The Iterative Science and Engineering Instructional Model

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ABSTRACT

Science is a multidimensional endeavor that requires deep engagement with phenomena. Science, Technology, Engineering, and Mathematics (STEM) discoveries often advance through a fluid and messy process that includes iterations of science investigation, engineering design, and interdisciplinary collaboration. In contrast, most pre-college STEM instructional programs do not foster experiences that promote deep engagement with phenomena through iterations of science investigation, engineering design and collective feedback and sharing with others, including key stakeholders. This poster presents the Iterative Science and Engineering (ISE) instructional model and student learning outcomes when an ISE instructional unit was implemented in nine secondary classrooms.

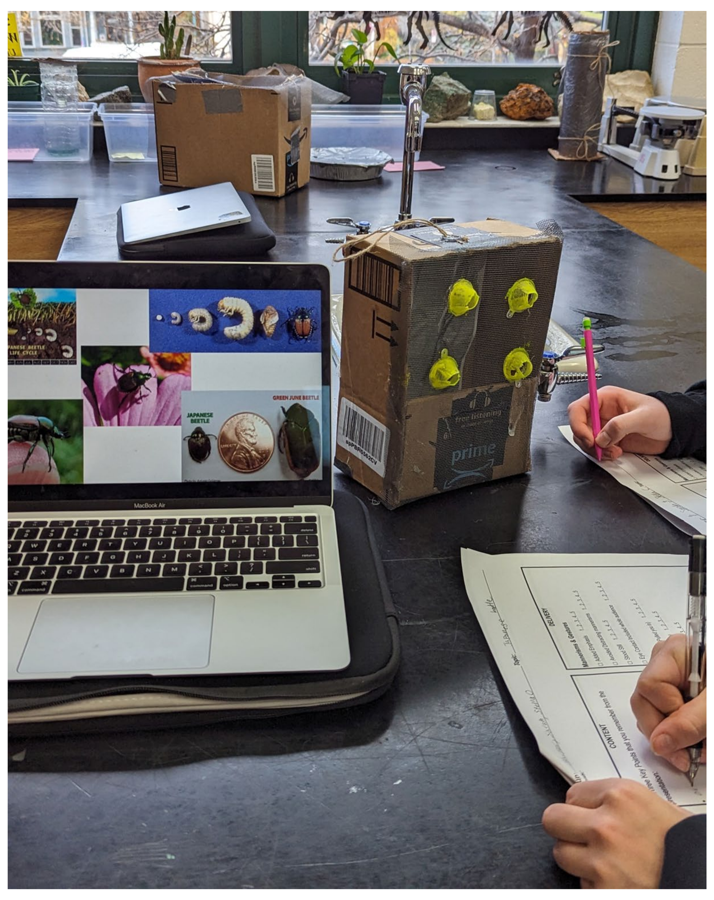
WHAT?

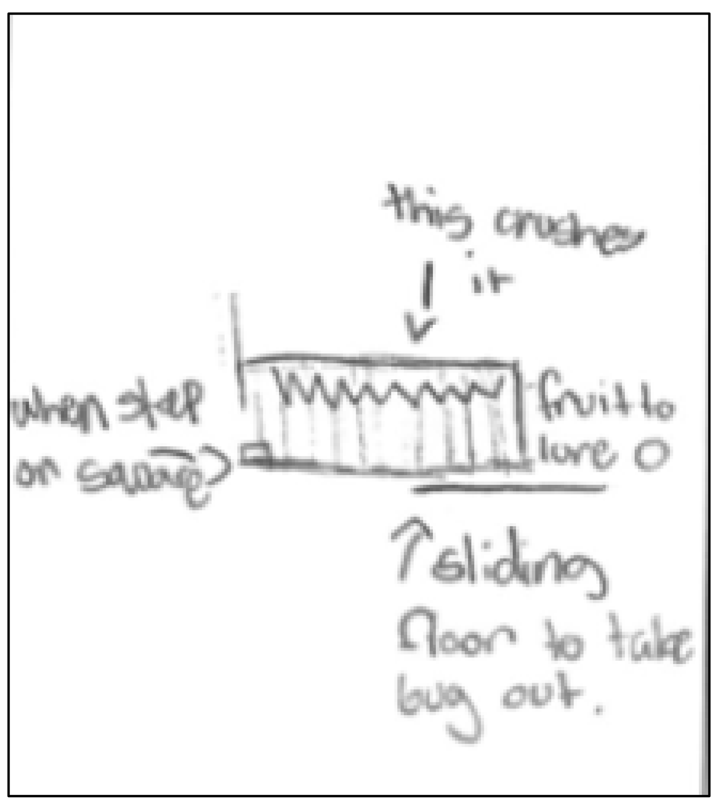
The ISE is an instructional model that interweaves phenomena-based 3D science investigation with 3D engineering design.

