



Investigating the Relationship Between Student Responsiveness and Learning in a Teachable Agent Environment



James R. Segedy, John S. Kinnebrew, Gautam Biswas

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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 Betty, an agent that students teach, and Mr. Davis, an agent that mentors students as they teach.



The Interface

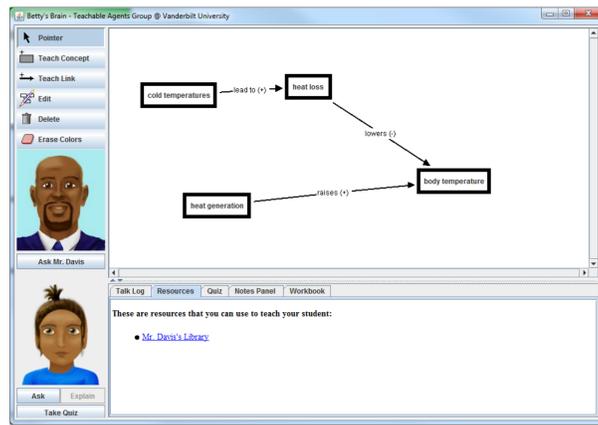


Figure 1. The Betty's Brain Interface

The Learning Task

A student's task in Betty's Brain is to learn about a scientific topic and re-represent it as a **causal concept map** by teaching Betty about concepts and their relations.

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.

Student Responsiveness

What is Student Responsiveness?

Student responsiveness describes activity metrics based off of a student's reactions to feedback delivered in an intelligent learning environment.

In Betty's Brain, agents deliver feedback to students as they use the system. Concerning this feedback, we measured two metrics of student responsiveness:

- **dialogue responsiveness**
- **action responsiveness.**

Dialogue Responsiveness

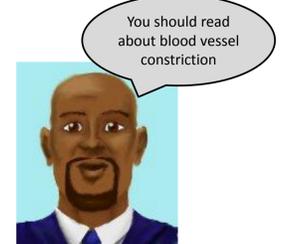


In Betty's Brain, agents ask for permission before delivering feedback. They might say "Excuse me, would you like some help?"

When students chose to accept help, they were considered **responsive to the agent dialogue**.

A student's **dialogue response score** is the percentage of time a student was responsive to the agent dialogue.

Action Responsiveness



Feedback in Betty's Brain is often prescriptive: it tells students what they should do in order to achieve more success.

When students chose to follow an agent's suggestion, they were considered **responsive by action**.

A student's **action response score** is the percentage of time a student was "responsive by action" to the agent dialogue.

Classroom Study and Results

Classroom Study

We conducted a classroom study where students use Betty's Brain to learn about the theory of climate change with 28 7th-grade students in middle Tennessee.

The intervention began with an overview of causal relations and concept maps during a 45-minute period. This was followed by a hands-on training session with the system on the next day. Over the following 5 days, students learned about the theory of climate change.

We collected the following metrics for analysis:

- Normalized Learning Gains via a pre/post test on climate change.
- A performance metric based on the quality of the student's map ("Map Score").
- Standardized Test Scores, which indicated prior achievement ("TCAP Score").

Data Analysis

We analyzed the data from this study to investigate three research questions:

- (1) Would more responsive students show greater learning gains?
 - a) *Is there a significant correlation between dialogue response and learning gain?*
 - b) *Is there a significant correlation between action response and learning gain?*
- (2) Would more responsive students build more complete concept maps?
 - a) *Is there a significant correlation between dialogue response and map score?*
 - b) *Is there a significant correlation between action response and map score?*
- (3) Is student responsiveness in Betty's Brain more predictive of learning gains and performance measures when compared with standardized test scores?
 - a) *Do TCAP scores have a higher degree of correlation with learning gain than do the response measures?*
 - b) *Do TCAP scores have a higher degree of correlation with map score than do the response measures?*

Results

| | Normalized Learning Gain | Map Score |
|-------------------|--------------------------|-----------|
| Dialogue Response | 0.477* | 0.149 |
| Action Response | 0.402* | 0.431* |
| TCAP Score | 0.245 | 0.405* |

Table 1. Correlation (R) of Learning and Performance with Responsiveness and TCAP (* p < 0.05)

- Both responsiveness metrics were significantly correlated with learning gains.
- The action response metric was significantly correlated with map score.
- The dialogue response metric was not significantly correlated with map score.
- Both responsiveness metrics had higher correlations with learning gain than did TCAP scores.

These results suggest a potential for using easy-to-calculate student responsiveness metrics as predictors of student performance and learning.