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.

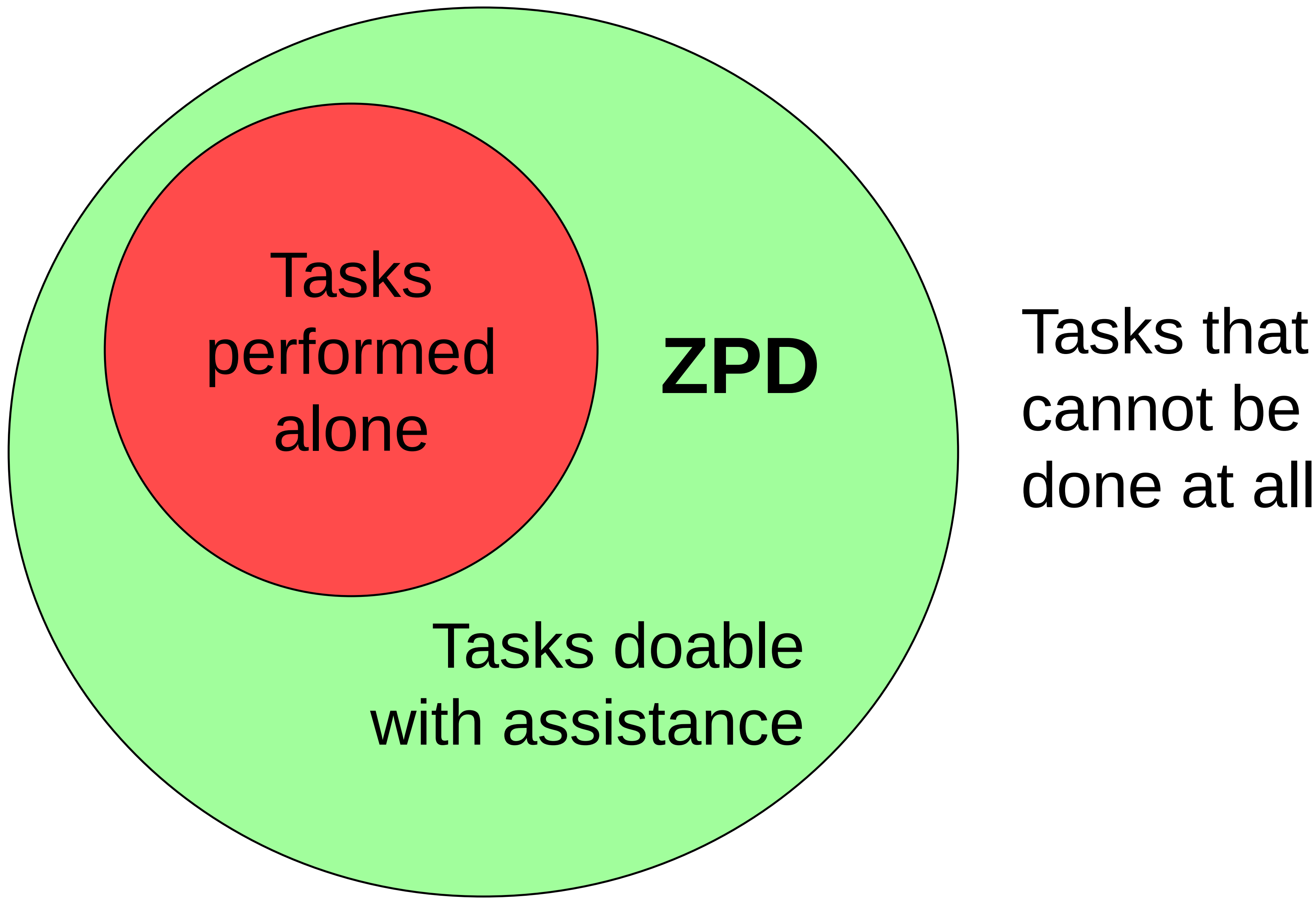
- i.e. Children "learn by doing,"
- They assemble and organize information for a purpose, e.g. winning a playground game.
- Successful learners also plan their own learning, assess their understanding, use strategies for memory etc.

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.

