Developing Ontological Schema Training Methods to Help Students Develop Scientifically Accurate Mental Models of Engineering Concepts

Project Summary

This proposal investigates development and testing of schema training strategies for helping engineering students develop more fundamentally accurate mental models of dynamic processes which occur at small length scales. Given the current interest in advances in nanotechnology (e.g.microfluidics, biotechnology, genetic engineering, nanoscale machines), new engineering graduates must have a firm grip of fundamental processes which are characterized by small-scale dynamic systems.

Unfortunately, little is understood about how people learn in such conceptual domains and there is ample evidence in the literature to suggest that students of all ages (including science and engineering students) do not easily understand fundamental small-scale phenomena such as heat transfer, diffusion, fluid mechanics, and electricity. Based on the ground-breaking research of Dr. Michelene Chi and her colleagues (including project co-PI Slotta) the problem is more than one of confusion or misunderstanding, but rather involves fundamental and robust misconceptions about how the dynamics of small-scale processes (e.g., the random motion of molecules, atoms, or sub-atomic particles) differ from the observable, macroscopic behavior that we experience in our everyday lives.

We propose to test Chi and Slotta's theory of emergent phenomena by creating effective schema training protocols and materials for helping engineering students create appropriate mental models of fundamentally important dynamic processes operating at small length scales.

Intellectual merit – The proposed work represents an integration of two research lines combining cognitive psychology with direct applications to engineering education. First, ongoing research by Miller and Streveler studying why engineering processes with emergent characteristics are so difficult to learn provides an optimum context in which to gain valuable new knowledge about how to better education the next generation of engineers to design and operate the nanotechnologies of the future. Second, Co-PI Slotta's prior research in the use of ontological schema as training protocols for emergent processes is combined with the Miller/Streveler educational context to offer a powerful new paradigm for misconception research.

Broader impacts – The results from this project have the potential to dramatically improve students' ability to understand a large ontological class of engineering concepts, exemplifying the intersection of basic cognitive research with engineering education applications. Moreover, our project will shed important light on the need for the engineering education community to focus on conceptual understanding (rather than just problem-solving and algorithmic knowledge which is often the case today). Finally, the project will involve underrepresented groups in the training cohort, helping our community gain insight about how to engage these important demographics.

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