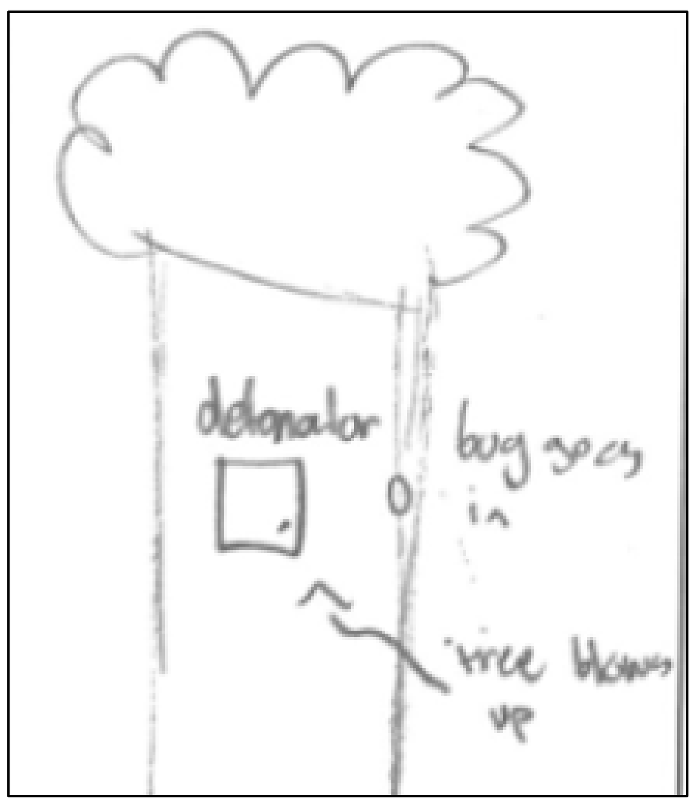
WHY?

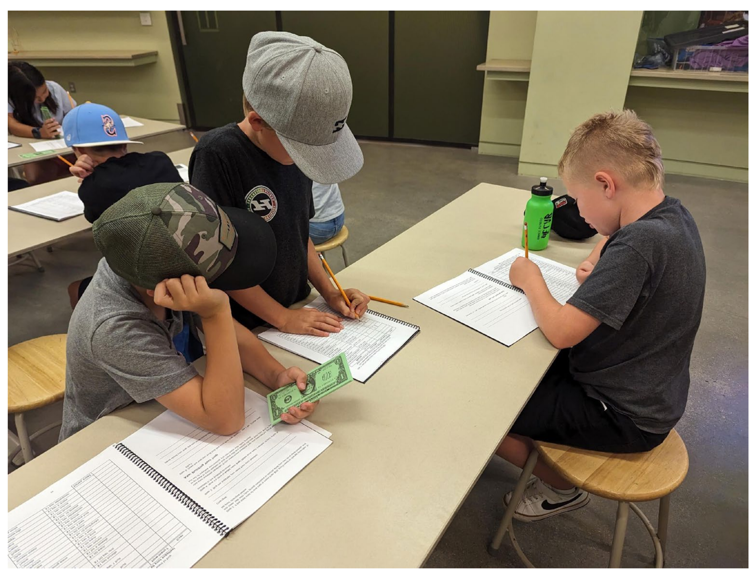
Recent research studies provide evidence that instructional materials and pedagogical approaches that engage students in science investigations or engineering design led to deeper conceptual understanding of scientific phenomena. Specifically, instructional materials that guide students to make sense of phenomena through three-dimensional (3D) science and engineering performances (NRC, 2012) and that provide opportunities for students to ask and address questions, participate in discussion, critique multiple explanations, and recognize multiple solutions lead to deeper conceptual understandings of scientific phenomena than traditional teaching methods (e.g., NASEM, 2019).

