Creating a Summative Assessment to Measure Elementary Pre-Service Teachers' Content Knowledge for Teaching (CKT) about Matter and Its Interactions

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Background

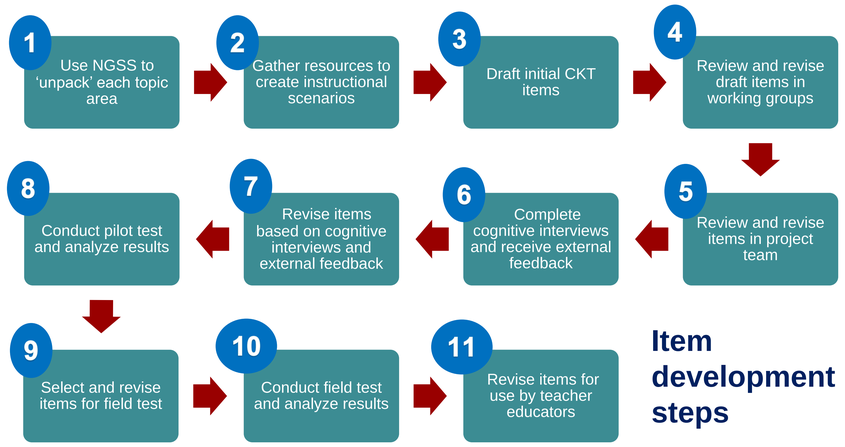
- Research emphasizes that content knowledge alone is insufficient for effective teaching. (Ball, Thames, & Phelps, 2008; National Academies, 2015; National Research Council, 2013; Shulman, 1986)
- CKT includes both subject matter knowledge and pedagogical content knowledge (PCK), and may especially benefit elementary science teachers, who tend to struggle with understanding science content and science-specific pedagogies to effectively support student learning. (Davis, Petish, & Smithey, 2006; Etkina, Gitomer, Locanangelo, Phelps, Seeley, & Vokos, 2008; National Research Council, 2007)
- CKT supports teachers' abilities to engage successfully in critical teaching practices. (Baumert et al., 2010; Hill, Dean, & Goffney, 2007; Hill, Ball, & Schilling, 2008; Schneider & Plasman, 2011)
- Most CKT assessments require substantial time to administer and score, making it challenging to implement on a large-scale to examine science teachers' CKT across multiple sites or longitudinally.
- Assessing CKT for foundational science topics, such as matter and its interactions, is critical to support preservice elementary teachers.

Work of Teaching Science

The 'Work of Teaching Science' (WOTS) framework details the science-specific teaching practices most critical for beginning elementary science teachers. (Mikeska, Kurzum, Steinberg, & Xu, 2018)

WOTS Instructional Tools Categories	Examples of Science Teaching Practices
1. Scientific Instructional Goals, Big Ideas, and Topics	Choosing which science ideas or instructional activities are most closely related to a particular instructional goal
2. Scientific Investigations and Demonstrations	Selecting investigations or demonstrations that facilitate understanding of disciplinary core ideas, scientific practices, or cross-cutting concepts
3. Scientific Resources (texts, curriculum materials, etc.)	Evaluating instructional materials for their ability to address scientific concepts; engage students with relevant phenomena; promote students' scientific thinking; and assess student progress
4. Student Ideas	Analyzing student ideas for common misconceptions regarding intended scientific learning
5. Scientific Language, Discourse, and Vocabulary	Anticipating scientific language and vocabulary that may be difficult for students
6. Scientific Explanations	Critiquing student-generated explanations or descriptions for their accuracy, precision, or consistency with scientific evidence
7. Scientific Models and Representations	Evaluating or selecting scientific models and representations that predict or explain scientific phenomena or address instructional goals

CKT Item Development Process



Step 3 — **Initial Item Draft**

Ms. Lopez claims that heat sometimes causes changes that can be reversed while other times the changes cannot be reversed. She shows her second-grade class a video of a raw egg being cracked, poured into a frying pan, and then being fried. She then shows a video of butter being melted in a pan which is then allowed to freeze back into solid butter. Ms. Lopez asks the students to explain how the videos showed evidence for her claim.

Select the student response that demonstrates a second-grade statement of evidence that is accurate and generalizable.

a) "They turned the egg into a solid with heat and then turned butter into a liquid. They're opposites."
b) "The butter melted and then become hard again but the egg stayed hard."
c) "You can keep turning the butter into hard and liquid over and over again."
d) "The butter stayed butter, and the egg stayed an egg."

Item following working group and project team revisions based on cognitive interviews, external feedback and pilot test results

Step 9 — **Item Revised for Field Test**

Ms. Lopez shows her second-grade class a video of a raw egg being cracked, poured into a frying pan, fried, and cooled down. She then shows a video of butter being melted in a pan and allowed to cool down. Ms. Lopez makes two claims —
1) Heat can cause a reversible change with butter.
2) Heat can cause an irreversible change with an egg.

The class identifies the following observations as evidence for each of her claims.

1. The solid butter melted into a liquid. It cooled and then turned back into a solid.
2. The egg was liquid that turned into a solid when heated. It didn't change back when it cooled down.

