Developing and Supporting Rigorous Science Education at the Elementary School Level

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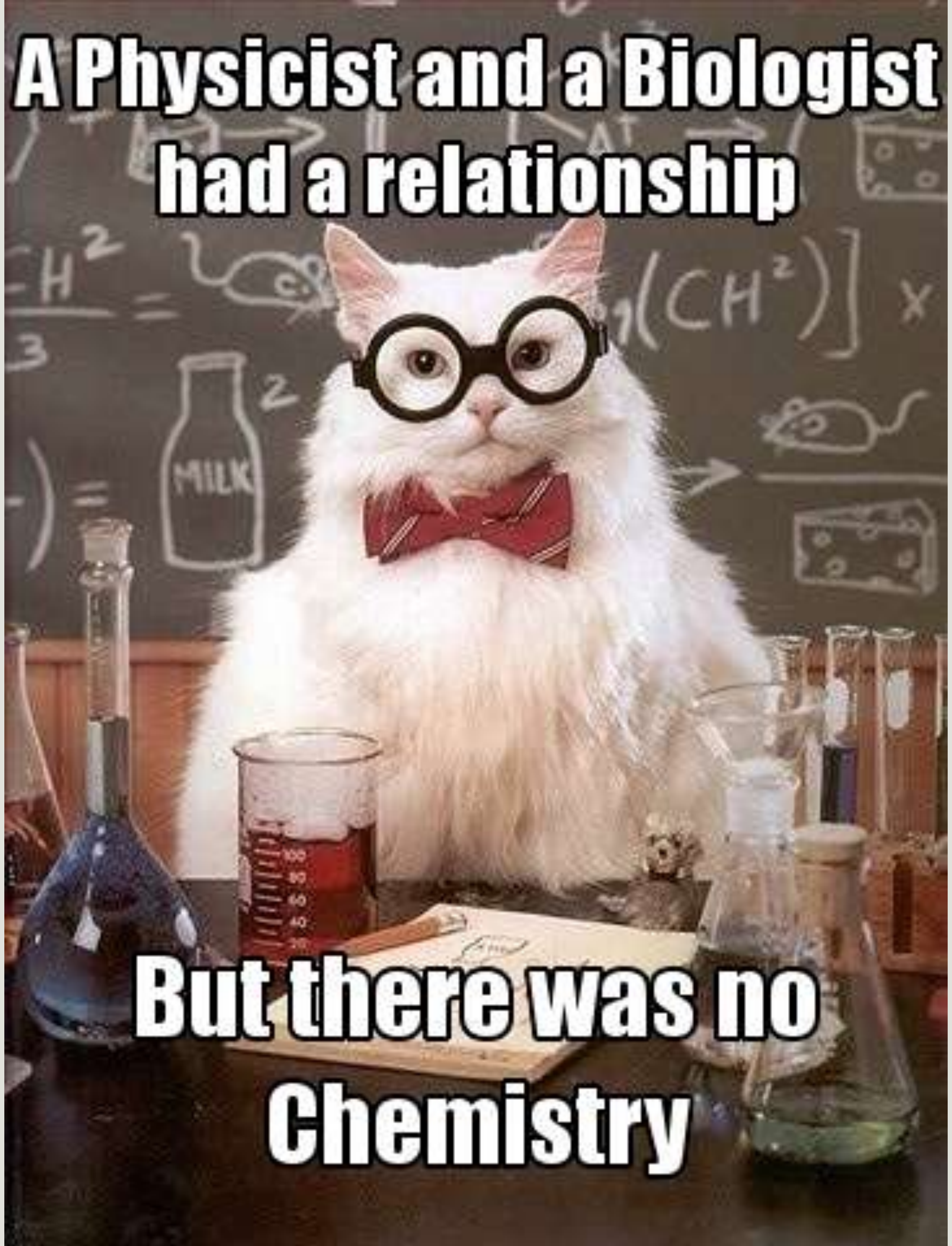
A Physicist and a Biologist
had a relationship
But there was no
Chemistry

- Introduction and Context
  - Elementary School Teacher Preparation
  - Policy
  - Time for Science and Engineering
- Next Generation Science Standards (NGSS)
    - Inquiry through practices
    - New challenges
- Inquiry at the Elementary Level
- Science Education Fellowship Study
  - Findings and points of note
- Future Directions and Discussion
- Questions

Elementary School Teacher Preparation

- Traditional generalist preparation (Keir, 2017; Appleton & Kindt, 1999)
  - inadequate preparation or academic background for teaching science (Lee *et al*., 2008; Tosun, 2000; Tilgner, 1990)
  - confidence and desire for teaching science at the elementary level (Appleton, 2013; Avraamidou, 2013; Abell & Roth, 1992)
- National concern (Olson *et al*., 2015)

Policy

- No Child Left Behind Policy (2001)
  - All students in grades 3–8 are assessed on language arts and mathematics annually
- District/Policy failings – ELA and Math focus (Blank, 2012; Buczynski & Hansen, 2010)

Time… or Lack Thereof

- Elementary school science has become a undervalued subject.
- Accountability measures and policies have pushed science off the daily school schedule.

