Learning and Games

CS160: User Interfaces
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Review

- Sketching and Storyboarding
- Creating a Low-Fi prototype
- Wizard of Oz prototype testing
This Time

• Children and Learning
• Teaching Techniques
• Learning Games
Piaget’s Ages and Stages

• Sensori-Motor Level (0-18 months)
  • Movement, perception, objects, causality
• Semiotic Period (18 months – 7-8 years)
  • Language, mental images, drawing, memories
• Concrete Operations (7-8 years – 11-12 years)
  • Classification, numbers, space, time
• Formal Thought (11-12 onwards)
  • Logic, abstraction,…
Piaget’s Constructivism

• Children don’t receive knowledge, they actively construct it.

• i.e. Children “learn by doing,”
• They assemble and organize information for a purpose, e.g. winning a playground game.
• Successful learners also plan their own learning, assess their understanding, use strategies for memory etc.
Social Constructivism

• Lev Vygotsky also emphasized the active role of the learner.

• But he argued that the child explored a world that is carefully structured by adults.

• Adults place objects in the child’s world (toys, games, stories) that help them learn from their exploration.

• They encourage, teach by showing, and critique the child.
Zone of Proximal Development

• Vygotsky argued that learning is fastest in the “Zone of Proximal” development.

![Diagram](image_url)

- Tasks performed alone
- Tasks doable with assistance
- Tasks that cannot be done at all
ZPD and Game Design

• For games we have

Tasks doable with effort, or help from peers, or cheats etc.

"ZPD"

Tasks that are too easy

Tasks that are too difficult
Metacognition

• Children don’t come equally equipped to learn.
• Since learning is an active, exploratory process, you can teach children how to learn.
• Children’s deliberate approaches to learning are called meta-cognition.
• These include strategies for finding information, remembering it, testing hypotheses, and testing understanding.
Privileged Domains

• Learners aren’t equally interested or prepared to learn different things.
• Children typically focus on certain topics (causality, persistence etc.) at certain developmental stages.
• E.g. Children in the late sensori-motor phase are learning about object persistence, and are fascinated by games of peekaboo.
Metacognitive Strategies

• Children and adults have limited short-term memory, 7 ± 2 items.

• Adults use chunking to stretch their memory capacity, e.g. 31-555-1234

• Memory capacity improves when children are able to categories things – this is a metacognitive strategy.

• To add 3+5, some children count up from the larger number, some from the smaller.
  • But children often experiment with strategies.
Teaching Strategies

• **Peer instruction (Mazur):**
  • Teacher covers some new background material.
  • Asks students a multiple-choice question, they vote.
  • Teacher tallies votes, presents results.
  • Students then discuss in small groups
  • They vote again
  • Teacher tallies, usually (not always) the tally moves toward the right answer.
  • Teacher analyzes the question and provides the right answer.
Peer Instruction

- Teacher covers some new background material
  - This is where traditional instruction stops.
  - Some of the material sinks in, but how much depends strongly on students’ individual meta-cognitive skills.
  - Some students catch little or nothing in live lectures, rely on reading notes or cramming for exams later.
Peer Instruction

• Teacher covers some new background material.

• **Asks students a multiple-choice question, they vote.**
  
  • Here students relate the new topic to their own experience, apply it to the new problem, and commit to an answer.
Peer Instruction

• Teacher covers some new background material.
• Asks students a multiple-choice question, they vote.
• **Teacher tallies votes, presents results.**
  • Creates a game aspect to the problem. Students are interested in how they compare to their peers.
  • Helps teacher understand students’ mental models for the problem.
Peer Instruction

- Teacher covers some new background material.
- Asks students a multiple-choice question, they vote.
- Teacher tallies votes, presents results.
- **Students then discuss in small groups**
  - Students hear each other’s explanation, contrast their own mental models with several others.
  - Excellent chance to improve meta-cognitive skills.
Peer Instruction

• Teacher covers some new background material.
• Asks students a multiple-choice question, they vote.
• Teacher tallies votes, presents results.
• Students then discuss in small groups.
• **Students vote again, teacher tallies…**
  • Game aspect again, this time it’s a team sport.
Peer Instruction

• Teacher covers some new background material.
• Asks students a multiple-choice question, they vote.
• Teacher tallies votes, presents results.
• Students then discuss in small groups
• They vote again, teacher tallies,…

• Teacher analyzes the question and provides the right answer.
  • Students have strong vested interest in the answer and in the rationale, are highly motivated to use the answer.
  • Students “learn by doing” from the experience.
Peer Instruction

• After the peer instruction, student attention continues to be much higher, even on other topics.
  • Recall IDEO’s strategy of “stretching mental muscles”

• Challenges:
  • Takes time, instructors have to remove some material.
  • Often happens only once per class
  • May be left until the end of the lecture

• Realities
  • Typical student “time-on-task” is < 50% in university classes
  • PI at the start of class can effectively lengthen the lecture
Teaching History

• Is hard because the material involves (usually dead) people and places far from the student’s experience – hard to make them care about these.

