

The Affective Meta-Tutoring Project: How to motivate students to use effective meta-cognitive strategies

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Abstract: Meta-tutoring applies the basic policies of interactive tutoring to get students to adopt effective meta-cognitive strategies. Unfortunately, when the meta-tutor is removed, students often revert to using ineffective strategies. This paper is an early report on the progress of the Affective Meta-Tutoring (AMT) project, which will use an affective learning companion to motivate students to more permanently adopt effective meta-cognitive strategies.

Keywords: Meta-cognition, self-regulated learning, intelligent tutoring systems, affective learning companions, affective computing

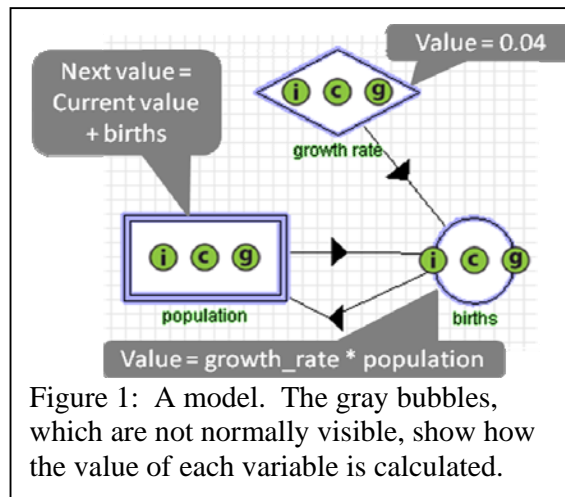
1. The task domain: Scientific modeling

Scientific modeling is the process of constructing and debugging a formal model of a phenomenon. There are many formal languages for such models, such as concepts maps, algebraic equations, agent-based modeling languages, etc.

We chose to focus on a system dynamics modeling language [1-3]. Each model is a directed graph (Fig. 1). The links indicate flow of numeric information and the nodes represent variables. A node/variable's value is an algebraic combinations of the numbers coming into it via links. Figure 1 shows a model for a population of rabbits with a 4% birth rate. Our students read text describing the system, then define nodes and links, enter equations in each node, run the model and compare its predictions to given facts. If any of the model's predictions are false, students must debug the model. Although such modeling engages the student in abstraction, causal reasoning, debugging and other sophisticated reasoning, even young students can become skilled at it [1-3].

2. Research goal

Unfortunately many students use ineffective modeling practices. Schwartz et al. [4] discovered that students spent most of their time making small changes to the model to see if that incrementally improved its predictions. Other studies have also observed widespread shallow



modeling practices [5-7].

In order to reduce shallow modeling, Leelawong and Biswas [8] added a self-regulated learning tutor to Betty, their modeling tool. For instance, one of its most successful tactics was to have Betty refuse to make predictions if the student had not made changes to the model. Crucially, the tutor did not teach domain knowledge (e.g., stream ecology). It only taught how to use the modeling system effectively in order to learn stream ecology. That is, it was a *meta-tutor*, because it taught meta-cognitive strategies.

Our system teaches students an meta-cognitive strategy that was highly successful in physics and probability [9]. The basic idea is to require students to pick a principle that applies to the problem, apply it and thus divide the problem into subproblems, and then repeat the process on the subproblems. The most difficult step for students was picking an applicable principle from a menu. Students soon learned that if they studied the principles and understood them deeply, they could more rapidly find an applicable one. In short, students learned the meta-cognitive strategy “focus on learning the principles.”

Unfortunately, the benefits of meta-tutoring tend to be temporary. While Betty’s meta-tutor was operating, students misused Betty less frequently and their learning rates increased [8]. However, when students were later allowed to use Betty without the meta-tutor, they tended to revert to their old ways [10]. This finding is not unique to Betty. For instance, meta-cognitive strategies for properly using hints can be taught, but students tend to resume abusing the hints when the meta-tutoring is removed [e.g., 11].

In short, it often does little good to teach effective meta-cognitive strategies, perhaps because most students already know about them; students simply choose not to use the strategies as much as they ideally should.

The goal of the AMT project is to find techniques for increasing students’ motivation for using appropriate meta-cognitive strategies.

3. Basic approach

Some pioneering projects have used affective, animated, relational agents to motivate people to do their exercises [12], avoid unsafe sex [13] or persevere at difficult tasks [14]. Our basic approach is to use such an agent along to motivate students to persistently adopt the meta-cognitive strategy taught by the meta-tutor. The software will use physiological sensors [e.g., 15, 16] to help the affective agent intervene at maximally effective moments.

In order to provide a more authentic context than a lab, evaluations are being conducted in summer camps for high school students interested in learning about engineering. This allows two “classes” per summer, each consisting of about 30 students and lasting about 3 hours.

4. A brief progress report

The first task of the project was to implement a modeling tool and instructions that were simple enough that high school students could become moderately proficient in a few hours. This proved to be quite challenging. We conducted four studies where all students gave verbal protocols as they worked. Analyses of the screen videos, audio and log data led to many changes. During the last study, most students were able to construct models of at least the complexity shown in Figure 1 within the first hour of instruction. This learning rate is considerably faster than other projects have been able to achieve [1, 2, 17].

The second task of the project was to develop the meta-tutor described earlier and evaluate it. A random-assignment experiment in the 2011 summer camps tested two

predictions: (1) Students who were meta-tutored during the first half of the experiment should learn faster than students instructed by the same system with the meta-tutor turned off. (2) When the meta-tutor was turned off during the second half of the experiment, the meta-tutored students should stop using the meta-strategy. Preliminary data analyses suggest small effects in the predicted directions but the analyses are not complete.

The last task of the project is to develop an affective agent that increase students' persistence in using the meta-cognitive strategy when the meta-tutoring is turned off. To this end, we collected physiological sensor data from our high school summer campers. The data will be used to calibrate affect detectors. The data were collected from a facial camera, a posture sensing chair, a skin galvanometer and a posture sensing chair.

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