Using 4 Big Ideas to Develop Secondary Preservice Teachers' Knowledge about Mathematical Modeling

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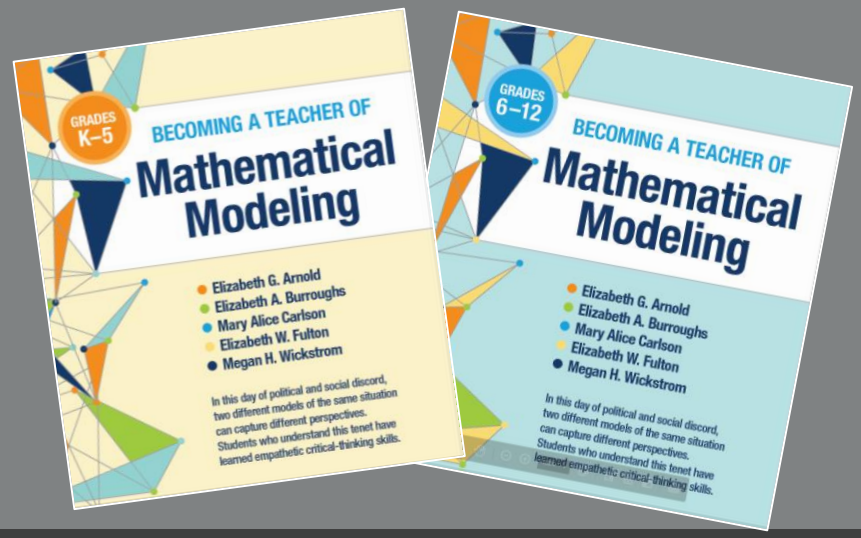
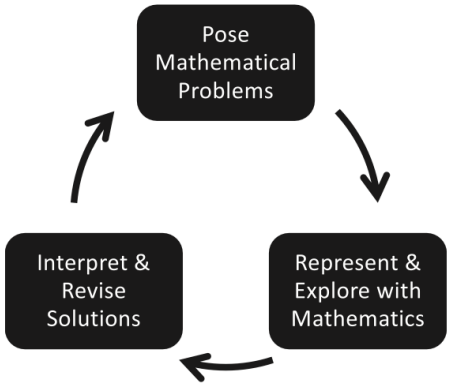
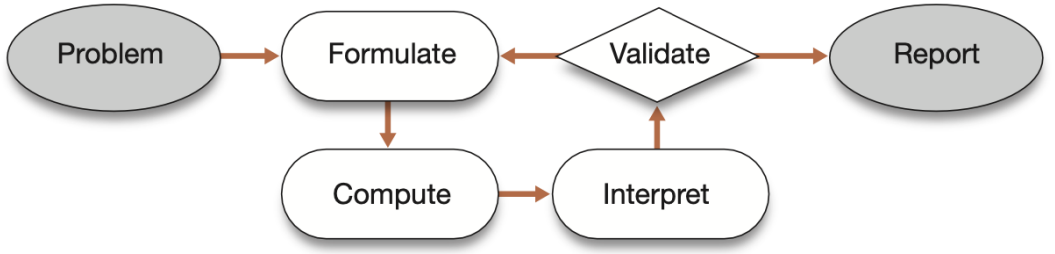
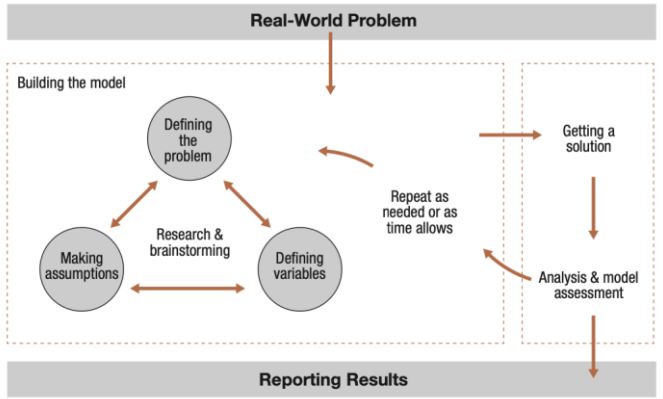


