Eliciting Abstraction: Designing a Qualitative Interview Situation for Theory Building

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Problem: Abstraction is a process by which a learner gives meaning to or extracts meaning from an object by extracting salient details, recognizing similarities, and developing generalities. A capacity for abstraction bolsters students' success in chemistry. We believe this is particularly true in undergraduate physical chemistry (p-chem), where the disconnect between conceptual and mathematical meanings of a concept is a salient, yet crucial, challenge for students. However, the domain-specific aspects of abstraction, particularly in problem solving, are undertheorized.

Research Question: How do physical chemistry students use abstraction for learning in problem solving?

Methodological Question: How can we design an interview scenario to best facilitate the emergence of abstraction?

Results: Framework for epistemic actions of abstraction in physical chemistry problem solving

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<tr>
<th>Concretizing</th>
<th>Manipulating</th>
<th>Restructuring</th>
<th>Generalizing</th>
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<tbody>
<tr>
<td>A + B = C</td>
<td>A + B = C</td>
<td>0</td>
<td>C &gt; A + B</td>
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<tr>
<td>C = S</td>
<td>A = C</td>
<td>B = C</td>
<td>B &gt; A, B = C</td>
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Actions increasing in abstraction

Adapted from Reference 6.

Practical Considerations:
- Interviewer plays an active role in sense-making and also needs to be analyzed.
- Need to be careful that interviewer probes do not push students into a “school game” frame, in which the students are trying to just figure out what the interviewer is thinking.

Theoretical Consideration: Support from a more knowledgeable other can scaffold students’ knowledge building. In interviews, scaffolding has been shown to facilitate students to reason more sophisticatedly than they do alone. This may be particularly useful to elicit abstraction.

Methodological Instantiation: Teaching interviews in which the interviewer asked probing questions to actively scaffold student reasoning; i.e., so the interviewer could scaffold student abstraction.

Example from Data:
“Interviewer: Okay. And so how can we find out with that, with those two factors [building on students’ explanation of the equations], whether the disease is going to spread or die out [requesting a conceptual bridge]?

Practical Considerations:
- Interviewer plays an active role in sense-making and also needs to be analyzed.
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Theoretical Consideration: Students working in groups are often capable of reasoning more abstractly than individuals alone, possibly because one of the members of the pair can behave as a more expert peer and support the other member to abstract. The two members may also bring unique resources to the problem that they can build on jointly as shared assets.

Methodological Instantiation: Two rounds of interviews with different problems, such that each individual was interviewed individually and as a pair; i.e., to maximize diversity of data sources and opportunities for abstraction.

Example from Data: "Okay. And so how can we find out with that, with those two factors [building on students’ explanation of the equations], whether the disease is going to spread or die out [requesting a conceptual bridge]?

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Theoretical Consideration: Productive problem solving in p-chem requires conceptual reasoning; however, many traditional p-chem tasks encourage algorithmic approaches, even when that is not the instructor’s intention. To elicit abstraction, a task should be designed that promotes both conceptual and mathematical engagement and that allows students to bring different resources.

Methodological Instantiation: A novel, difficult task that would require problem solving in which the rate application of equations would not be sufficient with the level of prior knowledge the participant population is expected to have; i.e., a task in which abstraction would be required for successful problem solving.

Example from Data: Given these rate laws, students were tasked with finding the ratio of SI that determined whether a disease was epidemic or died out (adapted from ref. 13):

\[
\frac{dS}{dt} = -rSI, \quad \frac{dI}{dt} = rSI - al, \quad \frac{dR}{dt} = al
\]

Practical Considerations:
- Unfamiliar, difficult tasks may be daunting.
- Students with a “school game” framing may try to map task to more familiar approaches (rather than abstract).

References and Acknowledgements

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