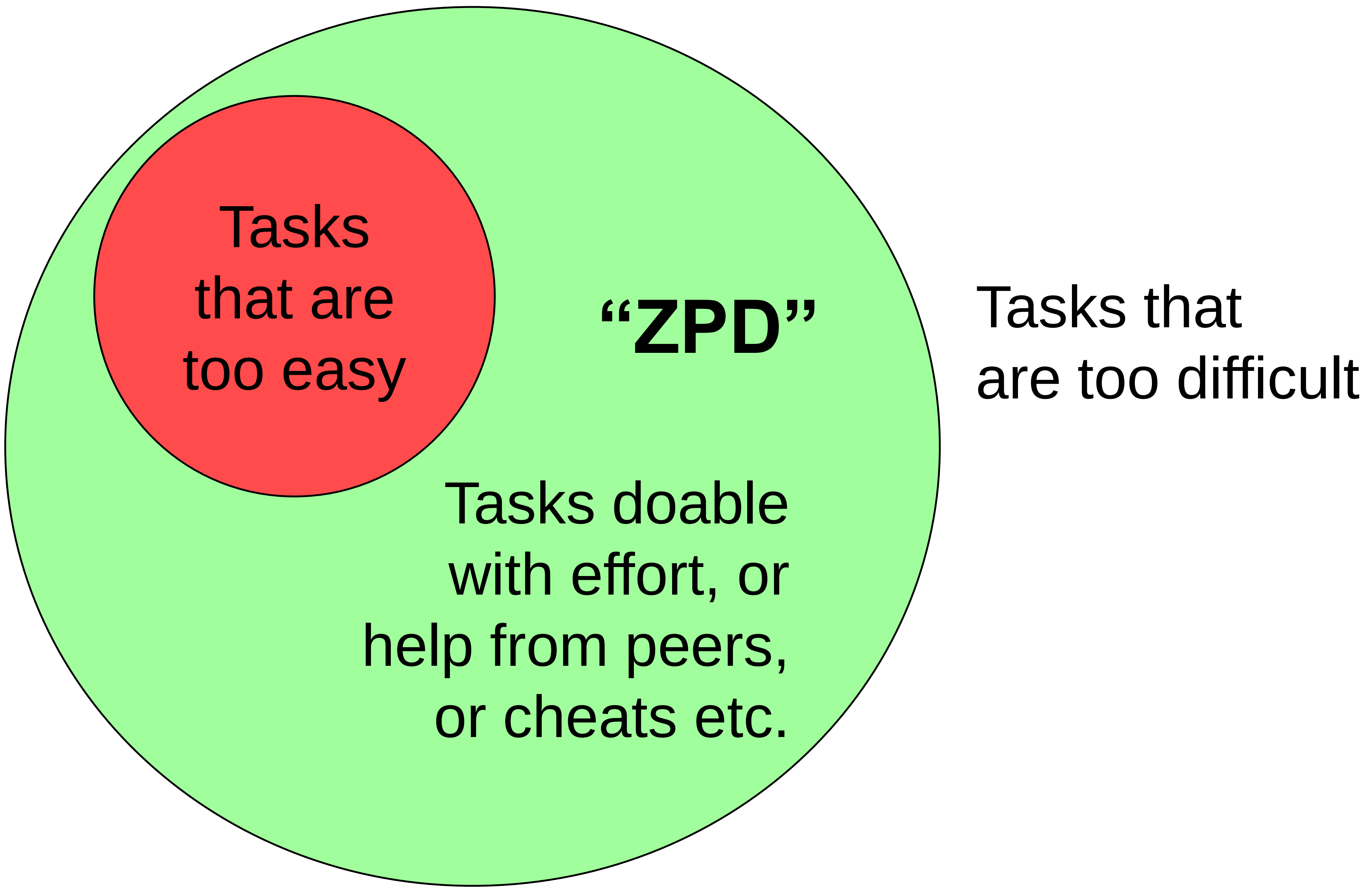
Zone of Proximal Development

- Vygotsky argued that learning is fastest in the "Zone of Proximal" development.



ZPD and Game Design

- For games we have



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?