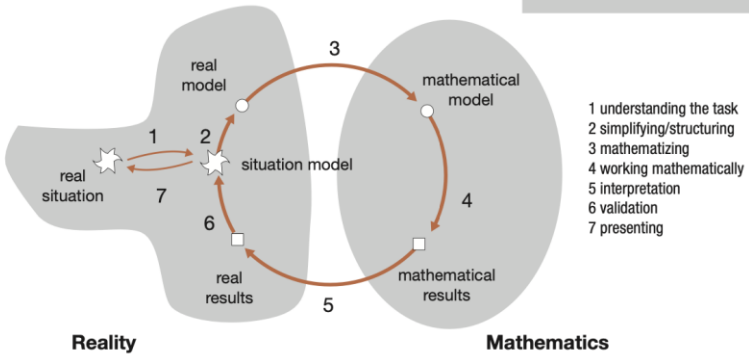
Mathematical Modeling as a Process/Cycle

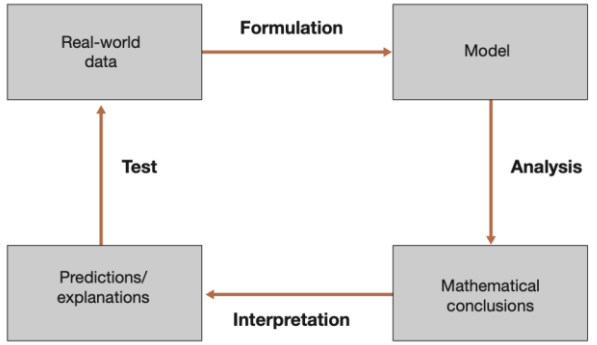
Mathematical modeling is the **process** of using mathematics to understand and make decisions about the world.







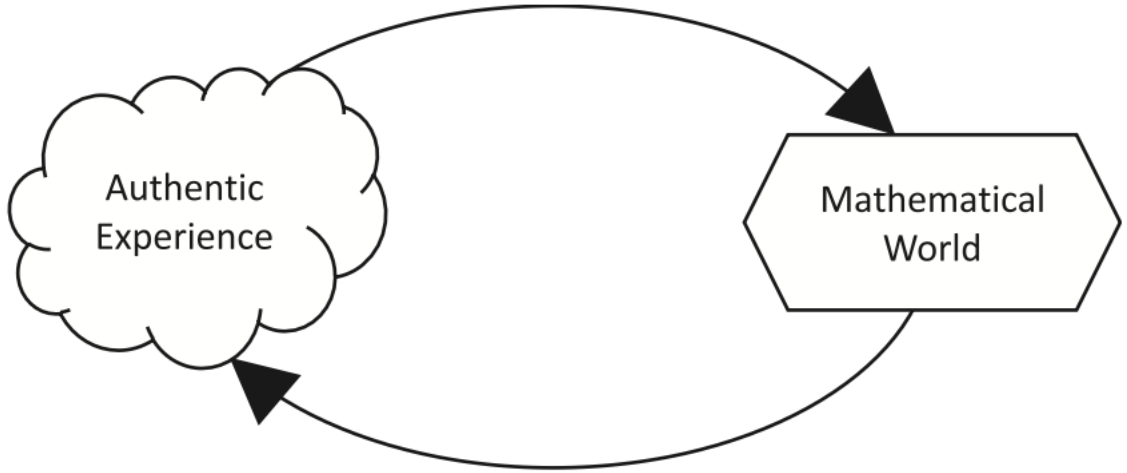




Images from APME 2016: Mathematical Modeling and Modeling Mathematics

4 Big Ideas in Modeling

1. Modeling begins and ends outside the mathematical world.
2. Modeling deals with situations that are open and complex.
3. Modelers exercise judgment when investigating problems. These judgments stem from a set of values.
4. Modelers decide when a solution is good enough.



Modeling problems are rooted in authentic, daily experiences that can be answered with mathematics.

- Reflect a felt need or issue
- Authentic from the learner's perspective
- Make a difference to students and their community

Big Idea 1:

Modeling begins and ends outside the mathematical world.

Problems that grow out of authentic experiences are often **ill-defined**. They don't have clear boundaries and rarely come with a prescribed solution strategy.

- The modeler's job is to take the open situation—something that is **complex** and has to be solved—and make it manageable as a mathematical problem.
- Moving from situations that are derived from day-to-day experiences involves **making choices** that remove some of the complexity from the problems human beings encounter in our daily lives.

Big Idea 2:

Modeling deals with situations that are open and complex.

Because modeling involves making choices, it also involves **exercising judgment**.

- Judgments about what is important are tied to what people **value**.
- Understanding what people value involves seeing situations from **others' perspectives**.

Modeling draws these values to the surface, as the modeler has to acknowledge what is important—that is, what is valued—in the situation being modeled.

Big Idea 3:
Modelers exercise judgment.

