Evidence based approaches to teaching, learning and assessment are the focus of Dr. Cooper’s research. Our goal is to characterize student thinking about major chemistry ideas and use this knowledge to improve teaching and learning. For example: Chemistry, Life, the Universe and Everything (CLUE) is a new NSF-supported general chemistry curriculum that was developed in collaboration with Mike Klymkowsky (University of Colorado at Boulder). CLUE is based on three core ideas of chemistry — structure, properties and energy, as three intertwined learning progressions that are developed simultaneously over the two semester course. CLUE represents a model for curriculum development based on five important questions: (i) What should students know and be able to do? (ii) In what order should they learn it? (iii) What do students bring with them to the course? (iv) What materials are best suited for different purposes? and (v) How can student understanding be assessed? Our research has focused on each of these questions. That is, we are interested in characterizing the core concepts of chemistry and, by providing opportunities to use these ideas in the context of scientific practices, we can describe what students should know and be able to do with that knowledge. For example, we ask students to construct and use models to predict and explain chemical phenomena, to use data to support and develop arguments and to construct explanations about important ideas in chemistry. To do this, we are designing evidence based learning progressions for the core ideas, structure, properties and energy using design-based research to investigate how students’ ideas about these concepts progress over time, and folding this research back into the design of the curriculum.

To design effective curricula we need to know what students bring to the table in terms of knowledge and science practices, and we also must understand how and why (under traditional curriculum structures) students develop ideas that are not scientifically sound. For example, we have shown that for many students, when they consider how the molecular level structure of a substance can be used to predict macroscopic properties, their ideas are often a loosely woven tapestry of concepts, facts and skills, rather than a useful framework of ideas. We have used this work to design a more coherent approach to structure-property relationships, and have shown that students who learn in this way are significantly better at both constructing and using structures to predict properties. We have followed these students through organic chemistry, and find that the CLUE students are still significantly better than a matched cohort of students who learned general chemistry in a more traditional setting.

Similarly, our recent work on the central (and cross cutting concept of energy) has focused on how students think about energy in chemical systems, and this work has informed our learning progression for energy.

We are also interested in developing formative assessment systems that allow students to construct (free form) structures, diagrams, and models, and to develop explanations for phenomena. Our system beSocratic (http://besocratic.chemistry.msu.edu) is designed to recognize and respond to student input. We are developing and assessing the effect of tutorials and formative assessment activities using beSocratic.