Mr. Vetro: a Collective Simulation Framework

Prof. Dr. Alexander Repenning
AgentSheets Inc., University of Colorado
Dr. Andri Ioannidou
AgentSheets, Inc.

Thought Amplifier

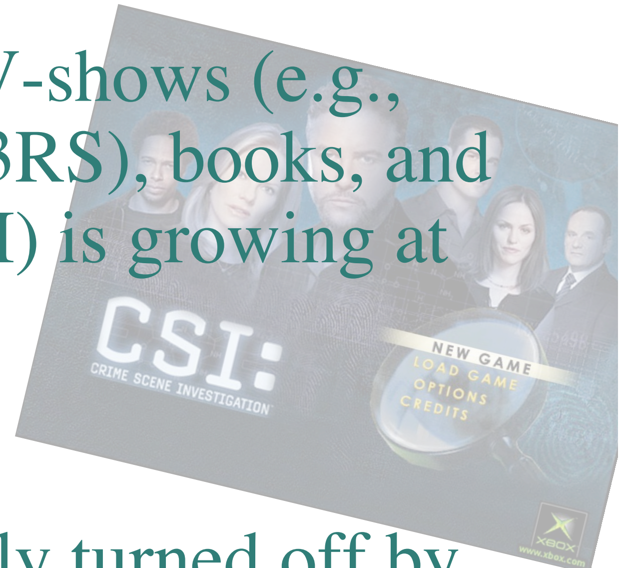
AgentSheets®

Introduction

history

- Origins: research in end-user programming and educational technology at the University of Colorado, Boulder
- The company, AgentSheets, Inc., was founded in 1996
- Core technologies: AgentSheets & Ristretto
  - simulation authoring tools that allow end-users to build their own interactive simulations and games and publish them on the Web
- AgentSheets, Inc. is supported by the National Science Foundation (NSF) and private funding

problem: science apathy



Interest in science related TV-shows (e.g., Discovery Channel, NUMB3RS), books, and even Video Games (e.g., CSI) is growing at record numbers.

BUT!

K-12 students are increasingly turned off by mathematics and science

Something must be terribly wrong in schools:

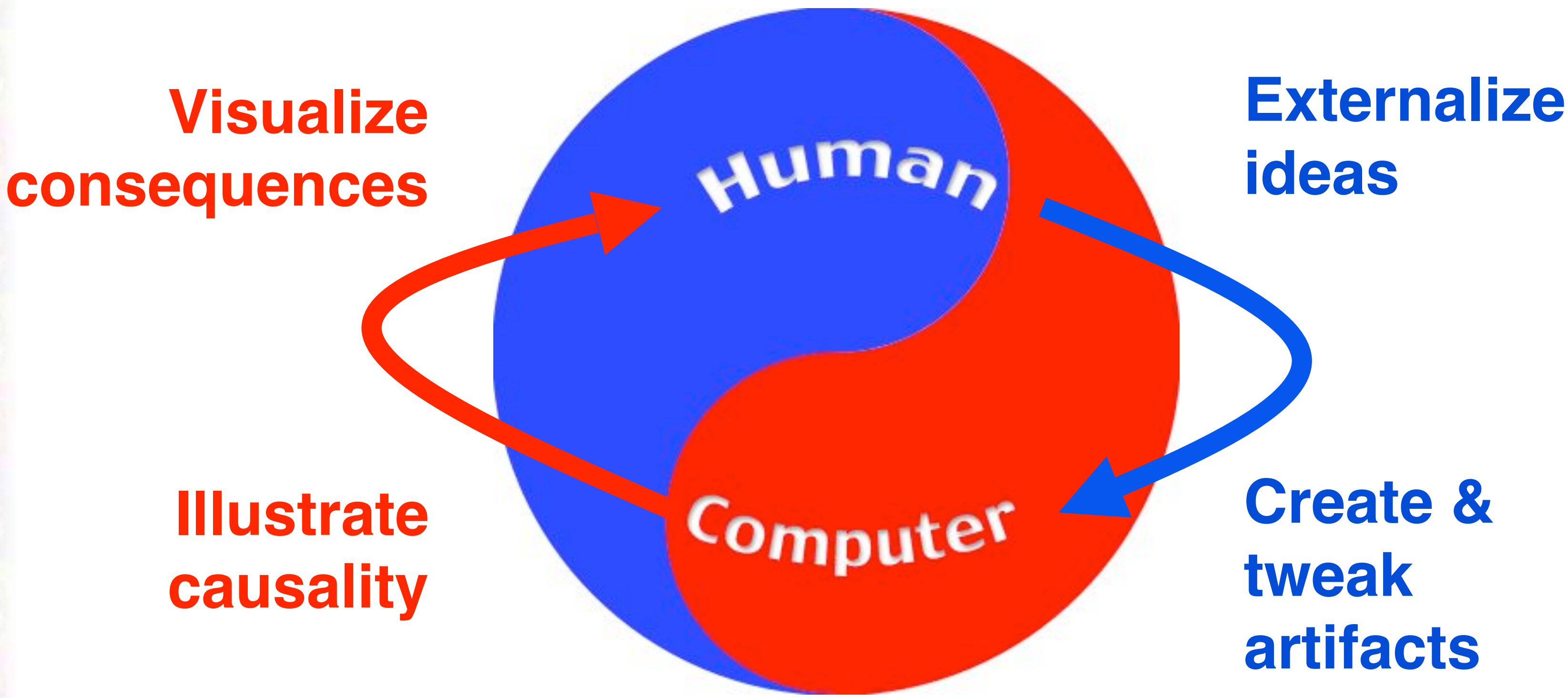
- how science is experienced in school
- how tools such as information technology are used to teach it

