Developing and Exploring Mathematical Modeling Curricula for Pre-Service K-8 Teachers

Megan H. Wickstrom, Montana State University
Hyunyi Jung, University of Florida
Award #1924678 & #2053155

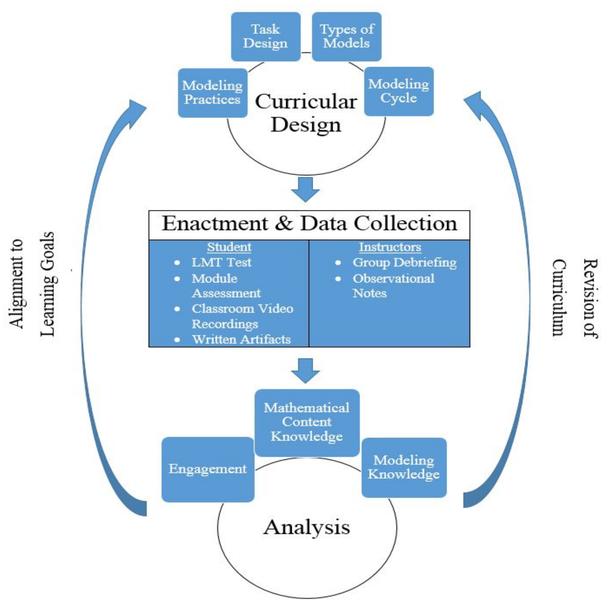
PURPOSE & MOTIVATION

- National Standards (AMTE, 2017) outline that K-8 preservice teachers (PSTs) should have the opportunity to engage in modeling tasks and also plan tasks for students. **Most preparation programs do not currently have modeling opportunities for PSTs** (Doerr, 2007).
- **PSTs must experience modeling as learners** prior to planning and enacting a modeling task (Anhalt & Cortez, 2016; Cai et al., 2014, Carlson et. al, 2016).
- **When modeling, it is important to draw attention to modeling attributes** such as: 1) task design and relevance, 2) the different aspects of the modeling process, 3) mathematical practices embedded in modeling, 4) types of models.

RESEARCH QUESTIONS

1. How can teacher educators support PSTs' understanding of attributes of mathematical modeling (task design, modeling process, and types of models) through the newly created modules?
2. How do PSTs' understanding of modeling attributes develop throughout the implementation of mathematical modeling modules?
3. What are the factors that support PSTs' motivation to engage in mathematical modeling and practices?

DESIGN FRAMEWORK



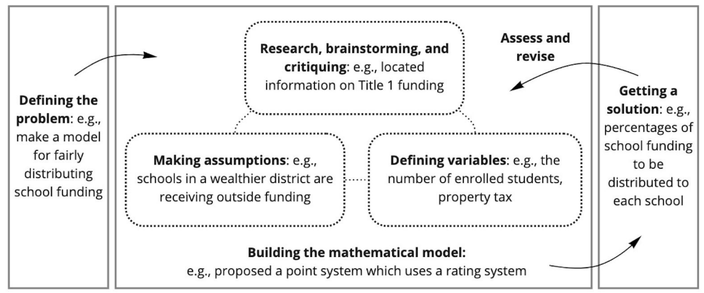
(Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003)

METHODS

Development of Modules	Module Enactment	Data
• 5 modeling modules developed: 1 Introductory Module, 2 Number and Operations Modules, 2 Geometry and Measurement Modules. • Each module focused on a different type of model.	• All modules were implemented and refined across two semesters. • Modules were then tested independently in different courses by PIs and graduate students in third and fourth semesters.	• PSTs Written Work and Artifacts from Completing Modeling Task (RQ1 and RQ2) • Video Data of Module Enactment (RQ1, RQ2, RQ3) • PST Journals (RQ3)

RESULTS: TASK DESIGN

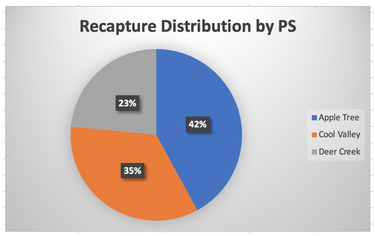
Example Task: Imagine you are working for the local department of education and that you are in charge of formulating a procedure for distributing funding to 4 schools. Data which can be considered has been provided by the department.



Important Features of Modeling Tasks: 1) Culturally and Contextually Relevant, 2) Features of the Modeling Cycle are Emphasized and Explored, 3) Parallel to Relevant Elementary Mathematics Content, 4) Vary Grain Size and Materials to Modify Difficulty and Openness, 5) Opportunities for Reflection as Learner and Teacher.

