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)

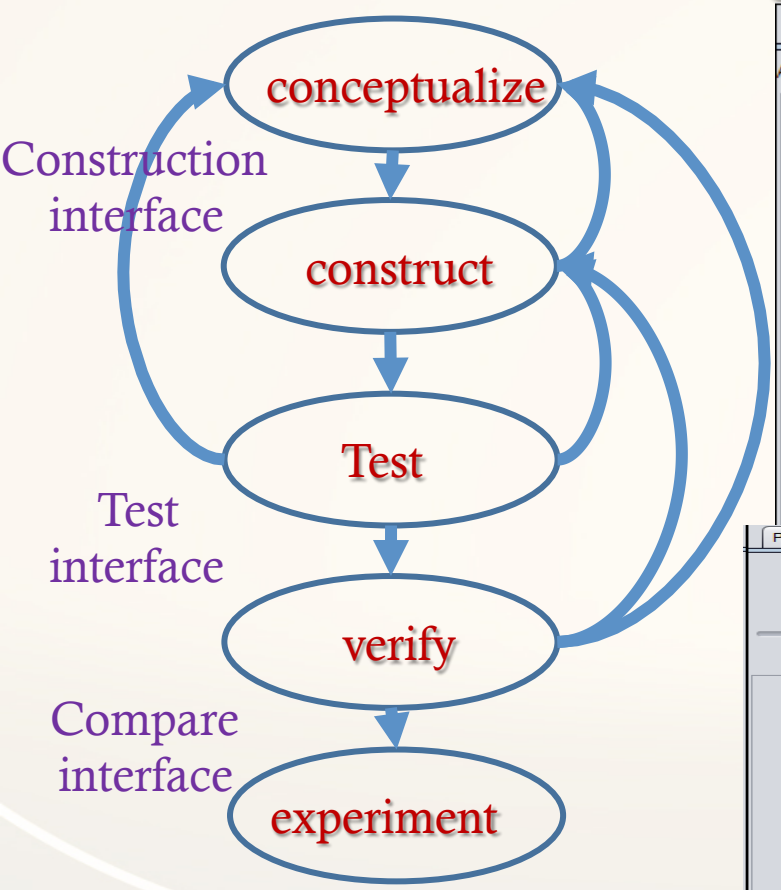
OELEs: Student Learning and Problem Solving

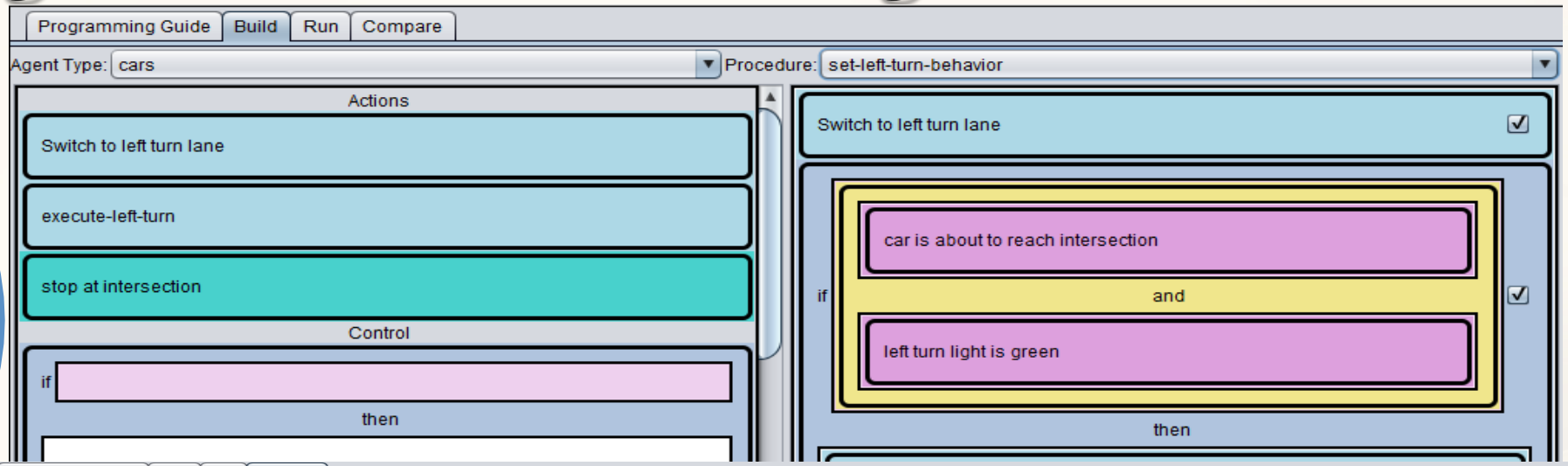
- Thinking-oriented interactions with limited external support
  - Students have to develop cognitive skills to use the tools provided in an effective manner
  - Students have to develop metacognition and self-regulation processes (how to combine use of the tools) to become effective learners and problem 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)

