Collaborative Research: Design and Development of a K-12 STEM Observation Protocol

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Self-Enroll in the STEM-OP Canvas Course by snapping a picture of the QR code!

Project Description

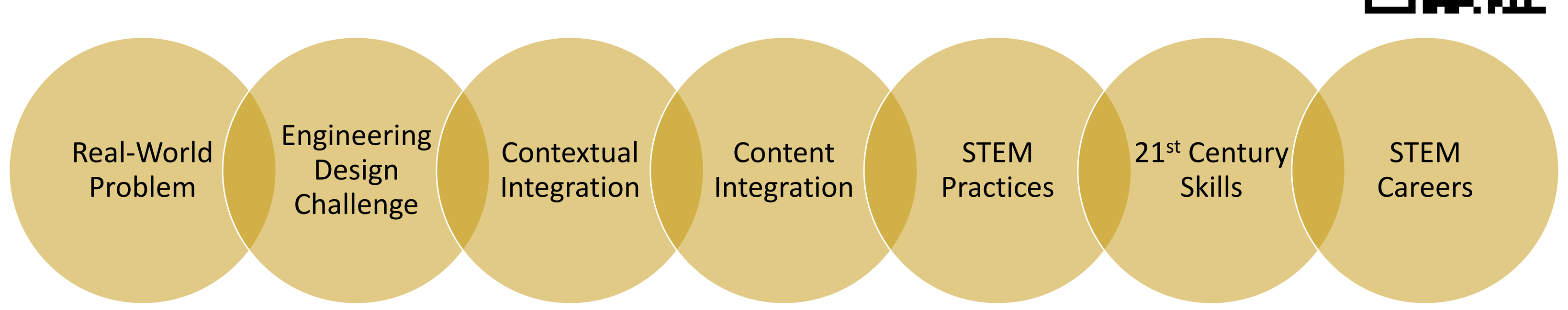
This project aimed to create a valid and reliable observation instrument focused on integrated STEM educational approaches. The STEM Observation Protocol (STEM-OP) was designed for use in K-12 science and engineering classrooms where integrated STEM education is being implemented. The purpose of the STEM-OP is not to assess quality of teaching, but to understand the degree of integrated STEM within an observed teaching event. Although the STEM-OP can be used for research purposes to measure and improve integrated STEM practices, it was designed for a variety of uses including pre-service methods courses, in-service teacher professional development, classroom coaching, and curriculum development. The final products of our project included developing an online platform for new users to learn about the STEM-OP and our conceptual framework for integrated STEM education.

