THE CHALLENGES OF PREPARING TEACHERS TO TEACH SCIENCE

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QUESTIONS TO ADDRESS

- What are the goals for science learning?
- What do beginning science teachers need to know and be able to do?
- What learning opportunities help beginning primary science teachers learn to teach science?

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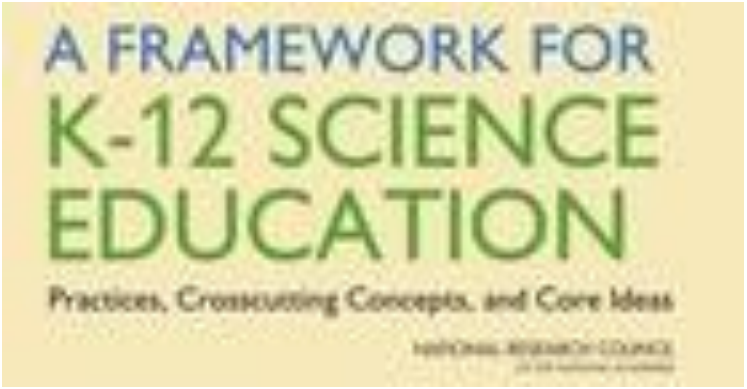
CURRENT UNDERSTANDING OF EFFECTIVE REFORM-ORIENTED SCIENCE LEARNING

- *not* linear, lockstep scientific method
- *not* expected to be uniform across science disciplines
- *not* stand-alone science processes
- *not* amorphous "inquiry"
  - not synonymous with "hands-on" or with "student-centered"

Engaging in meaningful, authentic *scientific practices* and applying the *crosscutting concepts* in support of learning *core scientific content*

- The new science standards in the US reflect this perspective



THE 3 DIMENSIONS OF THE NEXT GENERATION SCIENCE STANDARDS & FRAMEWORK

- Dimension 1: Disciplinary Core Ideas
  - such as *force and motion* or *evolution*
- Dimension 2: Science & Engineering Practices
  - such as *asking questions*, *developing and using models*, or *constructing explanations*
- Dimension 3: Crosscutting Concepts
  - such as *cause and effect* or *energy and matter*

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- What are the goals for science learning?
- **Given those goals for students… what do beginning science teachers need to know and be able to do?**
- What learning opportunities help beginning primary science teachers learn to teach science?

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WHAT DO BEGINNING SCIENCE TEACHERS NEED TO KNOW AND BE ABLE TO DO?

- Implications of the Framework for K-12 Science Education and the NGSS
  - Knowledge of science (disciplinary core ideas [DCI], crosscutting concepts [CCC])
  - Understanding and engaging in science and engineering practices
  - Content knowledge for teaching DCI, CCC, and practices
  - Teaching practices for teaching DCI, CCC, and practices

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ELEMENTARY OR PRIMARY TEACHING

- Interactive and contingent (Grossman et al., 2009)
- Unnatural and intricate (Ball & Forzani, 2009)
- Teach all academic subject areas
  - language
  - mathematics
  - social studies or history
  - science (all disciplines!)

UNIVERSITY OF MICHIGAN AS AN EXAMPLE

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OUR GOAL:
WELL-STARTED BEGINNERS

- Teachers who demonstrate beginning proficiency with a set of high-leverage practices
- "Subject-matter serious" elementary teachers who are able to represent the content with integrity
- Ethical teachers who recognize and can act on their professional obligations
- *…. all with room for further growth and development*

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PILLARS OF THE UM TEACHER ED PROGRAM

Practice-based Teacher Education

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CONSIDERATIONS FOR HIGH-LEVERAGE PRACTICES

- Considerations related to high-quality teaching: the practice is likely to be…
  - powerful in advancing students' learning
  - effective in using differences among students and confronting inequities
  - useful in many different contexts and content areas
- Considerations related to high-quality teacher education: the practice could be…
  - a building block for learning to teach
  - learned by a beginner
  - assessed
  - justified and made convincing to interns and others (i.e., face validity)
  - unlikely to be learned well only through experience

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HIGH LEVERAGE SCIENCE TEACHING PRACTICES: EXAMPLES

- To teach an elementary science lesson on condensation through scientific modeling, a teacher might need to be able to …
  - elicit students' ideas about the change of state from gas to liquid
  - adapt a lesson plan to meet the needs of her students
  - use a routine for developing classroom norms for critiquing others' scientific models

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CONTENT KNOWLEDGE FOR TEACHING (CKT)

- Content knowledge for teaching is knowledge that is used in practice for the work of teaching
  - "Work of teaching" refers to the activities in which teachers engage, and the responsibilities they have, to teach content, both inside and outside of the classroom

(Ball, Thames, & Phelps, 2008)

