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Investigating Alternatively-Certified Teachers' Mathematical Knowledge For Teaching Calculus

Presented by

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Additional Research Team Members:

National Context…

Mathematical knowledge is an influential factor in teachers' classroom practice (Ball, Thames & Phelps, 2008; Goldsmith, Doerr, & Lewis, 2014; Lampert, 2001).

Postsecondary studies of mathematics can have an important, positive impact on mathematical knowledge for teaching (Ball et al. 2008; Paolucci, 2015).

Teachers with little or no mathematical studies beyond their own K-12 education are likely to need support similar to out-of-field mathematics teachers – qualified teachers teaching mathematics without the required subject area training (Hobbs & Törner, 2019; Ní Ríodáin et al., 2017).

This is particularly important given links between out-of-field teaching and teacher quality and research suggesting that teachers often teach out of field in

- schools where students are already underserved and
- critical, foundational courses.

(Ingersoll, 2002; Nguyen & Redding, 2018)

Florida Context…

In Florida, aspiring mathematics teachers with undergraduate degrees in unrelated fields can earn temporary certification by passing the Florida Teacher Certification Exam (FTCE) Subject Area Exam in 6-12 Mathematics (SAE-Math).

Temporarily certified mathematics teachers are immediately eligible to teach.

Programs designed to meet professional certification requirements, such as Educator Preparation Institutes (EPIs), typically don't include content courses.

In these cases, preparation for the SAE-Math can be the primary support for development of content knowledge needed to teach.

Florida's SAE-Math

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Competency		Approximate Percentage of Total Test Questions
1	Knowledge of algebra	13%
2	Knowledge of advanced algebra	12%
3	Knowledge of functions	8%
4	Knowledge of geometry	15%
5	Knowledge of coordinate geometry	6%
6	Knowledge of trigonometry	7%
7	Knowledge of statistics and probability	10%
8	Knowledge of calculus	9%
9	Knowledge of mathematical reasoning	5%
10	Knowledge of instruction and assessment	15%

Competency 10—Knowledge of instruction and assessment

DIRECTIONS: Read the question and select the best response.

While checking student work during class, a teacher noticed the following examples on a student paper.

> Directions: Simplify completely.
> 1. $\sqrt{200}$ ANS: $2\sqrt{10}$
> 2. $\sqrt{75}$ ANS: $3\sqrt{5}$
> 3. $\sqrt{52}$ ANS: $13\sqrt{2}$

Which of the following is the most appropriate way to remediate the student's misconception?

- A. interviewing the student
- B. telling the student to work the problems again
- C. assigning a remediation worksheet for homework
- D. providing the correct answers

Competency 10—Knowledge of instruction and assessment

DIRECTIONS: Read the question and select the best response.

Students are given a checklist to use for problem solving. This is a form of which type of assessment?

- A. performance assessment
- B. formative assessment
- C. objective assessment
- D. summative assessment

Competency 10—Knowledge of instruction and assessment

DIRECTIONS: Read the question and select the best response.

When assessing students' knowledge of factoring, which of the following is an accommodation a teacher might use for an ESE student?

- A. having students work in a group on a worksheet
- B. telling the student how to factor
- C. giving the student extended time to complete the task
- D. providing a take home test for the student