Frequency with Which Self-Contained Elementary Classes Receive Science and Mathematics Instruction, by Subject

	Percent of Classes			
	Science		Mathematics	
Grades K–3				
All/Most days, every week	20	(1.5)	99	(0.4)
Three or fewer days, every week	39	(1.5)	1	(0.3)
Some weeks, but not every week	41	(1.9)	1	(0.3)
Grades 4–6				
All/Most days, every week	35	(2.6)	98	(0.9)
Three or fewer days, every week	33	(2.6)	2	(0.9)
Some weeks, but not every week	32	(2.5)	0	---†

† No grades 4–6 teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Average Number of Minutes per Day Spent Teaching Each Subject in Self-Contained Classes,† by Grades

	Number of Minutes			
	Grades K–3		Grades 4–6	
Reading/Language Arts	89	(1.7)	83	(2.2)
Mathematics	54	(1.0)	61	(1.4)
Science	19	(0.5)	24	(0.9)
Social Studies	16	(0.4)	21	(0.8)

† Only teachers who indicated they teach reading/language arts, mathematics, science, and social studies to one class of students were included in these analyses.

The Elephant in the Room

- Less than 4% of Elementary Science Teachers hold an undergraduate degree in engineering or science
- Elementary School Teachers Struggle with:

(the below figures show teachers who believe themselves to be very well/ well prepared for the following)

  - Anticipating areas of the content that students will struggle with in a unit (28%)
  - Encouraging the participation of females in Science and/or Engineering (30%)
  - Encourage students interest in science and/or engineering (28%)
  - Encourage participations of low socio economic status students in science/engineering (31%)
  - Encourage participation of racial or ethnic minorities in science/engineering (30%)
  - Plan instruction so that students of different levels can all increase their understanding of the lesson objectives (28%)
  - Teach science to students with learning disabilities (15%), physical disabilities (13%), and English Language Learners (15%)

Next Generation Science Standards (NGSS)

- http://www.nextgenscience.org/
- 26 states helped draft
- 17 have adopted

Arkansas
California
Delaware
District of Columbia (D.C)
Illinois
Iowa
Kansas
Kentucky
Maryland
New Jersey
Rhode Island
Vermont
Oregon
Nevada
New York (Sept 2017)
Washington
West Virginia

- 25 more are moving towards/ considering adopting (making their own standards reflect NGSS)

New Vision for Science Education

- Students’ experience year-to-year fosters *deeper* understanding of science
- Active engagement in scientific and engineering practices
    - A new approach to inquiry
- Deepened understanding of crosscutting concepts and content

Inquiry at the Elementary Level

- **The 5E model (now 6E)**
  - Engage
  - Explore
  - Explain
  - Elaborate
  - Evaluate
  - E-Learning

Five essential features of Inquiry

1. Learners engage in scientifically oriented questions
2. Learners give priority to evidence in response to questions
3. Learners formulate explanations from evidence
4. Learners connect explanations to scientific knowledge
5. Learners communicate and justify explanations.

The 6E Model for Lesson Planning

A structure to help elementary teachers incorporate inquiry based science education in their classrooms

- 5E model (Trowbridge and Bybee,1990)
- Provides a structure for science experiences
- Uses inquiry
- Fosters connected thinking
- Last "E" brings in important technology connection

1E: Engage

How to get started:

- Interesting question
- Student's own questions
- Prior knowledge acting as a bridge to new activity

What to do:

- Initial assessment to inform instruction
- Promote curiosity
- Promote enthusiasm
- Encourage new ideas

2E: Explore

What to do:

- Allow "free" exploration (on your terms!)
- Give students appropriate tools and vocabulary
- Scaffold exploration through teacher talk, cooperative learning, resources
- Foster excitement of exploring

Exploring with Inquiry

- Inquiry activities vary
  - Open-ended
  - Guided
  - Structured
- Use inquiry activities you are comfortable with
- Take a “cookbook” activity and make it inquiry-based in a way that works for your students
- Do a mini activity for inquiry

3E: Explain

- Emphasize the nature of science
- Encourage truthful sharing
- Facilitate discussion of findings by through good questioning
- Remind students to use appropriate scientific language
- Record and remember findings and questions through the use of a science/lab notebook

4E: Elaborate

- Using students’ findings as a springboard, expand and make connections
- Connect to the real world
- Facilitate application of what was learned through exploring and explaining

5E: Evaluate

- Assess throughout
- Formal and informal
- Did students really learn what you intended?

