The Impact of Scaffolding on Simulation Assessment Performance for Systems and System Models

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Abstract: Systems and System Models are prominent features of science education. This case study examines the performances of students using a computer-based simulation summative assessment on ecosystems and compares their performance to a parallel verbal task in which scaffolding is included by the interviewer. This study reveal that students may possess more developed understandings of complex systems than demonstrated in their written responses.

Introduction

With the growing need to reform science assessments there has been a rise in simulation-based assessments. Computer-based summative assessments focus on innovative assessments which can be created from this technology (Quellmalz, Timms, & Buckley, 2009), and has been considered to be well-suited for the study of complex concepts within science domains such as Systems and System Models. In the process of learning these concepts, students often display a shallow understanding of a construct, however with assistance, provided through scaffolds, they may be able to showcase a deeper understanding of these science concepts (Greeno, 2015). The notion of scaffolding introduced by Vygotsky (1978), provides help to learners which enables them to demonstrate higher levels of understanding that otherwise would not be possible without this assistance. For this case study, we seek to explore the following research questions: (1) *To what extent do students' written responses in simulation-based assessments reflect their understanding of complex systems?* (2) *What is the impact of scaffolds on learners' ability to demonstrate their comprehension of complex systems?*

Methods

Participants included 15 males and 15 females divided among grades six, eight and nine, were randomly selected to participate in a 30-minute computer-based simulation assessment focused on ecosystems. Upon completion, students engaged in a 20-minute semi-structured interview in which they verbally responded to a scenario designed to be parallel to that of the computer-based simulation. Interviewers provided prompts to help elicit responses from students. Oral and written responses were subsequently scored using learning progressions (LPs). For this case study, we selected, one 6th grade male participant, Jeffery, and one 9th grade female participant, Ann.

Findings

Case study 1: Jeffery's written responses were scored and assigned an overall learning progression of Level 1 as he provided brief descriptions of the phenomena, components and the mechanisms of the overall system. Jeffery only identified components and he neglected to discuss the relationship between components. Additionally, mechanisms of the system were not addressed. Having the student be able to describe why this control measure is not effective is paramount to his beginning to understand the complexities of systems. Jeffery's answers denote only a surface level of understanding. However, in the scenario presented in the interview, with the addition of prompting (indicated in italics in Table 1), Jeffery was able to expand his ideas within this scenario and better describe his understanding of the system. Jeffery attained an LP Level of 4 for his verbal responses. The interviewer prompted the student to think beyond the single interaction between the salmon and sea carp thusly providing an opening for Jeffery to elaborate his understanding. Overall, Jeffery produced a more developed answer by including an unmentioned impact on bears (which would be categorized as a mechanism), resulting in the verbal scenario obtaining an LP of Level 4.

Case study 2: This case involved Ann, a 9th grader. Here, the student also showcased a very limited understanding of systems and system thinking reflected in brief and under-developed written responses. These answers were scored as an overall LP of Level 1. Her verbal responses, however, considers other possible outcomes for the components in the scenario, revealing the student's thinking of a complex system as she moves from a general, basic understanding to a more developed way of thinking of ecosystems. Ann's response not demonstrating a deep understanding of the system, prompted the interviewer to reiterate the question (Table 1). Asking the question again encouraged the student to expand her response revealing her understanding of a possible

mechanism in the scenario. Although Ann was not able to achieve the highest possible LP Level of 4, she did move from Level 1 in her written responses, to Level 3 in the interview.

Table 1: Excerpts from Student Interview with Jeffery (J) and Ann (A) with the Interviewer (I)

Interview with Jeffery	Interview with Ann
(I) Why would the number of salmon be decreasing while the number of sea carp increases? (J) The sea carp are eating the salmon. (I) Mm-hmm (affirmative), that's one possible thing. *Any other possible options?* (J) The bears don't eat the sea carp, but they eat the salmon. (I) Yeah. What other ways might the park be able to help the salmon population? (J) Put more salmon in the river and not a lot of fishes and well, only stuff that the sea carp eat. Not stuff that salmon eat. (I) *Right. So in that way the sea carp would feed on what?* (J) Just put a bunch of other fish in there so they don't try to eat the salmon all the time.	(I) Why may the number of salmon be decreasing while sea carp increases? (A) The sea carp probably eat them. (I) *Any other reasons?* (A) Maybe they eat the same kind of food? (I) And how would this affect the number of bears? (A) Or if the, if the salmon aren't going to be there, the bears are going to leave to go find some somewhere else to eat. (I) *And if they can't leave, what happens?* (A) They get starved to death. (I) The park ranger says that they have started to allow fishermen to fish in the river to try and catch sea carp. Why would this strategy be helpful to the salmon? (A) Because they're obviously the reason why they're dying out. So if there's less of them, it'll be better for salmon. (I) *How would this benefit the salmon? Not having the sea carp?* (A) They would probably have more food to survive on.

Discussion and implications

It is clear from this case study that the students possessed the knowledge and understanding of the questions being posed, but they required help, through prompting, to provide a response sufficient to achieve a higher LP, signifying more sophisticated levels of systems thinking. This study highlights the importance of scaffolding and the shortcomings of traditional assessments and how they may not be designed to elucidate our learners' true potential. Given this, educators and researchers need to be cognizant that we design assessments which effectively elicit responses reflecting learners' understanding of science constructs. Simulation-based assessments are considered ideal for summative evaluations. The results here, however, suggest that such may be better suited as formative evaluations because they may surface misconceptions in learning, requiring intervention by the instructor. By juxtaposing students' prompted and unprompted answers to systems thinking, a lot can be gained through engaging students in scaffolded discussions, underscoring students' more sophisticated understanding than evidenced by their written responses.

References

Greeno, J. G. (2015). Commentary: Some prospects for connecting concepts and methods of individual cognition and of situativity. Educational psychologist, 50(3), 248-251.

Quellmalz, E. S., Timms, M., & Buckley, B. (2009). Using science simulations to support powerful formative assessments of complex science learning. In annual meeting of the American Educational Research Association. San Diego, CA.

Vygotsky, L. S. (1978). Mind in society: the development of higher psychological processes. Cambridge: Harvard University Press.

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