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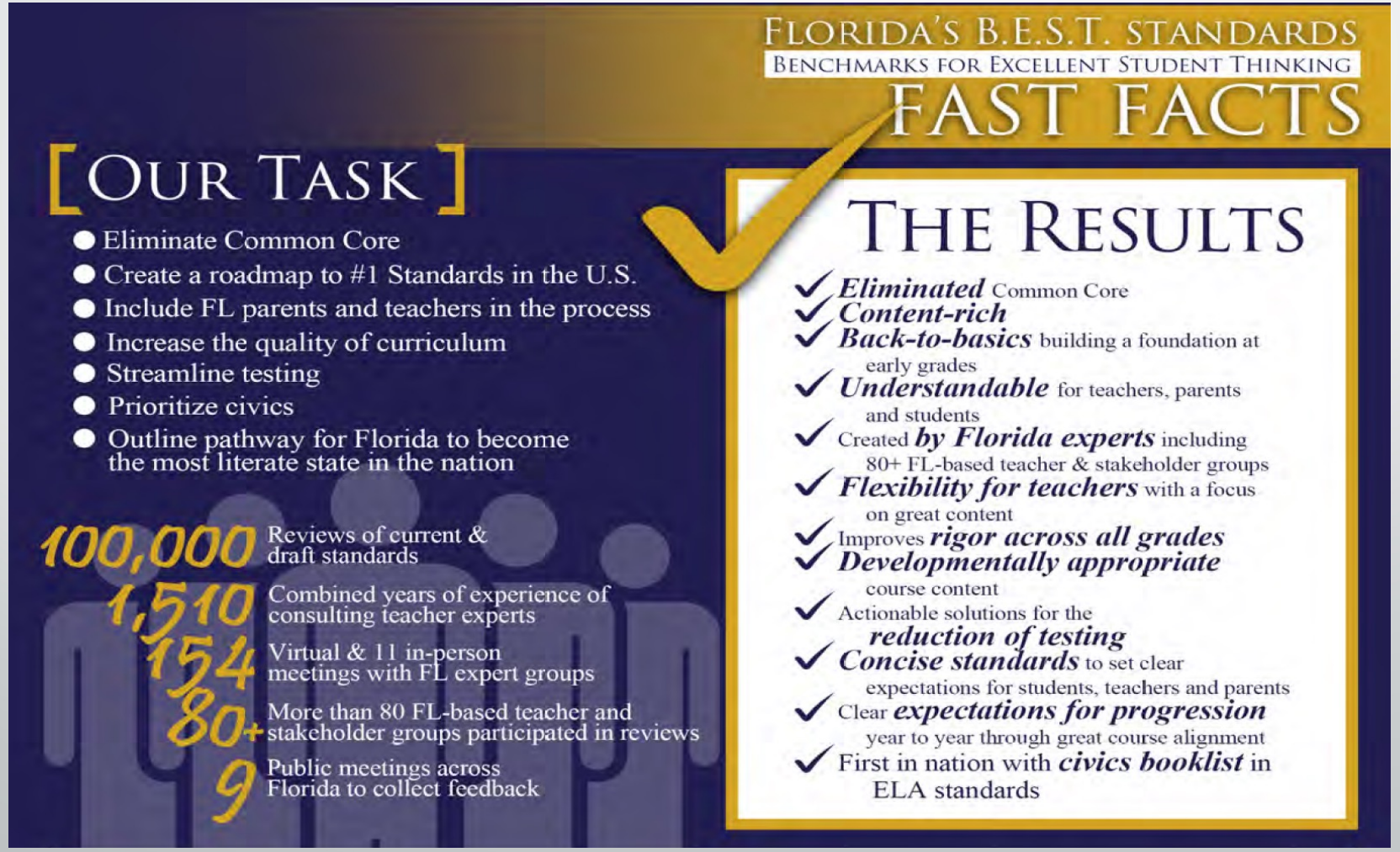
Florida Context…

Florida's transition to the BEST Standards means that teachers will be expected to adjust their mathematical knowledge to teach a new curriculum.



MATH

+ Ends "Confusing/Crazy Math" that was a roadblock for parents to help students at home
+ Flexibility given to students to show their unique "strategy" for problem-solving
+ Focus on correct ANSWER, not only the method
+ Balanced emphasis on skills vs. concepts will help struggling students catch up
+ Financial Literacy added throughout high school
+ Moves mastery of basic whole number arithmetic from 6th to 5th grade
+ Full glossary to give teachers and parents a comprehensive understanding
+ Clearer indications of how different topics connect within and from grade to grade
+ Includes real-world context to make math more valuable to overall education

[NEXT STEPS]

2020-2021

The FL State Board of Education will adopt the package all-in-one

&

Governor's proposed budget includes $3 million to support teachers

2021-2022

ELA curriculum will be updated

2022-2023

Math curriculum will be updated & Assessments will be complete

http://www.fldoe.org/core/fileparse.php/18736/urlt/StandardsOnePager.pdf

Research Aim & Goals…

Aim: Examine and develop targeted support for content knowledge development needs of Florida's alternatively-certified mathematics teachers.

Research Goal 1: Establish baseline trends in the mathematical backgrounds, knowledge, and experiences of Florida's aspiring and newly-certified mathematics teachers to better understand their content knowledge development needs.

Research Goal 2: Create and measure the effectiveness of an online dynamic assessment and learning tool that addresses gaps in alternatively-certified teachers' content preparation and supports content knowledge development aligned with Florida's B.E.S.T. standards.

