Making Pi and Rethinking Teacher Education Program

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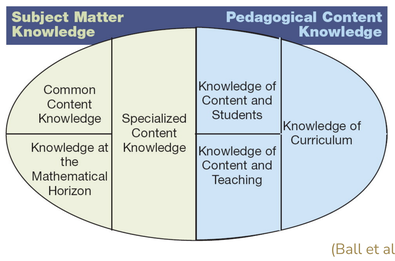
Introduction & Literature

T: What are the formulas to find the area and circumference of a circle?
S: $A=\pi r^2$, $C=2\pi r$, or $C=\pi D$.
T: Pi (π) appears in all of these formulas. So, what does Pi mean?
S: *(hesitate for a while):* Pi is 3.14

This is correct to some extent, but ....
PTs need to have a deeper understanding of Pi for their future career as teachers.

Literature

- **Reality:** PTs' understanding of geometry and measurement is **limited** and **weak**, relying on **memorized procedural processes** (Browning et al., 2014).
- **Expectation:** Mathematical Knowledge for Teaching



(Ball et al., 2008)

- **Recommendations:**
  - **From researchers:** Teacher education should be organized around a **core set of practices** to develop PTs' knowledge, skill, and professional identity (Grossman et al., 2009)
  - **From AMTE standards for preparing teachers of mathematics:** Effective mathematics teacher preparation program provides PTs opportunities to:
    - **Understand** mathematics **content** deeply
    - Develop **mathematical processes**
    - **Learn to teach mathematics**. (AMTE, 2017)

System Thinking Award Narrative

In the seminal paper, "Redefining teaching, re-imagining teacher education", Grossman et al. (2009) called for a **reconceptualization of teacher education**, in which the education of teachers is structured around a core set of practices and traditional curricular divisions between content and method courses are undone. Despite the passage of 14 years, **this separation remains dominant in teacher education programs across the U.S.** My project challenges this historical separation and echoes Grossman et al. (2009)'s call for a new approach to teacher education by showcasing an example of how this can be accomplished.

By participating in a carefully designed series of learning activities, prospective teachers in a content course were offered opportunities to deepen their mathematical knowledge and build their professional skills and identity simultaneously. Participants' reflections **evidenced the positive impacts of this approach** on their essential knowledge and skills for teaching as well as their dispositions and views toward mathematics education.

Through this project, **I restart the conversation around rethinking teacher education system.** By undoing the boundaries between content and methods courses, between departments, between universities and schools, we can foster professional preparation for prospective teachers. This, in turn, will positively **impact the next generation of American students**.

Research Questions

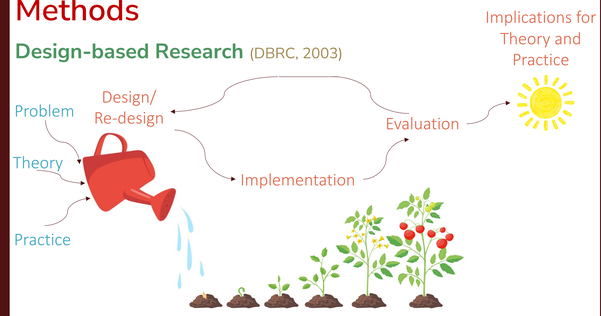
RQ1: How can we design a series of learning activities for PTs to develop a conceptual understanding of Pi, build mathematical processes, and learn to teach mathematics simultaneously?

RQ2: How do PTs engage with this series of learning activities?

RQ3: What are the benefits of participating in this series of learning activities as perceived by PTs?

Methods

Design-based Research (DBRC, 2003)



Procedures

- Based on theoretical and practical inputs to **design** the series of learning activities.
- **Pilot study** with 41 PTs in Spr 2022.
- **Implement & Collect data** with 18 elementary and middle school PTs in Fall 2022.

Data Sources

Class handouts, Homework assignments, Journal reflection

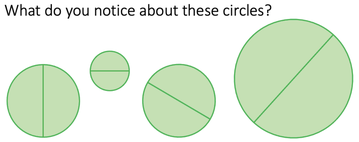
Data Analysis: Thematic analysis (Braun & Clarke, 2006)

Results

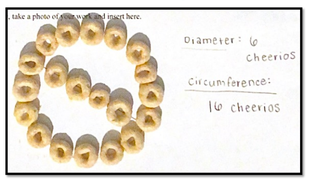
Series of Learning Activities & How PTs engaged with it

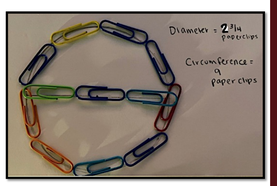
- **Motivation**

What do you notice about these circles?