consequences of science apathy

- ***Personal level***: bad decisions regarding physical exercise, nutrition and habits such as smoking and drinking.
- ***Economic level***: students are not motivated to enroll in science-oriented university programs. Dropping science enrollment aggravates the scientific personnel shortage in vital and growing industries such as biotech ⇒ science outsourcing
- ***Next-generation teaching level***: Students that dislike science are not apt to become science teachers

simulations provide great ways to combine human abilities with computer affordances

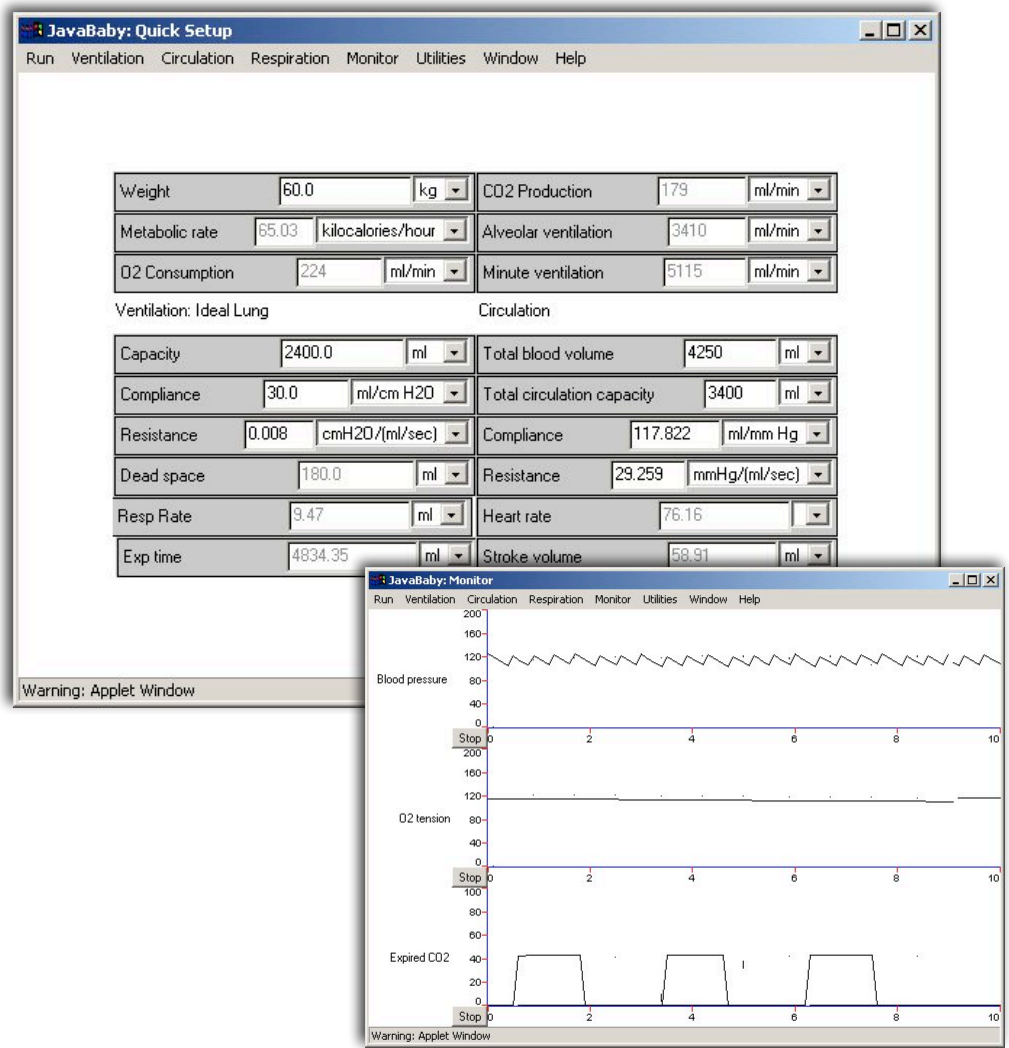
It's not just about the facts



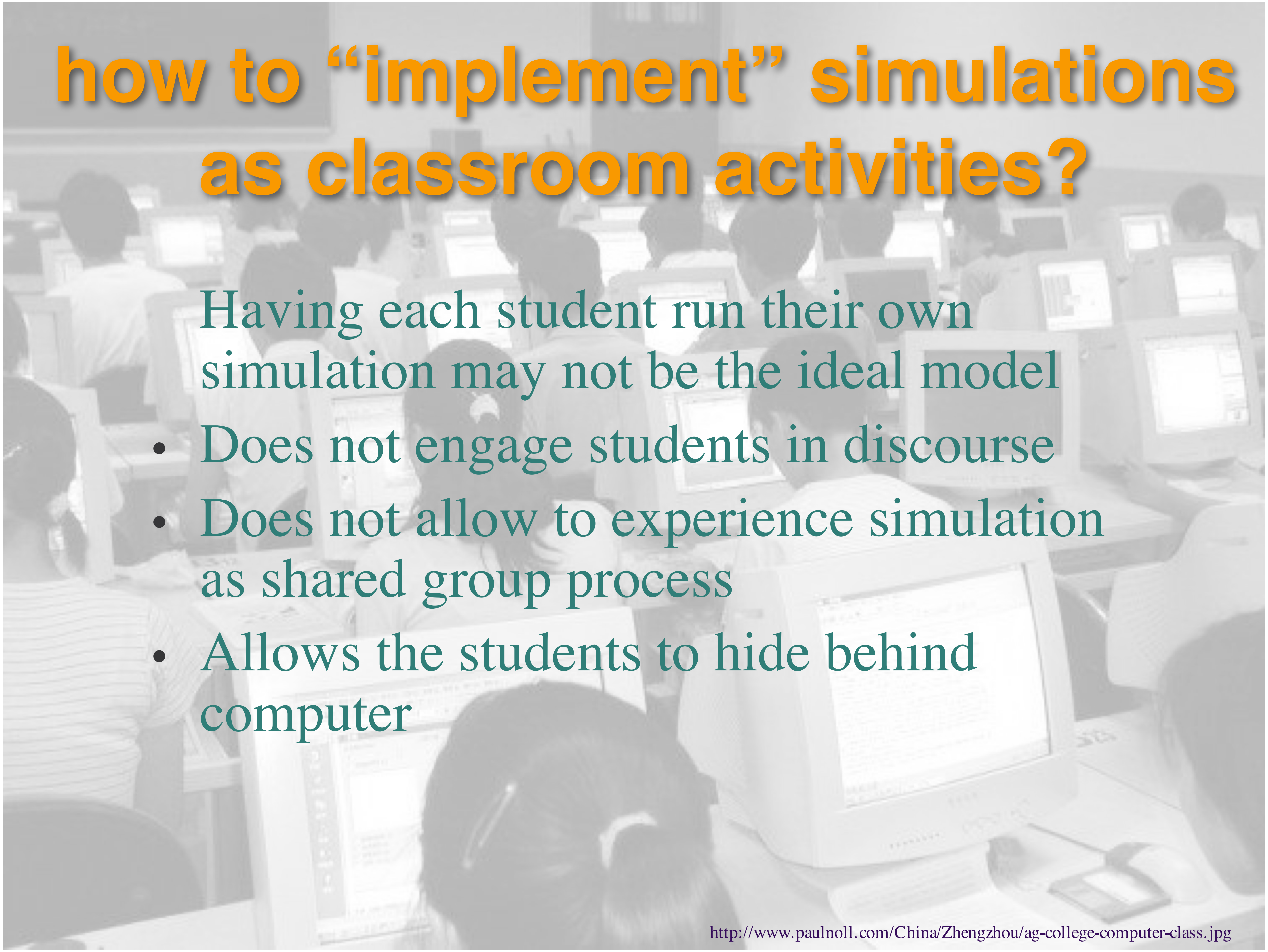
why simulations?

