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Assisting Inservice Mathematics Teachers in Utilizing RME and STEM Design Principles When Collaboratively Co-Imagining a Lesson

2018 RME6, Grand Caymans, Cayman Islands

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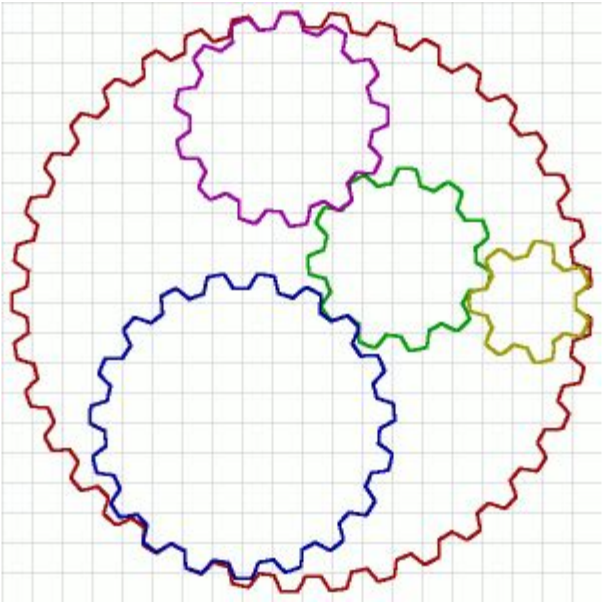
University of South Dakota

Design Process



http://mathpuzzle.com/LoonyGearsAnimation.gif

Math Education is STEM Education!

“This [numerous definitions of STEM education] complicates matters and allows each entity to define STEM education in its own way to fit its experiences, biases, and agendas—NCTM included. In some cases this leads to math or science classrooms where students build bridges or program robots, but fail to acquire a deep understanding of grade level (or beyond) math or science learning standards.

If students are not equipped to pursue a post-secondary STEM major and career, is it really an effective K–12 STEM program? My answer is no. No number of fun activities or shiny technology will overcome this fatal shortcoming.”

- Matt Larson, past NCTM president

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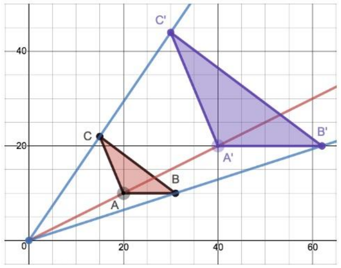
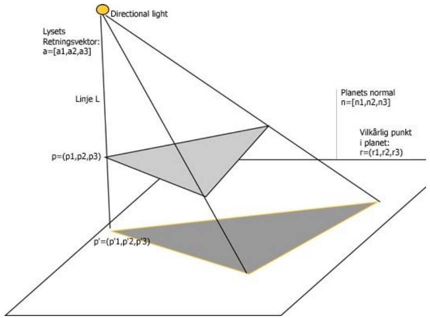
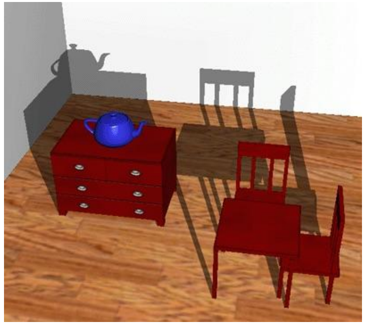
“Provide challenges, not assignments.”

Rosenthal Prize - Math - Competition where mathematics teachers vie for the single best activity for innovation and inspiration in math.

2017 Winner: “Bringing Similarity Into Light: Experiencing Similarity and Dilations Using Shadows.”







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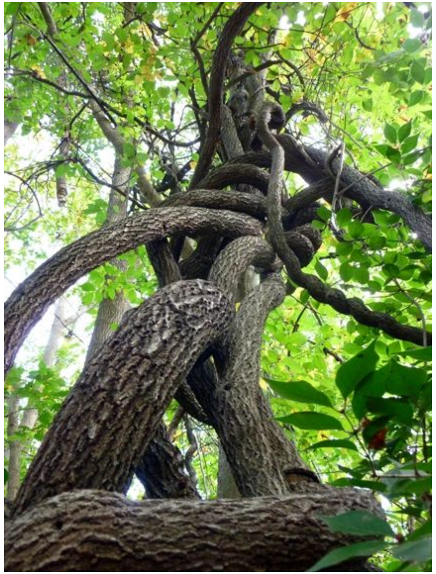
Frameworks & Principles Intertwined

Developing Great Math-Focused STEM Lessons [Utilizing RME]

"Practitioner-friendly constructs were a crucial bridge from the researcher language of MEA design principles to participants envisioning"

(Baker & Galanti, 2017, p.7).