Modelers decide when the solution they have proposed for the situation is **"good enough."**

- Is the solution useful?
- Whose perspectives does the model consider?
- What do you notice about different solutions?

These are challenging, but empowering, questions that prompt modelers to examine their mathematical decisions, reflect on complex situations, and consider their own and others' perspectives.

Big Idea 4:

Modelers decide when a solution is good enough.

Research Study

Arnold & Burroughs

- **Setting**

Course	PSTs	Non-PSTs
Mathematical Modeling course	9	19
Mathematical Modeling for Teaching course	7	0

- **Research Question**
  - What is the nature of pre-service teachers' conceptualization of the four big ideas of mathematical modeling and teaching with them?
- **Data Collected**
  - Written work, reflections, final exam

Modeling Activities

Each modeling activity addressed the 4 Big Ideas and highlighted fundamental aspects of mathematical modeling, with a focus on **who** the model benefits and **why.**

1. Language Task

Investigated the issue of Indigenous language disappearance and how to preserve these languages.

2. Creek Task

Addressed the issue of ethical water usage in a water source local to them.

3. Disease Task

Simulated disease spread in a group and developed agent-based models of disease spread and community models of disease spread.

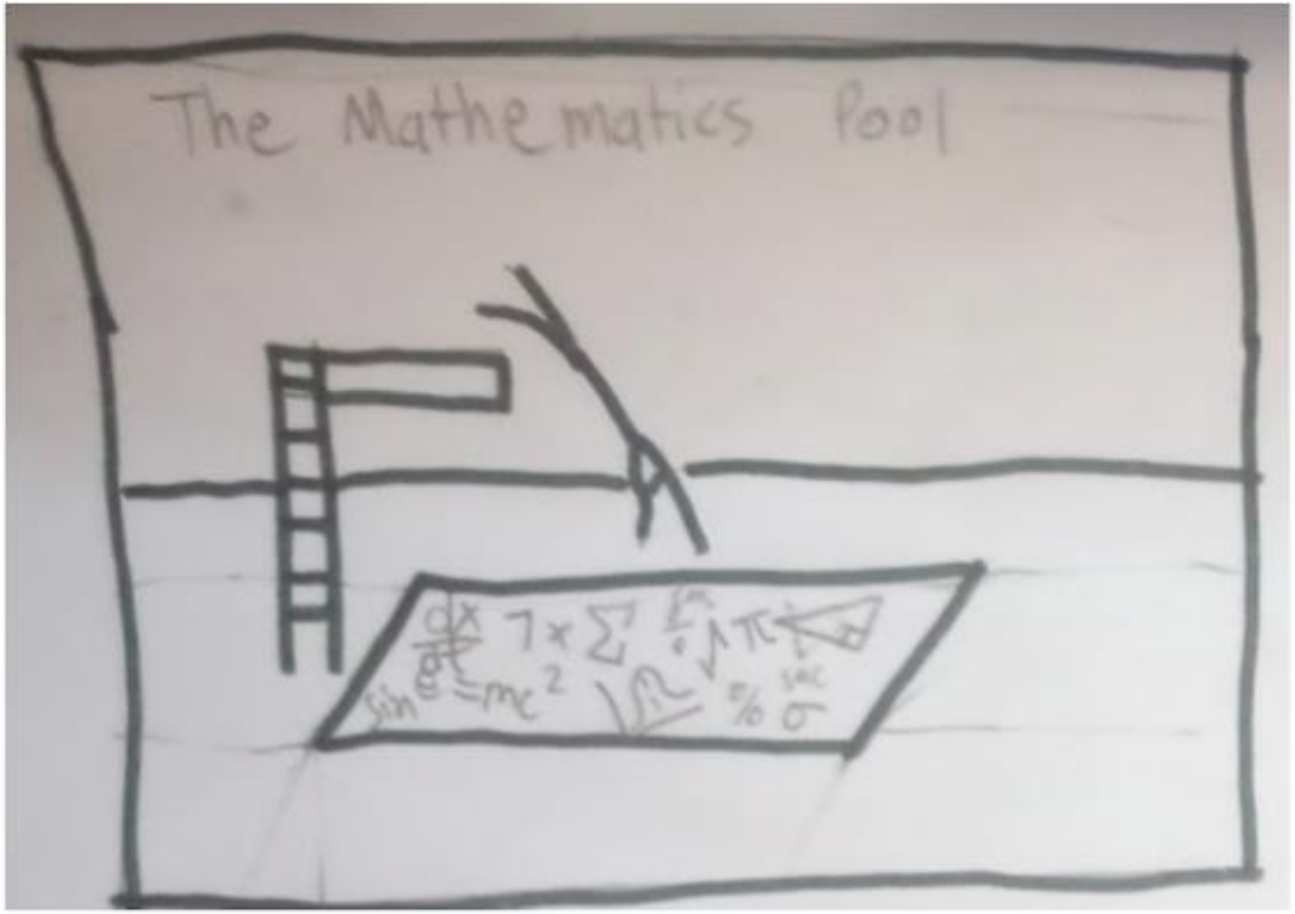
4. Wolves Task

Explored wolf conservation efforts and the reintroduction of wolves in Colorado/Montana.

