



Developing and Validating Assessments to Measure and Build Elementary Teachers' Content Knowledge for Teaching about Matter and Its Interactions within Teacher Education Settings



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Background

- Strong agreement in the field about the importance of science teachers' content knowledge for teaching (CKT)
- Limited instruments that can be easily administered and scored on a large scale to assess science teachers' CKT
- Need for such measures to monitor large groups of science teachers' CKT and investigate comparative questions about science teachers' CKT longitudinally

Study Purpose

Design and field test a summative assessment instrument that measures preservice elementary teachers' (PSETs') CKT in one high-leverage science content area: matter and its interactions

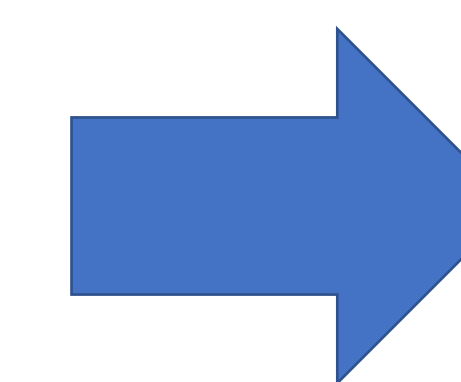
CKT Matter Assessment Item Design Matrix and Example CKT Matter Item

Work of Teaching Science 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



In Ms. Quintana's second-grade class, students explore the properties of different solids and liquids. Based on the exploration findings, students create definitions for solids and liquids. While completing the definition for liquids, one student makes the claim that "all substances that look like they take the shape of their containers are liquids." Ms. Quintana is planning to include a follow-up activity for students to collect more data and refine their ideas.

Which TWO of the following materials will best challenge the claim and help the student improve their definition?

- A) Maple syrup
- B) Ice block
- C) Salt
- D) Milk
- E) Rice

Research Question 1

RQ1: To what extent do the CKT about matter items on this instrument exhibit adequate item functioning?

Methods

- Administered 60 item CKT matter instrument to 822 PSETs
- Obtained classical item statistics (e.g., proportion correct and item-total correlations), conducted distractor analyses (e.g., flagging if any distractors correlated positively with the total score), and examined item timing data

Findings

- 8 of 12 items flagged were dropped from final form
- Final 52-item form:
 - mean proportion correct = 0.61 (min=0.28, max=0.92);
 - mean item-total correlation = 0.40 (min=0.23, max=0.55),
 - Cronbach's alpha = 0.918

Table 1. Numbers of items flagged by item type (includes flags by item statistics, visual inspection of empirical item characteristic curves, and item timing)

Item Type	Total Number of Items	Items with 1 Flag n (%)	Items with 2 or More Flags n (%)	Items Removed n (%)
Multiple Choice Single Selection	24	2 (8%)	1 (4%)	2 (8%)
Multiple Choice Multiple Selection	17	2 (12%)	2 (12%)	3 (18%)
Grid Multiple Selection	9	0 (0%)	4 (44%)	2* (22%)
Inline Choice Single/Multiple Selection	5	1 (20%)	0 (0%)	1 (20%)
Match Multiple Selection	5	0 (0%)	0 (0%)	0 (0%)

Research Question 2

RQ2: What is the nature, or structure, of the CKT used by PSETs in one science content area (matter and its interactions)?

Methods

- Ran exploratory factor analysis and analyzed scree plot
- Fit a series of multidimensional Item Response Theory (MIRT) models to item response data of 822 PSETs
 - Unidimensional model (1D)
 - 2D model by the two sub-content areas
 - 4D model by four Work of Teaching Science categories
 - 7D model with overall dim, 2 dims by content, and 4 dims by Work of Teaching Science categories

Findings

- Scree plot indicated a 1-factor solution
- Model fit statistics (AIC and BIC) favored 1D model
- Correlations between latent traits all near 1
- All results support the use of a 1D model over multidimensional models

Research Question 3

RQ3: How does PSETs' performance on the CKT matter instrument (a) compare across relevant background and preparation variables and (b) relate to their performance on other science knowledge measures?

Methods

- Administered background questionnaire to 822 PSETs
- Used one-way ANOVAs or t-tests to test for differences in mean CKT matter test performance between groups for background (e.g., gender), educational (e.g., GPA), and teacher preparation program (e.g., type of program) variables
- Correlated CKT matter test with two external measures (Praxis Science and Horizon AIM test on matter)

Findings

- No groups differences in CKT matter test performance for gender, major/minor, or teacher preparation program variables
- **Race/Ethnicity:** White > Asian or Asian American, White > Black or African American, Two or More Races > Black or African American
- **GPA:** High > Low
- **Degree Obtained:** Pursuing Bachelor's > Master's, Bachelor's Obtained > Master's
- **CKT test correlated** 0.53 with Praxis and 0.66 with AIM test

Research Question 4

RQ4: How do the PSETs perceive the importance, clarity, rigor, and relevance of the CKT matter instrument?

Methods

- Administered a perceptions survey after the CKT matter instrument to gauge PSETs' perceptions of the test
- Computed percentage strongly disagree or disagree vs. strongly agree or agree per item

Findings

- **Clarity:** 77% of PSETs found test questions clear
- **Rigor:** 78% of PSETs found test questions challenging; 50% had difficulty selecting among test question options
- **Coverage of content in teacher preparation:** content relatively new to PSETs—55% had not covered the material in their courses; 93% felt test questions made them think of aspects of teaching they had not considered before
- **Relevance of content to teaching:** 85% felt test covered material they were expected to teach; 82% felt teachers should be able to answer the test questions correctly

Participant Sample

- 822 PSETs across the United States who took ETS's *Praxis*® 5005: Elementary Education: Science Subtest licensure assessment between January 2018 and June 2019
- Stratified random sample with four stratifying variables: gender (Male, Female), geographical location (Midwest, Northeast, South, West), race/ethnicity (White vs. Not White), and *Praxis*® elementary science test quartiles (Q1-Q4)

Discussion

- Easily scored and administered instrument that supports valid inferences about PSETs' CKT about matter and assesses a construct distinct from pure subject matter knowledge
- Unidimensional structure of the CKT matter construct indicates that the items are not measuring separate dimensions
- Nature of PSETs' CKT within a science area may be less siloed and more integrated than previous research has suggested

Implications & Future Research

- Instrument has the potential to be used on a large scale across groups of PSETs within and across teacher education programs to inform: (a) individual PSETs about their CKT matter proficiency or (b) teacher educators and program leaders on PSETs' collective performance to determine future instructional support
- Future research should examine the structure of PSETs' CKT within other science content areas

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Project Website



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