Exploring the Affective Dimension of Integrating Computational Modeling with Science Learning

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Abstract: There is a movement in science education towards engaging students in authentic disciplinary practices, including computational modeling. This paper reports on a pilot study from a larger project in which we designed computational modeling curricula for public high school STEM classrooms. In this poster, we analyze video data of a pair of students' computational modeling to illustrate the role that epistemic emotions of surprise and uncertainty played in them conducting their own investigations.

The most exciting phrase to hear in science, the one that heralds new discoveries, is not "Eureka" but "That's funny..." – Isaac Asimov

Introduction

In K-12 science education, there is a movement towards designing learning experiences that mirror the work of professional scientists, including the practice of computational modeling (NRC, 2012). Work on integrating computational modeling into K-12 science classrooms has shown positive learning gains (Hutchins et al., 2020). However, this work has largely overlooked the role that emotions play, both for students and for professional scientists, as they computationally model phenomena.

Learning science necessarily involves students feeling and managing knowledge-related emotions such as uncertainty and doubt - collectively referred to as *epistemic affect* (Jaber, 2015). Epistemic emotions such as uncertainty, surprise, curiosity, and confusion can greatly impact students' approach to science, including their willingness to make sense of phenomena (Radoff, Jaber, & Hammer, 2019). Finding synergies between computation and physics necessitates attending to and being responsive to students' affect as they navigate the intersection of these domains.

Methods

This poster is part of a larger project to co-design computational modeling curricula for high school science classes in a large metropolitan district. This poster focuses on a pilot study of a Physics teacher's implementation of a unit on global warming. The driving question for the 5-lesson unit was: *Can we stop global warming?* Students worked with a computational model in StarLogo Nova to explore mechanisms underlying climate change, including the greenhouse effect and albedo feedback loops due to melting ice. The teacher implemented the unit in four sections with about 25 students each. We designed and administered a pre-posttest to assess student learning of science content and computational modeling skills. The analysis of pre- and post-tests revealed significant learning gains (Paired t-test $t(56) = 5.066$, $p<.001$), with biggest gains among female students. We looked to video analysis of student conversations for insights on how these gains may have happened.

Six student pairs were video recorded in each section during the unit, with the pairs selected largely based on convenience of camera placement among consenting students. Videos chosen for analysis were selected from the video files with audible conversations and visible computer screens. We used these videos to create content logs (Jordan & Henderson, 1995), which were used to select clips where students had extended conversations. Through an iterative process of collaborative viewing (Jordan & Henderson, 1995), we found episodes where students seemed to be predominantly in a sense-making mode (Scherr & Hammer, 2009) while engaged in synergistic learning of physics and computation (Hutchins et al., 2020). This clip shows students encountering surprising behaviors of their model and spontaneously investigating their causes.

Analysis and results

This episode comes from the last day of instruction. Two female students engaged in pair programming, with Dora taking the role of "driver" of the computer model with Natalia, as the "navigator", monitoring the group's progress on the lesson's worksheet. The pair had just investigated how albedo (reflectivity of the Earth's surface) would affect Earth's equilibrium temperature. They identified the Earth's equilibrium temperature on a graph of temperature vs. time, by looking at where the temperature curve "levels off" to a nearly horizontal line, though small fluctuations continued. As prompted by their worksheet, the students toggled on the "Ice Melting" button and discussed its effects as they played with the model. They noticed that when they hit the button the graph "actually" flatlined - a straight horizontal line with no fluctuations at all.

Line	**Speaker**	**Speech + ((Action))**
1	Dora:	You see? It's melting the ice! ((pointing to ice on the simulation screen))
2	Natalia:	Mmhm
3	Dora:	So it'll like ACTUALLY flatline ((points at very flat part of graph and zooms in))
4	Natalia:	Hold up. Click Run/Pause again? Cuz it only happened after you hit Run/Pause-
5	Dora:	'Cuz look! ((Still pointing at flat part of the graph))
6	Natalia:	Click Run/Pause again? ((Dora clicks Run/Pause again)) Yeah cuz every time you click Run/Pause it like, flatlines
7	Dora:	No, look! ((pointing at a bump in the graph after the flatline)) ((Dora keeps clicking Run/Pause, new flatlines appear after the bump))
8	Natalia:	See?
9	Dora:	That's weird.
10	Natalia:	Yeah that *is* weird.

The students noticed a strange behavior and spontaneously and fluidly designed their own investigation to explore the cause of it. Epistemic affect drove the students' investigation in this episode. They were surprised that the graph was flatter than usual and zoomed in on the graph where the fluctuations were missing from the horizontal line (Line 3). This led them to investigate further and run multiple tests (Lines 4, 6, 7). While they do this, they form a hypothesis about why that might be happening (Line 7, "Yeah cuz every time you click Run/Pause it like, flatlines"). At the end of it, they agree that it is "weird", which conveys surprise, confusion, or perhaps a shared suspicion that the flatlines are an unexpected artifact of the model (Lines 9-10).

Epilogue: Waiting for the ice to melt

Immediately after the episode above, the pair is still confused about the source of the flatline and they decide to run the model again, but without pausing. They see without toggling Run/Pause there are no "weird flatlines" and conclude it is a problem with the toggle button. In the process, they also notice a new surprise - the ice does not completely melt when "ice melting" is toggled on. They then investigate whether that is a bug or a feature.

Conclusion and discussion

This video clip illustrates how moments of integrated learning of physics and computational modeling can hinge on how the students respond to uncertainty in the moment. We provided an illustrative case of how one student pair's response to uncertainty was to investigate until they found the source of the surprising result - whether it is a bug or a feature.

References

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