Community-Situated Challenge-based Collaborative STEM Education
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C³STEM Vision & Architecture

- Focuses on K-12 and beyond STEM education
- Real-time collaboration between students across school and home boundaries through high quality video and multimedia using ubiquitous set of end devices
- Students interact with experts, city planners, and educators in real time for feedback and mentoring
- Students collaborate with community members to present their work and receive feedback (e.g., a virtual real-time science fair)

Format of a Challenge Problem
- Two phase learning process using real world traffic problem:
  1. Develop traffic flow models in the CTSiM environment using computational modeling and learning low level physics and mathematics concepts.
  2. Scaling up fundamental ideas to build real-world traffic flow models using the C³STEM Web-based Collaborative Learning Environment

CTSiM Computation Modeling Framework

- CTSiM seeks to teach computational thinking skills to middle school and high school students
- A visual programming environment allows students to focus on the mathematical connections involved with real world systems rather than the syntax and semantics
- Several modules are being developed to teach students the physics involved with road traffic, starting with the basics and moving on to more advanced topics
- Modules build on one another so students can focus on one aspect of the simulation at a time

C³STEM Web-based Collaborative Learning Environment

- Android App allows ubiquitous access to C³STEM system
- System users can monitor the traffic simulation and modify a variety of traffic parameters
- Conveniently upload images/videos to the Cloud and let C³STEM Middleware process the streamed data

System Implementation Architecture

- Simulation of Urban Mobility (SUMO) traffic simulation engine is used.
- SUMO servers, C³STEM Middleware, CherryPy web server, and MongoDB database run in the cloud environment.
- Requests can come from any of the web-based or mobile clients.
- Each request is received at the web server and delegated to the C³STEM middleware for processing.
- If multiple users request to run the simulation simultaneously, additional virtual machines are spawned dynamically and added to a pool.
- SUMO runs on each of these virtual machines and communicate through the TraCI library.
- Each request to the same SUMO server is added to a queue and processed by C³STEM middleware based on priority and FIFO logic.
- Results are logged to the MongoDB distributed database and also viewed by the users with the Google map based user interface

CTSiM Computation Modeling Framework

- CTSiM Computation Modeling Framework allows students to focus on one aspect of the simulation at a time
- Modules build on one another so students can focus on one aspect of the simulation at a time
- A visual programming environment allows students to focus on one aspect of the simulation at a time

Collaborative and Interactive Environment

- Google Hangout based collaborative environment
- Supports video, voice and text-based communication
- Students collaboratively solve problems, draw charts, study results and derive conclusions
- C³STEM web-based collaborative learning tool is embedded in the collaboration environment
- CTSiM based simulation results are shared using desktop sharing
- Students seek advice from teachers, researchers and domain experts
- The environment logs all the communications to be referenced later by the students, and is also accessed by the researchers to find the learning patterns

Results of User Studies

- Two small studies were performed in Nashville and in Chattanooga during summer 2013 involving a total of 16 students at the middle school and high school level
- CTSiM
  - Student activities in CTSiM were logged for later analysis, including over 12,000 snapshots of student models for the traffic domain
  - Novel analysis techniques are being developed to apply to these student code snapshots and find patterns in student learning
  - These patterns can then be applied in different learning environments to facilitate individualized student scaffolding

C³STEM Web-based Collaborative Learning Environment

- The results of the initial experiments are encouraging and demonstrate the flexibility of the framework to cater to both high school and middle school students
- Although some of the high school students had not had an advanced Physics class, with some initial scaffolding they picked up on the fundamental
- The students successfully solved the given problems using a combination of STEM and computational thinking concepts
- Based on feedback received, the tool capabilities are being enhanced to use in a STEM curriculum at two high schools in Spring 2014

Partnerships

- Enterprise Center, Chattanooga – Expertise in managing gigabit network, liaison to city planners, schools, & community
- Chattanooga State – High resolution videoconferencing, STEM education, Satisfaction assessment
- Initially, two Chattanooga high schools
- Ivy Academy (Charter school)
- Chattanooga Center for Creative Arts (Public school: Academic Magnet)
- Vanderbilt University – Educational technology, Virtual collaboration, STEM education, Transportation systems research, Domain expertise, Computing cluster