Research Questions…

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1. How does the mathematical content included in SAE-Math preparation materials align with the standards that frame the curriculum that Florida's mathematics teachers are expected to teach?

2. In what areas do the SAE-Math preparation materials support teachers' conceptual understanding of the mathematics they will teach?

3. What are the priority focus areas for professional learning tools designed to strengthen alternatively-certified mathematics teacher' content knowledge to support their teaching of Florida's new BEST standards?

Research Methods…

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1. **Collection of SAE-Math preparation materials**, including online tutorials and sample questions (open access; minimal cost; free online trials).

2. **Coding preparation materials with BEST Standards**
   Alignment with standards/indicators
   Partial fit (including not real world)
   Not in standards

3. **Scoring of materials for cognitive demand** with Bloom's Taxonomy
   Levels 1-2: Primarily assesses procedural knowledge (*Remember*, *Understand*)
   Levels 3-4: Assesses combination of procedural knowledge and conceptual understanding (*Apply, Analyze*)
   Levels 5-6: Primarily assesses conceptual understanding (*Evaluate, Create*)

BEST Terminology

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K-8 Example

Subject	*Grade Level*	*Strand*	*Standard*	*Benchmark*
MA.	**2.**	**NSO.**	**2.**	**1**
Mathematics	Grade 2	Number Sense and Operations	Add and subtract two- and three-digit whole numbers.	Recall addition facts with sums to 20 and related subtraction facts with automaticity.

9-12 Example

Subject	*Grade Level*	*Strand*	*Standard*	*Benchmark*
MA.	**912.**	**GR.**	**3.**	**4**
Mathematics	Grades 9-12	Geometric Reasoning	Use coordinate geometry to solve problems or prove relationships.	Solve mathematical and real-world problems on the coordinate plane involving perimeter or area of polygons.

Overall Findings (RQ1)

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Collected **103 sets of preparation materials** (lessons, videos, sample tests)

Coded **2,078 preparation items** (tutorial explanations, practice questions)

	BEST Benchmarks			In prep materials		
	6-8	9-12	Total	6-8	9-12	Total
Algebraic Reasoning	39	67	**106**	36	60	**96** (91%)
Calculus		52	**52**		33	**33** (63%)
Data Analysis & Probability	21	46	**67**	17	30	**47** (70%)
Financial Literacy		32	**32**		1	**1** (3%)
Functions	3	23	**26**	2	11	**13** (50%)
Geometric Reasoning	25	43	**68**	21	32	**53** (78%)
Logic & Theory		28	**28**		9	**9** (32%)
Number Sense & Operation	25	26	**51**	18	21	**39** (76%)
Trigonometry		25	**25**		10	**10** (40%)

Calculus Findings RQ1

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Standard	Benchmark	Code Count
C.912.1	1	13
	2	12
	3	3
	4	1
	5	1
	6	1
	7	0
	8	0
	9	1
	10	0
	11	0
	12	0
C.912.2	1	13
	2	6
	3	0
	4	28
	5	1
	6	8
	7	0
	8	3
	9	2
	10	6
	11	0
	12	0
	13	3

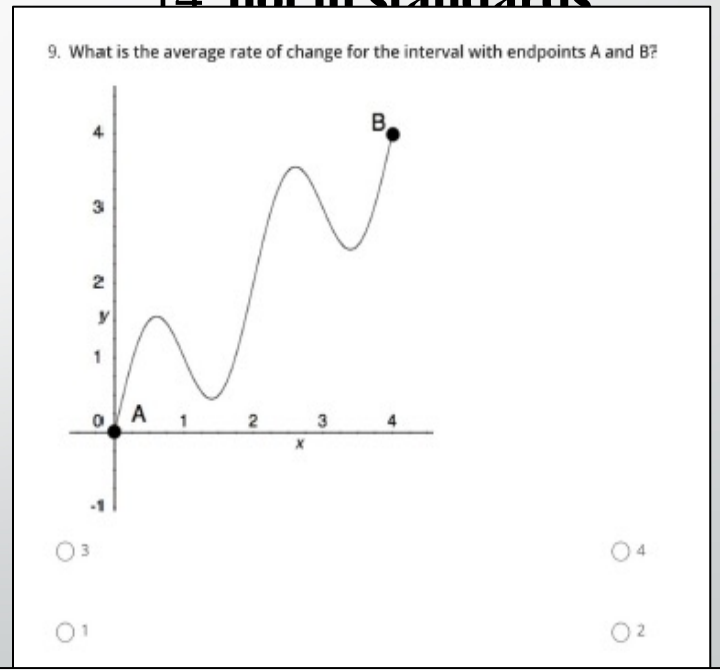
Standard	Benchmark	Code Count
C.912.3	1	5
	2	5
	3	6
	4	17
	5	14
	6	9
	7	0
	8	19
	9	0
	10	3
C.912.4	1	0
	2	0
	3	2
	4	0
	5	6
	6	9
	7	0
	8	4
	9	10
	10	0
C.912.5	1	3
	2	0
	3	0
	4	0
	5	6
	6	1
	7	2