- Simulations
  - are enormously powerful learning tools (President's Committee of Advisors on Science and Technology, 1997)
  - can illustrate the intricate relationships between individuals and aggregates in complex systems - biological, social, economic, political, organizational, weather, and traffic systems (Epstein & Axtell, 1996)
  - can provide a much more effective learning approach than drill-and-practice applications (Wenglinsky, 1998)
- So why aren't simulations more widely used in education?

physiology simulation example: JavaMan



- Underlying physiological model is impressive!
- But too complex and confusing to use: can manipulate too many parameters
- Mostly textual user interface; only numbers and graphs being displayed; no visualization of the human
- => not very engaging for students



how 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
- Does not allow to experience simulation as shared group process
- Allows the students to hide behind computer

http://www.paulnoll.com/China/Zhengzhou/ag-college-computer-class.jpg

solution:
collective simulations

collective simulations =

social learning *pedagogical models* **+** ***distributed simulation*** *technical frameworks*

Our goal is to create *collective simulations* as a conceptual framework that integrates *social learning pedagogical models* with *distributed simulation technical frameworks* in order to enable *meaningful learning* that engages students in science.

social learning pedagogical models

Need to understand the *social processes* and the *context* in which educational simulations are used

- Social aspect of learning:
  - Vygotzky: ***knowledge construction*** through active collaboration.
  - Hutchins: ***distributed cognition***; adds notion of tools and artifacts
  - Joel Michael: ***meaningful learning***

