# Learning to RECAST Students' Causal Assumptions in Science Through Interactive Multimedia Professional Development Tools

Understanding the nature of causality is critical to learning a range of science concepts from "everyday science" to the science of complexity. In earlier research, The Understandings of Consequence (UC) Project, funded by NSF, we found that students hold default assumptions about the nature of causality that can limit their science learning. We also found that curriculum designed to help students restructure their causal assumptions as they are learning science concepts leads to deeper understanding. As a result of that project, four curriculum books were developed, including one on ecosystems and one on density. The aim of the recently completed project was to develop a professional development website to make the curriculum innovations from the earlier project widely available to teachers so that they could learn to use the teaching methods well.

The UC team collaborated with the Science Media Group (SMG) of the Harvard-Smithsonian Center for Astrophysics to develop an interactive, multimedia set of professional development tools on-line. The project began with a series of workshops to test the best ways to teach the concepts to groups of teachers. The website was then designed in an iterative process that involved gathering regular feedback from teachers who tested the site out. When the site was finished, we tested the use of the website with teachers who had access to the site plus the curriculum to teachers who had access only to the curriculum materials.

We found that across both groups, teachers made significant gains in their understanding of the concepts and more importantly, that their students made significant gains. While teachers were largely able to teach ecosystems and density well from the curriculum materials (and some were inclined to only use those materials), in some conditions, access to the website made a significant difference in student performance. It appears that students of teachers who taught the ecosystems unit, which contains a wide range of causal concepts (domino and cyclic types of causality, non-obvious causes that you can't directly see) and had access to the website, outperformed students of teachers who did not. It also appears that some teachers used the videos and films from the site directly with their students. Therefore, these student gains may be more than just trickle down effects from having a more informed teacher; they may be direct outcomes of resources available to the teachers.

In addition to the PD activities on the site, we developed assessment materials, classroom approaches, videos, and additional curriculum guides to help teachers teach the inherent causal structures in science and to help students think about science in the ways that scientists do. The intellectual merit of the project is that it provides research-based resources that have been shown to be effective in addressing an important problem in science learning for the professional development of STEM teachers. It leverages an effective set of innovations and makes them widely accessible on the internet for teachers all over the world to enable broad impacts.