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Pre-service Teachers' Use of Content Knowledge to Inform Formative Assessment Strategies in an Integrated Life Sciences Methods Course

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Title:
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Abstract:
Pre-service elementary teachers should learn essential science concepts, how to apply those concepts to practice in elementary science learning environments, and how to effectively connect students' ideas to appropriate instructional strategies. In order to effectively engage students in scientific practices and connect students' ideas about science to appropriate instructional strategies, teachers should learn to engage in high-leverage instructional practices, such as formative assessment. However, teachers may not understand formative assessment or possess enough science content knowledge to effectively engage in related instructional practices. To address these needs, we developed an innovative course for elementary pre-service teachers built upon two pillars—life science disciplinary content and formative assessment. Students learned biological science content and how to connect disciplinary ideas to essential concepts in the K-12 science standards. The focus on formative assessment allowed pre-service teachers to utilize content knowledge to identify and respond to students' ideas. We included an embedded mixed methods study designed to evaluate the effect of this intervention on pre-service teachers' content knowledge and ability to engage in formative assessment practices for science. We found that increased content knowledge over the semester helped pre-service teachers to engage more productively in anticipating and evaluating student ideas, but not in choosing next instructional steps based on those ideas. Here we will present details of the course design and results of the embedded study.

Preservice Teachers' Use of Content Knowledge to Inform Formative Assessment Strategies in an Integrated Life Sciences Methods Course

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DBER Seminar

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Today's talk

Development of and research within an integrated life science and elementary methods course for preservice teachers

- Course development
- Embedded research
- Findings

Preservice teacher education

Elementary preservice teachers

- Often have limited science subject matter knowledge (Rice, 2005; Haefner & Zembal-Saul, 2004)
- Content they encounter in teacher ed programs is often not easily translated to elementary science learning environments (Rice, 2005; Haefner & Zembal-Saul, 2004)
- Should learn
  - Essential science concepts
  - How to identify those concepts within national and local standards
  - How to engage students in scientific practices
  - How to connect students' ideas about science to appropriate instructional strategies

Formative assessment (FA)

- Formative assessment is an important instructional practice (Bell & Cowie, 2001; Black & Wiliam, 2009; Coffey, et al., 2011)
- Allows teachers to create student-centered learning environments by
  - Genuinely engaging with student ideas
  - Taking individual student progress into account
  - Crafting responsive instruction (Bell & Cowie, 2001; Coffey, Hammer, Levin, & Grant, 2011)
- Involves
  - Anticipating and Evaluating students' ideas
  - Formulating and enacting Next steps to support students' learning

FA and content knowledge

- Formative assessment practices are discipline-specific (Coffey et al., 2011)
- Teachers' knowledge of disciplinary content is therefore critically important (Davis et al., 2006; Falk, 2012; Hill, Rowan, & Ball, 2005)
  - Elementary teachers may not understand FA or possess sufficient content knowledge to engage in the practice effectively (Coffey et al., 2011)
  - Teachers are typically better at determining what their students understand than they are in deciding what to do next with that information (Heritage et al. 2009)
  - Teachers need support to incorporate content knowledge in order to effectively engage in formative assessment (Coffey et al., 2011)

Course details

Teaching and Learning in the Biological Sciences

- University of Iowa, Fall 2013
- Integrated life science content with elementary science methods
- Two pillars: life science content and formative assessment

Course design

- Central lecture

  Focused on life science content

- Small-group methods labs

  Focused on connecting the content to teaching practices and collaborative work

- Focused on essential concepts identified in the Next Generation Science Standards (NRC, 2013)
- Combined adult content knowledge, national and local standards, and research on students' ideas

Purpose of the course

To provide undergraduate elementary preservice teachers with:

- the necessary tools to develop a robust understanding of essential concepts in the biological sciences.
- opportunities to implement elementary science curriculum materials to engage in effective instruction about biological concepts.
- resources and opportunities to connect the relevant pieces of adult content knowledge, national and local standards, and research on students' ideas.

Driving questions for the course

- What are the essential concepts in the biological sciences that constitute the elementary science curriculum?
- What has past research shown about elementary students' ideas and learning in the biological sciences?
- What are characteristics of effective elementary science curriculum materials designed to promote students' learning of essential concepts in the biological sciences?
- What are crucial instructional strategies that promote students' learning of essential concepts in the biological sciences?