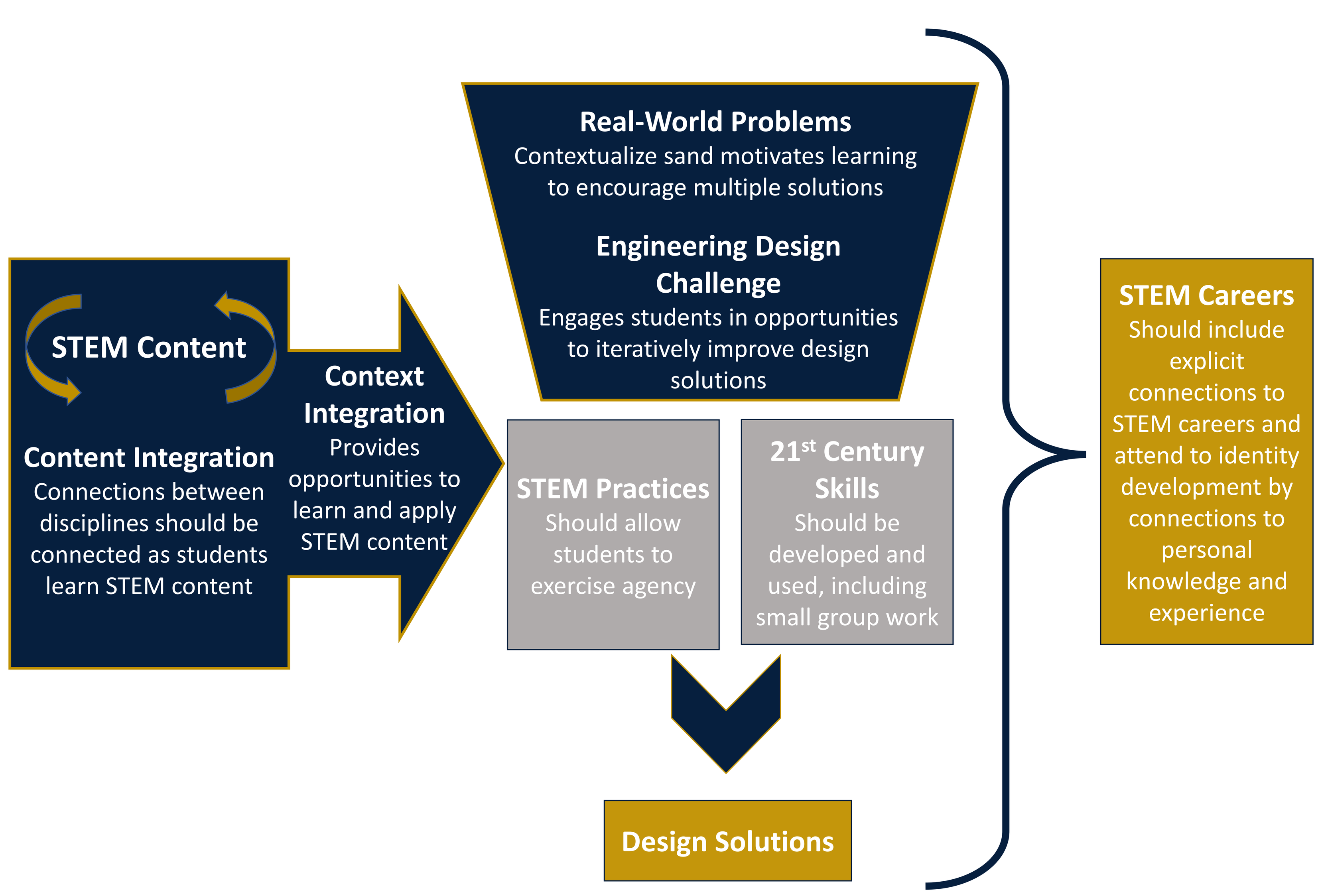
Conceptual Framework

As part of our work, we first had to develop a framework for defining integrated STEM education as no one definition exists. The framework arose out of the extant literature, drawing primarily from Kelley and Knowles' (2016) definition that broadly defines STEM education as "the approach to teaching the STEM content of two or more STEM domains, bound by STEM practices within an authentic context for the purpose of connecting these subjects to enhance student learning" (p. 3). To expand upon and provide more specifics to that definition, our framework centralizes engineering design in which students are presented with an authentic problem to solve. This framework includes seven key characteristics for integrated STEM education.

Key Characteristics of Integrated STEM Education

Roehrig et al. (2021)





Designing the STEM-OP

Our work included access to a large suite of classroom videos (> 2,000) of integrated STEM teaching collected from a previous NSF project (DRL-1238140). We used these videos to assist in the development of the STEM-OP, which followed five major steps over approximately 18 months.

Overview of Instrument Development Process

Dare et al. (2021)

Step 1: Establish an Integrated STEM Conceptual Framework
- Reviewed the existing literature related to integrated STEM education
- Used framework to develop and refine items throughout

Step 2: Develop and Refine Initial Items
- Developed initial codes from video observations
- Collapsed and revise codes
- Established initial draft of 18 items
- Wrote item scoring levels and reduced items to 16 with 5 scoring levels

Step 3: External Review and First Pilot
- Requested and received external feedback, focused on face and content validity
- Reduced the numbers of items to 13 with 5 scoring levels
- Conducted iterative piloting and revisions of protocol

