National Field Test Results Examining Preservice Elementary Teachers' Content Knowledge for Teaching about Matter

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Presentation Overview

- Overview on content knowledge for teaching (CKT)
- Study focus
- CKT items and instrument
- Data sample and collection
- Study methods and findings
- Study implications

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Background

Content Knowledge for Teaching (CKT)

CKT includes usable knowledge that teachers draw upon as they engage in the work of teaching

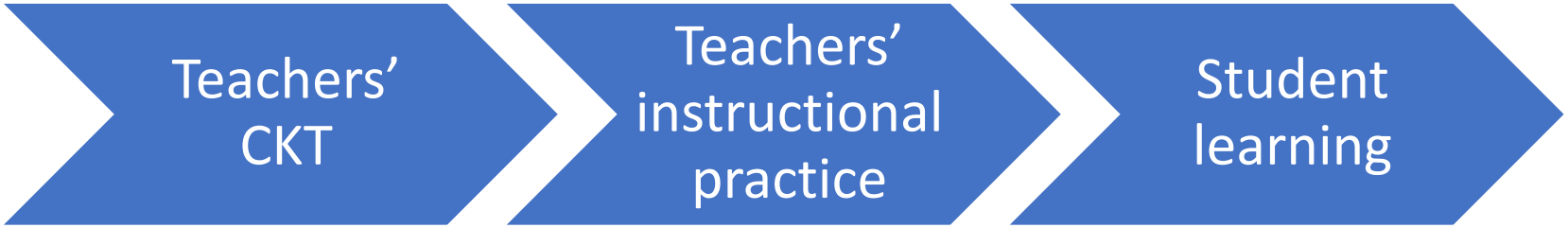
Subject Matter Knowledge

- How can matter be described and classified?
- Why is matter conserved when it changes form?
- How can the small particle model be used to explain observable phenomenon?

Pedagogical Content Knowledge

- What investigations are best used to help students learn about how different kinds of matter have different properties?
- What alternative conceptions might students have about why matter is or is not conserved?

Importance of CKT



- CKT is related to teachers' ability to engage in critical teaching practices, which impacts student learning
  - Eliciting and interpreting students' ideas
  - Selecting and implementing instructional activities to align with specified instructional goals
  - Critiquing student-generated explanations

CKT Measurement Landscape in Science Education

- Current CKT measures mainly target assessing science teachers' **subject matter knowledge**
- CKT measures that assess pedagogical content knowledge require
  - more extensive time and
  - resources to administer and score (e.g., interviews, graphic organizers, observations)
- Limited instruments that can be used efficiently and effectively on a **large scale** to assess the practice-based aspects of teachers' CKT
  - particularly their specialized knowledge and knowledge of students and instructional strategies

Study Focus and CKT Matter Instrument Development

Main Research Question

- To what extent does our CKT matter assessment provide valid and reliable inferences on preservice elementary teacher (PSET) performance?

CKT Assessment Framework

Work of Teaching Science (WOTS) Instructional Tools

	Instructional goals, big ideas, and topics	Scientific investigations & demonstrations	Scientific resources	Students' ideas	Scientific language and discourse	Scientific explanations	Scientific models & representations
Materials							
Properties of matter							
Model of matter							
Changes in matter							
Conservation of matter							

Assessing teachers' ability to evaluate instructional resources that assess student understanding about examples of matter

Assessing teachers' ability to support students in developing scientific arguments using evidence from investigations to establish that matter cannot be created or destroyed

CKT Matter Item Example

Ms. Wu is preparing a formative assessment for a third-grade unit on matter. She wants to find out if her students understand that matter includes things beyond objects and materials that they can see, feel, measure, and weigh. Ms. Wu locates four resources and each resource includes a list of four different examples for students to consider.
Which of the following is the most useful resource for Ms. Wu's purpose?
1. Resource A: a rock, a wooden board, a steel rod, a plastic ball 2. Resource B: shade, light, sound, heat 3. Resource C: takes up space, has weight, is visible, has color **4. Resource D: rock, dust, ant, air**

CKT Matter Assessment Items

- Variety of item types including:
  - Grid/table items
  - Multiple choice multiple select items
  - Inline choice items
  - Matching items
- Incorporated different stimuli within the opening scenarios (e.g., students' written work, students' talk, video clips, etc.)
- Discrete, automatically-scorable items

Field Test CKT Matter Instrument

- CKT matter items developed through an iterative process that included:
  - Peer review by item writers
  - Expert panel review
  - PSET review and interaction through cognitive interviews (n≈5 PSETs/item) and pilot testing (n≈200)
- Field test form included 60 CKT matter items that were selected to match the test blueprint
  - specified proportions across content matter topics and WOTS instructional tool categories

Data Sample and Collection

Field Test Sample

- 822 PSETs who took the Praxis licensure assessment between January 2018 to June 2019

Characteristic	Field Test Sample	Praxis Population
Female	93%	92%
White	80%	80%
Midwest	4%	4%
Northeast	22%	22%
South	46%	49%
West	28%	25%
Praxis Q1	22%	26%
Praxis Q2	27%	27%
Praxis Q3	24%	23%
Praxis Q4	27%	24%

Note: Praxis Q1 to Q4 represent the four quartiles of the Praxis Elementary Science test scores in our population (those who took this test from January 2018 to June 2019).