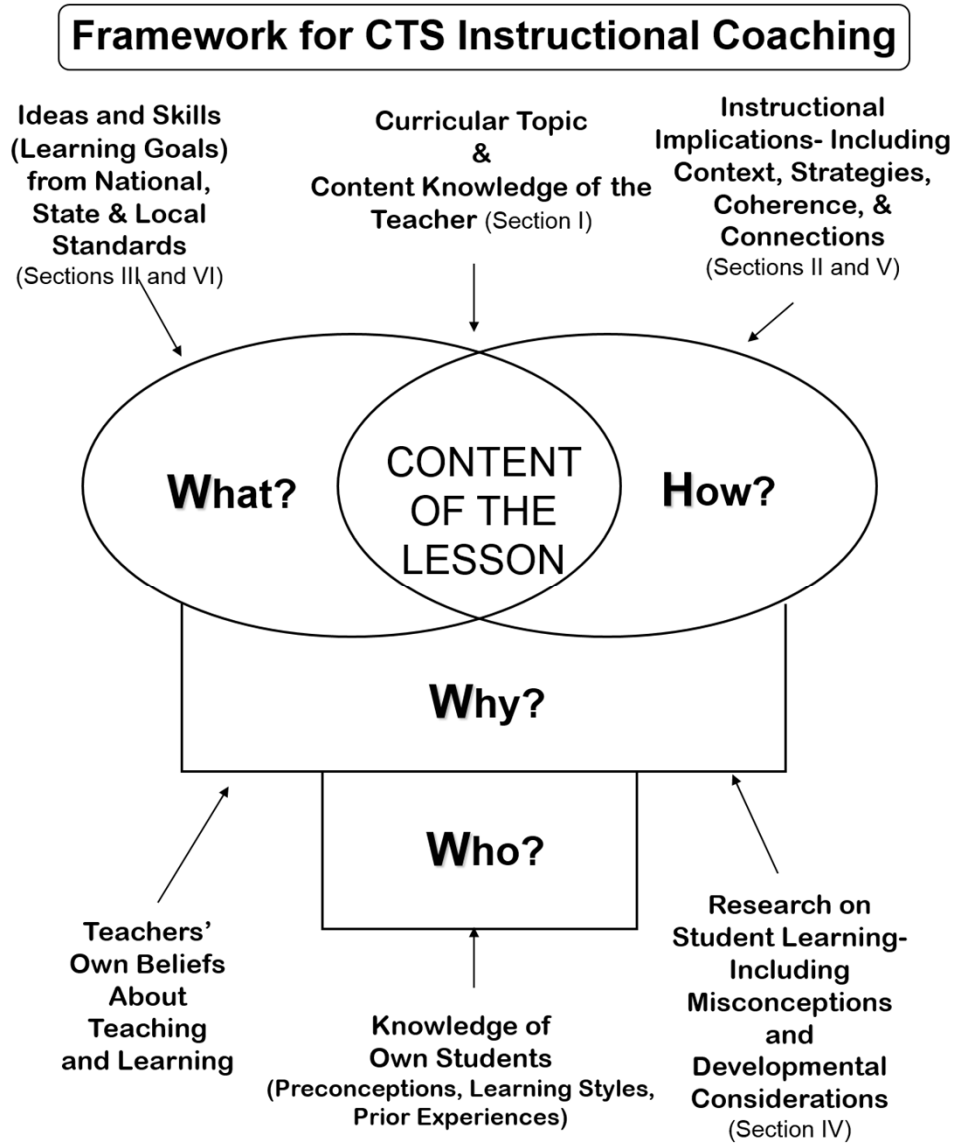
Student assignments

- Curriculum Topic Study (CTS) (Keeley, 2005)
- Pre and post content exams
- Weekly quizzes
- 3 in-class FA assignments
- Student interview project

Curriculum Topic Study (CTS)

- A set of tools and resources that allow teachers to focus on curriculum, instruction, assessment, and teacher content knowledge
- Incorporates content knowledge with science standards and research on student ideas
- Each guide is focused on a curricular topic and has 6 sections with links to readings within specific sources
  - Identify adult content knowledge
  - Consider instructional implications
  - Identify concepts and specific ideas
  - Examine research on student learning
  - Examine coherency and articulation
  - Clarify state standards and district curriculum

CTS Framework



Mundry et al. (2010)

Content exams and quizzes

- Content exams
  - Pre and posttests
  - 48 multiple choice questions
  - Selected from the AAAS assessment item bank, written to align with CTS topics (AAAS Project 2061, 2013)
  - Connect science content from CTS topics and lectures
- Weekly quizzes
  - 5 questions
  - Connect science content from CTS topics

Student interview project

- Select a life science concept
- Do background study to identify what elementary students should know about the topic
- Interview two elementary students and analyze their ideas
- Write paper and present findings

FA assignments

Included:

- Analysis of a science lesson plan
- Anticipation of students' ideas based on the lesson plan (Anticipate)
- Interpretation and evaluation of elementary student work samples (Evaluate)
- Decision-making about future instruction based on student work (Next steps)

Completed online in methods lab with class discussions throughout

Assignment 1

Seed dispersal (3rd grade)

Key concept: Seeds can be dispersed in many different ways based on their physical characteristics

How does this seed called a cocklebur travel? Why do you think it travels this way?