Step 4: Second Pilot, Review, and Revisions
- Completed training on 13-item protocol with 5 scoring levels
- Continued refining
- Requested and received second external review
- Completed first pilot of IRR
- Reduced number of items to 10 with 4 scoring levels

Step 5: Establish Inter-Rater Reliability
- Completed training on 10-item protocol with 4 scoring levels
- Seven coders individually watched and scored 104 video observations
- Calculated IRR to satisfactory performance

STEM-OP Key Elements

- 10 observable items that focus on teacher actions and implementation
- Brief item description
- 4-point Likert Scale (0-3) with detailed descriptions of each level
- A Companion Guide to assist observers

Item	Item Name	Krippendorff's Alpha (α)
1	Relating Content to Students' Lives	0.654
2	Contextualizing Student Learning	0.736
3	Developing Multiple Solutions	0.805
4	Cognitive Engagement in STEM	0.634
5	Integrating STEM Content	0.580
6	Student Agency	0.725
7	Student Collaboration	0.724
8	Evidence-Based Reasoning	0.699
9	Technology Practices in STEM	0.725
10	STEM Career Awareness	0.870

Example STEM- OP Items

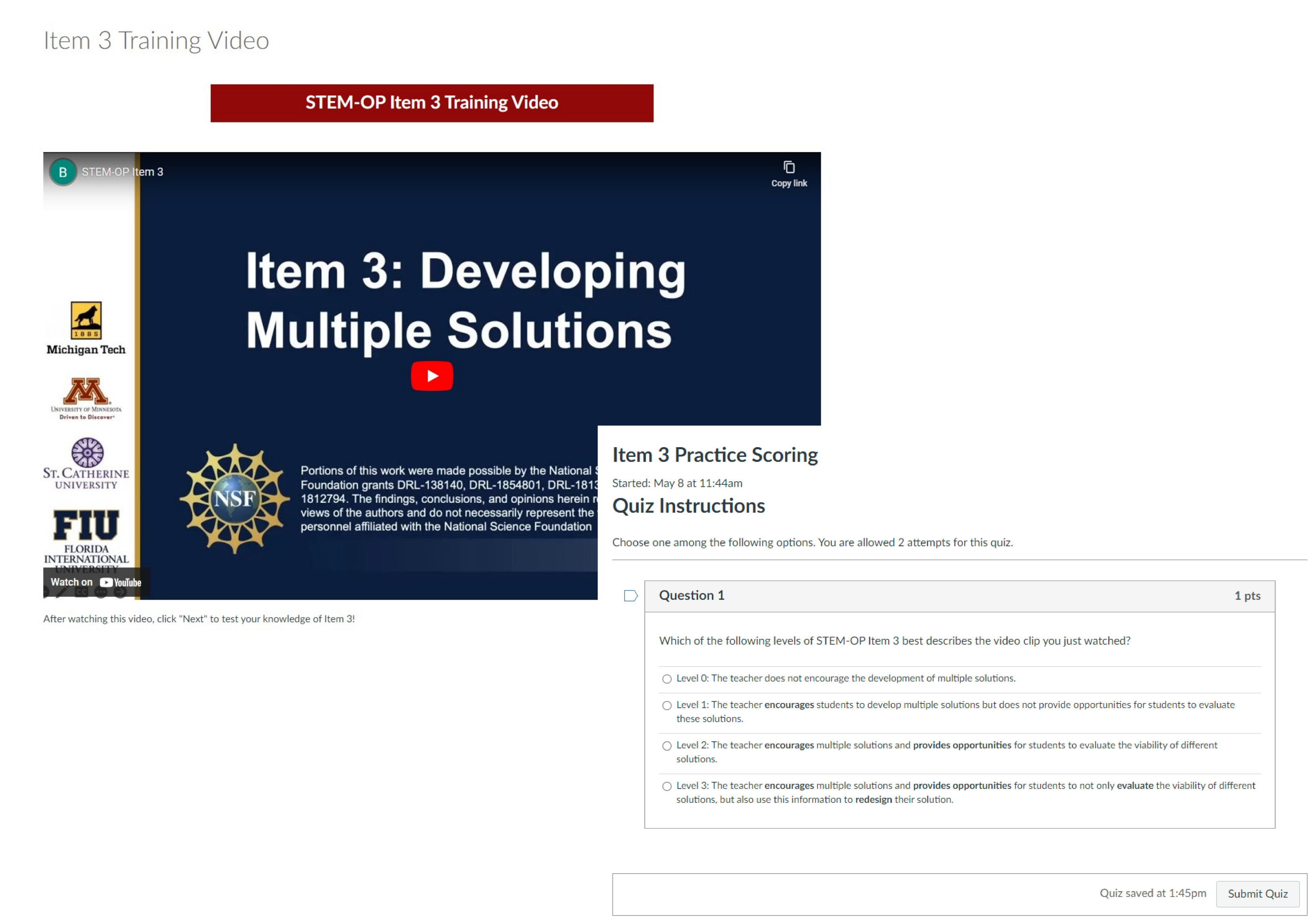
2	Contextualizing Student Learning
	Learning is contextualized within an appropriate (e.g., age, gender, race, etc.) real-world problem or design challenge that connects to the content of the lesson. Connections between students' learning and the context are explicit so that students understand the importance of their learning.
	0. The teacher does not contextualize the lesson within a real-world problem or design challenge.
	1. The teacher contextualizes the lesson by alluding to a real-world problem or design challenge, but does not connect to what the students are learning.
	2. The teacher contextualizes the lesson by briefly connecting a real-world problem or design challenge with what the students are learning.
	3. The teacher contextualizes the lesson by emphasizing the connections between the real-world problem or design challenge and what students are learning and helps them make explicit connections between the content and the context.