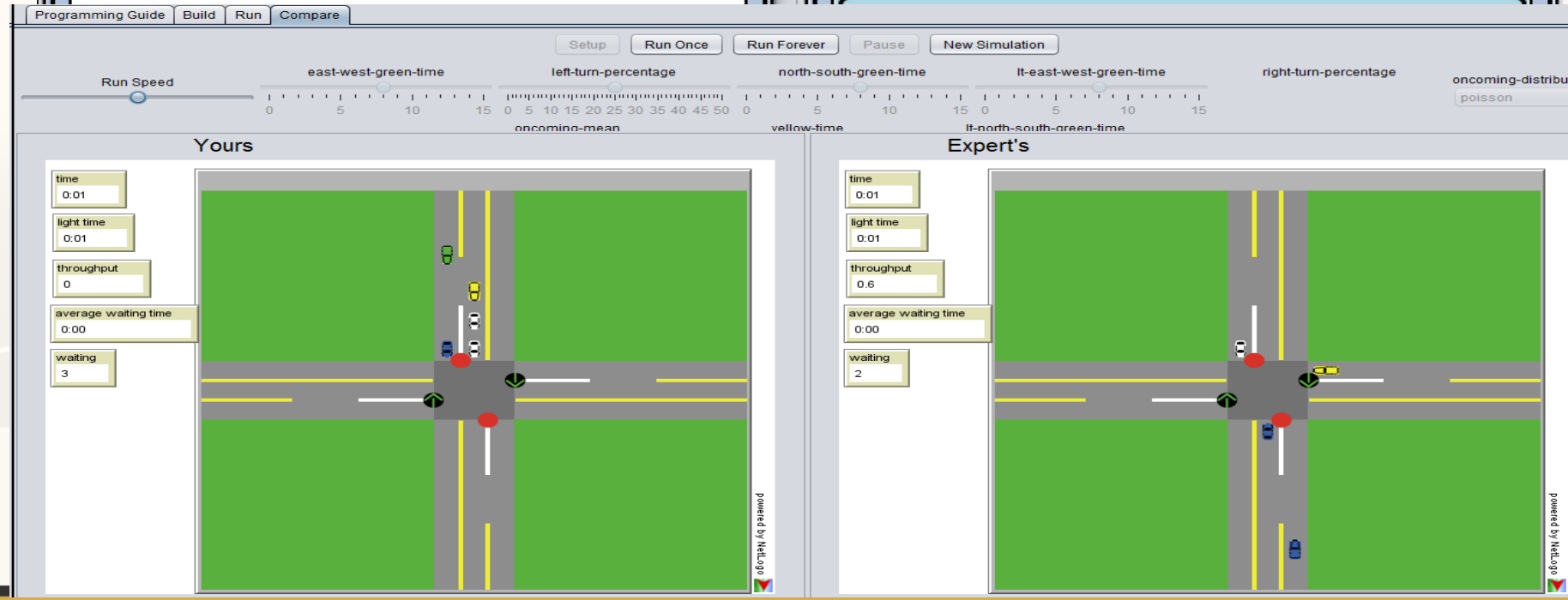
Example: Integrated Environment

- C^3STEM – 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 (**C**omputational **T**hinking using **Si**mulation and **M**odeling)
      - 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
    - C^2SuMo (**C**loud-based, **C**ollaborative, **S**caled-**u**p **Mo**deling)
      - Students visualize and analyze traffic flow using a Google Maps interface along with the high-fidelity **S**imulation of **U**rban **MO**bility (SUMO) to solve a variety of traffic flow problems