Student 1

By animal skin. It's prickly so I think it could go on animal skins.

Assignment 2

Skeletal system (4th grade)

Key concept: Bones have three major functions in the human body: support, protection, and locomotion

11. a. What are the three main functions of a skeleton?

(1) protect

(2) Movement

(3) Support

b. The skull is a hollow case, made of bony plates. Which of the functions you listed above is the primary function of the skull? protect

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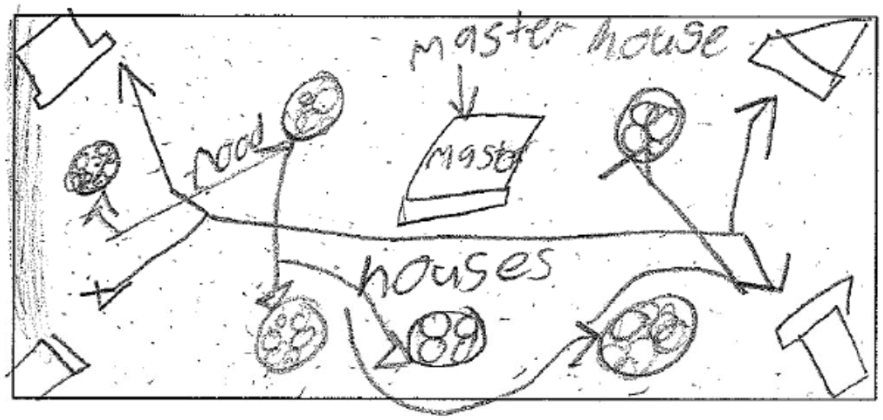
Assignment 3 student work

Habitats (3rd grade)

Key concept: Crayfish habitats must include clean, cool water; food; and shelter. These are what the animal requires to live in its habitat.

- Draw a habitat that would be suitable for several crayfish and label the objects you draw. (You don't need to draw the crayfish.)



- What basic needs are supplied by the objects in your drawing?

food, Protection Gravel

- What basic need(s) does the crayfish have that you could not draw?

the hole tire ocean

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Study design

- Embedded mixed methods design
- Research questions:
  - Does greater content knowledge enable preservice teachers to more effectively engage in formative assessment for science?
  - How do preservice elementary teachers draw upon their content knowledge to anticipate and evaluate evidence of students' thinking and to reason about instructional next steps?

Data Sources

- Scores from pre- and posttests (n= 49)
- Science background and interest survey (n = 49)
- Scores from 3 FA assignments (n = 49)
- Semi-structured interviews (10 purposely-selected students per assignment, n = 30)

FA assignment scoring

- Created a rubric with a five point scale from 0 to 4
  - Example: Connection to key concept
    - 4 Response is accurate linked to the key concept
    - 3 Response has some connection to the key concept
    - 2 Response is only vaguely linked to the key concept
    - 1 Response is not linked to the key concept
    - 0 No response
- Calculated a total score and subscores for each major component:
  - *Content* knowledge
  - *Anticipating* student ideas
  - *Evaluating* trends in student understanding
  - Choosing *Next steps* in instruction.

RQ 1

Does greater content knowledge enable preservice teachers to more effectively engage in formative assessment for science?

Data sources

- Exam scores
- FA assignment scores

Data analysis

- *t* tests
- Repeated measures ANOVA
- Multivariate ANCOVA

Content knowledge

Posttest scores were significantly higher than pretest scores

Pretest mean = 34.14; posttest mean = 40.12

$t(48) = 12.38$, $p = 1.51E\text{-}16$, Cohen's $d = 1.49$

➡ Preservice teachers' knowledge of life science content grew over the semester.

Engagement in FA

Repeated-measures ANOVA to determine if preservice teachers engaged more productively in FA over time

	F	df	*p*
Total assignment	5.223	2, 47	0.007*
Anticipating subset	3.694	2, 47	0.029*
Evaluating subset	8.089	2, 47	0.001*
Next step subset	2.311	2, 47	0.105

*Significant at 0.05

➡ Preservice teachers significantly improved in their ability to anticipate student ideas and evaluate student work, but not in deciding what to do with that information in developing next instructional steps.