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CONTENT KNOWLEDGE FOR SCIENCE TEACHING: EXAMPLES

- To teach an elementary science lesson on condensation through scientific modeling, a teacher would need to understand…
  - The mechanism of the process of condensation
  - Typical alternative ideas students may have about condensation or struggles they may have with scientific modeling
  - Experiences with the phenomenon that could help to address specific alternative ideas

ETHICAL OBLIGATIONS

- Commitments teachers should have to actively work to foster equity
- Statements that (begin to) operationalize how we can promote equitable learning and schooling opportunities for all students

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ETHICAL OBLIGATIONS OF SCIENCE TEACHING: EXAMPLES

- To teach an elementary science lesson on condensation through scientific modeling, a teacher would need to be able to …
  - recognize ways in which students' models were and were not scientifically accurate, and move them toward more accurate representations
  - engage all children in discussion
  - determine a range of examples from students' lives

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QUESTIONS TO ADDRESS

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OUR OPPORTUNITIES TO LEARN

- We provide **opportunities to learn** that work toward developing…
  - high-leverage teaching practices
  - content knowledge for teaching
  - ethical obligations of teaching
- … and that reflect a range of teacher education pedagogies
  - including pedagogies of practice

PEDAGOGIES OF TEACHER EDUCATION

- Pedagogies of reflection
- Pedagogies of investigation
  - →supporting beginning teachers in developing a knowledge base and analytical skills
- Pedagogies of practice
  - →supporting beginning teachers in being able to do the work of teaching

(Grossman, Hammerness, & McDonald, 2009;
also Ball & Forzani, 2009)

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TEACHING PROFESSIONAL PRACTICE: PEDAGOGIES OF PRACTICE

- Representations of practice
  - video records
  - cases
- Decompositions of practice
  - working on elements of lesson planning
  - practicing writing on the board or using one's voice
- Approximations of practice
  - engaging in a role play or rehearsal
  - teaching a small group of students

(Grossman, Compton, et al., 2009)

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OPPORTUNITIES TO LEARN: APPROXIMATING PRACTICE EXAMPLE #1

- Children as Sensemakers #1 class
  - Course focus: Developing an orientation that children are constantly engaged in making sense of the world, and knowledge and skills related to supportingthat sensemaking
  - First month of teacher education program
  - Field-based class assignments include a series of (supported) interviews and interactive reading with one lower-elementary child.
  - High-leverage practice focus: eliciting, interpreting, and developing students' thinking
  - Science content focus: day and night

- (video)

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WHAT DO WE SEE THIS TEACHER DOING?

- The teacher begins to read the text, and uses a teaching strategy she's been taught, asking "What is the author comparing the earth to?"
- Addresses literacy practices related to reading informational text: Helps child…
  - consider key details
  - clarify meaning
- Addresses scientific practices: Engages child in…
  - obtaining, evaluating, and communicating information

- (video)

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WHAT DO WE SEE THIS TEACHER DOING?

- The teacher introduces the physical model of the earth and sun, and asks child to help manipulate it.
- Addresses literacy practices: Helps child…
  - use the illustrations to describe key ideas
  - identify similarities and differences between two “texts” (the book and the model)
- Addresses scientific practices: Engages child in…
  - Obtaining, evaluating, and communicating information
  - Developing and using models
  - Building to: constructing explanations

OPPORTUNITIES TO LEARN: APPROXIMATING PRACTICE EXAMPLE #2

- Science methods class
  - Course focus: Developing knowledge and practices to enact science lessons.
  - Third semester of the teacher education program
  - Class involves a continuum of approximations
    - peer teaching: teaching lesson segments with a small group of peers and one or more teacher educators
    - small-scale, field-based teaching experiences: teaching lesson segments with elementary students
    - full science lessons with elementary students
  - High-leverage practice focus: Engaging students in science investigations
  - Science content focus varies across lessons

- (video)

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WHAT DO WE SEE THIS TEACHER DOING?

- Working with multiple small groups of children on a complex investigation of decomposition (rotting cucumbers)
- Addressing literacy practices: Helps children
  - Integrate information from two “texts” (the workbook and the decomposition cup itself)
- Addressing scientific practices: Engages children in
  - Planning and carrying out investigations (making observations)
  - Obtaining, evaluating, and communicating information
  - Building toward analyzing and interpreting data and constructing explanations

WHAT DO WE GAIN FROM THESE APPROXIMATIONS OF PRACTICE?

- Novice teachers have a chance to
  - engage in increasingly complex and authentic work of teaching
  - build toward more sophisticated teaching
- Teacher educators have a chance to provide very focused support for teaching practice, content knowledge for teaching, and ethical obligations

CONCLUSION

- What are the goals for science learning?

  → students should have the opportunity to integrate science concepts with scientifc practices

- What do beginning science teachers need to know and be able to do?

  → teachers need rich content knowledge for science teaching and to have skill with a suite of high-leverage science teaching practices

- What learning opportunities help beginning primary science teachers learn to teach science?

  → a range of opportunities to learn, including approximations of practice, to build their CKT and skill with teaching practices