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Evaluating Collaborative Problem-solving Skills with Electronics Simulations

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Measuring Collaboration in Complex Computerized Performance Assessments

(MC^{3}PA)

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Project Background

Teaching Teamwork, 2014-2017
(NSF DUE-1400545)

- Used simulated hands-on-lab assessments to collect, analyze, and quantify evidence and effects of collaboration by students.
- Sought ways to measure, encourage, and facilitate collaboration among remote students using a simulated *electronics scenario*.
- Computer **logs every action, behavior, and chat.**
- The project team is still refining the semi-automatic analysis of the **voluminous data.**

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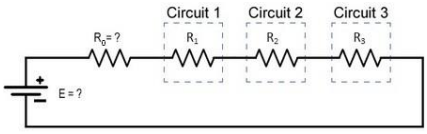
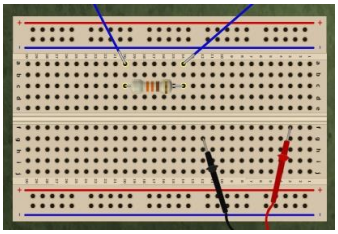
The Student Activity

Series-resistance problem.

- **Given:** A battery and four resistors in series; and a DMM
- Each student can manipulate DMM and their **one R_i** and connections on a breadboard.
- **E, R_0** are "external." Can't be measured.
- On-screen calculator and chat window.
- **Goal:** Collaborate to obtain specified voltages across **R_1, R_2,** & **R_3.**
- We log **every student action and chat**.





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The Student Activity

The Concord Consortium

Teaching Teamwork

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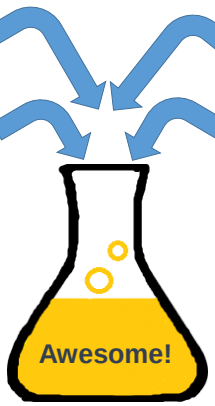
What ETS Does…

Behavioral Analytics

Learning Sciences

Statistics

Data Mining



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Necessity

- ✓ Log files hold a lot of useful information
- ✓ But they are notoriously hard to analyze
  - Actions rather than answers
  - Very small grain-size
  - Interpretations depend on task context
  - Interpretations also depend on prior actions
- ✓ In-Task Assessment Frameworks address these challenges:
  - ✓ Develop a methodology for **extracting relevant features** of student performance from the log files
  - ✓ Allows assessment of students from "**in-task**" behaviors

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What Sets Apart In-Task Assessment Frameworks (I-TAF)?

- Much of the work to date has relied solely on **bottom-up** exploratory approaches OR **top-down** approaches
- **Bottom-up**
  - Left with high-level summaries of students' behaviors (e.g., types of strategies, counts of actions) but no process for linking behaviors to constructs in targeted domain
- **Top-down**
  - Identifies features a-priori, not allowing emergence of others
  - Only certain behaviors can be identified
- **I-TAF *combines*** top-down and bottom-up approaches
  - Mixed methodological approach
  - Ontology based (theory driven)
  - Data mining / machine learning (data driven)

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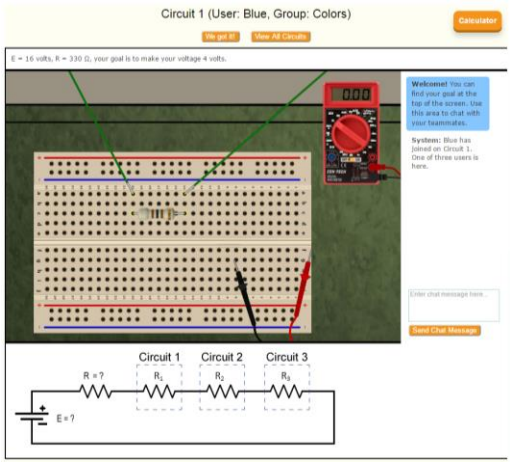
Three-Resistor Simulation

- Three students work independently, but collaboratively, to solve a given realistic problem.
- As a computer simulation, **every action** is logged—more than just the final "answer."
- Can these logs reveal evidence of:
  - Cognitive understanding?
  - Hands-on skills?
  - Behavioral skills?
  - Other unexpected findings?



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I-TAF Framework (Five Levels)

1. Generate an Ontology
   - ✓ Delineate concepts and relationships
   - ✓ Creates unified definition of the domain
2. Expand to a Behavioral Ontology
   - ✓ Domain must be operationalized at the level of behaviors
   - ✓ Identify potential strategies that demo mastery of concepts
3. Expand to a Cognitively Enhanced Ontology
   - ✓ Affordances of task can change tactics used to carry out strategies
   - ✓ Link to tactics allowed by the task
4. Extract Features
   - ✓ Identify relevant sections of log data
5. Create Chains-of-Evidence
   - ✓ Link features to ontological concepts

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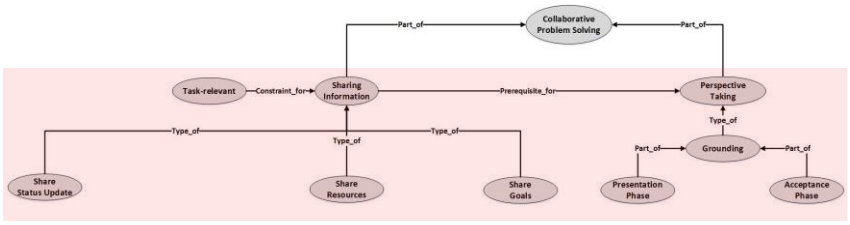
Generate an Ontology