5	Integrating STEM Content
	Within the lesson, multiple content areas are represented that cut across two or more STEM disciplines. The tasks assigned to students should make it clear that students need to draw from these multiple areas and recognize that they are drawing upon multiple disciplines.
	0. The teacher does not include STEM content or includes content from only one of the STEM disciplines in the lesson activities.
	1. The teacher includes content from more than one STEM discipline.
	2. The teacher includes content from more than one STEM discipline and explicitly makes a connection between the different content areas for the students.
	3. The teacher includes content from more than one STEM discipline and includes specific and/or sustained connections between these content areas within the lesson.

Online Platform

To assist others in learning about the STEM-OP, we created a Canvas course that provides new and prospective users with information about the nature of the STEM-OP and how to use it. After reviewing introductory material, users are guided through 10 modules organized by item where they watch narrated presentations about how to score each item. These narrations include example integrated STEM video clips from real classrooms for each scoring level. Each item module ends with a "test your knowledge" example where users watch a video clip and score it; the quiz provides users with immediate feedback. After the user completes all 10 modules, they can practice their knowledge of the STEM-OP by watching up to three longer video clips and score multiple items simultaneously.

STEM-OP Canvas Course



Select Project-Related Publications

Dare, E. A., Ellis, J. A., Rouleau, M. D., Roehrig, G. H., & Ring-Whalen, E. A. (2022, June). Current practices in K-12 integrated STEM education: A comparison across science content areas and grade-levels (Fundamental). In *Proceedings of the 2022 ASEE Annual Conference and Exposition*.

Ellis, J. A., Wieselmann, J. R., Sivaraj, R., Roehrig, G. H., Dare, E. A., & Ring-Whalen, E. A. (2020). Toward a productive definition of technology in science and STEM education. *Contemporary Issues in Technology and Teacher Education – Science*, *20*(3), 472-496.

Forde, E. N., Robinson, L., Ellis, J., & Dare, E. A. (2023). Investigating the presence of mathematics and the levels of cognitively demanding mathematical tasks in integrated STEM units. *Disciplinary and Interdisciplinary Science Education Research*, *5*(3), 1-18.

Roehrig, G. H., Rouleau, M. D., Dare, E. A., & Ring-Whalen, E. A. (2022). Uncovering core dimensions of K-12 integrated STEM. *Research in Integrated STEM Education*, *1*, 1-25.

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