On the Structure of Students’ Mechanistic Reasoning in Organic Chemistry

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While many studies report on students’ difficulties with mechanistic reasoning in organic chemistry, there remains much to be learned about the structure of their mechanistic reasoning. The theoretical framework we developed, based on theoretical considerations in philosophy of science, provides a new approach for analyzing and scaffolding the structure of students’ mechanistic reasoning.

Philosophy of science describes mechanisms to be composed of entities, e.g. molecules, and activities, e.g. transformations of molecules. Chaining is a reasoning strategy used by scientists to reason about unknown activities based on known entities and vice versa. It mirrors the directionality of mechanisms and thus informs analysis of forward and backward reasoning patterns. In a qualitative, secondary data analysis, we investigated how undergraduate organic chemistry students use chaining and in what ways this reflects their professor’s expectations. Students mostly fulfilled their professor’s expectations but also employed backward chaining in inappropriate contexts. Interestingly, causality that connects electronic structure with energetics and is necessary to differentiate between appropriate and inappropriate contexts was missing in students’ reasoning and in their professor’s expectations.

Philosophy of organic chemistry divides mechanistic reasoning into structural and energetic accounts. Within structural accounts of comparative mechanistic reasoning, one constructs relations between differences of two entities and changes that occur during an activity both entities undergo. In a qualitative interview study, we revealed how students change from reasoning about structure to reasoning about energy when explicitly asked to do so, and how the relations they construct can be characterized. In a teaching experiment, we demonstrated that the framework can be used to scaffold students’ construction of multiple relations.

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