Modeling traffic scenarios using CTSiM







Studying traffic simulations using C²SuMo

- 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

C^3STEM Characteristics

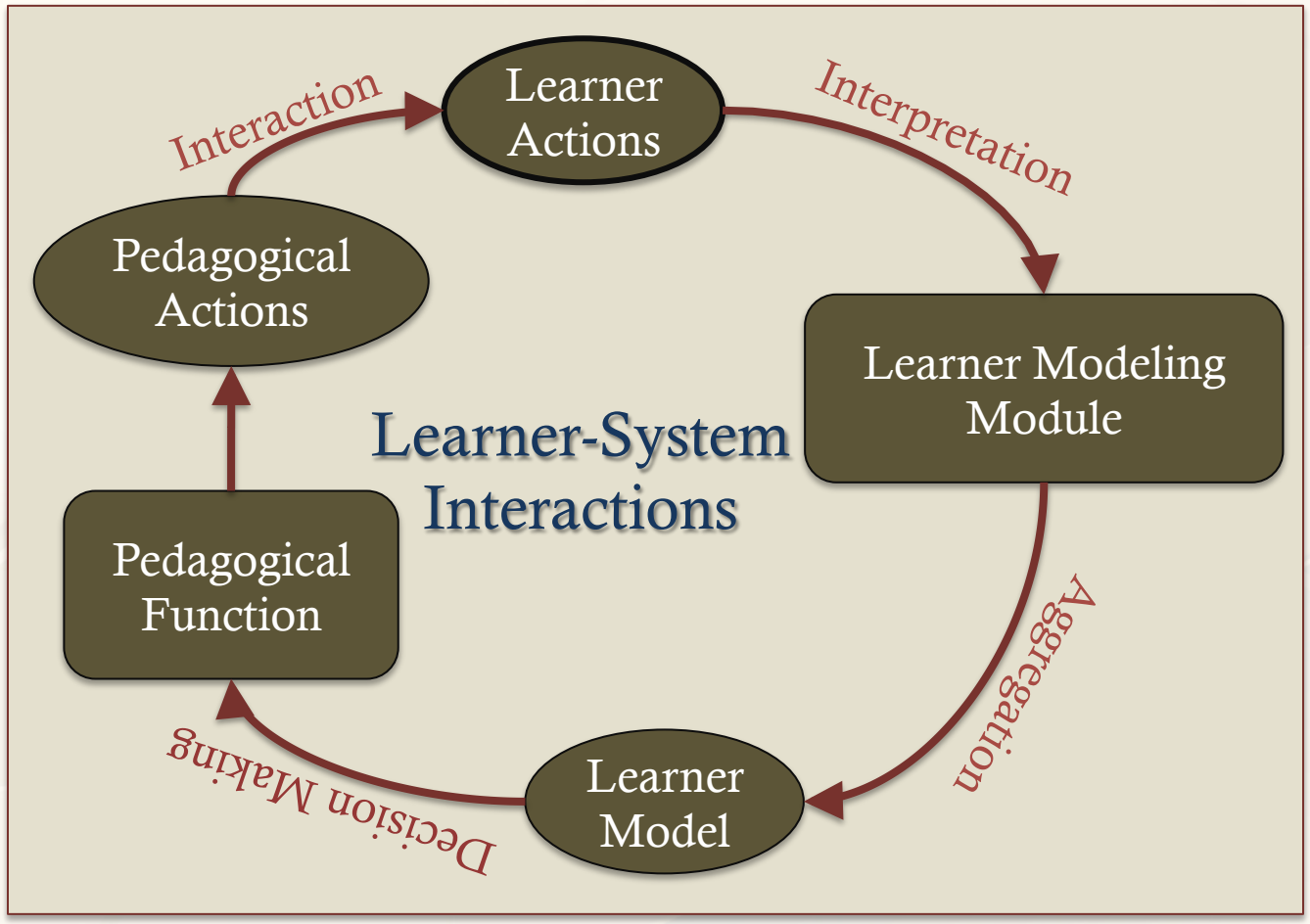
- Brings together multiple modes of learning
  - Learning of fundamental concepts and principles linked to authentic problem solving environments
    - Domain concepts and principles
    - Simultaneously, learning of Computational Thinking and Computational Modeling Skills
  - Problem- or Project-Based 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

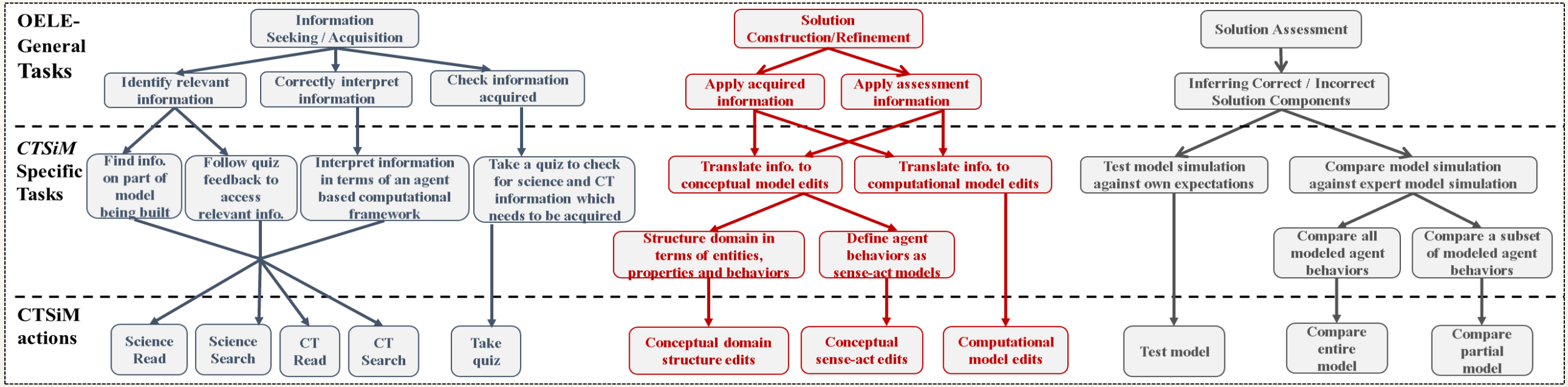


Interpretation and Aggregation functions

- 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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