ICME-15
7-14 July 2024 • ICC Sydney, Australia
Come and be counted

TSG 3.16: Mathematics and interdisciplinary education/STEM education

Exploring Pre-Service Teachers' STEM Identities and Thinking

Vecihi S. Zambak & Michelle Schpakow

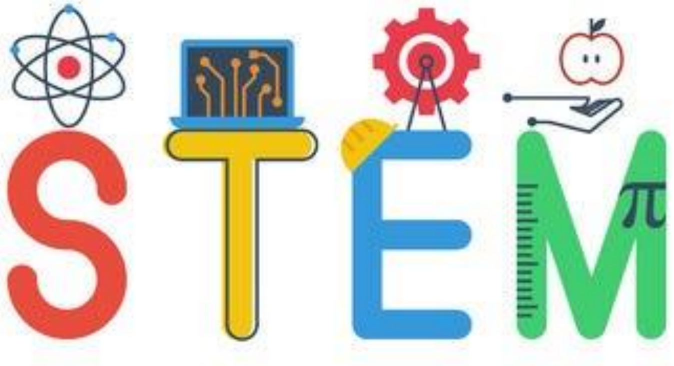
Abstract

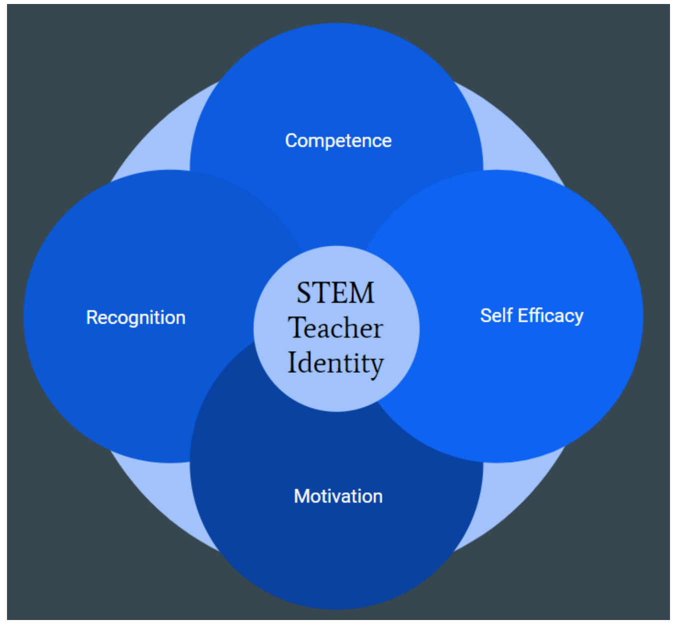
Whereas standards and policy documents recommend elementary teachers to teach interdisciplinary STEM as much as possible, recent studies show that they do not have the necessary attitudes or teaching skills to effectively integrate STEM. This presentation describes elementary pre-service teachers' STEM identities and thinking. Model-eliciting STEM problems have been used in mathematics and science methods courses to support the development of PST STEM identities. These problems and their implications will be shared.

MONMOUTH UNIVERSITY

Rationale

- Developing competencies in early STEM education has been regarded as an urgent goal of current educational systems, mainly due to shortages in the STEM workforce (English, 2016).
- Teachers' STEM identities are critical in enacting effective STEM instruction; however, many elementary teachers do not see themselves as STEM teachers (Rinke et al., 2016).
- It is imperative to expose elementary pre-service teachers (PSTs) to integrated STEM instruction during teacher preparation as their identities develop (Carrier et al., 2017).
- For our study, we define STEM thinking as PSTs' ability to connect STEM concepts and practices to activities in their lesson plans and STEM identities as their self-image and motivation to teach STEM.





Previous Study (1st Cohort)

In Spring 2023, we initially examined PSTs' STEM thinking and identities. In phase 1, we asked 48 PSTs how they view themselves as STEM teachers and categorized their written responses into three levels. PSTs were then asked to design an interdisciplinary mathematics lesson plan to support their elementary students' STEM thinking. These lesson plans were analyzed and categorized into three stages based on their support for STEM thinking.

