Innovate to Mitigate: Teacher Role in a Student Competition

Gillian Puttick, Brian Drayton, Santiago Gasco
gilly_puttick@terc.edu, brian_drayton@terc.edu, santoago_gasca@terc.edu
TERC

Abstract: The Innovate to Mitigate (I2M) project poses challenges for secondary-school students to design feasible, innovative strategies that mitigate CO_2 emissions and thus global warming. Design is informed by research on problem-based learning, pedagogy for which poses demands on teachers. This paper presents preliminary evidence about how I2M teachers supported student teams to engage in science and engineering practices.

Introduction

The Innovate to Mitigate (I2M) project (https://terc.edu/innovatetomitigate) poses design challenges in climate change mitigation for middle- and high-school students. Student teams propose a mitigation strategy, describe how they consider it an innovation, and how feasible it might be to implement. The design of the challenge is informed by research on problem-based learning and on participatory pedagogy (Tucker-Raymond et al., 2021). Our initial research (Puttick et al., 2017; Drayton & Puttick, 2018) suggests that this open challenge can galvanize creativity and engagement among young people, and support "3-D learning" (NRC, 2012). In this paper, we present preliminary findings about the experience of four teachers as their students participated in the 2021-2022 I2M challenge. We ask: (i) How did teachers perceive their role in supporting student teams engaged in open-ended design challenges that mitigate global warming?

Building teacher capacity to support problem-based learning

In PBL contexts that drive towards pre-determined learning goals, the challenges that face teachers result from the tension between grounding student work in a general question that has multiple possible investigation methods and is not bounded by a curriculum, and this desired "end point." In the I2M challenges, unbounded by content learning goals, the science practices (NRC, 2012) themselves are the articulated learning goals. In this context, the teacher acts as facilitator, asking meta-cognitive questions to guide students. We expected that teachers would need assistance in supporting PBL and in helping students to understand science as an "evidence-based, model and theory building enterprise" (NRC, 2012).

Context and methods

Teachers support students through several phases: Submitting an abstract that outlines a mitigation strategy online for public discussion, revising based on these discussions and developing a prototype over the next 3 months, and finally submitting a short video and paper. At 3 transition points, teachers were oriented to (i) the purpose of participant crowdsourced conversations to improve designs, (ii) mentoring strategies and supporting distributed expertise, and (iii) supporting student epistemic agency using "science-as-practice" (Stroupe, 2014).

Participants

The four experienced teachers in the study signed up 10 student teams. Ms. Rotham, a mathematics teacher at a parochial high school, was recruited as mentor by a transfer student in 12th grade, who had participated in I2M previously. Ms. Schaaf, an environmental science teacher in a large urban school district, had 5 teams participating in independent study for an upper-level course. Ms. Staples, a language arts teacher at a private school, had two middle school teams in her special needs class. Ms. Hayter, a science teacher in a large urban school district, had two middle school teams participating in an after-school club.

Data sources and analysis

Data included transcripts of teacher post-interviews that focused on teacher role, challenges faced by students and teachers, perceptions of student learning, motivation, and school-related constraints on participation. Three researchers independently applied a concept-driven framework to code all data (Spencer et al. 2014). Codes were teacher role (general aspects of teachers' role in supporting students), PBL (affordances and challenges of PBL), science practices (NGSS science practices). Researchers iteratively discussed coded data. After coding was stable, a researcher wrote an interpretive research narrative pertaining to each code. The research team discussed narratives to test inferences, identify area requiring further analysis, and maximize the value of the data.

Findings

Across diverse learning contexts, all 4 teachers described how supporting student engagement in practices primarily centered on various aspects of working with data, and on constructing arguments. Not surprisingly, younger students needed support in how to take and record data. Ms. Hayter reported, “I kind of gave them a little template […] any time that they tested, we would take pictures and then we would write a little tidbit about what happened.” Ms. Rotham’s independent study students needed help identifying variables, “they were challenged as to what are the variables we’re measuring, what’s the independent variable.” Both Ms. Hayter and Ms. Rotham reported that they also provided guidance about what to do with data once it was in hand. As Ms. Hayter put it, “there's a difference between data information, so you can have all these numbers, but actually putting meaning to it...” Furthermore, students needed to understand how to use data to build a persuasive scientific argument. For example, Ms. Rotham reported that she pushed her students to collect data from the prototype they were building, “you can't just build something and say it works,” in other words, the claim needed substantiation.

For the senior independent study students, providing empirical rationales for their claims (Sandoval & Millwood, 2005) was a challenge. Ms. Schaaf observed, “[it was] a little bit of a learning curve for them, because I don't think they're used to defending their arguments.” She reported that she pushed them on this, asking, “how can you support the claim that you're making…? Where is it coming from?”

Comments from three of the four teachers centered on the need to cede control (Puttick et al., 2015). Ms. Hayter’s comment was representative, “So [I was] very much hands-off. So that was a bit of a change for me where it's not on giving them as many instructions,” while Ms. Staples spoke about being challenged by the science, “I spent quite a bit of time studying so that I could help them understand the chemistry or the physics or whatever.”

Discussion and significance

Working with the wide range of subject areas and possible technologies that were determined by student project choice, teacher moderation was focused on the practices. This mostly freed the teachers to cede authority (Puttick et al., 2015) and effectively support student directed PBL. The teachers made effective strategic use of targeted procedural questions, suggestions of resources, and project management strategies to support students’ agency and capacity to conduct investigations. Within each context, McNeill et al. (2017) in a study focused on argumentation, found that teachers’ decisions sometimes focused on surface features of argumentation rather than understanding it as an epistemic practice (Stroupe, 2014). Our preliminary data indicate that these teachers understood this deeper meaning of argumentation as a science practice. Teachers’ guidance of argumentation practices will be one focus of future research.

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