



Modeling Learner's Cognitive and Metacognitive Strategies in an Open-Ended Learning Environment

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The Betty's Brain Learning Environment

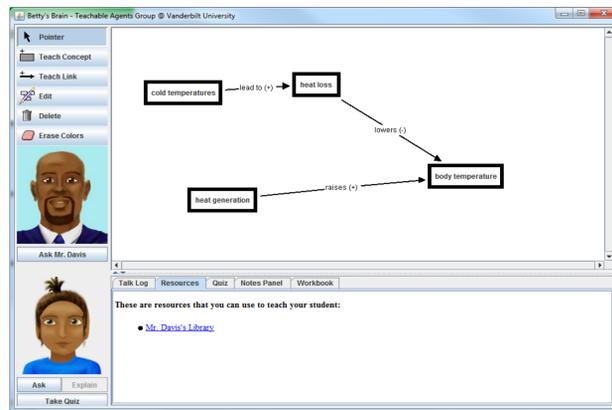
What is Betty's Brain?

Betty's Brain is a computer-based learning environment that implements the learning-by-teaching paradigm to help middle school students develop cognitive and metacognitive skills in science and mathematics domains.

It features a **Teachable Agent (TA)**, an agent that students teach, and a **Mentor Agent, Mr. Davis**, who guides students as they teach.



The Interface



The Betty's Brain Interface

The Learning Task

The students' task in Betty's Brain is to learn about a science topic and represent their understanding of the material as a **causal concept map** by teaching their TA about concepts and their relations.

Students have access to resources, and they can ask Betty questions and get her to take quizzes as they teach her. Both Betty and the Mr. Davis provide feedback as the student teaches and learns.

When Betty has learned everything she needs to know, she'll be able to pass Mr. Davis's quiz.

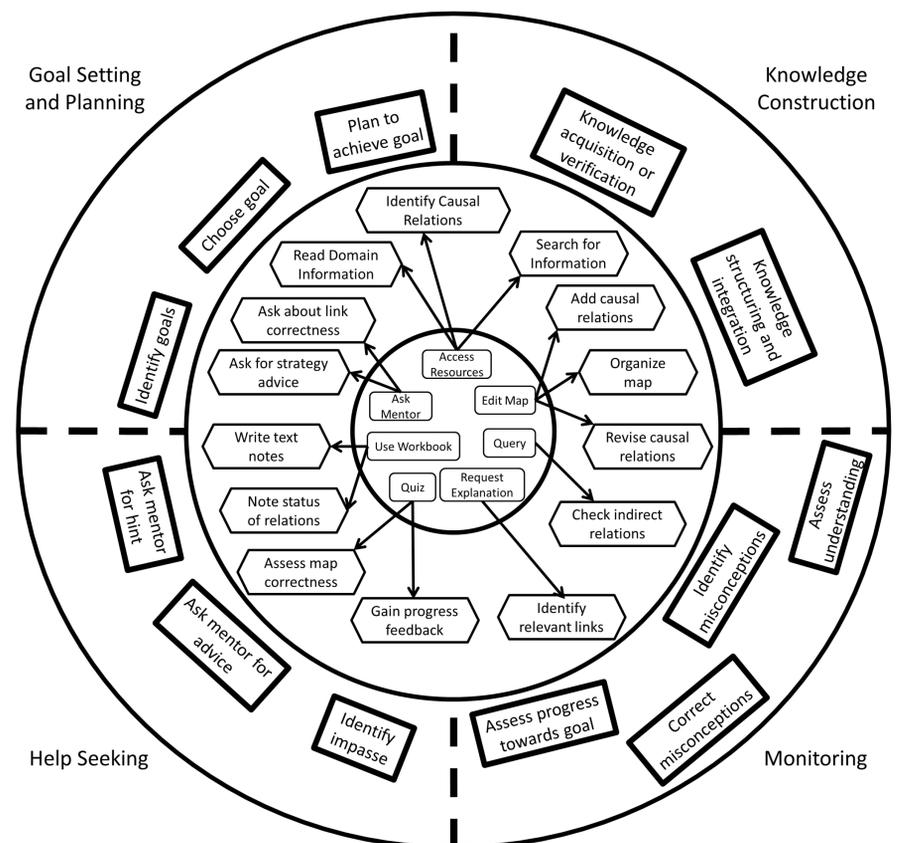
When Betty receives a poor quiz grade, students know that they need to monitor their understanding, learn some more, and revise their concept maps.

Modeling Cognitive and Metacognitive Strategies

Cognitive Activities in Betty's Brain

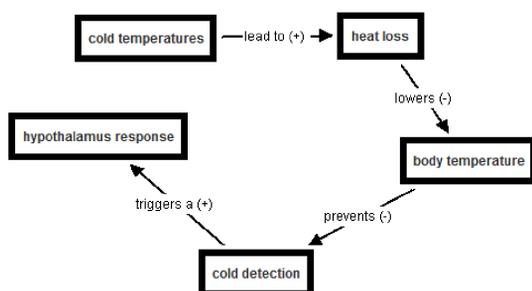
Basic Action	Cognitive Activity
1. Access Resources	Read domain information (e.g., about entities, their role in the process(es) under study, and their relationships) Identify specific causal relation(s) Search for information (about specific concepts or causal relations)
2. Edit Map	Add causal relation(s) between domain entities (concepts) Organize map (e.g., group by sub-process based on concept-process associations) Revise causal relation(s)
3. Query	Check indirect relations (i.e., chain of links) between two concepts
4. Request Explanation	Identify relevant links involved in answering a query or quiz question
5. Quiz	Assess correctness of specific areas of map (by acquiring a set of correct and incorrect answers to questions posed by the Mentor) Gain progress feedback (from correct/incorrect quiz questions)
6. Workbook	Note status of specific causal relation(s) (as to whether or not you know that they are correct) Write text notes as a memory aid
7. Ask Mentor	Ask for strategy advice (i.e. how can I achieve my goal?) Ask about the correctness of, or any problems with, the TA's answer to a question Review how to organize and build causal maps

Connecting Activities to Strategies



Understanding Student Actions in the Context of the Model

A Simple Target Map



This example concept map describes how cold temperatures lead to a hypothalamus response in warm-blooded animals. It is an excerpt from a concept map students encounter using Betty's Brain.

When learners try to build a map such as this one, they run into problems.

Ineffective Strategies for Map Building

- Teaching unverified prior knowledge:** students think they "know the answer" and add links right away.
- Utilizing quiz results for ad hoc map construction:** students look at a quiz question that their TA got wrong, and they teach a direct link. For example, if their TA can't answer how cold temperatures affect cold detection, they may incorrectly add a direct link from one to the other.
- Adopting a guess-and-check strategy:** students, when they run out of ideas for how to teach their TA, resort to randomly adding links and seeing if their TA gets better quiz scores.

Using the Model to Generate Feedback

- Identify behavior indicative of frustration or disengagement:** Success, however unorthodox, does not need additional guidance. Rather, we provide feedback when students begin repeating errors or stop making progress.
- Interpret their strategy in terms of the model:** When we decide to offer feedback, we need to classify student behavior and intentions in order to understand and respond.
- Identify differences:** how does the student's strategy differ from the strategies in the model? If the student is struggling, we can use this difference as the basis for feedback.