



Research to Practice Article
Implementing STEM Design Challenges in Classrooms

Based on the published SSM Journal Research Manuscript: Supporting middle school teachers' implementation of STEM design challenges

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Overview

Interdisciplinary projects can be difficult to construct and enact in classrooms. This article provides insight into how teachers can collaborate with each other, and their students, to produce learning experiences that promote 21st century skills, mathematics, science, and engineering practices and engage all learners. Thirty-four middle grades teachers took up this challenge in the *Teachers Exploring STEM Integration* (TESI) project, a 2.5-year partnership with a local university.

The project began with a weeklong professional development session that introduced the teachers to STEM-focused design challenges (DCs), such as growing crystals for industry clients or using Lego robots to deal with rising sea levels due to climate change. Participation in these DCs allowed teachers to collaboratively reflect on content and discuss strategies, modifications, and needed supports for implementing these or similar activities in their classrooms. In a second weeklong session later in the summer, middle school students joined teacher teams each morning to collectively construct solutions to STEM DCs. In the afternoons, the teachers reflected on the implementation of the DCs and their role as facilitators of learning.

Each school year, teachers also received three additional days of professional development and met monthly as grade level teams within their building. These days provided continued learning opportunities for teachers and supported the planning, development and implementation of additional DCs within their classrooms.

Research Question

In 2010, President Obama's Council of Advisors on Science and Technology recommended principles for K-12 STEM education (Kennedy & Odell, 2014). These principles included initiatives to create STEM-related experiences that excite and interest students and to provide experiences that allow them to develop their own understanding of STEM ideas. These goals are key to engaging learners as constructive, concerned and reflective citizens.

Most teachers, however, have had little formal preparation on how to engage students in rich problem-based activities that integrate the STEM disciplines (Fulkerson, 2013). Further, instructional materials at the middle school level are primarily designed in isolation of other disciplines. Given the support teachers may need, this research sought to understand the ways professional development may enable teachers to implement STEM-focused DCs in their classrooms. Our research questions were:

- What benefits did teachers find in implementing STEM design challenges (DCs)?
- What challenges did teachers encounter in implementing STEM DCs with diverse students in a traditional school setting?
- What supported teachers' efforts to implement these DCs?

Discussion of Findings

To help address these research questions, teachers completed surveys following each professional development opportunity. In looking across survey responses, we gained insight on teacher perceptions about DCs in relation to 21st century skills, mathematics and science practices, student capabilities and teacher collaboration.

Teachers Value 21st Century Skills

STEM DCs present teams with real world problems requiring complex analysis and creative solutions. Such tasks provide a different learning experience as compared to most traditional math and science curricula. These opportunities allow students to engage in critical thinking, collaboration, and communication. Teachers in this project appreciated that the structure of DCs supported students in developing these “soft skills” needed for college and career readiness, even though specific mathematics or science content goals were sometimes sacrificed.

Teachers Used DCs to Emphasize STEM-focused Practices

The Common Core State Standards in Mathematics (Common Core State Standards Initiative, 2010) and the Next Generation Science Standards (National Science Teachers Association, 2013) provide a focus on mathematics, science, and engineering practices. The STEM DCs provided teachers a context for engaging students in these practices, such as creating models to represent real world problems and developing rational arguments for approaches to problem solving. Teachers noted how students were much more likely to persevere and problem solve on DCs compared to traditional assignments or class projects.

Teachers Developed New Appreciation for Students' Capabilities

Students who struggle with core academics often disengage from activities, leading to frustrations for both the student and the teacher. Students who participated in the second week of the summer sessions were targeted by teachers and principals as low achieving for the explicit purpose of illustrating students' capabilities when provided with enriching and motivating learning tasks. While most interventions for struggling students focus on skills remediation, STEM DCs provide students with an opportunity to use higher-level thinking strategies, thereby promoting engagement. Teachers commented that students were engaged in the task, presented innovative and creative solutions to problems and developed meaningful understandings of mathematics and science concepts.

Teachers' Collaboration and Integration Was Critical to DC Implementation

While implementing STEM DCs, teachers struggled with the need to alter their lesson designs, embed appropriate mathematics and science content into the engineering learning experience, and change instruction from teacher-centered to a more open learning environment. In facing these challenges, teachers often turned to their colleagues for support. The creation of mixed disciplinary teams allowed each teacher to bring a unique set of content background, skills and experiences to the group. This integration provided valuable support as teachers navigated the implementation process through the school year.

Implications for Practice

Based on the values, challenges, and supports identified by teachers in this project, we offer specific teacher actions to support the implementation of STEM DCs in classrooms.

Recognize that STEM DCs Are a Different Type of Classroom Activity

When learning experiences change drastically, there will be conflicts with existing or traditional school structures. Slowly integrating project-based learning activities that promote student engagement with 21st century skills, such as collaboration, critical

thinking and communication, will support student success.

- Begin with small DCs to introduce engineering design.
- Embrace the messiness and ambiguity that comes from real-world problem situations.
- Develop classroom norms for engaging in open-ended problems and student-led discussion.

Focus on Engaging Students in Practice-based Learning Goals

Teachers and students who implemented STEM DCs value the real world connections and problem solving. Through inquiry, students engage in practice standards that encourage deep, transferable thinking.

- Become familiar with content-specific practices and look for ways to integrate science, mathematics and engineering practices.
- Be willing to “let go” of content pressures to provide activities that focus on the practices.
- Embrace process-oriented student-learning goals such as problem solving and perseverance.

Set High Expectations and Provide Access for All Learners

DCs provide engaging activities that build conceptual understanding for all learners. All students can succeed when given opportunities to participate in DCs that highlight strengths that otherwise might be overlooked.

- Believe that all students are capable and benefit from engaging in difficult problems.
- Provide scaffolds and organizers to help student groups stay on track throughout the engineering design process.
- Support students' team building and communication skills.

Build Collaborative Teams across Content Areas

Teachers implementing STEM DCs value the collaborative nature of the projects and receive support from school-based teams.

- Work with grade-level colleagues to find natural connections between mathematics and science content.
- Develop common vocabulary and identify overlapping components of the practices.

- Seek help from administrators and staff to create flexible structures and schedules that allow sufficient time for planning and implementation.

Resources for implementing STEM DCs

1. Buck Institute for Education resources for project-based learning. <http://bie.org/>
2. Commonalities Among the Practices in Science, Mathematics and English Language Arts. NSTA. <http://nstahosted.org/pdfs/ngss/PracticesVennDiagram.pdf>
3. Bybee, B. (2010). *Advancing STEM Education: A 2020 Vision*.

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