Social Computational Thinking Tools

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21st Century Skills

- “Computational Thinking” is a national priority (National Science Foundation, National Academy of Science)
- Jobs: Bioinformatics, Cheminformatics, Chemometrics, Computational biology, Computational chemistry, Computational economics, Computational electromagnetics, Computational engineering, Computational finance, Computational fluid dynamics, Computational forensics, Computational geophysics, Computational linguistics, Computational mathematics, Computational mechanics, Computational neuroscience, Computational particle physics, Computational physics, Computational statistics, Computer algebra, Environmental simulation, Financial modeling, Geographic information system (GIS), High performance computing, Machine learning, Network analysis, Neuroinformatics, Numerical weather prediction, Pattern recognition, ...
challenges

economy

perception

“computer science is hard and boring”

but

image

most kids really like technology such as cell phones, games, ...

interest by women

time

interest

jobs

computer science is for nerds

interest

by women
computational thinking tools

synthesize human abilities with computer affordances

start with question: how does a mudslide work?

visualize consequence of thinking

express ideas computationally

revise model

run model
but why

“social”

computational thinking tools?

3 examples
Mr. Vetro, a social human physiology simulation as role play of organs
how NOT to “implement” simulations as classroom activities

Having each student run their own simulation may not be the ideal model:

• does not engage students in discourse
• limited *educational* value of students sharing the same classroom space
In an engaging educational activity, the server runs a collective simulation portraying Mr. Vetro, a simulated human being with a collection of simulated organs that are distributed on handhelds. The server gathers data from client simulations and serves as a simulation coordination and visualization tool.

With a wireless network, the handhelds send data to the server.

The collective simulation is projected to the entire class and therefore serves as a classroom discussion tool.

In a simulation running on a handheld, students control the lungs of Mr. Vetro by varying lung parameters (breathing rate and tidal volume) as a response to changing conditions such as exercise and smoking.

Another group of students controls the heart of Mr. Vetro by varying heart parameters such as heart rate and stroke volume to adjust to changing conditions such as increased exercise intensity.

The teacher orchestrates the educational activity by assigning the control of different organs of Mr. Vetro to groups of students, giving them tasks to complete as a team, monitoring progress, and facilitating classroom discussions.

A Life Signs Monitor keeps track of Mr. Vetro's vital signs and displays them in the form of graphs or numerical values. ECG, heart rate, breathing rate, oxygen saturation, and oxygen delivered to tissue are some of the physiological variables.
Collective Simulation findings

• motivation: almost too engaging
• education: stronger learning gains than control group
  • recall of facts
  • making connections, evidence of critical thinking
  • retention
• cost: low, immersive interfaces are not limited to first person 3D games
• impact:
  • “Her mom emailed me and was so excited - nothing else ever touched her daughter to stop smoking. This is what did it!” – high school teacher

Reinventing computer science in public schools by motivating & educating all students including women and underrepresented communities to learn about computer science through game design starting at the middle school
Computational Thinking Approach

- start at middle school with game design
  - and elementary schools with Kris Gutiérrez (El Pueblo Magico project)
- advance from game design to STEM simulation design
- explore inner city, remote rural and Native American communities
- broaden participation by embedding game design in public schools with required/”forced elective” courses:

  after school computer club: < 10% girls
  required courses: ~50% girls
make first game in a week

- middle school teachers
  - no programming background
  - 35 contact hours training
- students
  - no programming background
  - make their first game in one week (5 x 45 minutes)
advance to sophisticated AI games

game world

\[ u_{0,t+1} = u_{0,t} + D \sum_{i=1}^{n} (u_{i,t} - u_{0,t}) \]

sophisticated visualizations

advanced math (diffusion)
transition to computational science models
can measure computational thinking using Latent Semantic Analysis inspired approaches

early indicators of transfer from game design to STEM simulation design

more: AERA, Computational Thinking symposium in K-12, Monday 12:25, Hotel Monteleone
Scalable Game Design findings

- Reach: already > 4000 students in year 2 of three-year project (Alaska, Colorado, Ohio, Oregon, South Dakota, Tennessee, Texas, and Wyoming)

- Broadening participation: 45% girls, 55% boys; 44% white, 56% racial minorities

- Motivation: 61% of the girls, 71% of boys; 71% of white students, 69% racial minority students want to continue with similar courses

- Learning outcomes: Computational Thinking Pattern Analysis: every game submitted (one every 14 seconds during class) gets analyzed
Collective Programming

making programming more social
the “Google docs” of programming
Colorado: Boulder

Wyoming: Rock Springs

330 miles away

08:10:57
Collective Programming findings

- shifts motivational thresholds:
  - even simple programs become interesting: competition & collaboration
  - programming can become a spectator sport

- supports leadership and negotiation skills:
  - individual skills were discovered quickly resulting in fluent collaboration: produced a good start of a game in about one hour
conclusions

Social computational thinking tools

- enable a complete new class of collaborative design experiences
- allow middle schools students to learn from more advanced students including university undergraduates
- broaden participation across gender and ethnicity
- make learning experiences motivational AND educational
thank YOU!

please join our AERA symposium on Computational Thinking in K-12, Monday 12:25, Hotel Monteleone

http://scalablegamedesign.cs.colorado.edu