PSTs' Conceptualizations of the 4 Big Ideas (as ***learners***)

#1: Modeling begins and ends outside the mathematical world

"Modelers begin outside the pool in the real-world. Then, they enter the pool of mathematical context and move differently than they would outside of it. Of course, no one stays in the pool forever, so a modeler will exit it and return to the real-world, hopefully exiting with a useful model."

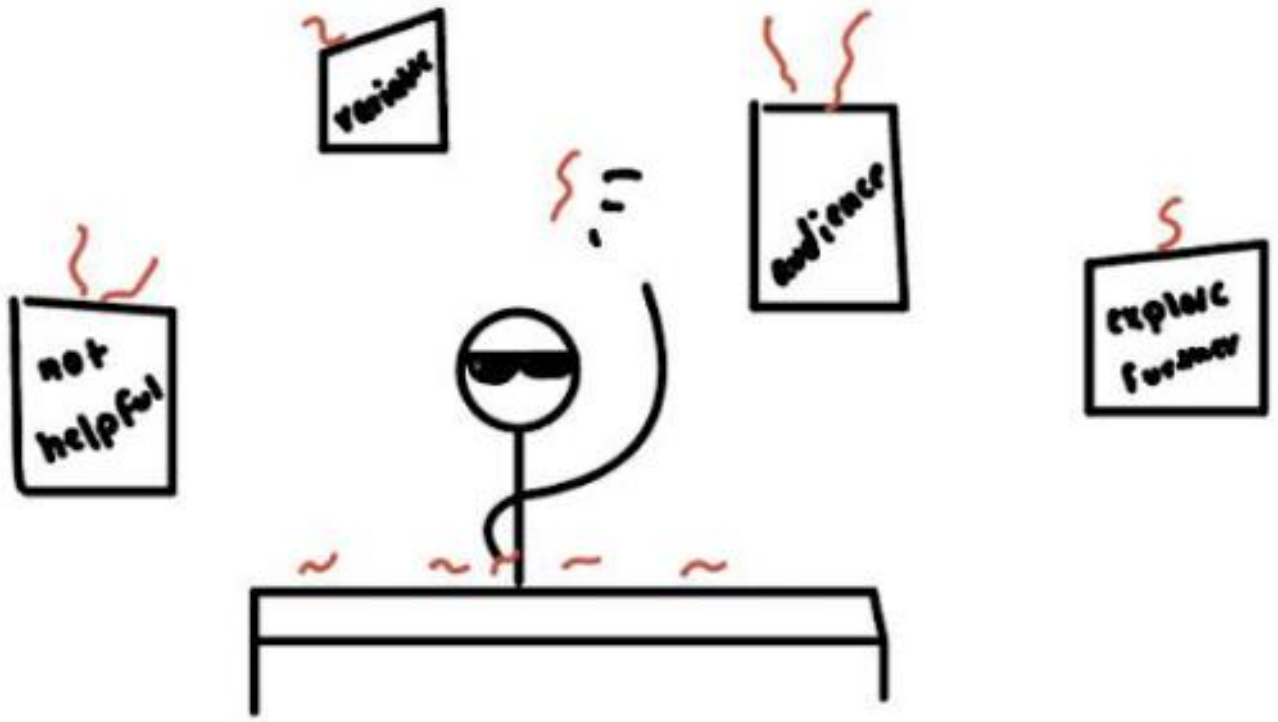


#2: Modeling deals with situations that are open and complex.

"It's like an open box. Modeling situations should be open and complex, so there are multiple ways to see into this box, or situation. However, there are spikes or mountains coming from the box, so each person must decide how to deal with these mountains to see in."