Content knowledge and FA

Multivariate ANCOVA to analyze the assignments – final exam as a fixed factor, pretest as a covariate – to determine if preservice teachers' knowledge of life science content predicts effectiveness in engaging in the FA tasks

	F	df	*p*
Assignment 1	2.391	15, 33	0.018*
Assignment 2	1.996	15, 33	0.048*
Assignment 3	1.192	15, 33	0.325

*Significant at 0.05

➡ Content knowledge allowed students to engage more productively in the overall formative assessment process for the first two assignments, but not for the third.

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RQ 2

How do preservice elementary teachers draw upon their content knowledge to anticipate and evaluate evidence of students' thinking and to reason about instructional next steps?

Data analysis

- Qualitative coding using pre-established codes
  - Content
  - Anticipate
  - Evaluate
  - Next steps
- Queried codes with overlap between Content and each of the three FA components (Anticipate, Evaluate, Next steps)
- Identified emergent themes

Anticipating

Anticipated student alternative conceptions based on their own misunderstandings or lack of knowledge

> "They probably might think … well, I didn't even know that seeds were living" (Sarah, Assignment 1 interview)

Evaluating

Had difficulty evaluating students' ideas due to uncertainty with how to interpret the answers

> "…unless I was 100% sure that they understood it by having all three of the concepts, or the key concepts, or the three basic needs written down, then I said they still did not get it fully" (Nicole, Assignment 3 interview).

Content connection

- Relied on the lesson plan or the key concept to determine what content they evaluated in the student work

  "When I was reading through both the teacher knowledge and stuff that you should know to teach students about crayfish, I think I wrote down that they might not view crayfish as an animal, and I forget why ... because they may not even view a human as an animal." (Alyssa, Assignment 3 interview)

- References to their own content knowledge were typically connected to information they learned in class or the CTS

Next steps

- Assignment 1:

  Next steps consisted of the same procedures as in the original lesson

- Assignment 2:

  Next steps included ideas that were different from the original lesson, but did not necessarily connect to the specific trends in student work

- Assignment 3:

  Next steps focused more on connecting to the specific issues in the student work

Assignment 1 next steps

"I thought it was really important to bring in actual seeds, so that the kids handle and observe, and use with a magnifying glass or something. To just be able to look for themselves, and to see, oh, this seed has a burr, and it can stick to my clothes. Or this seed is really light, and it could travel by wind" (Megan, Assignment 1 interview).

- Same procedures as in the original lesson
- Any new ideas presented were only slight changes – using different seeds

Assignment 2 next steps

"I'd try to do something with motion because at jump rope, they really got it for that one. The movement. A lot of them got the movement part, and I thought it's because they did something that was fun, and it was memorable, and it was right there. For the protection, I'd try to do other movement activities and such so that they would also as well get what the other functions were..." (Sarah, Assignment 2 interview).

- Connects to student understanding
- Does not articulate how she would connect the protection function to movement activities
- Does not indicate how it would enhance students' understanding of the key concept

Assignment 3 next steps

"My follow-up lesson would be showing them a video clip of a crayfish living in the real bio-habitat. First I would explain the basic needs of the crayfish in the classroom habitat and then we would watch the video…Then we could find similarities and differences between those, so the crayfish living in our classroom might use pots as their shelter, but the crayfish in the wild don't have that, so they would use rocks or find something else" (Megan, Assignment 3 interview).

- Still lacking some rationale for how the ideas would enhance student understanding
- Clearly identified what steps she would take
- Connected the ideas to the problems that she identified in the student work

Use next step strategies

- Began using next step strategies learned in class in Assignment 3
- Proposed strategies were used generically and did not necessarily contain specific content from the lesson
- Still in the process of learning the strategies - may be why they did not show increased scores on this subset of questions.

Summary of findings

- Development of content knowledge over a semester allowed preservice teachers to engage more productively in formative assessment practices, particularly in effectively anticipating and evaluating student ideas.
- Tended to rely on content from the class (lectures and CTS) or the lesson plan/key concept
- Increased content knowledge did not help them propose next instructional steps, at least during the semester.
- Increased use of newly-learned strategies did not connect to the identified concerns with the student work

Course improvements

- Practicum – students need classroom experience to put practices into context
- CTS – changes based on Next Generation Science Standards (NRC, 2013)
- Further integration of content with the methods

Implications

- Combining content knowledge with instructional methods can lead to gains in how preservice teachers engage in high-leverage instructional practices (Ball & Forzani, 2009).
- Preservice teacher education should include directed content knowledge instruction and support for connecting that content knowledge to classroom practice and evaluation of student ideas.
- Integration of these pieces can provide prospective teachers with preparation to create the kind of effective science learning environments that utilize student ideas to increase their understanding of the natural world (NRC, 2007).

For More Information

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