• Typically presented as “fait accompli” – the outcome is known, students have no influence over it.

• Characters and events on a grand scale, what can students draw from for their own experience?
Activating History

• Have students choose the artifacts they believe are important – actively define “historical significance”.
  • Connects with personal experience

• Explain history as a process of inquiry, so that students take an active role in defining it.
  – Becomes more of a detective story, look for evidence, produce and test theories, refine hypotheses.
  – Events happened for a reason, discovering those causal influences means deeper understanding of history.
Historical Strategy Games

• Civilization IV and Europa Universalis give detailed historical contexts for strategy gameplay.
Historical Strategy Games

• Players actively “make history”
• Act as famous heads-of-state, and interact with other (computerized) leaders.
• Other world events unfold realistically around the gameplay.
Historical Strategy Games

• But emphasis is really on gameplay, conquering other civilizations, or improving your own.
• No control over where you play and what you actually learn.
• Allow and encourage playful distortions: Napoleon commanding Persia,…
Structure vs. Freedom

• Games usually benefit by allowing users more freedom.
  • Gameplay is more surprising, novel, funny,
  • Replay value improves.

• But deep learning requires breadth, topics reinforce each other, and haphazard coverage can lead to major gaps in knowledge.
Serious vs. Games

• Like it or not, there is a real tension between good learning titles and many self-proclaimed “educational games”.

• The difference is, serious learning games have an explicit meta-cognitive strategy – they aim to teach the content through appropriate exercises.

• This normally involves a detailed curriculum with interrelated learning goals.
Game Scenarios

• Most games can be tailored as much as needed to match a curriculum.
• Sites like this one present tailored curricula built on top of games (Civilization IV in this case). These curricula can form the base of college-level history courses.
Other History Games

• An ambitious historical recreation was MIT’s *Revolution*, built on top of the Neverwinter Nights game engine.

• Revolution recreated civil was scenarios in Colonial Williamsburg, VA.

• A design process summary is [here](#).
Teaching Math

• Challenging for many students:
• Goal is to eventually develop abstract, symbolic, reasoning skills.
• But student’s experience with numbers is quite concrete – as counts of things.
• How to bridge and build from student’s concrete, informal, numerical thinking to “understanding” of mathematics?
• Students don’t start with logic, so they can’t prove an test hypothesis in a mathematical sense.
Understanding understanding

• Learning scientists have spent much effort elaborating what “understanding” is. A concept is understood not by a dictionary definition, but by success in applying in a wide range of examples.

• i.e. a student of math understands “commutativity” not because they can give a dictionary definition, but when they can successfully apply it to many different examples.
Activating Math

• Encourage children to think concretely about math (using Piaget’s concrete operations of thought), to draw conclusions that might generalize.
  • E.g. use underground floors to model negative numbers

• Interestingly, they cant “prove” their ideas, but the intuition is often right.
  • Probably closer to the way mathematicians think, than to the way math is sanitized in textbooks.
Activating Math

- Connecting math with physical systems is a great way to make it more concrete (and help students care).

- An good example of this is a game called “Math and Music” by Wildridge Software.

- An online manual is [here](#), and the web site includes example activities.
Activating Math

- Timez Attack is a simple but surprisingly effective game that teaches multiplication tables. A simplified version is available for free download.
Teaching Science

• Challenges: students already have informal theories about the physical world, and can reason concretely. But these “theories” are often wrong.

• Formal theories fight with naïve ones during learning.
  – “Lab physics” vs. “road-runner physics”

• Science learning is an ideal domain for metacognitive development. Ideas of “hypothesis” and “experiment” are explicit in science learning.
Teaching Science

• Good science learning systems “Make Thinking Visible” to help children improve metacognitively.

• Inquiry Island from UC Berkeley
Teaching Science

In the Classroom
- Ask a driving question: Is Alameda Creek Healthy?
- Use computer to make predictions, build models, view web evidence & take notes
- Learn how to use probeware
- HotSync creek data, enter mean values, compare to other creeks, draw conclusions, revise model

Back in the Classroom

On the Field Trip
- Help from Local creek steward
- Monitoring water quality with Palms, ImagINworks™, and Probes
- Sorting & identifying macro invertebrates

Alameda Creek Project
Summary

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