Supporting teachers' use of curriculum materials for science: Empirically-grounded perspectives on teachers' curriculum design competencies

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What are Curriculum Materials?

- Instructional resources such as textbooks, lesson plans, and student worksheets
- Critical tools with which teachers engage in instruction
  "The curriculum and its associated materials are the material medica of pedagogy, the pharmacopia from which the teacher draws those tools of teaching that present or exemplify particular content and remediate or evaluate the adequacy of student accomplishments."
  (Shulman, 1986, pg. 10)

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How Should Teachers Use Curriculum Materials?

- An ongoing tension in the field
  - 'Teacher-proofing' curricular interventions
  - Notions of 'fidelity of implementation'
- These are empirical questions grounded in design spaces associated with the teacher-curriculum relationship
- Emphasis on teacher design competencies or *pedagogical design capacity* (Brown, 2009)

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Presentation Overview

- What does it look like for teachers to engage in curriculum design?
  - Conceptual foundations
- Why should teachers be prepared to use curriculum materials effectively?
  - Empirical work

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Practice-Based Nature of Expertise for Teaching

- Teachers' work and expertise grounded in practice (Ball & Forzani, 2009; Grossman et al., 2008)
- Systems perspectives on teaching and teacher learning (Brown, 2009; Thompson et al., 2013; Grossman & McDonald, 2008)
- Focus on 'relational' phenomena in classroom systems
- "Is the learner to be understood primarily as an individual or as a community?" (Engestrom & Sannino, 2010, pg. 2)

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A Derived Framework for Instructional Practice

	Pedagogical reasoning (Shulman, 1987)	**Curriculum materials use** (Remillard, 2005)	**Epistemic actions** (Engeström & Sannino, 2010)
Problem-atize	Reflection	Design/construction/mapping	Questioning/analyzing
Plan	Transformation	Design arena	Modeling and examining model
Perform	Instruction/Evaluation	Construction arena	Implementing model
Process	Comprehension	Design/construction/mapping	Consolidating

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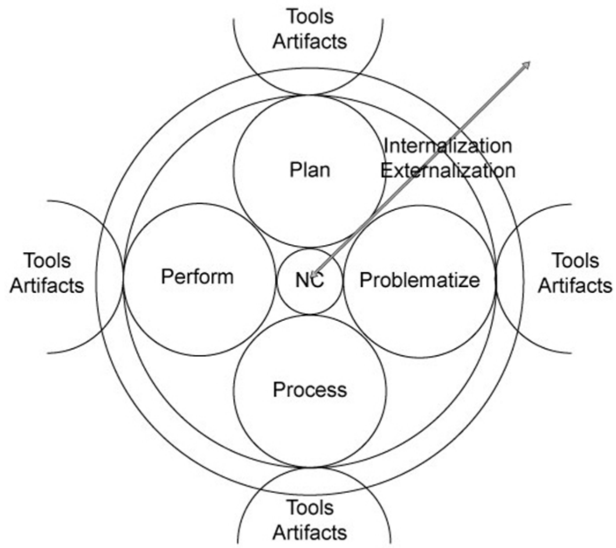
Model of Teacher Practice



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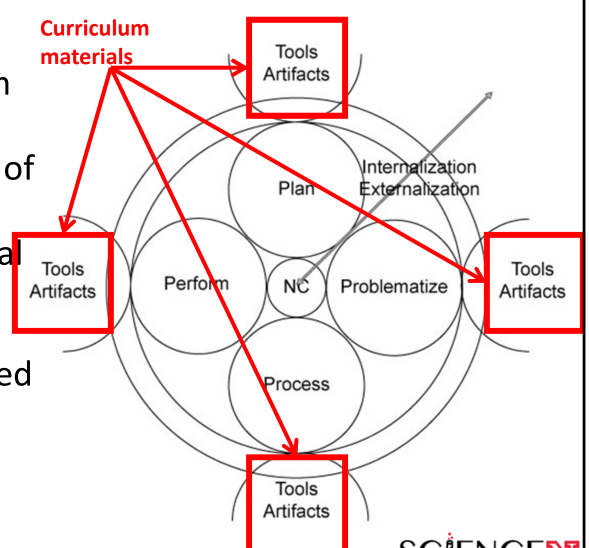
CM as Artifacts and Tools

- Ground curriculum enactment
- Evolve as artifacts of practice
- Situate professional communication in common contexts
- Emerge as proposed solutions to instructional challenges



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Pedagogical Design Capacity

- Capacity to accomplish educational goals in particular bounded settings (Brown, 2009)
- A property of learning environments (i.e., systems)
  - Teacher characteristics (knowledge, beliefs, identity)
  - Characteristics of curriculum materials
  - Students
- Honors the classroom-specificity of learning and instruction

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Why Curriculum Design?