- **Activity 1: Funky Units**





Here are some results that PTs came up with

Non-standard Units	Circumference (C)	Diameter (D)	Ratio C/D
Paperclips	9	2 ¾	3.28...
Cheerios	16	6	2.67...
Pills	9	2	4.5
...	...	...	...

Why do the results vary?
How could we measure with even better accuracy?

- **Activity 2: Round Things**

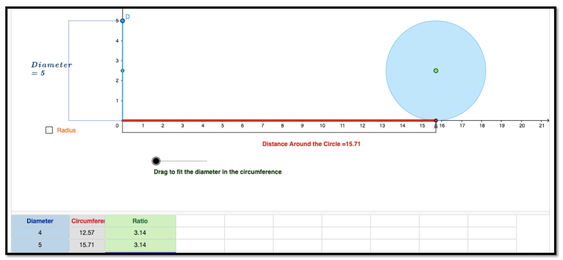
Watch a Demonstration of Activity 2

Interact with GeoGebra in Activity 3

Object	Diameter	Circumference	C/D
Perfume Bottle	5.5 cm	19.5cm ≈	3.55cm
Roll of Ribon	8.5 cm	27 cm ≈	3.18 cm
Ritz Crackers	5 cm	15.5 cm ≈	3.1 cm

There seems to be a better approximation.
How could we measure with even better accuracy?

- **Activity 3: GeoGebra**



- **Activity 4: Comparison & Discussion**

PTs discuss & compare activities 1, 2, and 3 in small groups

- What are the **pros** and **cons** of each activity?
- Which activity that **you prefer**? **Why**?
- Which activity that you think **students might enjoy**? Why?
- What **previous knowledge** do students need to have to participate in each activity?
- What **conditions** are needed if you want to use each activity in your class?
- ...

Here are some ideas that PTs came up with

Funky Units	Round Things	GeoGebra
• Measure with **non-standard** units (candies, chalks...) • **Hands-on,** interesting for students • **Foster understanding** of big ideas of measurement • Require students to know how to **divide two whole numbers**. • Preciseness of the estimation: **Least**	• Measure with **standard** units (inch, cm) • Foster understanding of measurement tools and skill to use ruler to measure length. • Require students to know how to **divide two decimal numbers**. • Preciseness of the estimation: **Medium**	• Use geometric dynamic **software**. • Technology can be **engaging** for some students. • Measures and ratios are calculated by software • **Save time**, but **no opportunity** to practice using tools to measure length. • Need to have **computers, projectors**, and teachers need to have **skills** to use GeoGebra • Preciseness of the estimation: **Best**

Benefits Perceived by PTs

In their journal, PTs reflected on

- The **standards** and grade levels that these learning activities aim at.
- **Modifications** they would like to make.
- The **benefits** of participating in these learning activities for them as future teachers.

Themes	Codes	Freq
CK	Meaning of Pi	6
	Standard and Non-standard Units	1
	Use Protractor and Ruler	1
Processes	Visual Representation	1
	Accurate	1
PK	Students Learn Differently	6
	Word Choices, Not Confuse Students	1
	Many Methods, Hands-on	4
KCT	How to Teach Circle Circumference	15
KCS	How Students Learn, Their Difficulties	5
Technology	How to Use GeoGebra	2
	Teaching	3
Core practice	Analyze Learning Activities	7
	Identify Learning Objectives	1
	Modify Activities	2
	Organize Activities	1
Disposition/Views	Confident	2
	Do not Like Technology	1
	Open to Fun Activities	1
	The Importance of Understanding	1
Resources	GeoGebra as a Resource	2
	Use These Activities in the Future	4
Themes: 9	Codes: 22	68

Kelly: These activities did better help me understand the correlations between pi and the circumference, **after 13 years of school** and I **FINALLY** understand how to find the circumference of a circle.

I also learned that it is fun to have **multiple ways of teaching** one concept and that some people understand better using **hands on activities** because it allows them to **see the math happening right in front their eyes**

Conclusion & Discussion

- PTs engaged with these activities & perceived potential benefits for their future career as teachers.
- **Rethink Teacher Education Program:**
  - Should PTs acquire CK, PK, and PCK **separately?**
  - Or could we structure our program around **core practices** & give PTs opportunities to develop necessary knowledge & skills **simultaneously**?

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