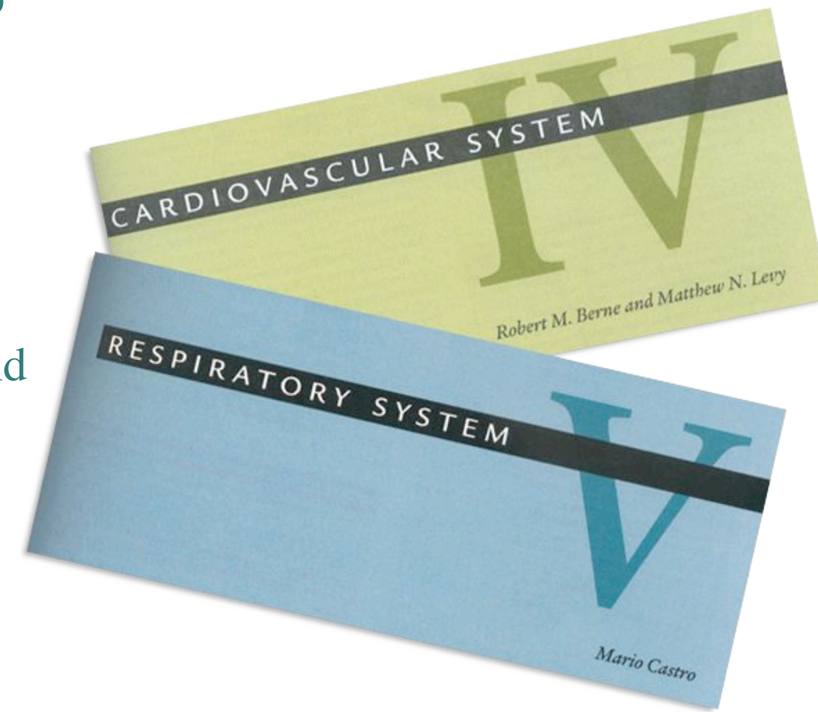
meaningful learning

"One of the most 'active' ways to help students to challenge with their own mental models is to get them to 'talk physiology.' Discussing, justifying, or explaining their answers to questions with one another, or with the instructor, is a powerful way to encourage ***meaningful learning***."

– Joel Michael

comprehension of interdependent complex systems

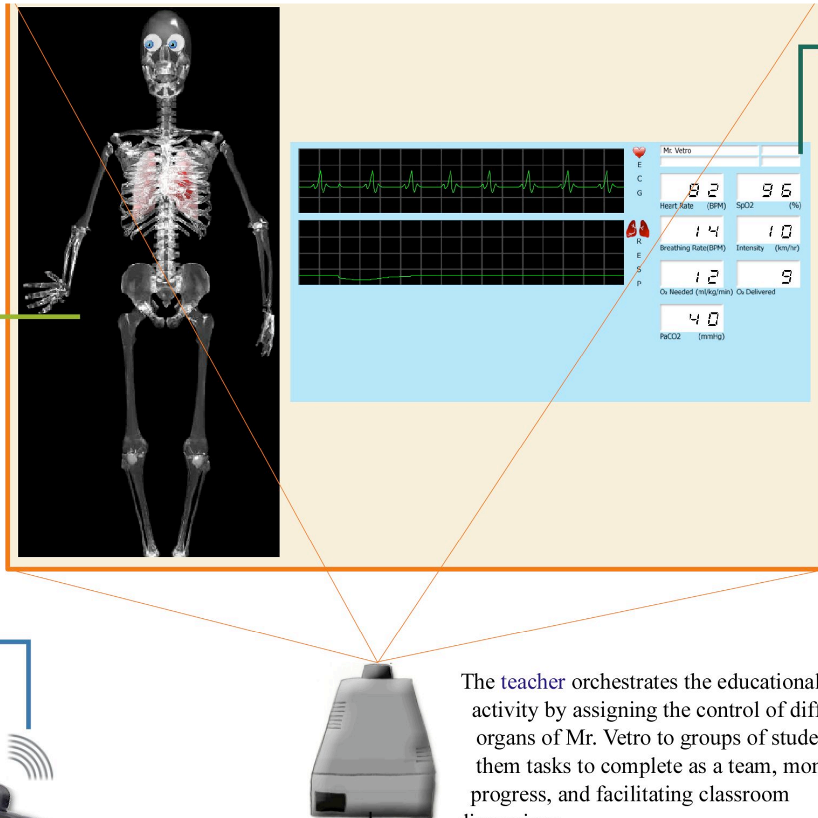
- Comprehension of interdependent complex systems is a curriculum requirement but is a big challenge to teachers and learners
- We reviewed physiology teaching materials
  - middle, high school, and university levels
  - textbooks, interactive CD-ROMs and Web-based material
- All structured human body into decoupled subsystems (e.g., respiratory and circulatory)
  - separate chapters
  - often by separate authors
- Found a ubiquitous absence of explanations for how systems ***interact***



Mr. Vetro: the human physiology collective simulation

- Mr. Vetro: a ma n made out of glass
  - “vetro” Italian for glass
  - Rendered from 16,000 polygons (Skelton only)
- Different systems or organs of Mr. Vetro are simulated on wirelessly connected handheld computers
  - Individual students or groups of students control them
  - Teacher can act as the decision-making part of Mr. Vetro’s brain to control decisions such exercise intensity
- A central 3D simulation aggregates parameters from organs and computes vital signs
  - Projected on the screen for entire classroom to see
- Systems
  - Respiratory - parameters: breathing rate, tidal volume
  - Cardiovascular - parameters: heart rate, stroke volume