Data Collection Process

- Administered surveys and CKT matter assessment online to 822 PSETs in fall 2019
- Each PSET completed:
  - Background survey
  - Self-efficacy questionnaire
  - External measure of their subject matter knowledge about matter and its interactions (Horizon's AIM test)
  - Field test CKT matter assessment form

Methods and Study Findings

Data Analysis: Part One

- Used PSETs' responses to obtain classical item statistics including:
  - Proportion correct
  - Item-total correlations
  - Raw score distributions
- Checked item behavior and identified any potential issues with them
- Flagged and removed 8 items based on statistical and content concerns
- Constructed "final form" using 52 of the 60 field test items for the dimensionality and scaling analyses

Data Analysis: Part Two

- Conducted dimensionality analysis to examine nature of PSETs' CKT and to make scaling decisions using 52 well-functioning field test items
  - Does the test support subscores by content and/or WOTS categories or only an overall proficiency score?
- Involved fitting various Item Response Theory (IRT) models to assess internal structure
  - Uni-dimensional IRT model
    - all items measure single construct
  - Multi-dimensional IRT (MIRT) models
    - correspond to theorized content and WOTS categories

(M)IRT Models (I)

- Grouped similar sub-content areas into two categories
  - Materials and properties of matter and their measurement (21 items)
  - Model of, change in, and conservation of matter (31 items)
- Grouped 7 WOTS areas into 4 categories
  - WOTS 1-3: Scientific goals, resources, and models (20 items)
  - WOTS 4-5: Student ideas and scientific language (14 items)
  - WOTS 6: Scientific explanations (9 items)
  - WOTS 7: Scientific investigations (9 items)

(M)IRT Models (II)

- Model 0: 1D
  - Each item loaded on the single overall dimension
- Model 1: 2D by Content
  - Each item loaded on one of the two content dimensions
- Model 2: 4D by WOTS
  - Each item loaded on one of the four WOTS dimensions
- Model 3: 7D with an overall dimension and dimensions by Content and WOTS
  - Each item loaded on the overall dimension, a content dimension, and a WOTS dimension
  - All dimensions were uncorrelated
- Note: All models used 2-PL models for item responses

Model Fit

Model	AIC	BIC	logLik	Model fit test compared to 1D model for nested models
1D	47011.2	47501.2	-23401.6	
2D by Content	47010.6	47505.4	-23400.3	$P(\chi^2(1) > 2.59) = 0.11$
4D by WOTS	47029.6	47547.9	-23404.8	$P(\chi^2(6) > -6.39) = 1.0$
7D model	47032.1	48012.1	-23308.0	

Model fit results suggest 1D model fits best

Correlations among Dimensions

Model	Dimensions	Latent correlation estimate from MIRT model	Correlation between simple (raw) sub-scores	Disattenuated correlation between simple (raw) sub-scores
2D Content	1 & 2	0.98	0.84	0.99
4D WOTS	1 & 2	0.99	0.80	1.02
4D WOTS	1 & 3	0.98	0.75	1.00
4D WOTS	1 & 4	0.98	0.72	1.03
4D WOTS	2 & 3	0.97	0.71	0.99
4D WOTS	2 & 4	0.98	0.70	1.04
4D WOTS	3 & 4	0.97	0.66	1.02

Latent correlations between content and WOTS dimensions all near 1, further supporting use of 1D model.

Scaling Decisions and Test Properties

- Use 1D model – supports inferences about the overall integrated content and teaching practice construct
- Do not report individual test-taker subscores by content or WOTS categories
- Test properties using 1D scaling were reasonable
  - (IRT) test reliability for 1D scale was high at 0.911
  - Correlations with external measures (of content knowledge) were moderate as expected
    - r = 0.53 with Praxis Science
    - r = 0.65 with AIM Horizon Test

Study Implications

Implications and Significance

- It is difficult to parse proficiency by content or practice sub-domains.
  - If test-takers are good at integrating their content knowledge with teaching practices for one content area or type of teaching practice, they are good at it for others.
  - Findings are consistent with results for NGSS-aligned K-12 assessments that measure integrated constructs of content knowledge and science and engineering practices.
- It is possible to make an automatically scorable CKT assessment in Science.
  - Similar studies could be conducted in other content areas in Science and Math.

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Example Items

Since a main goal of this work is to develop a CKT assessment instrument that can be scored efficiently and used as an indicator system on a large scale, we only developed discrete, automatically-scorable items. They included several item types: single-select multiple choice, multiple-select multiple choice, grid, and drag-and-drop items.

CKT Matter Item Overview

Here we provide examples of various CKT assessment items about matter and its interactions that we developed and piloted during this project. Each CKT item:

- is aligned to one of the five matter topics and one of the seven WOTS instructional tool categories.

Content Focus:

- Changes in Matter
- Conservation of Matter
- Materials
- Properties and Measurements of Matter
- Small Particle Model

Work of Teaching