Ms. Lopez asks the students to use scientific reasoning to explain how the evidence supports her claims.

Select the student response that demonstrates a second-grade statement of evidence that is accurate and generalizable.

a) "The egg and the butter did opposite things when heated."
b) "The butter melted and then became a solid again when cooled, but the egg stayed solid, even when cooled."
c) "You can keep changing the butter from solid to liquid over and over again."
d) "The butter stayed butter, and the egg stayed an egg. Nothing changed for either when they were heated."

Tools and Resources to Support Item Development

Step 2 — **Resources for Creating Item Scenarios: Content Main Ideas**

- Melting and freezing are generally explained as being a result of heating (warming) and cooling the liquid, with explanations stating that "ice changed into water" or "water changed into ice".
- Explanations for evaporation and condensation are challenging for K-2 students.
  - * Struggle to realize that the liquid must have gone somewhere (evaporation)
  - * Think that the "coldness turned into water" or that the water came through the container (condensation)
- Particle level explanations are inappropriate at this level.

Step 3 — **Item Identification and Alignment**

- Item type: Multiple choice single selection
- NGSS PE: 2-PS1-4 Construct an argument with evidence that some changes are caused by heating or cooling can be reversed and some cannot.
- Work of Teaching Science Instructional Tool: Scientific Explanations. Critiquing student generated explanations and descriptions for their generalizability, accuracy, precision, or consistency with scientific evidence.

Step 4 — **Item Review and Revision in Working Groups: Item Evaluation Checklist**

- Does the item require the teacher to apply the CKT needed to engage in the science teaching practice (STP)? ✓
- Does the teacher-focused scenario, including the stimulus, align to the specified Next Generation Science Standard performance expectation? ✓
- Is the teacher-focused scenario, including the stimulus, authentic and grade-level appropriate? ✓
- Does the stem present a complete idea, clearly define the teacher's task, and include all details to understand how to respond to the item (including the required number of options)? ✓
- Does the item have a single best answer or answers [(for technology enhanced items (TEIs)]? ✓
- Are the distracters plausible? ✓
- Are the options (key and distracters) about the same length and level of complexity? ✓
- Are there no irrelevant clues that make the key or any distracter more attractive? ✓

Evidence for Item Revision

Step 4 — **Working Group Feedback**

Team member 2 – 1/20/2019
I am wondering if the scenario can be reorganized. Exploration first—claim and evidence later.

Team member 3 – 1/23/2019
The sequencing suggested by team member 2 is generally what is recommended for elementary students. Also, you do not have to "freeze" butter for it to become a solid again. Perhaps use a different description in the scenario for the word freeze.

Step 5 — **Project Team Feedback**

Could this item be included in cognitive interviews as is or with minor revisions?
(Criteria: Scenario/stem/options not too confusing, no unintended incorrect content, no issues with the key)

Reviewer A	Reviewer B
Yes	Minor revisions -- think a word (or two) is missing in option C (does not make sense as written)

Step 6 — **Feedback from Cognitive Interviews**

Answer Accuracy and Justification
Three preservice teachers (PSTs) responded correctly to the item; however, only two of these provided the appropriate justification. One PST misread the item and ultimately resorted to guessing an answer. One PST overlooked that the item required a single response and tried to answer the question by unsuccessfully eliminating the distracters.
Unclear/Confusing Aspects
One participant noted that the item options should make explicit the connection between the evidence and the teacher's claims about both reversible and irreversible changes.

Step 6 — **Feedback from Expert Reviewers**

Feedback: Response Information (options).

Reviewer 1. Response wording seems fine.

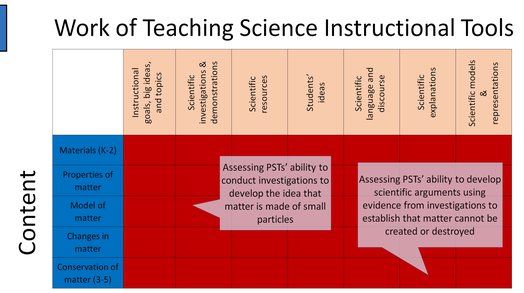
Reviewer 2. These [responses] do not seem to me to connect to the claim. They repeat the observations.

Reviewer 3. Is the teacher suggesting an egg starts as a liquid in the scenario? In choice B is the egg hard at the beginning. This is incorrect and 'hard' is a common misconception of a solid. For instance butter is soft as a solid.

Mapping of CKT Matter Items

Our team developed a variety of assessment items to measure pre-service elementary teachers' CKT for teaching matter and its interactions.

- Item assignments were organized so that each WOTS category was represented in each content category for all grade bands.
- Item writers were instructed to vary different aspects of their items (e.g., item type, teachers' gender and ethnicity, use of graphics, etc.) to generate a broad array of CKT matter items.
- Individual item data was tracked to manage each item's status and specifications.



Next Steps and Resources

- Use field test data to further refine assessment items.
- Use CKT assessment to determine specific areas of CKT that preservice teachers need to develop in university courses.
- Develop CKT instructional materials to support preservice teachers.

Scan for more information

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