Conceptual Goals While Using a Simulation: Three Different Sources and Learning Outcomes

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Abstract: Although there is a broad research base demonstrating positive science learning outcomes from simulation use, less is known about the learning processes that may mediate these outcomes. This study investigated the source of conceptual goals that students pursued while using a simulation. Using a case study approach, we found that student goals were from three main sources: instructional materials, self, and instructor. Findings suggest that self-selected conceptual goals may result in more stable knowledge.

Introduction and theoretical framework

Although there is broad consensus that computer simulations are effective for promoting science learning outcomes, less is known about mediating learning processes (Rutten, van Joolingen, & van der Veen, 2012). Thus, this study investigates sources of conceptual goals that students pursue while using a simulation and their implications for learning outcomes. In addition, this study involves investigating student engagement in constructing explanations and modeling, which is timely and relevant because these are two practices that are emphasized in the Next Generation Science Standards (NGSS Lead States, 2013). This study addresses the following research question: *What are sources of the conceptual goals that students pursue while using a seasons simulation to model and construct explanations?*

This study is framed by a view of conceptions as dynamically emergent structures (Brown, 2014). In this view, there is unison of seemingly dichotomous perspectives on student conceptions as fragmentary and theory-like, and it suggests affordances of examining conceptions in multiple ways. Importantly, this view suggests that conceptions "are dynamically emergent from the interactions of conceptual resources" (Brown, 2014, p. 1473). This dynamic view of conceptions highlights the importance of closely examining the contexts in which conceptions are developed.

Method

This study was conducted from an interpretivist paradigm (which can be considered a subcategory of the qualitative research paradigm). Accordingly, this study used instrumental case-study methods (Stake, 1995) to investigate the research question. The data for this study come from video observations and interviews. Video recordings were made of one group of three middle-school students using a simulation intended to help them develop explanations for causes of the seasons. The video was combined with synchronized screen recordings, so it was possible to see what students were doing within the simulation. Video recordings of individual students giving explanations of the seasons after using the simulation were also included in the data set. The classroom teacher was asked to select students who had permission to be video recorded to work in groups. The study took place during normal classroom instruction of an eighth-grade astronomy unit in a public middle school located in the Midwestern United States. During the study, students used a novel learning environment called a gesture-augmented simulation. This type of simulation differs from conventional simulations in that it affords interaction using hand motions rather than a mouse or trackpad. While students were using the simulation, they were provided with a worksheet that indicated settings to select in the simulation windows to create various "setups." The worksheets also asked students to focus on specific aspects of the simulations such as depictions of the angle of light rays or spacing of light rays hitting a patch of ground.

Findings

Case analysis showed that there were three main sources for the conceptual goals that students pursued while using the simulation: (a) instructional materials, (b) self, and (c) instructor. Two of these categories are illustrated in the following sections.

Conceptual goals from instructional materials

In this episode, students used settings in the simulation that were listed on a worksheet, which asked students to focus on the angle of light rays.

S2: June is when it's the most straight down [gestures to show steep angle of light rays], and

S1: Yeah.

S2: December's like the lowest [clicks and drags the earth in its orbit from June to December and then to March and back to December].

S3: Yeah. When you go back to March it gets higher, then it gets lower.

S1: Mmhmm.

In this episode students noticed the difference in the angle of the light rays between summer and winter for the selected city. All students in the group expressed agreement for the idea, and then they continued with the activity without further discussion of the underlying reasons for the difference in the angle of the light rays.

Conceptual goals from self

In this episode, one student in the group spontaneously changed settings in the simulation.

S2: [clicks to load an earth view in a third window that had previously been empty] Hey, that's cool. Look at that.

S1: Oh, whoa! Use your hand, use your hand now.

S2: No, I just want to watch it.

S1: No, I want to see. I wanna use my hand.

S2: We're the closest in June. Dang. We're the closest to the equator in June.

S3: We are?

S2: We're the closest to the equator in June.

S1: [uses gesture control to view simultaneous changing of light ray angle, orbit, and earth] That's so cool.

In this episode one student changed settings in the simulation to investigate an idea that seemed to come up spontaneously. When he loaded the "earth view" he mistakenly identified the line depicting the earth's orbit as the equator. After watching the simulation for a few moments, the student concluded that his city moves closer to the equator in summer and farther from the equator in winter. Another student in the group expressed surprise and interest in this idea ("We are?") while the other group member did not acknowledge the comment.

Conclusions

This study responds to a need to better understand learning processes when students use simulations by showing how students pursue conceptual goals from various sources. These results are important because they show that ideas that were generated from self-selected conceptual goals seemed to be more salient than ideas generated from other sources. Returning to a dynamically emergent perspective of conceptions (Brown, 2014), this may suggest that conceptions from self-selected goals may form stronger "attractor" states for students, and thus, those ideas may be the most salient ones used in explanations provided by the student. This raises new issues for practices such as modeling and explanation with regards to the extent to which learners converge on shared understanding of phenomena. Additional research is needed to further explore connections between the source of conceptual goals, as well as other aspects of learning processes, and student learning outcomes.

References

Brown, D. E. (2014). Students' conceptions as dynamically emergent structures. *Science & Education, 23*, 1463–1483.

NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states*. Washington, DC: The National Academies Press.

Rutten, N., van Joolingen, W. R., & van der Veen, J. T. (2012). The learning effects of computer simulations in science education. *Computers & Education, 58*, 136–153.

Stake, R. E. (1995). *The art of case study research*. Thousand Oaks, CA: Sage.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No.DUE-1432424. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.