- W.H.E.R.E. Framework
- MEA Design Principles
- RME Design Principles
- Lesson Imaging Framework



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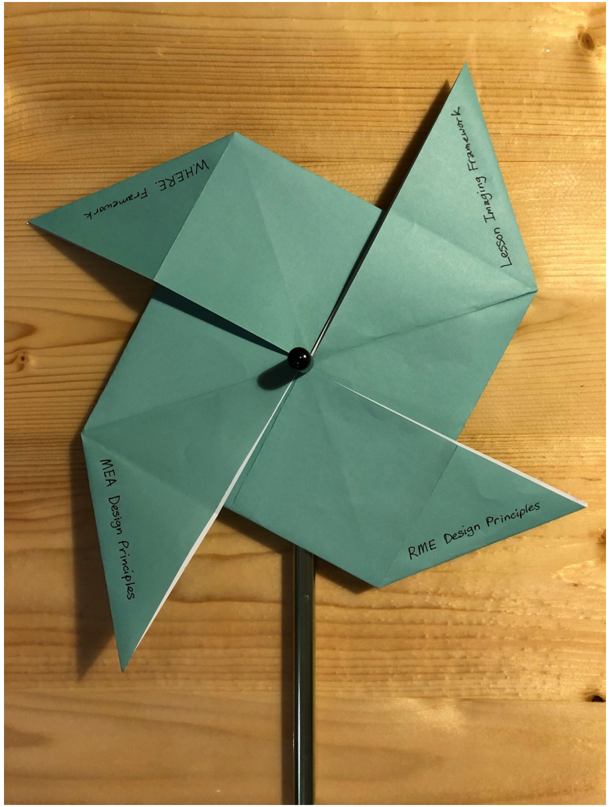
Generating Momentum



To be that efficient, the pinwheel needs to be balanced. If it has too few blades, it will have to work too hard trying to generate any momentum. On the flipside, if it has too many blades, none of which can get any real traction. The blades are all in what fluid dynamicists call ‘*Dirty Air*’

Lesson Imaging

"...*lesson planning* involves choosing the activities and structuring the time. Lesson imaging goes further by anticipating how students will engage in those activities, the questions they may have, and the questions teachers might ask to promote deeper reasoning about the central goal of the task" (Stephan, Pugalee, Cline, Cline, 2017, p.4)

"Imaging is a process in which teachers visualize what will take place in their classroom when they present a task." - George McMagnus middle school math teacher, Florida

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Steps to Lesson Imaging

(1) Solve the Task Yourself

(2) Unpack the Lesson Objective(s) (pp.27-47)

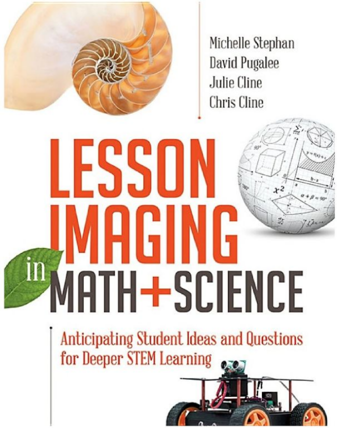
(3) Talk Through How to Launch the Task (pp.48-64)

(4) Anticipate All Strategies and Student Engagement (pp.65-87)

(5) Orchestrating Sharing Out (pp. 88-98)

(6) Decide Questions to Provoke Thinking and Reflection (pp. 99-110)

(7) Determine What Counts as Evidence (pp. 111-136)



Lesson Imaging

"We contend that engaging in the practices we outlined above (lesson imaging ***with peers****, reading research on learning trajectories and cognition, trying the task yourself, and conducting interviews to elicit students' pre-unit informal strategies) can improve your ability to predict how students will participate in problem solving successfully"* (Stephan, Pugalee, Cline, Cline, 2017, p.83)

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Evidence & Examples - Products Produced

Lesson Imaging Templates

- Polygon Spoons (Secondary Mathematics Teachers)
- Solar Oven (Early Elementary Teachers)

Lessons

- Polygon Spoons
- Solar Oven

CCSS.MATH.CONTENT.HSG.GMD.A.3
Use volume formulas for cylinders, pyramids, cones, and spheres to solve problems.

