Elementary science teachers’ ways of coping with science knowledge in their teaching practice

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* (This work has been done with Andy Anderson)

Before watching the videos

• Context of the Cases
  • Collected cases of six elementary teacher candidates in the final two years (their senior and intern years) in Michigan State University’s 5-year teacher preparation program
  • Chose three interns who represented a range of backgrounds and approaches to science teaching

• Process for the Cases Collection
  • Content knowledge interviews on six content topics - simple machines, sounds, electricity and magnetism, condensation/evaporation, land pollution, and contraction/expansion
  • Written assignments: their journals, lesson plans/reports, autobiographies, portfolios, and activity worksheets
  • Classroom observation of their teaching & Making field notes
  • Pre- & Post - Lesson interviews
  • Stimulated recall interviews
Informants

- **Steve** – Pre-medicine major; took many science courses; two years of laboratory experience in the Medical Center; taught 4th grade Simple Machine
- **Leigh** – B.A. in Botany and Plant Pathology; worked at the Plant Research Lab helping with a research project for over 12 years; taught 6th grade Heating and Cooling, Expansion and Contraction
- **Sandy** – B.A. in language arts; took few science related course works; taught 5th grade Makeup of the Earth and Land Pollution

Analytical Background

- **Science Knowledge and Scientific Practice** *(Anderson, 2003)*
  - Inquiry (constructing explanations from patterns in experience)
  - Experience (data, phenomena, systems, objects, events)
  - Patterns (generalization, laws)
  - Explanation (hypotheses, models, theories)
  - Application (using scientific patterns and theories to describe, explain, predict, design)

- **Sense-making strategies** *(Anderson, 2003)*
  - **Procedural display** - producing correct answers by following memorized procedures
  - **Practical reasoning** (craft knowledge) - achieving practical results by reasoning that is action-oriented, person- and context-bound, tacit, integrated, and based on beliefs
  - **Narrative reasoning** - engaging narrative explanations of systems and phenomena in the material world
  - **Model-based reasoning** - developing and using explicit models or theories that account for phenomena within a domain of applicability
The Science Content
the three teachers taught

- "What model-based reasoning for that topic would look like?"
  - Case 1: Steve – Simple machine (Lever)
  - Case 2: Leigh – Expansion & Contraction
  - Case 3: Sandy – Makeup of the Earth

Watching the Videos

1. "Are the teachers being successful in helping their students engage in Model-based reasoning?"
2. "What approaches to sense-making strategies did the three elementary teachers exhibit in their reasoning in teachers' classroom teaching practice and students' classroom practice?"

- Video 1: Steve’s teaching
- Video 2: Leigh’s teaching
- Video 3: Sandy’s teaching

Cases Analysis

<table>
<thead>
<tr>
<th>Interview</th>
<th>Teachers’ Teaching practice</th>
<th>Students’ classroom practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Science knowledge &amp; Scientific practice</td>
<td>- How to distinguish types of science knowledge - EPE</td>
<td>- All of the data analysis on the left columns included</td>
</tr>
<tr>
<td></td>
<td>- How to engage in scientific practice: Inquiry and Application.</td>
<td>- How to respond to Ss various knowledge and ideas on the topics</td>
</tr>
<tr>
<td>2. Sense-Making Strategies</td>
<td>- Procedural display, practical reasoning, narrative reasoning, model-based reasoning</td>
<td>- The types of their scientific reasoning when teaching the important scientific ideas</td>
</tr>
<tr>
<td>3. Scientific habits of mind</td>
<td>- Whether Ts showed curiosity and rigor of the scientific world</td>
<td>- Whether Ts showed curiosity/ rigor to teach science content to Ss</td>
</tr>
</tbody>
</table>
Findings

- Steve: Limited Practice of Model-Based Reasoning
- Leigh: Accomplished Practice of Model-Based Reasoning
- Sandy: Inquiry as Finding Facts in Books

Limited Practice for Model-Based Reasoning: Steve

- In the Interview:
  - He worked back and forth flexibly between experiences, patterns, and explanations
    - We’ve already done one experiment with levers, this experiment we’re actually going to record some data, do some measurements and so some recording, and what I hope that they get out of this is that they’ll learn that work is, levers make work easier because the force is being applied to a greater distance than the object is actually being moved.
  - He wanted to have students gather data, find patterns in multiple observations of the lever system
    - Our task today is to measure the distance that the load was raised and the distance that the force traveled.

