MODEL-DRIVEN ASSESSMENT OF LEARNERS IN AN OPEN-ENDED LEARNING ENVIRONMENT

James R. Segedy, Kirk M. Loretz, & Gautam Biswas

Institute for Software Integrated Systems
Vanderbilt University, Nashville TN, USA
OPEN-ENDED LEARNING ENVIRONMENTS

- Learner-centered, and based on constructivist theories of learning
  - Jonassen, 1991; Land, Hannafin, & Oliver, 2012

- Learners construct knowledge by negotiating meaning with the world in which they exist
  - Learning by doing: attempting solutions, making mistakes, reflecting on results

- Learning environment provides:
  - A learning context (e.g., you are designing a wheelchair ramp for your grandfather)
  - Tools for:
    - Accessing and acquiring information
    - Constructing problem solutions
    - Assessing problem solutions
OPEN-ENDED LEARNING ENVIRONMENTS

Provides opportunities for exercising metacognitive skills related to managing one’s own problem solving tasks such as **planning** and **reflection**

This is difficult!
OVERVIEW: ADAPTIVE SCAFFOLDING

Pedagogical Actions → Learner Actions

Constraints

1. Real-time Analysis of Individual Students
2. Small amount of data

Pedagogical Function → Learner Model

Learner Modeling Module

Pedagogical Actions
When humans shiver, their skeletal muscles expand and contract, and this creates friction.
**Correct:** All links used to answer the question are correct

**Incorrect:** At least one link used to answer the question is incorrect

**Can’t Answer:** At least one link is missing
**Information Seeking/Acquisition**
Searching for and studying information that can be used during solution construction

**Associated System Tools**
- Searching the Resources
- Accessing Resource Pages

**Solution Construction**
Using what you know to construct a solution to the problem

**Associated System Tools**
- Adding, modifying, and removing concepts and links
- Positioning concepts and links on map
- Exploring the solution (Betty’s knowledge) via questions and explanations

**Solution Assessment**
Submitting your solution to automated assessments and interpreting the results

**Associated System Tools**
- Taking quizzes
- Asking for explanations
Reflection

• Did my plan work? Why?

Goal Selection and Planning

Metacognitive Strategy Understanding

Cognitive Process Understanding

Goal Selection

Plan

Plan Execution

Execution Monitor

Monitoring: is plan working?

Control: changing or abandoning plan

Reflection
• Assess cognitive process understanding via **effectiveness**

**Solution Construction Effectiveness**: The addition, removal, or modification of a causal link is *effective* if it improves the quality of Betty's causal map.

**Solution Assessment Effectiveness**: A question evaluation, quiz, or explanation is *effective* if it generates information about the correctness or incorrectness of a causal link.

• Assess metacognitive strategy understanding via **coherence among actions**

**Coherence**: Two actions in an OELE are *coherent* if the second action, $y$, logically follows from information generated by the first action, $x$.

$x$ provides *support* for $y$, and $y$ is *supported* by $x$. 
POST-HOC ANALYSIS OF DATA FROM BETTY’S BRAIN

• 40 8th grade students from a middle TN public school.

• Procedure:
  • Day 1: brief introduction to thermoregulation
  • Day 2: pre-test
  • Days 3-4: instruction on causal reasoning and how to use Betty’s Brain
  • Days 5-9: students worked on Betty’s Brain
  • Day 10: post-test, identical to pre-test
ANALYSIS: MEASURES CALCULATED

- **Actions per Minute**: How often did students use tools related to solution construction and assessment?

- **Solution Construction Effectiveness Rate**: Percentage of map edits considered effective

- **Solution Assessment Effectiveness Rate**: Percentage of solution assessment actions considered effective

- **Information Seeking Support Rate**: The percentage of causal map edits supported by previous resource accesses (10 minute window)

- **Solution Assessment Support Rate**: The percentage of causal map edits supported by previous solution assessment actions (10 minute window)
RESULTS – ALL STUDENTS

<table>
<thead>
<tr>
<th></th>
<th>Actions/Min</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solution Construction</td>
<td>0.439 (0.190)</td>
<td>0.525 (0.113)</td>
</tr>
<tr>
<td>Model Assessment</td>
<td>0.194 (0.126)</td>
<td>0.370 (0.218)</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Information Seeking Support %</td>
<td>60.2% (18.5%)</td>
<td></td>
</tr>
<tr>
<td>Model Assessment Support %</td>
<td>0.8% (1.4%)</td>
<td></td>
</tr>
</tbody>
</table>
RESULTS – HIGH VS. LOW

<table>
<thead>
<tr>
<th></th>
<th>Solution Construction</th>
<th>Total Support %</th>
<th>Model Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Mean</td>
<td>0.528 (0.162)</td>
<td>0.618 (0.087)</td>
<td>0.224 (0.110)</td>
</tr>
<tr>
<td>Low Mean</td>
<td>0.367 (0.187)</td>
<td>0.445 (0.082)</td>
<td>0.178 (0.153)</td>
</tr>
</tbody>
</table>

Actions/Min

<table>
<thead>
<tr>
<th></th>
<th>Effectiveness</th>
<th>Effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Mean</td>
<td>0.618 (0.087)</td>
<td>0.697 (0.191)</td>
</tr>
<tr>
<td>Low Mean</td>
<td>0.445 (0.082)</td>
<td>0.532 (0.160)</td>
</tr>
</tbody>
</table>

Effectiveness
QUESTIONS

Contact:

Jim Segedy: jim.segedy@vanderbilt.edu
Kirk Loretz: kirk.m.loretz@vanderbilt.edu
Gautam Biswas: gautam.biswas@vanderbilt.edu

For more information, or to try Betty’s Brain at home:

www.teachableagents.org