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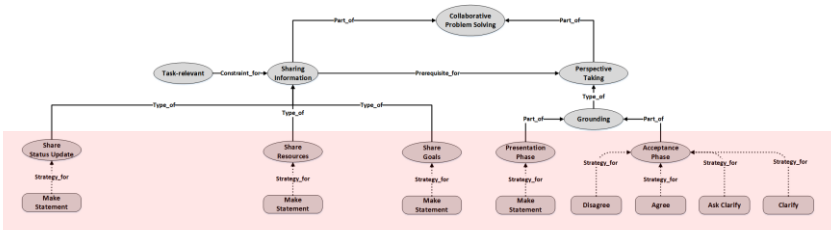
Expand to a Behavioral Ontology



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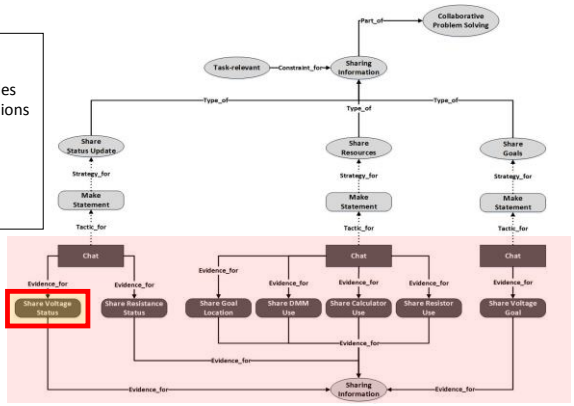
Expand to a Cognitively Enhanced Ontology

Legend

Node Shapes
Ovals = latent or calculated variables
Rounded Rectangles = inferred actions
Rectangles = observed actions

Node Colors
Light Gray = task independent
Dark Gray = task dependent



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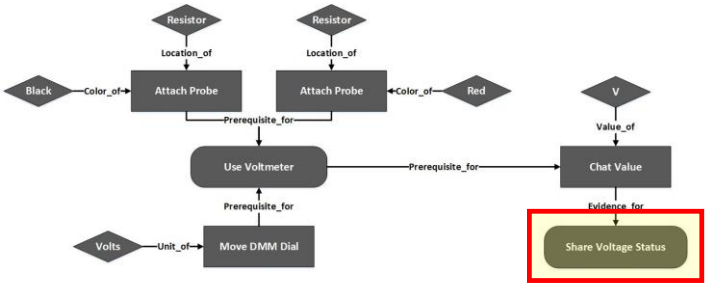
Extract Features



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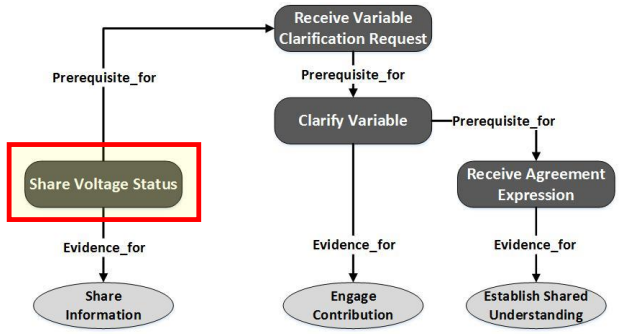
Create Chains-of-Evidence



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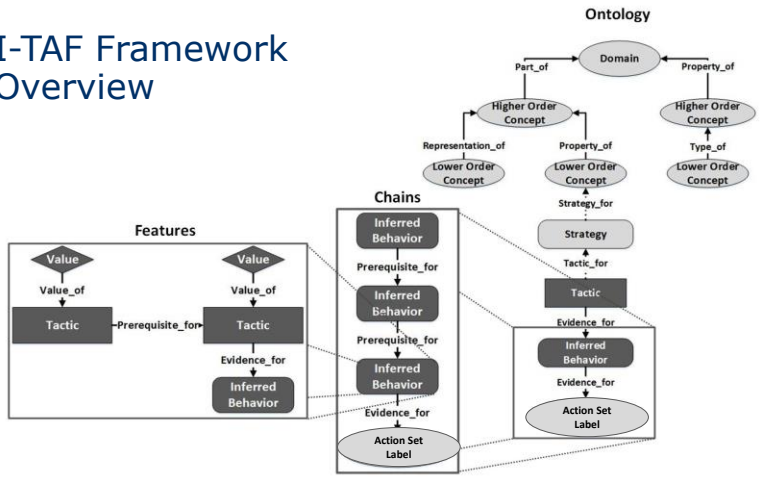
I-TAF Framework Overview



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Next Steps

- ✓ Revising the simulation to better characterize the log data
- ✓ Collect data for detailed analysis (2017-2018)
- ✓ Seek additional features through data mining
- ✓ Identification of errors / misconceptions
- ✓ Input for models
  - Observable variables can be operationalized from action set labels (e.g., share information)
  - Example: Counts of the label, correct or incorrect, proportion of instances of correct or misconceived action observed
- ✓ Consider how I-TAF can apply to other domain simulations