- Classroom activity should be outcome-oriented
  - Achieve specific objectives
  - Realize planned versions of classroom activity
- Classroom systems are 'engineered' systems, not naturally occurring
- Primary entry points for changing classroom systems
  - Teachers (teacher education, professional development)
  - Curriculum materials (curriculum development)

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The Crucial Role of Teachers

- Locality of classroom practice positions teachers to ‘fine-tune’ learning environments design
- Teachers orchestrate mobilization of tools to foster practices toward some objective(s)
  - Goals
  - Scaffolding
  - Norms
- TO BE A TEACHER IS TO ENGAGE IN DESIGN

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My Work

- Critical assumption underlying my work over the past 10 years
- Supporting elementary teachers to engage in effective science instruction
- Two contexts
  - Teacher education
  - Professional development
- Curriculum materials as a platform and vehicle for pedagogical change

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Two Primary Strands

- Better engaging students in the practices of science (i.e., scientific inquiry)
- Using students' thinking to shape instruction (i.e., formative assessment)

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Strand 1 - Background

- Science as inquiry and practices of science
- Need to provide students opportunities to 'do science'
  - Science-as-inquiry (NRC, 1996; 2000)
  - Scientific practices (NRC, 2007; 2013)
- Fundamental assumption – students learn science content more effectively by participating in authentic scientific activities or processes
- Elementary teachers often struggle to engage early learners in these practices (Beyer & Davis, 2008; Metz, 2011)

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Strand 1 - Rationale

- Elementary students are capable engaging in scientific inquiry(Lehrer & Schauble, 2004; Metz, 2008, 2011; McNeill, 2011)
- Sensemaking is typically deemphasized in elementary science (Forbes et al., 2013; Abell & McDonald, 2004)
- Widely-used elementary science curriculum materials do not do this well (Forbes, 2010; Forbes, Biggers, & Zangori, 2013; Metz, 1995; 2008)
- Teachers need to learn to use curriculum materials ‘flexibly’ to engage elementary students in inquiry

Strand 1 - Projects

- Center for Curriculum Materials in Science (CCMS)
- Curriculum Access System for Elementary Science (CASES)
- Promoting Inquiry-Based Elementary Science through Collaborative Curriculum Co-Construction (PIESC^3)

Publications

- Biggers, M. & Forbes, C.T. (in progress). Inquiry in elementary science learning environments: Investigating fidelity of implementation of science curriculum materials.
- Biggers, M., Forbes, C.T. , & Zangori, L. (2013). Elementary teachers' curriculum design and pedagogical reasoning for supporting students' comparison and evaluation of evidence-based explanations. *The Elementary School Journal*, *(114)*1, 48-72.
- Forbes, C.T. (2013). Curriculum-dependent and curriculum-independent factors in preservice elementary teachers' adaptation of science curriculum materials for inquiry-based science. *Journal of Science Teacher Education*, *(24)*1, 179-197.
- Forbes, C.T., Biggers, M., & Zangori, L. (2013). Investigating essential characteristics of scientific practices in elementary science learning environments: The *Practices of Science Observation Protocol* (P-SOP). *School Science and Mathematics, (113)*4, 180-190.
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- Zangori, L., Forbes, C.T., & Biggers, M. (2013). Fostering student sense-making in elementary science learning environments: Elementary teachers' use of science curriculum materials to promote explanation-construction. *Journal of Research in Science Teaching, (50)8, 887-1017.*
- Biggers, M. & Forbes, C.T. (2012). Balancing teacher and student roles in elementary classrooms: Preservice elementary teachers' ideas about the inquiry continuum. *International Journal of Science Education, 34*(14), 2205-2229.
- Forbes, C.T. (2011). Preservice elementary teachers' adaptation of science curriculum materials for inquiry-based elementary science. *Science Education, 95*, 1–29.
- Forbes, C.T. & Davis, E.A. (2010). Curriculum design for inquiry: Preservice elementary teachers' mobilization and adaptation of science curriculum materials. *Journal of Research in Science Teaching, 47*(7), 365-387.
- Forbes, C.T. & Davis, E.A. (2008). The development of preservice elementary teachers' curricular role identity for science teaching. *Science Education, 92*(5), 909-940.