RESULTS: EXAMPLE OF PST MODEL

	A	B	C	D	E
1	School	Apple Tree	Blue Mtn	Cool Valley	Deer Creek
2	Grades	PK-8	PK-6	PK-8	3rd-8
3	Number of Grades	9	7	9	6
4	Number of Students Enrolled	969	516	504	320
5	Fraction of ELL students	1/3	1/6	1/7	1/20
6	Fraction of SPED students	1/7	1/25	1/6	1/26
7	Percentage of students meeting standards in Math	13%	65%	30%	59%
8	Percentage of students meeting standards in English	16%	61%	34%	57%
9	Percentage of students meeting standards in Science	18%	71%	21%	68%
10	Percentage of Students which are Low Income	90%	22%	75%	12%
11	Student to Teacher Ratio	14:01	16:01	16:01	11:01
12	Median Home Cost	$ 123,100.00	$ 365,400.00	$ 140,400.00	$ 330,330.00
13	Property Tax Rate	1.43%	2.51%	1.51%	2.28%
14					
15	Property Tax per Median Home Cost (Funding per student from property tax)	$ 1,760.33	$ 9,171.54	$ 2,120.04	$ 7,531.52
16	Funding from property tax (from all students)	$1,705,759.77	$4,732,514.64	$1,068,500.16	$2,410,087.68
17	Points System:				
18	Number of Grades	3	3	3	2
19	Number of Students Enrolled	10	8	8	5
20	Fraction of ELL students	15	5	5	3
21	Fraction of SPED students	10	2	10	2
22	Percentage of students meeting standards in Math	1	6	3	6
23	Percentage of students meeting standards in English	2	6	3	6
24	Percentage of students meeting standards in Science	2	7	2	7
25	Percentage of Students which are Low Income	15	0	10	0
26	Student to Teacher Ratio	3	6	6	3
27	Total	61	43	50	34
	Minimum Funding Total per Student	$8,000.00	$8,000.00	$8,000.00	$8,000.00
	Funding Gap between Local Funding and Minimum Funding	$6,239.67	-$1,171.54	$5,879.96	$468.48
	Recapture Amount	$ -	$ 1,171.54	$ -	$ -
	Recapture Distribution	$ 492.05	0	410.039	269.4542
	State Funding	$5,747.62	$0.00	$5,469.92	$199.02



"Blue Mountain school was able to meet the needs of every student from property taxes alone. Any extra money that came from them got recaptured and redistributed to the other schools based on their needs found in the points breakdown. Schools like Apple Tree and Cool Valley have lower property tax rates and more of their students come from low income families. Their need for State funds or recaptured money from Blue Mountain was higher than Deer Creek's."

RESULTS: PSTS' PERCEPTIONS

Modules	Main Objectives and Tasks	PSTs' Perceptions
Teacher Pay	Algebraic reasoning through prediction modeling - Imagine you are working for your state government or a local teacher's union in charge of adjusting teacher pay. How much do you think new teachers should be paid? Is their pay fair?	*" I thought that the task was super useful. It broke down where school funding comes from and allowed us to take a look at the system which many claim is flawed. I now have an opinion on the school funding system that is much more knowledgeable than my previous opinion…I really found that this task was super humbling to view from a teacher's perspective. I did not realize how much of my future was based on the government's decisions of what is fair. It is almost daunting.* ***I found that as far as usefulness goes, this task has allowed me to grow in my knowledge of mathematics as well as my knowledge of government funding systems and equity based practices.*** *"*
Campus Tour	Distance, time and rate through descriptive modeling - The Office of Admissions has requested your help in designing a campus tour for prospective students. In an hour, you should highlight important parts of campus.	*"I found this useful because* ***it allows students to critically think about distance in a fun and engaging way*** *rather than just making conversions. It* ***helps students understand why they are learning*** *these conversions and they are able to apply them to real life situations which I think allows them to remember it better."*
School Funding	Fraction and percents through rating and ranking models - You are working for the district and in charge of making a model for fairly distributing school funding.	*"Through this task I learned more about school funding. As for my mathematical self I'm learning that I really love financial models and learning about budgets, and money distribution. I find myself working a little harder on those tasks. In relation to teaching* ***I'm learning that the same problem can be interpreted so differently by people.*** *I'm learning about all the ways my peers think about things and I'm starting to see how all of our backgrounds and experiences influence our model thinking. F****or future models I think I have learned that keeping an open mind and hearing all of my partners ideas is very beneficial to creating a stronger model that goes more in depth.*** *"*
Resource Room Design	Geometry and measurement through optimization and rating and ranking models - Design a resource room space for multiple uses and use a rubric to assess the design.	"I think as a teacher this task is SUPER useful. It really shows you how rubric construction can influence the product, and also how to construct a rubric to best communicate expectations and allocate points where points are due. **When we revised our rubric for the final time I think it really helped me to see how to construct a rubric that is general enough to yield creative results, but still communicates expectations.**"

DISSEMINATION

Presentations:

- Wickstrom, M., & Jung, H. (accepted). Mathematical modeling, emotional engagement, and promoting productive dispositions. 45th Psychology of Mathematics Education.
- Stepp, Z., Jung, H., & Wickstrom, M. (accepted). The effects on preservice teachers' self-efficacy from engaging in a mathematical modeling task. PME-NA 44 in Nashville, TN.
- Wickstrom, M., & Jung, H. (2022). Promoting productive dispositions toward mathematics through modeling. The Association of Mathematics Teacher Educators 2022 Annual Conference.
- Jung, H. & Wickstrom, M. (2022). Designing and enacting culturally responsive mathematical modeling tasks. The Association of Mathematics Teacher Educators 2022 Annual Conference.
- Wickstrom, M., & Jung, H. (2021). Supporting elementary preservice teachers as modelers. The Association of Mathematics Teacher Educators 2021 Annual Conference.

Publications (in progress):

- Jung, H., & Wickstrom, M. (2022). Modeling library funding. In T. G. Bartell, C. Yeh, M. D. Felton-Koestler, & R. Q. Berry III (Eds.), *Upper elementary mathematics lessons to explore, understand, and respond to social injustice*. Corwin and the National Council of Teachers of Mathematics.
- Jung, H., Wickstrom, M. H., Piasecki, C. (2021) Connecting Modeling with an Environmental Problem: The Great Pacific Garbage Patch. Mathematics Teacher: Learning and Teaching Pre-K-12.
- Wickstrom, M. H., & Jung, H. (under review). Pre-Service elementary teachers as mathematical modelers: Forging bridges between lived and mathematical spaces.
- Jung, H. & Wickstrom, M.H. (under review). Teachers Creating Mathematical Models to Fairly Distribute School Funding.