PROJECT SUMMARY

Overview:

This project in the STEM Learning strand investigates the use of visual cueing and feedback to improve problem solving skills in STEM. Visual cueing has been shown to facilitate solving problems in which the visuospatial component is central to the problem. Numerous STEM problems fit this description, yet visual cueing has not been systematically researched with such problems. Similarly, correctness feedback is commonly used in online tutoring systems. Yet, no systematic research on the use of feedback in conjunction with visual cues has been investigated.

Objectives: We study the effects of a) cueing, b) feedback, and c) their interaction, on 1) problem solving performance, and 2) eye movements. Furthermore, we investigate these effects both i) during training, and ii) at transfer. In our studies we control for students? prior domain knowledge, initial problem solving skills, and initial eye movements on the problems.

Methods: Two studies with students in introductory college mathematics and physics courses will explore the influence of malleable factors (visual cues and feedback) and moderating factors (prior domain knowledge, initial problem solving skills and eye movements) on outcomes (improved problem solving performance and expert-like eye movements) in STEM problem solving. Building on the work of a prior NSF FIRE grant, we use a 2 (cue, no cue) x 2 (feedback, no feedback) between subjects design to investigate the effect of cues and feedback as well as their interaction on problem solving performance and eye movements, both on training problems which are presented in the conditions as well as future transfer problems.

This project is a collaborative effort between researchers in STEM education and visual cognitive psychology. An expert panel of two cognitive psychologists (Brian Ross and David Irwin), a physics education researcher who also works in cognitive psychology (Jose Mestre) and a science education researcher (Eric Wiebe) serve as the Advisory Board and evaluators for this project.

Intellectual Merit :

1. The main intellectual merit lies in its novelty and potential to transform research on the use of diagrams in STEM (particularly math and physics) problem solving. This project is one of the first of to explore and exploit the link between cognition and eye movements as manipulated by cueing and feedback in STEM problem solving.
2. We combine the theoretical perspectives on problem solving (representational change theory) with theoretical perspectives on multimedia learning (cognitive theory of multimedia learning) with empirical research on visual cueing and feedback to develop and refine a conceptual model for STEM problem solving.
3. Based on these theoretical perspectives and prior empirical work, the project develops and tests novel predictions for understanding and improving STEM problem solving.

Broader Impacts :

Beyond its immediate scope, the project will:

1. potentially change the ways visual media are used in STEM instruction to more effectively facilitate students? problem solving skills in math and physics,
2. benefit the field of STEM education research by infusing ideas from cognitive psychology regarding visual cueing into STEM education research, and
3. build human capital in the field of STEM education research by training faculty and graduate students in the knowledge and skills of visual cognitive psychology applied to their field.