Strand 1 – Findings Theme #1

- Teachers' ideas about inquiry and the practices of science vary tremendously
- Strong emphasis on 'hands-on' activities
  - Connecting with real life
  - Conducting investigations
- Less emphasis on sensemaking
  - Explanation-construction
  - Argument

Strand 1 – Findings Theme #1

- Consistent trends
  - Recognizing trends in data = explanation
  - Communicating/sharing findings = argument
  - Student-directed inquiry is better inquiry
- Preservice and inservice teachers share many of the same ideas

Strand 1 – Findings Theme #2

- These ideas impact teachers' curriculum design practices (adaptations to curriculum materials)
  - Maximizing active, hands-on elements of lessons
  - Modifying to engage in more student-directed inquiry
  - Minimizing sense-making practices
- When using new curriculum materials, trends are independent of experience
- Evidence of interactions between teacher characteristics and curriculum materials (Brown, 2009; Remillard, 2005)

Strand 1 – Findings Theme #2

- Other factors also impact teachers' adaptations to curriculum materials
  - Curricular goals and objectives
  - Professional norms and expectations
  - Expectations for student behavior
  - Time for science instruction (daily schedule)
- Highlights the role of 'context' in teachers' curriculum design practices (Brown, 2009; Remillard, 2005)

Strand 1 – Findings Theme #2

- How do adaptations shape outcomes of interest?
  - In natural settings, teachers' adaptations do not change the nature of classroom inquiry
    - Adapt in ways that do not impact outcomes (shifting from student to teacher-directed)
    - Do not adapt
  - When emphasized as a professional goal, teachers are able to adapt curriculum materials to better engage students in inquiry (Forbes & Davis, 2010)
- Highlights need for targeted outcome to be a priority for teachers

Strand 2 - Background

- *Formative assessment* is a 'high-leverage' instructional practice (Ball & Forzani, 2009) in which teachers use evidence of students' thinking to drive instruction
- Teachers may need to modify instruction to account for students' ideas (alternative conceptions)
- A strong rationale for the need for teachers to engage in pedagogical design

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Strand 2 - Rationale

- The use of formative assessment to ground instruction in students' thinking is not widespread in elementary classrooms (Levin, Hammer, & Coffey, 2009; Sherin & van Es, 2009)
- Teachers may not understand formative assessment or possess robust knowledge of science content to use it effectively (Coffey, et al, 2011)
- Need to support teachers' learning to use formative assessment

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Strand 2 - Projects

- Reflective Assessment for Elementary Science (RAES)
  - 45 inservice teachers
  - 50 preservice teachers
- Research questions
  - How do teachers engage in formative assessment practices?
  - How do teachers use students' models as evidence of their thinking?
  - Does their content knowledge impact their formative assessment practices? If so, how?

MOHSES Modeling Hydrologic Systems in Elementary Science

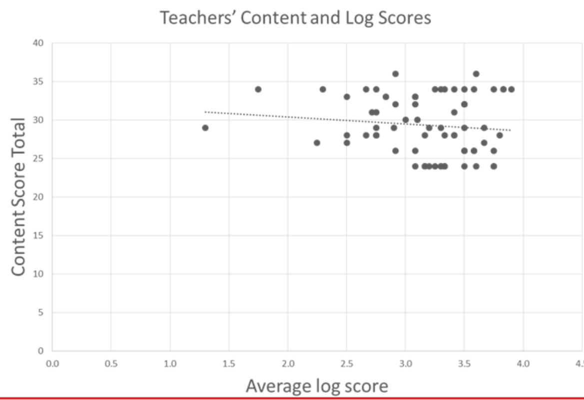
RAES REFLECTIVE ASSESSMENT FOR ELEMENTARY SCIENCE

Strand 2 - Findings

- Teachers can accurately characterize students' thinking
  - Using models (Vo, Forbes, Schwarz, & Zangori, 2014)
  - Earth science (Sabel, Forbes, & Biggers, 2014)
- Teachers need support for reasoning about next-steps instruction
  - Utilizing a range of instructional strategies
  - Aligning strategies with goals and practices (i.e., modeling)
- What support do they need?