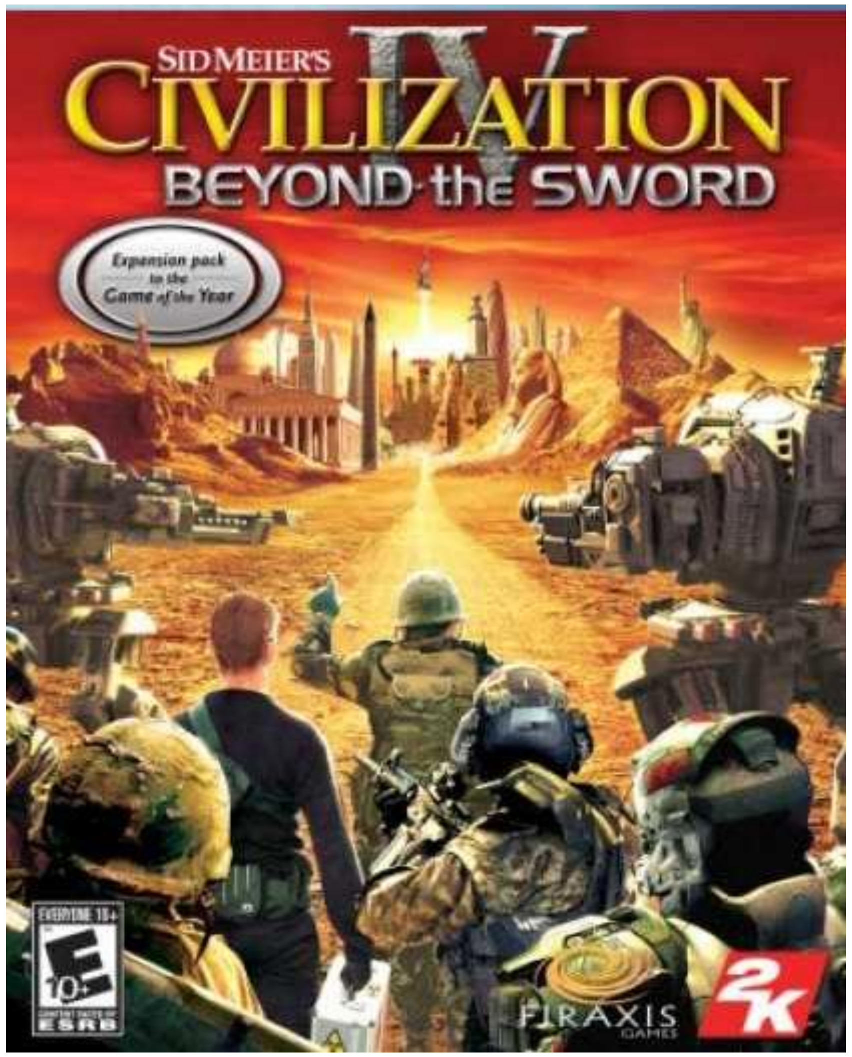
Activating History

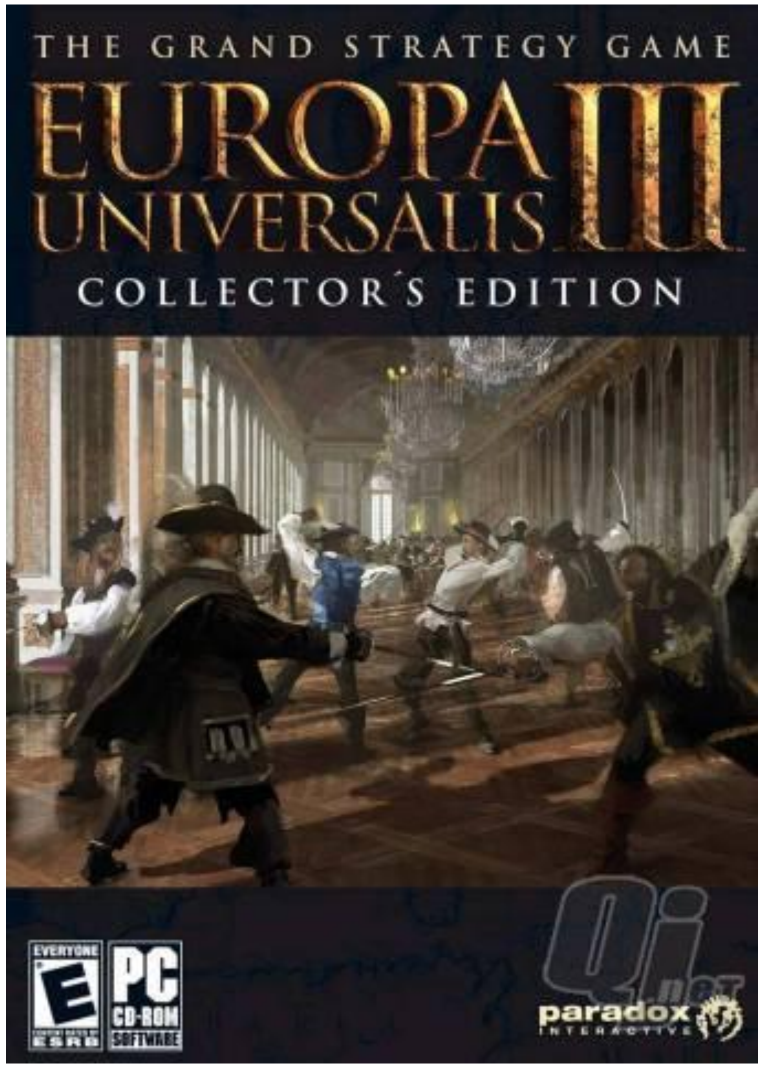
- Have students choose the artifacts they believe are important – actively define "historical significance".
  - Connects with personal experience