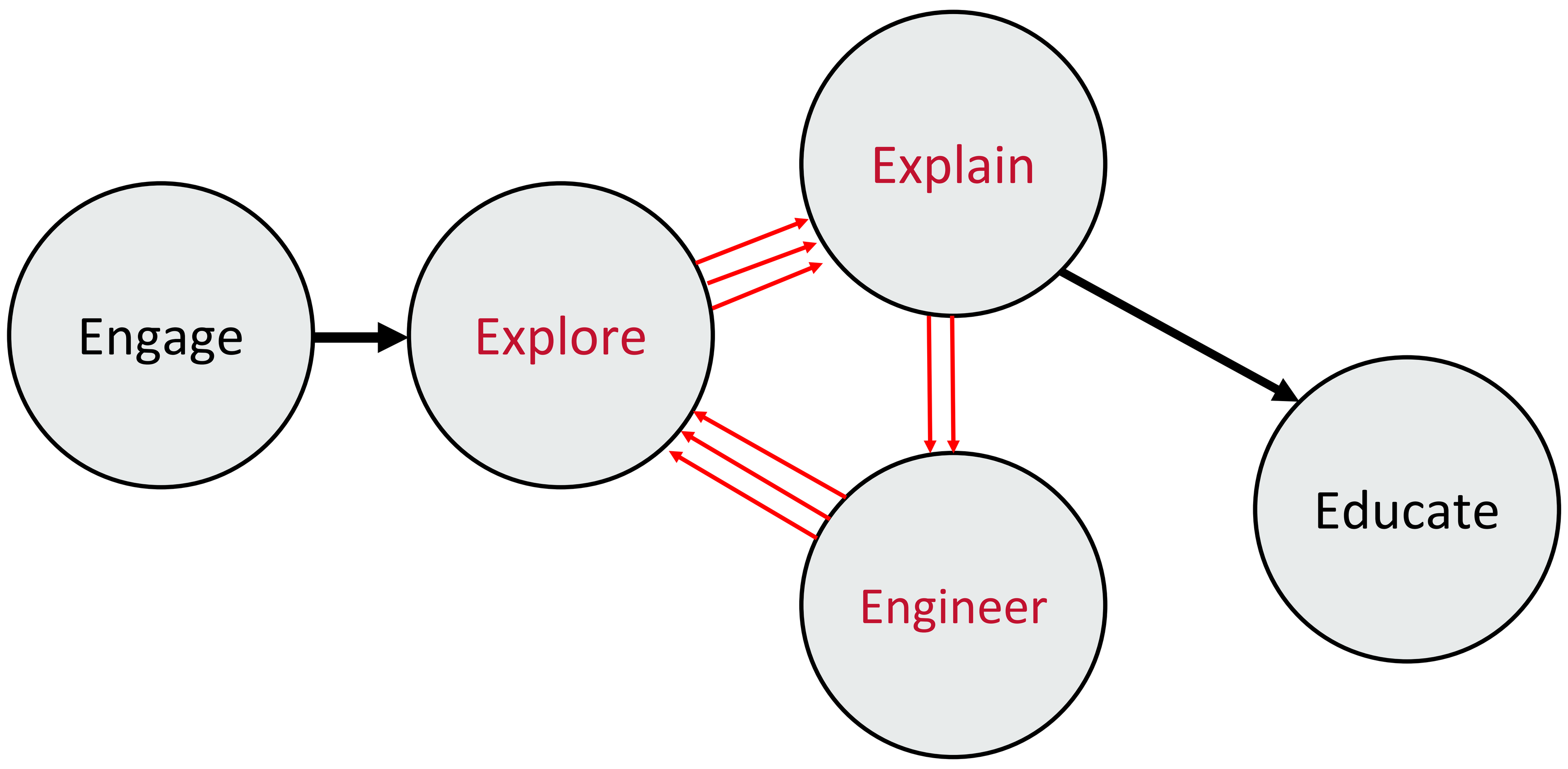
ISE in Practice











THE ISE INSTRUCTIONAL MODEL

Engage	Students ask questions about a phenomenon that engages their curiosity and provides a purpose for why they study this problem.
Explore 1	Students **collect data** to **use as evidence** for their problem.
Explain 1	Students **analyze data** and **use data as evidence** to **construct arguments** to address questions and **consider solutions.**
Engineer 1	Students **define a problem, design, and build a solution** to meets specific design constraints.
Explore 2	Students **collect data** to **use as evidence** to evaluate their first build (solution).
Explain 2	Students **analyze and use data** to **construct arguments** to address questions and **revise their solution**.
Engineer 2	Students **revisit their problem, design and build a second solution** that provides an improved or efficient design.
Explore 3	Students **place** and **collect data to use as evidence** of the **effectiveness of their solution.**
Explain 3	Students **analyze data** and **use their data as evidence** to **construct arguments** and determine solution effectiveness.
Educate	Students synthesize key ideas from **designs and data** to **educate** local stakeholders about their solution and local implementation.

STUDENT OUTCOMES

		Pretest		Posttest	
Grade	**Category** (max score)	Mean	SD	Mean	SD
Grade 9	Overall (19)	10.86	3.32	12.86	3.27
(n = 66)	Scientific Argument (9)	5.44	2.18	6.24	2.08
	Science - Other (7)	4.53	1.29	5.18	1.20
	Engineering Design (3)	0.86	0.88	1.45	0.96
Grade 7	Overall (19)	8.40	3.81	12.66	2.97
(n = 73)	Scientific Argument (9)	3.89	2.47	6.60	1.98
	Science - Other (7)	3.89	1.40	4.88	1.08
	Engineering Design (3)	0.62	0.79	1.18	0.84

Both groups made statistically significant improvements ($p < .01$) from pretest to posttest in all categories.
In this final DBR cycle when we added additional Explore, Explain, Engineer phases, students had statistically significant improvements in the Engineering Design pre-posttest task.