CCSS.MATH.CONTENT.HSG.MG.A.3
Apply geometric methods to solve design problems (e.g., designing an object or structure to satisfy physical constraints

Select and read a piece about Emergent Modelling

https://tinyurl.com/RMEDesignPrinciples

In the hyperlinked pdf articles, find the segment about models, emergent models, role of models, etc., and read that section. Everyone read something different in your triad.

As a large group synthesize, in bullet points, key ideas of emergent modeling here:

https://tinyurl.com/RME6participation

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Secondary's Launch - Tiny Homes for Veterans

What do you think is a larger issue/problem that needs resolution in tiny house living?

https://www.youtube.com/watch?v=fEm6cDuyXqM

RME Launch - Polygon Spoon

Which template is the prototype of the tablespoon?
Or, is it even one of the three? How would you know for sure?

Polygon Spoons -
Sizes 1, 2, 3

Polygon Spoon Video

Brainstorm & plan ideas on how to determine. Write a project proposal plan to test for the tablespoon.

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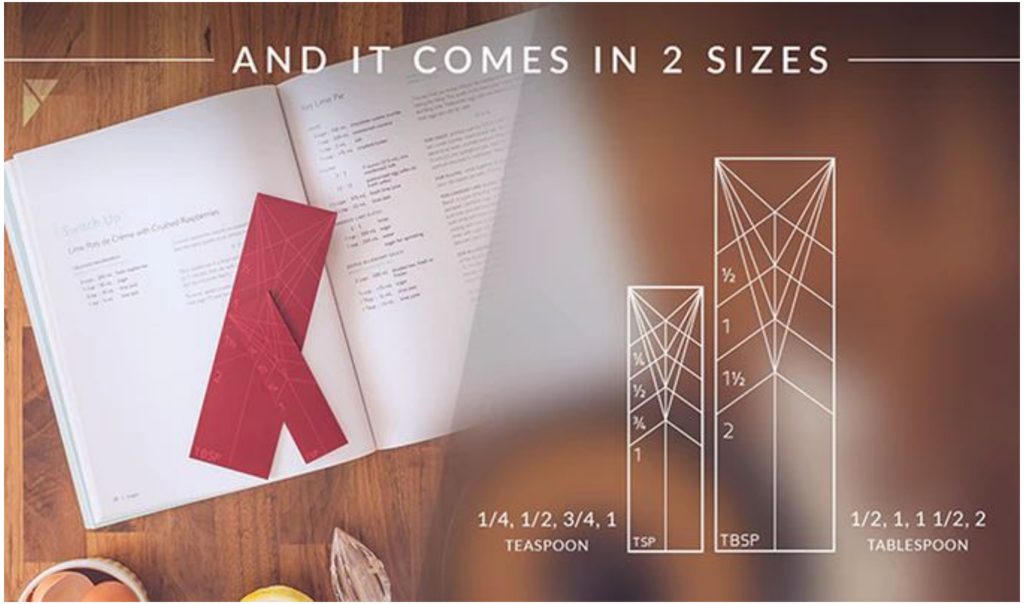
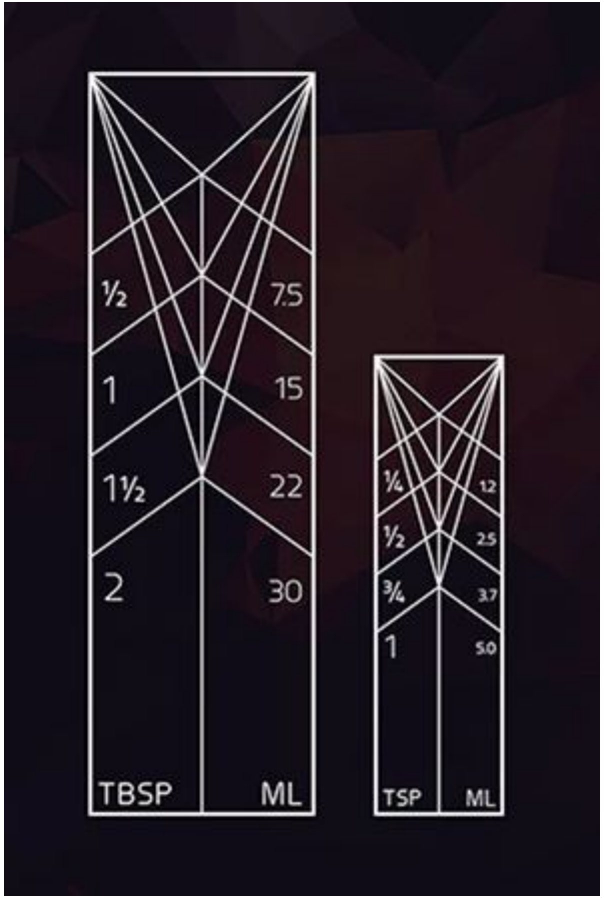
Images from the Web site





