A Cross-Faculty Symposium on Science Teaching and Learning: Theoretical and Practical Perspectives

Flynn research group's work in organic chemistry education

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Abstract:
Research has found that organic chemistry students struggle to develop deep conceptual understanding of chemistry. Our group seeks to understand, improve and support students' learning and experiences through innovative curriculum design, pedagogical approaches, and new open access learning tools. In our research, three main frameworks guide our work: (1) Theory of meaningful learning, (2) Chemistry's triplet, and (3) Learning outcomes-centered evaluation. During our presentations, we will share the research questions that guide our projects, which we briefly describe below.

(1) uOttawa's new Organic Chemistry Curriculum: Where are we and what's next?

Authors: Mark A. R. Raycroft, Alison B. Flynn

This project in centered on evaluating and improving the recently-created organic chemistry curriculum at the University of Ottawa. We are using learning outcomes as the foundation of an evaluation framework that explores the **intended, enacted, and achieved** aspects of the curriculum. To evaluate the **intended** curriculum, we are using fine-grained learning outcomes to assess intra- and inter-course alignment and evaluating the learning outcomes for evidence of science practices, crosscutting concepts, and disciplinary core ideas—components of the US Next Generation Science Standards. Next, we are evaluating the **enacted** curriculum by investigating which learning outcomes have been taught, practiced, and assessed in each course. Finally, we are designing a multi-dimensional approach to evaluating the **achieved** curriculum, to establish evidence for student success in attaining the learning outcomes. Results from this study will inform testable modifications that will be implemented and evaluated in future years.

(2) Patterns of reactions: A card sort task to explore students' connections across organic chemistry reactions

Authors: Kelli R. Galloway, Min Wah Leung, Alison B. Flynn

In one part of our new organic chemistry curriculum, chemical reactions are organized by the patterns how molecules react, rather than what type of molecule they are (the traditional way). To investigate how students are making connections across reactions within the new curriculum, we developed a card sort task in which organic chemistry students (N=16) were asked to sort cards showing reactions into categories. Participants were asked to explain the characteristics of each category

and their sorting process. The interviews were transcribed and analyzed and we will present findings to date.

(3) Exploring learning outcomes when using multimedia for chemistry reaction mechanisms

Authors: Amanda Bongers, Alison B. Flynn

Common approaches to teaching organic reaction mechanisms (the bond breaking and forming processes that form new molecules) involve showing static images on Powerpoint slides or drawing reactions out by hand, but neither method represents the dynamic nature of chemical reactions. Animations provide the opportunity to convey at least some elements of reaction dynamics, but student learning while using animations has not been well studied at the behavioural or the neurological levels. This presentation will focus on students' use of these animations for learning chemistry's language. Preliminary research into using brain imaging to explore the individuals' learning process will also be discussed.

(4) Meaningful learning, metacognition, and attitudes toward chemistry: finding ways to help students integrate knowledge and become stronger learners

Authors: Nicholas E. Bodé, Alison B. Flynn

Synthesis-type problems are among the greatest challenges in organic chemistry courses; even students with strong content knowledge can struggle to integrate their knowledge and may lack problem-solving strategies. The goal of our research is to improve current practices in how synthetic problem solving skills are taught to novices, so that they are better able to integrate their chemistry knowledge and achieve metacognitive and strategic skill learning outcomes. We offered three separate workshops to Organic Chemistry II students, which guided students through synthetic problem solving activities in three formats. Each workshop was conducted using a group active learning format, a decision we based on social constructivist theories of learning, and the benefits observed after implementing this format in a broad variety of flipped classrooms. We will present our research questions, methods, findings, and implications for instruction.