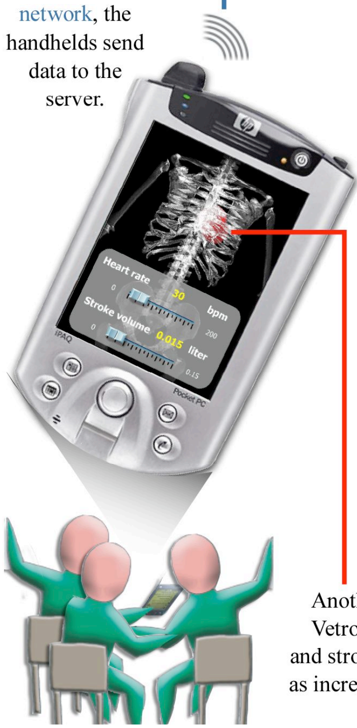
In an engaging educational activity, the server runs a collective simulation portraying Mr. Vetro, a simulated human being with a collection of simulated organs that are distributed on handhelds. The server gathers data from client simulations and serves as a simulation coordination and visualization tool.



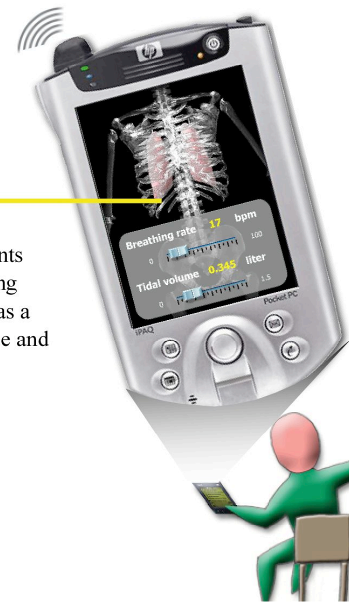
A Life Signs Monitor keeps track of Mr. Vetro's vital signs and displays them in the form of graphs or numerical values. ECG, heart rate, breathing rate, oxygen saturation, and oxygen delivered to tissue are some of the physiological variables.

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.

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.

