learning Summary

- People construct new concepts from old ones
- The process of generalizing is called transfer
- Learners often learn with the help of others, in their ZPD (Zone of Proximal Development)
- Learning is most effective when it connects with the learner’s experience
Human Learning Summary

- Transfer is influenced by
  - Similarity between old and new situations
  - Understanding of the old situation
  - Generality of the original concept
  - Learner’s motivation
  - Abstraction of the original concept

- Metacognition - the learner’s management of their learning process - is a very important factor in learning
Human Learning summary

- Piaget identified systematic stages in development.

- Concrete and Formal thought styles differ among the population.

- A concrete → abstract progression is manifest in learning of particular concepts.
Differences in Learning

- School - learning about the world (through books)
- College - learning from books (specialized knowledge)
- Graduate school - interpreting texts critically
This time

- Some practical approaches using technology
Techniques for child learning

- Bringing exciting real-world curricula into the classroom.
- Scaffolds and tools to enhance learning.
- Feedback, reflection, revision.
- Building communities of teachers, parents, researchers...
- Teacher learning tools
Real-world curricula

- A real-world curriculum taps what learning principles we discussed?
- What other benefits does it have?
Real-world curricula

- The benefits of real-world curricula are greater for younger children, and children of poorly-educated parents.

- Both these groups are not fluent in abstract reasoning, and are much more comfortable with concrete, knowledge-from-experience.
Real-world curricula

- NASA’s KSN (Kids Science Network) for children K-2 and 3-5, engages kids in online science activities.

- The activities follow an inquiry-based learning paradigm.
Inquiry cycles

- Inquiry-based learning makes student’s meta-cognitive strategy explicit.
- It also treats learning as a kind of scientific research.
Inquiry cycles

- **Question**: a new problem for the learner

- **Hypothesis**: Learner proposes a solution or a way to understand the problem better

- **Investigate**: Learner figures a way to try out the hypothesis (often an experiment)
Inquiry cycles

- **Analyze**: understand the results of the investigation.

- **Model**: Construct a model or principle for what’s going on.

- **Evaluate**: Evaluate the model, the hypothesis, everything that came before.
Inquiry cycles

- See http://thinkertools.soe.berkeley.edu

- Thinkertools uses software agents to personify the different stages in inquiry cycles.

- The agents help scaffold the child through the cycle.
Real-world curricula

- As well as the child’s direct experience, the curriculum can connect with professions, e.g. working scientists.

- E.g. GlobalLab for environmental science: http://globallab.terc.edu
Break
Scaffolding

- Refers to the process of shaping the learner’s experience while learning, by creating a “scaffold” to guide their actions.
- Generally, the teacher begins by doing most or all of the task.
- The task is repeated, with the learner doing more and more of it.
- Eventually, the learner does the entire task themselves - the scaffold is removed.
Scaffolding and ZPD

- Scaffolding produces a steady progression through the learner’s ZPD (Zone of Proximal Development)
Scaffolds and Tools

- First-generation learning tools were “electronic flashcards”
  - System flashes a new item on the screen
  - User has to enter the right input (typing, multiple choice etc.)
  - System learns user’s weaknesses, and focuses its examples on those weak cases.
  - Quite effective for low-level learning (e.g. Morse code).
2nd Generation Scaffolds

- Allow exploration of a knowledge domain:
  - Calculators, spreadsheets, graphing programs, probes etc.
  - Modeling/Simulation (e.g. Interactive Physics)
  - Matlab + packages
MicroWorlds

- An idea promoted by Seymour Papert (creator of Logo).
- A Microworld is a simplified model of the physical world, which emphasizes certain physical principles and omits other detail.
- E.g. 2D geometry (turtle geometry).
MicroWorlds

- Microworlds encourage less structured exploration by learners.
- The idea is that the learner's discoveries will be driven more by their own goals, leading to better learning.
- The structure of the Microworld should ensure that they make the right inferences.
Feedback, Reflection, Revision

- One of the most important principles in learner-centered design is “Early Feedback”
- The learner should be given feedback as soon as possible as they form new concepts.
- This can take the form of a multiple-choice question - so the answers can be given immediately.
Feedback, Reflection, Revision

- Reflection tools encourage meta-cognition.
- “Thinkertools” which we mentioned earlier encourages learners to follow an inquiry cycle.
Feedback, Reflection, Revision

- Small-group discussion is another way to encourage reflection.
- Discussion makes each learner reflect on their understanding to explain to others, and to interpret others’ explanations.
- Systems that do this: CSILE (Vanderbilt)
Feedback, Reflection, Revision

- Peer instruction (Mazur) is a pattern that encourages all these steps:
  1. Students are given a multi-choice question
  2. They write down an individual answer
  3. The class “votes” their answer
  4. Students discuss in small groups, then answer again.
  5. Another vote is taken
  6. The instructor explains the right answer.
Livenotes

- (Berkeley) students take notes and share comments with a small peer group.
- Undergrads tend to take turns note-taking
- Graduate students do more discussion.
Computer Tutors (the final frontier)

- One-on-one tutoring is by far the best learning method (classrooms are close to the worst).
- So called “Master learning” - structured form of tutoring has demonstrated $2\sigma$ (2 standard deviations) improvement in learning.
- Less structured tutoring often achieves $1\sigma$ or more.
- Computer tutors, even naïve ones, have demonstrated spectacular results.
Computer Tutors (the final frontier)

- The “geometry tutor” was an early example.
- Computer tutors exist for several programming languages, and OSES.
- Most have been guided by AI principles, or human learning principles, but not both.
- There is a great opportunity for improvement in this area.