- 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

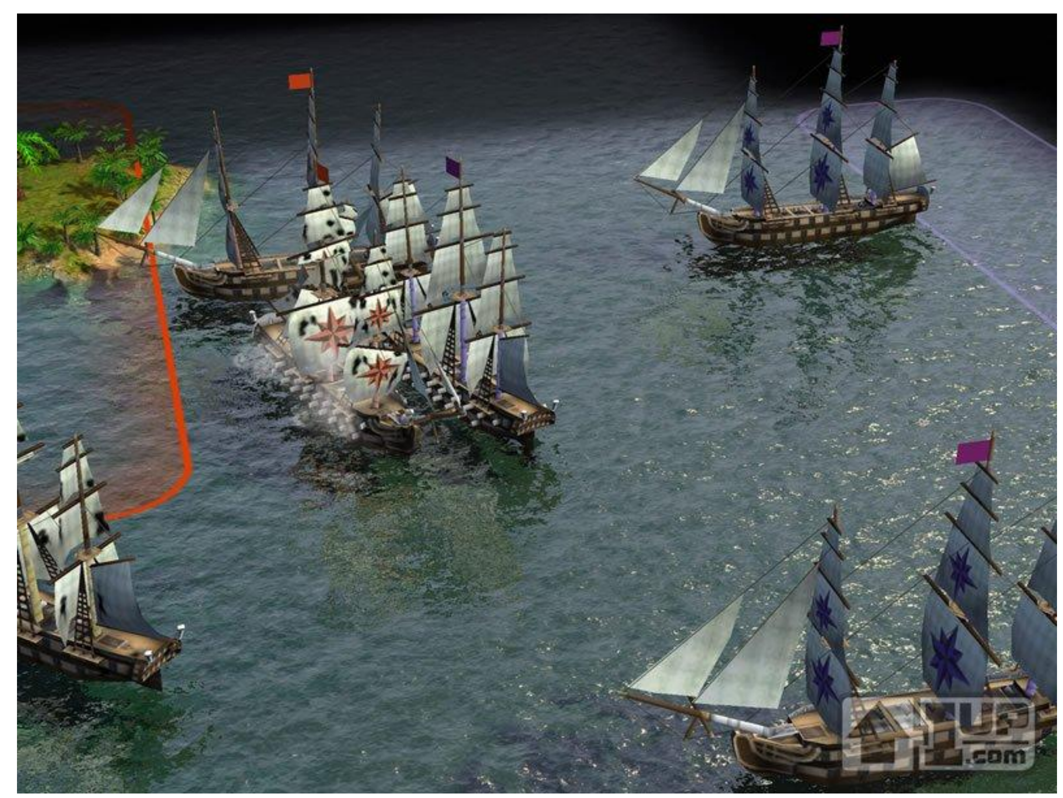
- Civilization IV and Europa Universalis give detailed historical contexts for strategy gameplay.