Goals of Emergent Modeling

- Starting point is in the contextual situation of the problem that has to be solved
- Begin with students' informal solution methods
- The mathematics starts within common sense and stays within common sense
- The informal ways in which they solve the problem 'anticipate' or give way to the more formal ways or concepts
- Process of gradual growth in which formal mathematics comes to the fore as a natural extension of the student's activity / experiential reality
- Through organizing activity, the informal, later as a result of reflection, becomes formal

Goals of Emergent Modeling

- The problem situations and activities bring the students to identify mathematical structures and concepts
- Their models support and prompt the level raising, fulfilling a bridging by shifting from *model of* to *model for*

Which formal mathematics should come to the fore?
How do the students' informal strategies/routes/pathways... give way to more formal mathematics? What formal mathematics?
What can be schematized and/or generalized through organization and reasoning?

STEM Challenge

“Re-engineer” or design an item to fit the needs of the tiny house for homeless veterans.

Steps from the STEM Challenge Forward

5. Help students identify the challenge.
6. Discuss what success looks like and what fulfillment of the client's need looks like.
7. Select an engineering design process for planning.
8. Involve students in researching the content for the challenge/need in triads.
9. Encourage triads to develop their own ideas about how to solve the problem.
10. Guide triads to choose one idea to test and then create their prototype.
11. Facilitate the processes of testing and evaluating their prototype.
12. Involve triads in communicating their findings in whole-class discussions.
13. Prompt redesign after hearing and learning from other triads.
14. Report the changes.

What is the “Secret Sauce” for STEM learning?

One student gained more focus for the group by defining *“secret sauce - a special feature or technique kept secret by an organization and regarded as being the chief factor in its success… only the special features and techniques were uncovered for us rather than kept secret.”*

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Focusing on...

“The recipe for the secret sauce includes focusing on real world problems by closely and carefully defining them, conducting research, brainstorming solutions, developing and creating a prototype, test, evaluate, and redesign when necessary.”

Math as Foundational

"...science cannot be done without mathematical formulas, engineering requires math when building structures and science when looking at the environment the tool is being used, technology runs on a basis of math and aids with science and engineering, thus, a truly effective STEM program breaks down the walls that separates the subjects out and brings them all together while utilizing authentic contexts and hands on learning experiences."

Truly Authentic Contexts

"By incorporating challenges, truly authentic contexts, and interactive activities to really engage and excite students, teachers can help students develop a sense of ownership, pride, and understanding in their learning."

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Powerful Learning

"My goal for STEM would lead to increased student engagement and powerful learning by discussing and working through real-world, authentic problems together."

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Being More Intentional

"This was more time consuming and messy than I ever imagined, yet led to so many good discussions and realizations. Again, I believe the power in this experience, was grounded in the collaboration piece. I certainly changed my way of thinking about planning STEM lessons, and quite frankly, any lesson for the future. Being more intentional at each stage of the process, especially the launch and choice of the authentic context and its potential for eliciting models, is so important and creates a more effective learning experience for my students."

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Future Research & Recommendations

- Continue to investigate how practitioner-friendly characteristics/tenets of RME and it's design principles can bridge inservice mathematics teachers to envisioning better STEM lessons and contexts.

- Determine which synthesizing language, examples and readings provide the bridge.

Steps and Frameworks Provided

[Developing Great Math-Focused STEM Lessons [Utilizing RME]]

https://tinyurl.com/RMESTEM

Questions?

Splash pages:

W.H.E.R.E. Framework - https://tinyurl.com/WHEREframework

MEA Design Principles - https://tinyurl.com/MEADesignPrinciples

RME Design Principles - https://tinyurl.com/RMEDesignPrinciples

Lesson Imaging Framework - https://tinyurl.com/LessonImaging

This portrayal of RME as an evolving set of interrelated practices implies that it is one thing to attempt to understand a particular approach to design by reading about it and quite another to engage competently in the process of developing designs. As a consequence of reading books by leading contributors to RME (e.g., Gravemeijer, 1994; Streefland, 1991; Treffers, 1987), one can become reasonably proficient at commentating on the design theory, but designing lessons is quite difficult. (Cobb, Zhoa, & Visnovska, 2008)

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