Model-Evidence Link Diagrams: A Scaffold for Model-Based Reasoning

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Abstract: This poster explores the ways in which students participating in a scientific modeling curriculum engaged with a specific scaffold, the 'Model-Evidence Link' (MEL) diagram, designed to reduce cognitive load and facilitate modeling literacy. Completed MEL diagrams, along with the small-group argumentation sessions they supported, represent rich sources of data on students' norms for model-evidence coordination, both before and after the scaffold's introduction. We consider various approaches to coding these data and present preliminary results.

Objectives & Theoretical Framework

This poster presents ongoing results from the PRACCIS (Promoting Reasoning And Conceptual Change in Science) project, a microgenetic investigation of the effectiveness of classroom argumentation around scientific modeling for promoting learning and reasoning in middle school life-science classes. PRACCIS has explored ways in which the challenges of developing sophisticated model-based inquiry might be met in instruction. The effectiveness of scaffolds in promoting authentic, reflective inquiry suggests that they might be the kind of instructional tool for engendering model-evidence fluency among science students (Hmelo-Silver et al., 2007).

Previous research by the project team has identified the central evaluative modeling and argumentation criteria used by students engaged in the PRACCIS research project has and tracked changing patterns of criteria use over the course of the school year (Pluta et al., 2009). Here we investigate the ways in a specific modeling scaffold served to facilitate and constrain the reasoning and argumentation practices of students.

A goal of the analyses presented in this brief paper is to critically assess students' use of a scaffold used prominently in the PRACCIS curriculum—the model-evidence link (MEL) diagram (see Figure 1). This scaffold is a graphical representational and reasoning tool designed to facilitate the coordination of multiple pieces of evidence in the evaluation of one or more models. When using the MEL diagram, students use different kinds of arrows to denote different kinds of relationships between evidence and models: *supports*; *strongly supports*; *is irrelevant to*; or *contradicts* a model. The scaffold encourages students to present reasons for particular model-evidence relations and to consider how model-evidence relationships can vary not only in direction (support versus contradict) but also in strength (e.g., strongly support versus support). The scaffold allows students to consider multiple models against multiple pieces of evidence, each of varying relative strength. Accomplishing this kind of reasoning presents multiple difficulties for students unaccustomed to modeling practices, not least due to the cognitive load involved.

Methods and Data Sources

Data are drawn from a yearlong microgenetic study of 16 classes taught by 7 teachers, including a full school year of class video and small-group audio recordings. Our analyses focused on the use of the scaffold in written pretest and posttest assessments in the classes of four teachers. Additional data are drawn from written work and from class and group discourse sampled (a) several weeks before, (b) during and (c) several weeks after the introduction of the MEL diagrams.

The data analyzed in this paper come from two separate inquiry investigations in which MEL diagrams were embedded, allowing for counterbalanced assessment of students reasoning. For reasons of space we shall briefly describe one of these—a problem in which students used evidence to determine which of two explanations of the cause of gastrointestinal ulcers should be preferred. Students considered two models: (a) a stress model, on which increased tension leads to overproduction of stomach acid which damages the stomach lining; and (b) a bacteria model, in which bacterial infection results in damage to the stomach lining. After deciding which model they initially considered better, students were presented with three pieces of evidence: (1) the pain produced by the action of stomach acid on wounds in the stomach lining; (2) associations between stressful jobs and ulcers; and (3) the effectiveness of antibiotics (which kill bacteria) on alleviating ulcers. Students then completed a MEL diagram that presented the models and evidence in a perspicuous form, and students justified their choice of links they considered to be the most important for comparative model evaluation.

Completed scaffolds provide a concise, justified summary of a student's reasoning. In our analyses, we coded students' completed diagrams to capture the particular pattern of weighted links for each student, as well as the argumentation strategies revealed in their justifications. Students' patterns of link judgments were initially assessed against those generated by domain experts solving the same problems.

Results and Significance

Students' justifications were coded in several ways First, according to their degree of elaboration, specifically in terms of the nature of the link between the model and evidence they coordinated. *Highly elaborated justifications*, e.g. "… because ulcers are commonly found in dangerous jobs, like firefighter, or coal miners… jobs [that] can be hard on the body causing stress that lead to excessive body acid which causes ulcers" typically introduced a new element or perspective which served to fit some feature(s) of the evidence with the model. *Low elaboration answers* merely asserted the presence of a substantive link, without taking steps to integrate them in unifying explanation, or simply restated the characteristics of the model and/or evidence. This coding scheme provides a useful way of delineating high and low quality of reasoning in student responses, as high levels of creative elaboration is needed to bring apparently disparate models and evidence together in successful explanation. Creativity and narrative fluency appeared to play an important role in students' reasoning.

Additional coding categories included various classes of factual and inferential error, including responses in which the relevance of evidence for a model was missed (e.g., many students judged the antibiotic evidence as irrelevant to the bacterial model, as it only dealt with the healing of ulcers and not explicitly with their causation). Students appear to need to learn strategies that can help them recognize the relevance of such evidence.

More sophisticated strategies such as 'exclusion' (e.g. "the evidence supports the stress model, because it contradicts the bacteria model") were also documented, as was 'meta-modeling' facility, in which different criteria for good and bad models were expressed in their justifications. Less sophisticated strategies were also evident, including 'non-justificatory' responses, in which model-evidence judgments were defended in ways that failed to provide genuine reasons (e.g. "…because that is what I think").

The MEL diagrams provided students with an intuitive and simplifying means of representing complex sets of model-evidence relations, and they supported collaborative argumentation about issues such as the strength of evidence. However, the impact of the diagrams varied somewhat between teachers. Gains in the quality of students' justifications were mixed. Differences were noted in the frequency of non-justificatory responses between two groups of teachers demonstrating quite different styles of classroom inquiry and argumentation management. The students in classes taught by the teachers who were considered to most effectively balance teacher-scaffolded instruction and feedback with student-led inquiry and discussion exhibited a decrease in the non-justificatory responses (that is, responses that failed to provide substantive reasons for claims). However, the students of teachers who provided less clear scaffolding or dominating the inquiry discourse in their classrooms increased slightly in their tendency to give non-justificatory responses. It appears that in the context of this learning scaffold, the instructional styles of teachers may substantively impact students' justificatory practices.

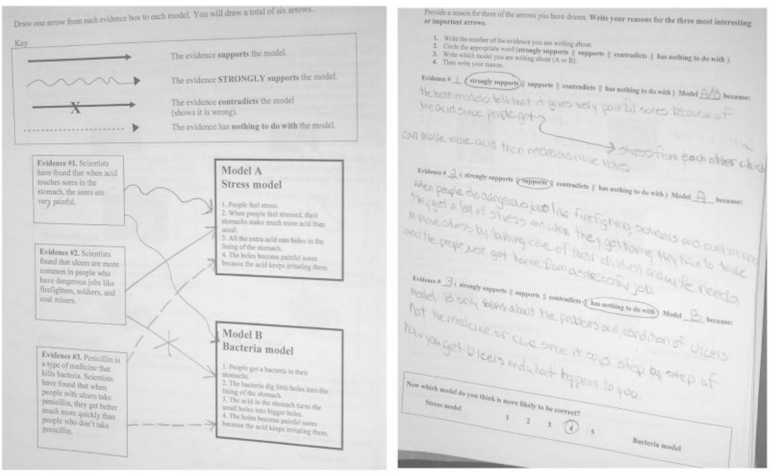

Figure 1. A completed Model-Evidence Link Diagram.

References

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