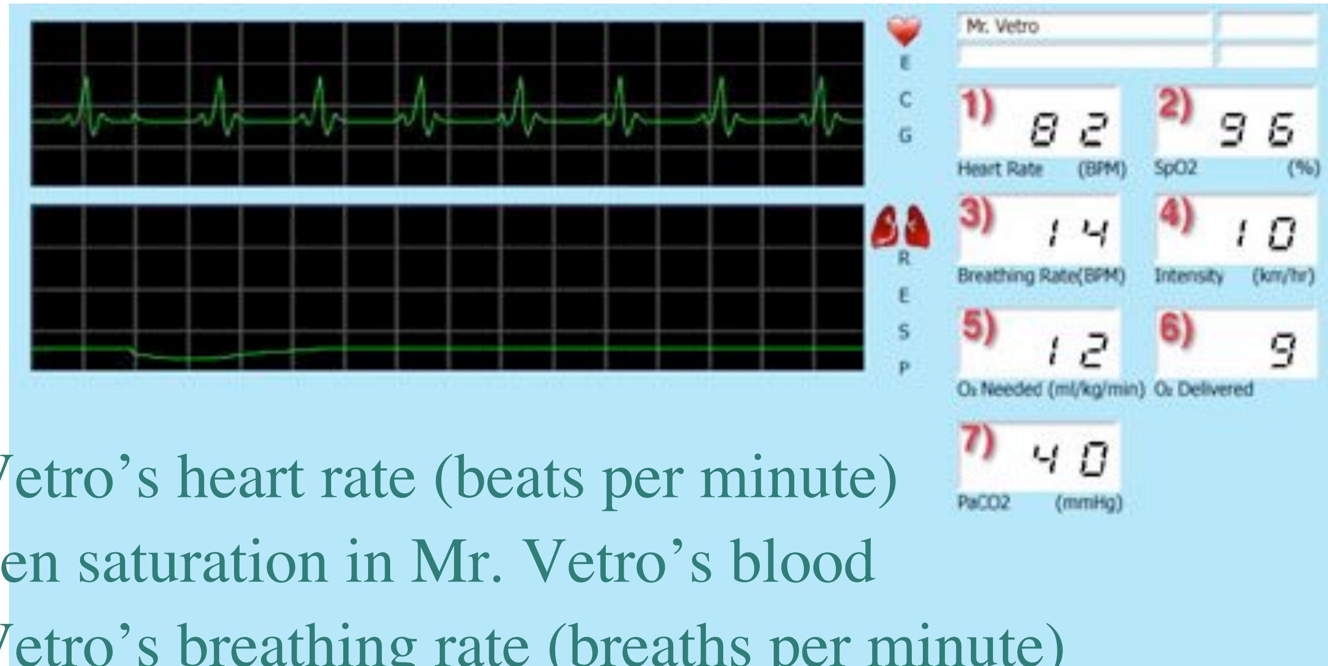


In a simulation running on a handheld, students control the lungs of Mr. Vetro by varying lung parameters (breathing rate and tidal volume) as a response to changing conditions such as exercise and smoking.

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.

Run demo

life signs monitor



1) Mr. Vetro’s heart rate (beats per minute)
2) Oxygen saturation in Mr. Vetro’s blood
3) Mr. Vetro’s breathing rate (breaths per minute)
4) Exercise intensity that Mr. Vetro is subjected to - essentially running speed in kilometers per hour
5) Oxygen needed for Mr. Vetro’s muscles
6) Oxygen delivered to Mr. Vetro’s muscles
7) Partial pressure of carbon dioxide in Mr. Vetro’s blood

distributed simulation technical frameworks

Our technological infrastructure, called ***C*^5**, can address learning about complex systems by creating an immersive simulation-based learning environment that lets students collaboratively experience system interactions.

the C^5 simulation framework

- **Collective**: server aggregates data from individual simulations running on handhelds into a central simulation
- **Compact**: simulations are small along different dimensions (memory footprint, display size, ..)
- **Connected**: client simulations communicate with the central simulation and with each other via wireless networks
- **Continuous**: different running modes: real-time
- **Customizable**: end-user programmable simulations

=> *compelling* simulations!

why handhelds?

- Form factor and price of regular desktop computers are prohibitive, lead to lab setups
- Handhelds are fast and computationally powerful, include wireless networking (WiFi, Bluetooth), high-resolution color displays that can represent and manipulate intricate interactive content
  - ⇒ Can create interesting interactive content.
  - ⇒ Going from hyperlinked note taking, scheduling, and graphing to interactive simulations that enable explorations of complex learning subjects and perform "what-if" experiments.

alternatives…

cell phones

portable game consoles

pilot study

- High school students in a Biology class at New Vista High School, Boulder, CO
- Two teams of students: one controlling the heart, the other the lungs
- Subjected Mr. Vetro to different levels of exercise
- Controlled heart and lung parameters to optimize his physical condition; recorded data and used it to reach conclusions and answer questions prepared by their teacher
- Example scenario: Mr. Vetro is a smoker and students simulate the effects of smoking and nicotine via the lungs' tidal volume and the heart's stroke volume

before using Mr. Vetro students …

- did have good general sense of heart rate
- did have a more limited sense of breathing rate
- did not have sense of connection between circulatory and respiratory systems

observations

- Collaboration through handhelds was very natural
- Teacher was surprised at the high degree of engagement
  - vivacious discussions
  - and a sense of real-time drama

preliminary results

- Use of handhelds afforded discussions that would not happen in a traditional lab setup
- The distributed simulation cannot be operated without discourse:
  - The heart team cannot directly control the lungs; they must communicate with the lungs team and involve the entire classroom
  - Requests need to include justifications
  - Misconceptions get externalized and discussed

⇒ the collective simulation infrastructure fosters a *social style of learning* that emphasizes *distributed cognition*

future directions

- Technical
  - Use live data from sensors (e.g. heart rate monitor)
- Content
  - Short and long term effects of alcohol & drug abuse
  - Add more systems
    - Gastrointestinal (add metabolic functionality)
    - Endocrine (add hormones)
  - Mr. & Mrs. Vetro - genetics
- Educational
  - Perform larger scale evaluation studies
    - With local teachers and students in Boulder
    - Remotely in sites that *Harvard Graduate School of Education* and *Drexel University College of Medicine* will run

some credentials

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