Our preliminary findings (N = 48) from the first cohort are shown in the table below:

STEM Identities	Strong	Developing	Limited
	5 (10.4%)	17 (35.4%)	26 (54.2%)
STEM Thinking	**Robustly Supporting**	**Partially Supporting**	**Not Supporting**
	0 (0%)	2 (4.2%)	46 (95.9%)

PSTs' written responses revealed ten themes related to **STEM identity**, emphasizing the following: ***Interdisciplinary Connections***, ***Motivation***, ***Problem-Solving, Critical Thinking***, *Creativity, Conceptual Understanding, Real World Application, Collaboration, Hands-On Approach, and Information Retrieval.*

Lesson plans revealed six themes related to the support of **STEM thinking**: *Focusing on a single STEM Subject, Sequencing Subjects with an emphasis on Quantitative Reasoning, Sequencing Subjects with an emphasis on Scientific Inquiry*, ***Identifying a Central Theme about Science***, *Identifying a Central Theme about Math, and Practicing with Learning Skills.*

PST9: *STEM lessons allow students to see connections to concepts in other subjects and increase student engagement...Some benefits of STEM lessons include increased student engagement, authentic learning experiences, increased critical thinking and problem-solving, and an opportunity for students to develop an interest in several content areas…*

Brief of PST4 STEM Lesson Plan:

- *The teacher will begin the lesson by discussing the weather and what to wear.*
- *4th-grade students will complete a weather journal and define the weather and how it could be shown with data, graphs, and tables.*
- *Based on the weather data they have, students will learn how to input it as x and y in the coordinate plane.*
- *At the end, students will make predictions of the weather for tomorrow and next week, following the pattern they observe in their graphs.*

Current Study (2nd Cohort)

- **Collaboration:** In Fall 2023, math and Science Education professors collaborated to identify and create model-eliciting activities (MEAs) used in elementary math and science methods courses.
- **Partnership:** In Spring 2024, we partnered with a high-needs public elementary school in New Jersey to practice the MEAs with 4-5th-grade students.
- **Data collection:** We collected pre- and post-discussion data, exploring their STEM identities. We also collected 4+4 MEAs, group reports, and individual reflections examining STEM thinking.

Model-Eliciting Activities:

MEA 1: Greenhouse Simulation

- Exploring greenhouse gas effect on temperature using PhET simulation.
- Predicting the gas and temperature levels in the past and future.

MEA 4: Black Skimmer Colonies

- Determining the number of nest colonies in two different regions from given aerial maps.
- Practicing with sampling, geometrical reasoning, and scaling.

(NASA Jet Propulsion Laboratory, n. d.; Karahan et al., 2014; Meyers, 2000; PhET Interactive Simulations., n. d.)

Preliminary Analysis and Findings I:

- **STEM identities:** We analyzed the distribution of teacher candidates' STEM self-image and motivation to teach STEM in pre- and post-discussion boards.

	Pre STEM Self-Image	Post STEM Self-Image	Change in Motivation to Teach STEM	
STEM does not factor in	5 (20%)	0 (0%)	Decreased	0 (0%)
STEM does factor in (generally speaking)	7 (28%)	10 (40%)	Low before, and still low now	1 (4%)
STEM does factor in (more specific)	13 (52%)	12 (48%)	High before, and still high now	2 (8%)
			Increased	19 (76%)
No Response	0 (0%)	3 (12%)	No Response	3 (12%)

PST50: *Elementary school is where children learn fundamental skills and knowledge … I see my self-image as an elementary teacher as more a list of character traits rather than subjects, so STEM, while I know it is important, isn't as connected to my self-image.* [Pre-discussion]

PST49: *Yes, my motivation as a teacher has changed after I engaged with STEM problems. Now, I know the importance of including STEM in an elementary classroom and how it impacts student knowledge. Students can learn life skills from various STEM projects. As a class, we can discuss how a problem like this can help us in the real world, and then students can apply this knowledge to their experiences when needed.* [Post-discussion]

Preliminary Analysis and Findings II:

- **STEM Thinking:** We analyzed the number of challenges teacher candidates faced while working with the MEAs, whether or not they overcame them, and the extent of teacher candidates' ability to connect their experience with MEAs to their everyday lives.