Strand 2 - Findings

- CK for elementary teachers (Ball et al., 2008; Diamond et al., 2014)
- No evidence of CK impacting formative assessment



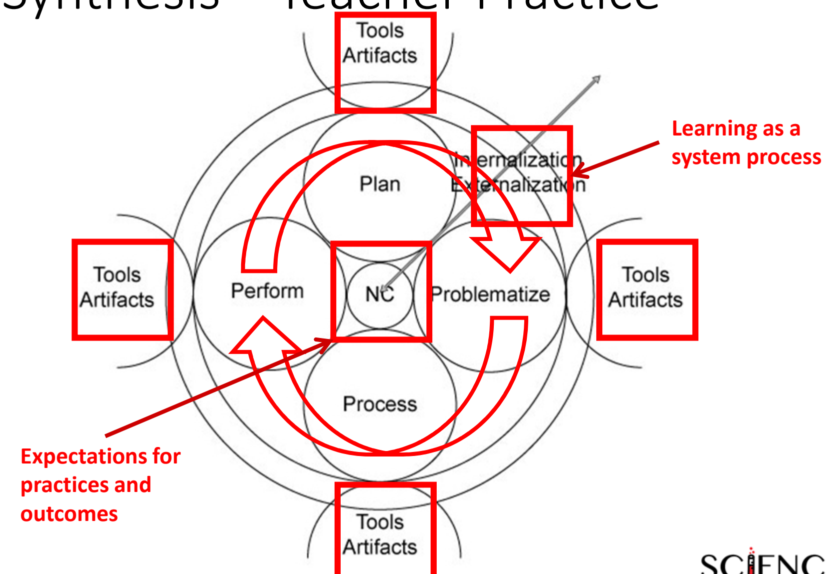
Strand 2 - Findings

- Teachers' decision-making grounded in pedagogical knowledge
  - What instructional approaches 'work'
  - 'Fun' and 'engaging' activities for students
- How do we help teachers link CK to PK and put PCK to use?
- Need for frameworks linking classroom practices/pedagogical approaches to disciplinary content (see *Next Generation Science Standards*)

Findings – The Big Picture

- Lots of reasons to engage in curriculum design
  - Students have many scientifically-inaccurate ideas
  - Elementary science curriculum materials may not embody reform-based science
- Teachers bring important resources to bear on the curriculum design process
- Teachers can effectively adapt and enact curriculum materials
- Context matters (A LOT)

Synthesis – Teacher Practice



Moving Forward – Promoting Pedagogical Design Capacity

- Explicit goals and desired outcomes
- Curriculum materials and 'teacher characteristics' as artifacts and tools
- Highlight place of students in classroom systems and perspectives on PDC
- Curriculum design as learning – ongoing process
- Recognize the influence of interacting systems

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Implications – Fostering Teachers' Design Competencies

- Grounding teacher learning experiences in classroom practice (Ball & Forzani, 2009; Grossman et al., 2008)
  - What does inquiry look like in the classroom? (Bryan, 2003; Bryan & Abell, 1999; Haefner, & Zembal-Saul, 2004)
  - What ideas do students have?
- Reinforcing twofold role of curriculum materials (Beyer & Davis, 2009; Davis, 2006; Forbes & Davis, 2008; Schwarz et al., 2008)
  - As tools to influence classroom activity
  - As records of teachers' expertise and learning
- Foregrounding professional communities for teachers

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Again, Why Pedagogical Design?

- Those who actually engage in classroom activity (i.e., teachers and students) must have a significant hand in shaping the activity itself
- Primary contradiction is, “an objective pressure, manifesting itself in various forms, toward taking over the mastery of the whole work activity into the hands of the people who participate in that activity” (Engeström, 1987, pg. 82)
- Increasing agency is the defining characteristic of expansive learning (Engeström & Sannino, 2010)

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A Final Thought

- …the institutional culture of public education is severely constrained by economical, ideological and pedagogical conditions. Such constraints have the effect of promoting certain forms of curriculum, instruction, and assessment practices while denying others on the basis of cost effectiveness; e.g., professional development for K-12 teachers. On the other hand, research on learning and research on science learning are contributing to a richer understanding of the classroom contexts and conditions that promote scientific reasoning and understanding. Do we fit the research on learning into the instructional culture of schools or do we change the culture of schools to accommodate the learning research? There are significant policy and practice issues that come to the table. (Grandy & Duschl, 2007, pg. 158)

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Thank you

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