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 cant 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"

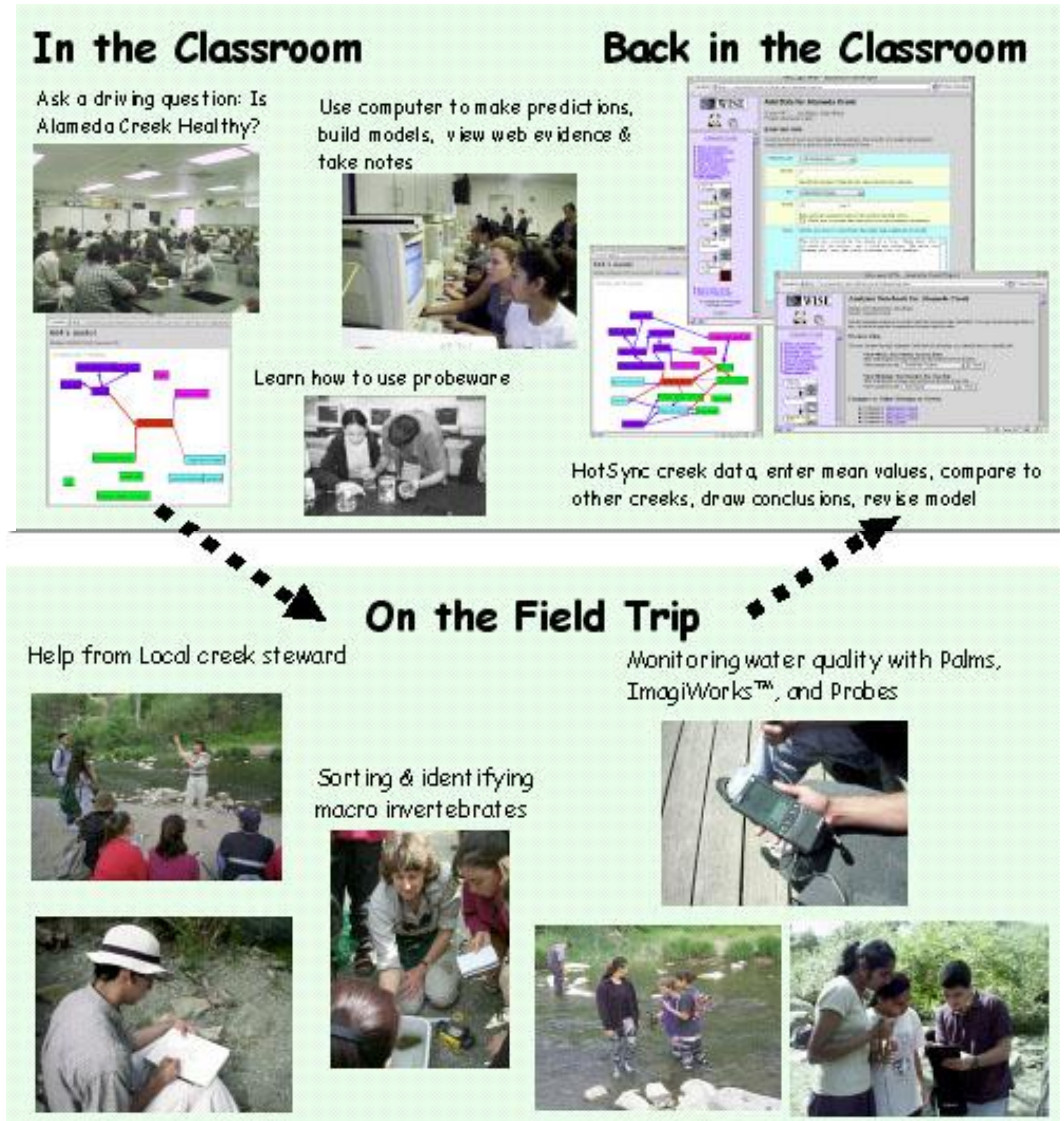
- Science learning is an ideal domain for metacognitive development. Ideas of "hypothesis" and "experiment" are explicit in science learning.

Teaching Science

- Good science learning systems "Make Thinking Visible" to help children improve metacognitively.

- Inquiry Island from UC Berkeley

Teaching Science



Alameda Creek Project

Summary

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- Teaching Techniques
- Learning Games