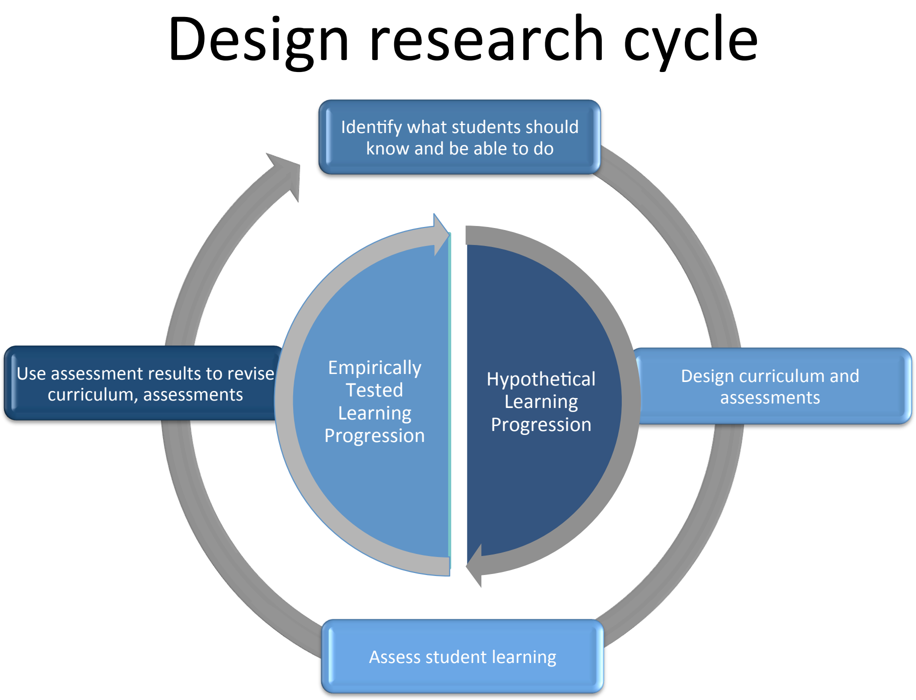
Evidence based approaches to teaching and learning are the focus of Dr. Cooper's research. One of the prime outcomes of this research is the development and assessment of evidence-driven, research-validated curricula. For example: ***Chemistry, Life, the Universe and Everything (CLUE)*** is a new general chemistry curriculum that 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 (3). 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 defining and developing the core concepts of chemistry and by combining them with scientific practices to produce performance expectations for students. Performance expectations require students to use their knowledge – that is, 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 (4). 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 (7). 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 (in preparation).

Similarly our recent work on the central (and cross cutting concept of energy) has focused on how students think about energy in chemical systems (1), 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 (2).



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Evidence-based Approaches to Improving Chemistry Education

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Selected Publications

1. *College chemistry students' understanding of potential energy in the context of atomic-molecular interactions*, Cooper. M. M. & Becker, N. M., *J. Res. Sci. Teach.* **2014**, *in press.*
2. *Using technology to collect and analyze data for research*, Cooper, M. M.; Underwood, S. M.; Bryfczyinski, S., Klymkowsky, M. W., *ACS symposium series*, **2014**, *in press.*
3. *Chemistry, Life, the Universe and Everything (CLUE): A new approach to general chemistry, and a model for curriculum reform*, Cooper. M.M. Klymkowsky, M.W., *J. Chem. Educ.*, **2013**, *90*, 1116-1122.
4. *An Investigation of College Chemistry Students Understanding of Structure-Property Relationships*, Cooper. M.M. Corley, L; Underwood, S.M., *J. Res. Sci. Teach.* **2013**, *50 (6)*, 699–721.
5. *Cooperative Chemistry Laboratories, a 20 year study*, Cooper. M.M.; Sandi-Urena, *ACS Symposium Proceedings* **2014**, doi: 10.1021/bk-2013-1145.ch004
6. *The Trouble with Chemical Energy*, Cooper, M.M., Klymkowsky, M.W., *CBE Life Sci. Educ.* **2013**, *12(2)*, 306-12.
7. *Development and Assessment of a Molecular Structure and Properties Learning Progression*, Cooper, M. M.; Underwood, S. M.; Caleb Z. Hilley, and Michael W. Klymkowsky, *J. Chem. Educ.* **2012**, *89(11)*, 1351–1357.
8. *Development and validation of the Implicit Information from Lewis Structures Instrument (IILSI): Do students connect structures with properties?*, Cooper, M. M.; Underwood, S. M.; Hilley, C. Z., *Chem. Educ. Res. Pract.* **2012**, *13*, 195-200.