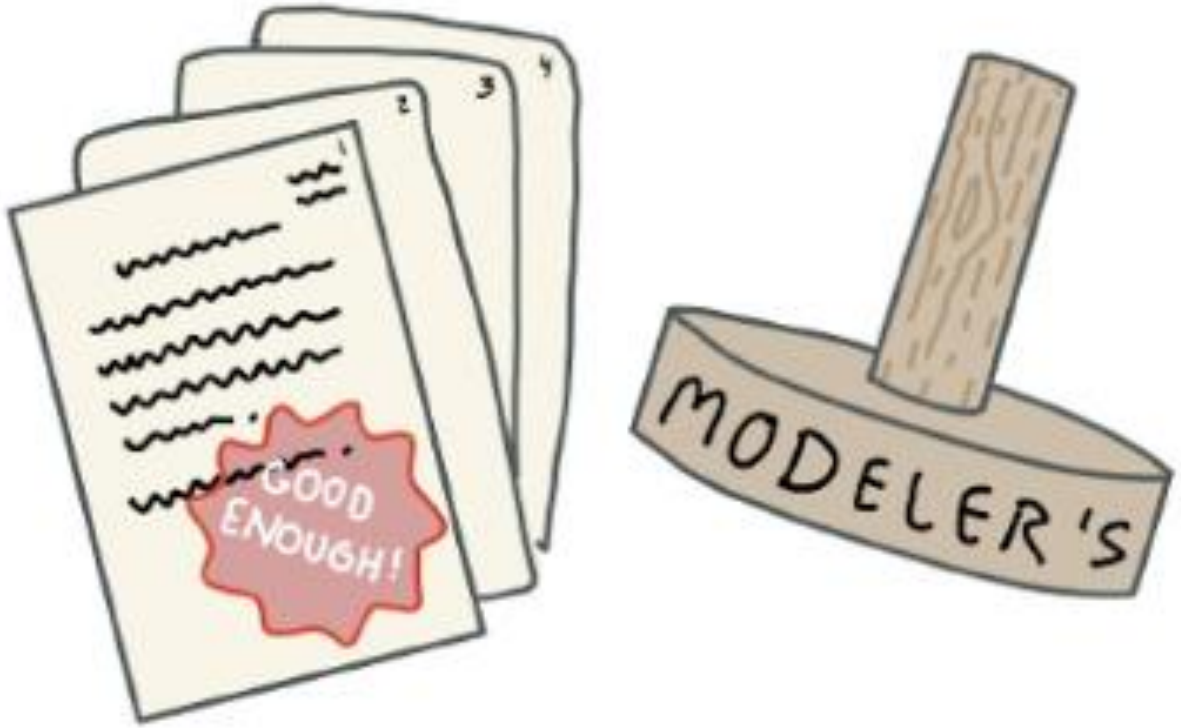
#3: Modelers exercise judgment

"[The modeler is] making assumptions and judgments. What will the variables of the model be? What do we need to assume about the topic? What do we need to do external research on? What audience are we going to target with the model?"



#4: Modelers decide when a solution is good enough

"A play on the typical 'seal of approval,' here represented as a seal of 'good enough.' The seal has been placed with a stamper that belongs to the modeler. The point is that the modeler gets to decide when their model and subsequent answer are good enough."



The 4 Big Ideas are connected & interdependent

- PSTs' conceptualizations often included connections to the other Big Ideas

> "Models seek to deliver useful and illuminating answers to a real world situation, but come from open and complex problems, requiring judgment and sight into what is 'good enough.'"

- If one Big Idea was not addressed, PSTs often described how there are issues with the other Big Ideas.

PSTs' Conceptualizations of ***Teaching*** with the 4 Big Ideas

Tensions exist between Big Idea #2 and Big Idea #4

- PSTs were excited about the openness (Big Idea #2) but struggled with the notion of having to decide themselves when their model and its solution are "good enough" (Big Idea #4)

> "[Mathematics] is black and white … with one correct answer. … [So] what is the difference between 'good enough' and just the correct answer."

- PSTs were uncomfortable about facilitating openness in their classroom.

> "I'm still struggling with this idea of openness. I haven't been around long enough to anticipate where the modeling process is going to go."

Empathetic critical thinking skills emerged!

- PSTs want to foster their students' sense of mathematics and community.

> "I learned a lot about empathy that goes along with [making] decisions. I like the idea of including empathy in a math class."

> "Mathematics education should be just as active and empathetic as modeling."

> "It is vital for modelers to have empathy for the people their model can impact."

- Mathematical modeling is a powerful practice to incorporate in the classroom.
- These 4 big ideas provide a foundation to ensure the focus remains on modeling as we implement/work on modeling tasks.
- Future Work: In what ways can other mathematics courses support PSTs' understanding of (comfortableness with) openness and agency in mathematics?

Closing Thoughts

Thank You!