Little Learners, Big Concepts

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Why systems thinking?

Topics**:** *zone of proximal development, complex thinking, scaffolding*

Our world is made up of complex relationships and problems; therefore, it is critical to support reasoning about these systems. Critical thinking, reasoning, and creative problem solving are all skills that can be developed as students consider complex systems. When teachers utilize different question formats, visual aids (e.g., graphic organizers), and norms for engaging in systems reasoning, they can both support and reveal what students know about complex systems. These strategies are transferable across disciplines.

Background

The study focuses on how different questions support student reasoning of complex systems and in particular, whether sequencing questions reveal different aspects of students' reasoning.

Research Design

Three groups of five students each worked with the teacher using the BeeSign software to discover how honeybees behave in a complex system. After 30-40 minutes of instruction, students participated in individual interviews where they were asked a series of questions designed to encourage students to explain what would happen in certain scenarios in order to determine their understanding of the complex system.

Student interviews were then coded using two complex systems approaches, an agent-based perspective (Wilensky & Reisman, 2006) and the components, mechanisms and phenomenon framework (Sinha et al., 2012). Descriptive statistics highlighted the number of times agent-based codes, components, and mechanism (CM codes) were mentioned in student talk. To understand the likelihood that students were going to to mention a particular type of code in each question, the average students utterances per question were compared to the total number of coded concepts (i.e., odds-ratio analysis).

Findings

How do the different interview questions support student reasoning of complex systems?

A. Students' explanations generally focused on descriptions of components in a system, and less on mechanisms. This is still critical because systems understanding depends on the ability to describe fundamental components of a system.
B. Agent-based descriptions such as positive feedback, iteration, and path formation were more difficult to observe from student responses since this required inferencing.
C. Students' descriptions of components in the system decreased across the sequence of questions, especially when questions were redundant. Students' descriptions of

mechanisms, however, increased. This suggests that students are less likely to repeat themselves and focus more on aspects of mechanisms especially if the prompts support their thinking.

Are students' agent-based or mechanistic descriptions different depending on where they occur in the sequence (e.g., with or without prompting)?

A. Students generally required follow up questions in order to provide robust answers when asked to explain the mechanisms and agent-based descriptions. These follow-up questions took the form of revoicing statements and clarifying students' statements.
B. Needing follow-up questions may show that students do not realize what information the interviewer was initially asking about.
C. Providing students with opportunities for direct comparison prompted students to discuss the mechanisms of the system and often helped to identify students who understood complex systems and students who did not.

How does this research translate to my classroom?

Problems that learners might face when learning about complex systems:

1. Too much focus on components or surface-level explanations.
2. Not understanding the norms of scientific practices.
3. Inability to recognize gaps in knowledge.
4. Students know an idea but are not able to articulate this understanding effectively or in the traditional 'expert' way.

Potential solutions:

1. **Use visual aids**
    a. Visualize the problem space and identifying parts/components of it
    b. Identifying relationships between parts of the problem
    c. Examining WHY relationships or impressions exist
2. **Generate classroom norms**
    a. Being held accountable to claims and ideas presented
    b. Being ok with being wrong in initial beliefs/understandings & recognizing gaps in knowledge
    c. Supporting a "change" mindset: Going beyond personal impressions and 'first ideas'. Suspending initial beliefs and impressions. Willing to reconsider the issue from a different perspective
3. **Use specific types of prompts**
    a. Revoicing strategies: Including wait time & positive feedback (e.g., mhm, nods, etc.)
    b. Unpacking student statements, engage with their ideas and validate these ideas
    c. Sentence starters

You could find the Infographic of this paper here.

Source

Danish, J., Saleh, A., Andrade, A., & Bryan, B. (2017). Observing complex systems thinking in the zone of proximal development. *Instructional Science, 45*(1), 5-24.