Additional Findings

# of Calculus items

69 **partial fit**

14 **not in standards**



3.8: Find average and instantaneous rate of change. Explain the instantaneous rate of change as the limit of the average rate of change. Interpret a derivative as a rate of change in applications, including velocity, speed, and acceleration.

Calculus Dominant Benchmarks*	Code Count	Partial Fit
Apply the rules for finding derivatives of sums, products, quotients and the Chain Rule to solve problems with functions limited to algebraic, trigonometric, inverse trigonometric, logarithmic, and exponential	28	1
Find local and absolute maximum and minimum points of a function.	17	8
Find average and instantaneous rate of change. Explain the instantaneous rate of change as the limit of the average rate of change. Interpret a derivative as a rate of change in applications, including velocity, speed, and acceleration.	19	13

*Dominant Benchmarks made up 28% of the total Calculus codes

What's missing?

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Standard	Benchmark	Code Count
C.912.1	1	13
	2	12
	3	3
	4	1
	5	1
	6	1
	7	0
	8	0
	9	1
	10	0
	11	0
	12	0
C.912.2	1	13
	2	6
	3	0
	4	28
	5	1
	6	8
	7	0
	8	3
	9	2
	10	6
	11	0
	12	0
	13	3

1.7 - **Justify** whether a function is continuous at a point.

2.3 - **Prove** the rules for finding derivatives of sums, products, quotients, and the Chain Rule.

2.12 - **Demonstrate** and use the relationship between differentiability and continuity

4.7 - **Analyze** function graphs by using derivative graphs and the Fundamental Theorem of Calculus.

5.4 - **Display** a graphic representation of the solution to a differential equation by using slope fields, and locate particular solutions to the equation.

Standard	Benchmark	Code Count
C.912.3	1	5
	2	5
	3	6
	4	17
	5	14
	6	9
	7	0
	8	19
	9	0
	10	3
C.912.4	1	0
	2	0
	3	2
	4	0
	5	6
	6	9
	7	0
	8	4
	9	10
	10	0
C.912.5	1	3
	2	0
	3	0
	4	0
	5	6
	6	1
	7	2

Conceptual Development (RQ2)

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BT Level	Code Count	% of Total
1: Remember	1060	49.6%
2: Understand	939	43.9%
3: Apply	112	5.2%
4: Analyze	5	0.2%
5: Evaluate	1	0.0%
6: Create	0	0.0%

Calculus Code Count	% of Calculus Total

Sample 'Procedural' Items

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Level 1:
Remembering

5. **Velocity is a rate of change of ____.**

- ◯ position as a function of time
- ◯ speed as a function of position
- ◯ speed as a function of time
- ◯ altitude as a function of position

Level 2:
Understanding

7. **Find the derivative of f(x).**

$f(x) = x^5$

- ◯ $f'(x) = 5x^4$
- ◯ $f'(x) = x^5$
- ◯ $f'(x) = 5x$
- ◯ $f'(x) = 5x^5$

Initial Conclusions & Next Steps

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Content gaps in preparation materials identified through missing or uneven distribution of benchmarks can **inform development of targeted professional learning** to support teachers' transition to the BEST standards.

Preparation materials mostly support content engagement and learning in ways that require **low levels of cognitive demand** and focus primarily on **procedural knowledge**.

Additional analysis will identify items with the **potential to be high-cognitive demand items focused on conceptual understanding** but **reduced to low cognitive demand** or an **entirely procedural focus** because of their **multiple-choice structure and content**.

Priority areas?? – dynamic assessment and learning tools

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Thank you!

We welcome your questions and discussion.