Computer-Aided Personalized Education (CAPE) Workshop
Panel on Modes of Learning

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Computer-Based Learning Environments

• **Traditional Emphasis**
  – One on One Learning (Tutoring)
  – Personalization
  – Problem Solving
  – Feedback to support Learning & Problem solving
  – Stand-alone systems linked to one or more curricular units
Computer-Based Learning Environments

• Needs for the next generation
  – Integrated Environments
    • Fundamentals, Problem solving, Provide anchoring contexts
    • Project-based components; use of standardized tools
  – Combine Personalized + Collaborative Learning and work
  – Ubiquitous
  – Notion of Preparation for Future Learning (Bransford & Schwartz)
    very important
    • Support development of 21st century skills
    • Develop abilities to “learn how to learn”
STEM learning in Open-Ended Learning Environments
Supports multiple modes of learning

- Present a authentic, complex, open-ended task
  - Build a cause-effect model to demonstrate the effect of human activities on global climate change
  - Build simulation models of traffic flow in city streets

- Set of tools to scaffold learning and problem-solving process
  - Hyper-text resources; causal map-building editor; quizzes to check correctness of evolving causal model
  - Visual, block-structured, domain-specific modeling language to build simulation model

- Learner-centered
  - Promote thinking-intensive interactions with limited external support

(Clarebout & Elen, 2008; Land, 2000; 2012)
OELEs: Student Learning and Problem Solving

• Thinking-oriented interactions with limited external support
  – Students have to develop cognitive skills to use the tools provided in an effective manner
  – Students have to develop metacognition and self-regulation processes (how to combine use of the tools) to become effective learners and problem solvers
  – Students have to make choices, evaluate their choices
    • Responsible for managing, coordinating, monitoring, evaluating, and reflecting on relevant cognitive processes and metacognitive strategies

• OELEs support Preparation for Future Learning (Bransford & Schwartz, 1999)
Example: Integrated Environment

- C³STEM – a community-situated, challenge-based, collaborative learning environment for STEM
  - Involves working on real-world traffic problems, both individually and collaboratively
  - Comprises two core learning environments
    - CTSiM (Computational Thinking using Simulation and Modeling)
      - Students use a visual interface to build computational models of vehicle dynamics and driver behaviors using an agent-based paradigm, and compare their traffic simulations against expert traffic simulations
    - C²SuMo (Cloud-based, Collaborative, Scaled-up Modeling)
      - Students visualize and analyze traffic flow using a Google Maps interface along with the high-fidelity Simulation of Urban MObility (SUMO) to solve a variety of traffic flow problems
Modeling traffic scenarios using CTSiM

- Conceptualize
- Construct
- Test
- Verify
- Experiment

Construction interface
Test interface
Compare interface

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Studying traffic simulations using $C^2$SuMo

- Allows students to control various traffic related parameters
  - Run experiments on a scaled-up simulator called SUMO – Simulation of Urban Mobility
- Observe corresponding simulations of traffic flow
  - Simulation results are projected onto a Google Maps interface – depicts real city streets
  - Students perform experiments, analyze results, document their conclusions
C³STEM Characteristics

• Brings together multiple modes of learning
  – Learning of fundamental concepts and principles linked to authentic problem solving environments
    • Domain concepts and principles
    • Simultaneously, learning of Computational Thinking and Computational Modeling Skills
  – Problem- or Project-Based Learning
    • Scaled up problem solving
  – Collaborative Problem Solving
OELEs: Challenges to the Novice Learner

• Lack proficiency in cognitive skills
  – Lack fundamental knowledge
  – Application of this knowledge to problem solving situations
• Lack proficiency in mapping skills to the tools provided
• Lack of metacognitive strategies
  – Awareness
  – How to combine skills and actions in an effective manner
• Lack of monitoring and self-regulation skills
  – Monitoring one own learning
  – Reflection and Revision
OELEs: How do we scaffold & support student learning?

• Challenges
  – Interpreting learner behavior in a choice-rich environment
    • Choices, e.g., acquire information, construct solution, assess and test solution
    • Skills in the context of using tools
    • Strategies (Cognitive & Metacognitive)
    • Self-Regulation (Including Affect)
  – Making decisions on when and how to provide feedback to the learner
    • E.g., how to effectively use formative assessments & help (support) provided in system
Interpretation and Aggregation functions

- Interpret and understand students’ learning behaviors in OELEs
  - Have to track and interpret students’ activities
    - **Method 1**: Analytic measures (Segedy, Kinnebrew, & Biswas, 2015)
      - Model-driven metrics and Context-driven hypotheses about the students’ learning tasks
      - Developed a novel approach for modeling learners called Coherence Analysis
    - **Method 2**: Exploratory Mining Methods for discovering students’ learning behavior patterns (Kinnebrew, Loretz, & Biswas, 2013)
      - Sequence Mining and Differential Sequence Mining of students’ activity data
  - More recent approach (Kinnebrew, Segedy, & Biswas, in review)
    - Combine methods (1) and (2) to provide a more expressive framework
Extra Slides
The CTSiM task model

• Task Model – Directed acyclic graph from Domain general to CTSiM specific tasks and subtasks to lowest levels – correspond to CTSiM actions (directly observable)
Strategy Model

- Captures the relationship between tasks
  - Sequencing information, i.e., Temporal Ordering
  - Shared Context between the tasks
    - Example: IA → SC: Read a page or two of the resources then construct model
      Are the information acquisition and solution construction actions related?

Describes how actions & tasks combined to achieve higher level goals
Coherence Analysis

• Good problem solving flows from good task understanding and skill levels:
  – Students know how to interpret/utilize the information they encounter
  – Students refrain from excessive “shot-in-the-dark” guesses

• Coherence
Two actions \((x,y)\) taken by a student in an OELE are said to be *coherent* if the second action, \(y\), logically follows from information generated by the first action, \(x\). In this example, \(x\) supports \(y\).

*Action x generates potential that action y uses.*
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