

Facilitating the Acquisition of Mental Models of Programming with GIL: an Integrated Planning and Debugging Learning Environment

Brian J. Reiser

School of Education and Social Policy
and The Institute for the Learning Sciences
Northwestern University

Effective learning in mathematics, science, and programming domains, in which students must reason about the behavior of objects in the world and express solutions in a formal notation (e.g., equations, diagrams, tables, computer languages), requires that students link their manipulations of the formal notation with their understanding of the behavior of objects in the world. Unfortunately, students' reasoning often focuses on solution formalisms and notations rather than reasoning about causal mechanisms. Much problem solving instruction focuses on the form of solutions rather than the reasoning processes by which students should construct such solutions, and much of the causal structure of phenomena is difficult for students to discern, because hidden causes and intermediate results intervene between the initial change and final outcome (Merrill & Reiser, 1994).

In this talk, I will present an overview of GIL (Graphical Instruction in LISP), an interactive learning environment designed to address these barriers to learning programming. GIL is designed to be reasoning-congruent --- GIL provides a better fit with the structure of students' solution plans, makes the structure of solutions more visible, and provides access to invisible behavior. The environment also scaffolds effective problem solving strategies such as prediction and self-explanation. Thus, GIL enables *scaffolded incremental planning*, in which students productively record inferences in the external environment, relying on spatial organization to reflect the mental problem space in the external world. Students can run, observe, and repair partially completed solutions. In this way, students can productively integrate planning, implementation and debugging.

I will also describe several empirical studies examining the effectiveness of various versions of GIL and VSE, an implementation of the reasoning-congruent learning environment principles as effectively as possible within a text-based notation. These results suggest that the reasoning-congruence of a system strongly affects how well it can facilitate student learning. Second, the principles of reasoning-congruence can be implemented in text-based systems, and cannot be equated simply with the presence of a graphical rather than text-based interface. Finally, the data do suggest that the principle of reasoning-congruence can be more effectively achieved relying on spatial

organization, suggesting that graphical notations are more effective vehicles for reasoning-congruent learning environments.