The Number of Challenges Faced

	0	1	2	3
Task 1	1 (4%)	12 (48%)	12 (48%)	0 (0%)
Task 4	0 (0%)	13 (52%)	9 (36%)	3 (12%)

Challenging STEM Areas

Science	Tech	Engineering	Math
8 (32%)	8 (32%)	0 (0%)	12 (48%)
0 (0%))	2 (8%)	19 (76%)	19 (76%)

Finding STEM in everyday Life

None	Yes (in general)	Yes (connected to the Task)
5 (20%)	13 (52%)	7 (28%)
11 (44%)	7 (28%)	7 (28%)

__PST49:__ *The only slight struggle I had in the beginning was stepping right into the simulation without reading the page before. Initially, I did not understand the definition of greenhouse gas, the greenhouse effect, sunlight photons, and infrared photons. It was good that these definitions were right above to guide my thinking.* [Task 1]

__PST50:__ *We used engineering, specifically design, when figuring out how to make a chart over the outline of the colonies. We used math to calculate the scale that we needed to use and how big our boxes within the chart would be… We used technology to do some of the calculations with our phones….I don't think these stem practices, besides doing basic calculations with the calculator app on our phones, are connected to our daily lives. For those who go into architecture and design, creating graphs and using conversions and scales will be essential to their work, but that doesn't necessarily apply to my daily life.* [Task 4]

TSG 3.16: Mathematics and interdisciplinary education/STEM education

Conclusions:

- Model eliciting activities (MEAs) provide a teaching model for future elementary teachers to understand and embrace interdisciplinary STEM.
- Systematic engagement with such problems supports elementary PSTs' STEM self-image, motivation to teach STEM, and, thus, their STEM teaching identities.
- There are differences in PSTs' STEM thinking throughout the semester, depending on the cognitive demand of the MEAs and PSTs' confidence with specific STEM subjects.
- To support PSTs' STEM thinking, teaching around MEAs may need to emphasize the connections of STEM practices to everyday lives.
- Based on these preliminary findings, we are implementing STEM clinics where elementary PSTs engage 4-5th grade students with the same MEAs for eight weeks.

References:

Carrier, S. J., Whitehead, A. N., Walkowiak, T. A., Luginbuhl, S. C., & Thomson, M. M. (2017). The development of elementary teacher identities as teachers of science. *International Journal of Science Education*, *39*(13), 1733-1754.

English, L. D. (2016). STEM education K-12: Perspectives on integration. *International Journal of STEM Education*, *3*, 1-8. https://doi.org/10.1186/s40594-016-0036-1

NASA Jet Propulsion Laboratory. (n. d.) *Graphing global temperature trends (Classroom Activity)*. California Institute of Technology. https://www.jpl.nasa.gov/edu/teach/activity/graphing-global-temperature-trends/

Karahan, E., Guzey, S. S., & Moore, T. (2014). Saving pelicans. *Science Scope*, *38*(3), 28.

Meyers, C. (2000). *Black Skimmer, Rynchops niger.* New Jersey Department of Environmental Protection (NJDEP), Division of Fish and Wildlife, Endangered and Nongame Species Program. https://www.audubon.org/field-guide/bird/black-skimmer

PhET Interactive Simulations. (n. d.). *Greenhouse effect (Teaching Resources)*. University of Colorado Boulder. https://phet.colorado.edu/en/simulations/greenhouse-effect/teaching-resources

Rinke, C. R., Gladstone-Brown, W., Kinlaw, C. R., & Cappiello, J. (2016). Characterizing STEM teacher education: Affordances and constraints of explicit STEM preparation for elementary teachers. *School Science and Mathematics*, *116*(6), 300-309.