- In the teaching practice:
  - However, Steve had difficulty helping students learn science through inquiry and application
    - Steve’s difficulties – The lack of pedagogical skills and organization of classroom activity
  - Ended up telling the students what kinds of facts, rules and patterns are needed – procedural display
During Students’ learning activities:
- Students were unable to achieve the lesson objectives of inquiry and application
- Off-task, fooling around, simply waiting for Steve’s help
- The students could not understand “what” to do with the lever and “how” to collect data to fill out the data table. Most students were not able to appropriately fill out the data table on the worksheet
- Students relied mostly on procedural display to learn about simple machine

Accomplished Practice for Model-based Reasoning: Leigh

In the Interview:
- Leigh demonstrated a thorough understanding of the content
- She showed substantial understanding about experience, patterns, and explanations; came up with personal observations and examples; and developed patterns among the various experiences

We used a hair dryer to blow a ping-pong ball, have you ever seen this one? The ping-pong ball is in the stream of air, and it floats in the air. It’s really cool. Why does the ball stay in the air? It’s because the molecules of air are coming up out of the hair dryer, and hitting it, so yeah, it proves that there’s particles and they’re doing something. Yeah, it’s really cool. And we also did it with a leaf blower and a beach ball, so you see the leaf blower, the big thing blowing leaves, and the beach ball that’s big, and it really flies up in the air and it floats. It’s really great. So we saw that, and then the next day we did a distillation. The water vapor was coming through, and it was coming down the tube, and it was actually blowing down into the water, and making it bubble.

In the teaching practice:
- carried out her idea of helping students find patterns in rich experiences and develop scientific explanations
- worked hard to help students engage in Model-based reasoning in the classroom

I think that every day, we try to have a real life example that applies to what we’re talking about. Well, one of the questions that they had was the question of when they’re cooking on the stove, and they lift the pot lid up ... So, I always ask the kids, can you think of an example? Sometimes the kids come up with better examples than I think of, you know? They do!
During Students’ learning activities:

- Tried to explain the real world examples based on what they learned; applying the pattern of expansion and contraction and the theory of molecular property to several examples (Model-based reasoning)
- Students exhibited high curiosity and rigor
  - actively engaging in classroom discussion with many “why and how” questions;
  - completing the worksheets with detailed reasoning;
  - showing their ability of relating their observations to the theory of molecules

**Inquiry as Finding Facts in Books: Sandy**

- In the Interview:
  - Was able to list facts about the topics that she taught, but connected them loosely around a theme, rather than constructing a clear narrative or theoretical model
  - Sandy’s aspiration for teaching science was to help students engage in scientific inquiry
  - To her, however, scientific inquiry means to mainly find the answer in the book; and to teach definitive answers and factual knowledge from the materials

In the teaching practice:

- Sandy relied heavily on textbook reading and a review test, and delivery of factual definitions and information
  - often discussed thematically associated words, charts and stories in the book
  - rather than discussing particular examples of concepts
- She was quite satisfied with the lesson Because
  - students had a chance to learn important scientific information and stories about the scientific world
  - most of the students participated in the class; kept quiet during the class and stayed on task
  - she accomplished inquiry-based teaching, finding the answer in the book
During Students' learning activities:
- Students focused mostly on reading the textbook, listening to Sandy's explanation, and filling out the answers to the fill-in-blank types of questions (Procedural display)

<table>
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<th>Comparison of the Three Cases</th>
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<td>(Sense-Making Strategies)</td>
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<tr>
<td>Steve</td>
<td>model-based reasoning</td>
<td>attempted for model-based reasoning, but ended up with procedural display</td>
<td>gained factual definitions based on procedural display from the lecture</td>
</tr>
<tr>
<td>Leigh</td>
<td>model-based reasoning</td>
<td>accomplished teaching for model-based reasoning</td>
<td>practiced model-based reasoning</td>
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<tr>
<td>Sandy</td>
<td>procedural display -- thematically connected facts</td>
<td>engaged in &quot;inquiry&quot; in which students were supposed to learn facts from materials</td>
<td>learning for procedural display</td>
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Discussion
- “Based on teachers’ sense-making strategies, Why did the three teachers chose the strategies that they did?”
Conclusion

Engaging students in scientific sense making requires a combination of deep science knowledge, pedagogical skills, personal experience in scientific reasoning, and understanding of students.

Inquiry is a difficult practice that is deeply embedded in scientific knowledge and world views, so preparing elementary teachers to teach by inquiry will be formidably difficult.