6E: E-learning

- Use throughout and regularly
- Can be a mode to implement the other five Es!
- Use in a meaningful way

How can we develop and support rigorous elementary science education?

Wipro Science Education Fellowship (SEF)

Fellowship Goals:

- To create and support a corps of teachers and leaders;
- To institute a culture of active and reflective instruction;
- To improve teacher quality through vertical alignment within content and horizontal alignment within grade bands, meeting in small groups, and PD to improve student achievement.

Wipro SEF

Regional Sites:

- Boston – UMass Boston
- New Jersey – Montclair State University
- Greater New York – Mercy College

Our Fellowship

- 2 Years
- Professional Development (Monthly)
  - Deeply embedded in subject matter (CTS model) (Mundry, et al, 2010)
  - Designed to involve active learning
  - Able to connect teachers' to their own practice
  - Part of a coherent system of support (Reiser, 2013)
- Professional Learning Communities/Peer support
  - (Hord, 1997; Hord & Sommers, 2008; Apple, 2008)
  - Vertical and Horizontal PLCs

Wipro SEF: Year 1

- Vertical PLCs: alignment by content (e.g., Physical science, Life Science)
- Horizontal PLCs: alignment by grade level (e.g., elementary, middle, high school)
- Lesson Observations and Debriefing
- Curriculum Topic Study
- Annual Convening of Fellows

Wipro SEF: Year 2

- Individual Growth Plan System (GPS):
  - Individual growth plan
  - Project that aligns with district-wide initiative
  - One-on-one advising with faculty

Vertically Aligned Professional Learning Communities for Professional Growth, Development and Support of Elementary Science Teachers

Introduction

With the shift to NGSS or NGSS aligned standards, there is a critical need for high quality science instruction in elementary schools. This study examines the experience of elementary teachers engaged in a two year professional development fellowship. The fellowship is designed to support them as they engage in professional learning communities aligned to reflect the new standards and comprised of other science teachers from both middle and high school settings.

Vertical Articulation

- The Next Generation Science Standards (NGSS) (NGSS Lead States, 2013)
- Collaborative coaching and learning in science model (Boston Science Partnership, Chen, et al, 2014)
- Curriculum Topic Study as a context for work (Mundry, et al, 2010)
- Vertical teaming (Bertrand, Roberts & Buchanan, 2006)

Professional Development:

- Deeply embedded in subject matter

  (Luft & Hewson,2014; Banilower *et* al., 2007; Garet *et* al.,2001; Cohen, 1990)

- Designed to involve active learning

  (Wilson,2013; Banilower *et* al.,2007; Mundry & Loucks-Horsley, 1999)

- Able to connect teachers' to their own practice

  (Heller *et al*., 2012; Fullan, 2007; Loucks-Horsley & Mastumoto, 1999)

- Part of a coherent system of support

  (Whitworth & Chiu, 2015; B J Reiser, 2013; Birman *et al.*, 2000)

Professional Learning communities:

- Grounded in social constructivism (Kent *et* al.,2016; Palinsar, 2005; Duit & Treagust,1998; Berger and Luckmann, 1966)
- Five dimensions of PLCs (Dufour, 2013; Hord & Sommers, 2008; Hord, 1997)

  1) supportive, shared leadership
  2) collaborative learning with a student needs focus
  3) shared vision and values focused on student learning
  4) supportive structural and interpersonal conditions
  5) shared practice

Research Question

Amongst practicing elementary science teachers, to what extent and how do vertically aligned professional learning communities (V-PLCs) provide opportunities for professional growth, support and development?

Methodology

- Intrinsic Collective Case Study (Stake, 1995)
- Bounded System(Creswell, 2013; Denzin & Lincoln, 2005; Merriam, 1998)
- Qualitative analysis of data
- Open and Axial Coding (Charmaz, 2000; Glaser & Strauss & Corbin, 1990)

Rigor in Analysis

- Using multiple data sources
  - increased trustworthiness and richer description of the findings (Creswell, 2013)
- Wide variety of documents
  - Objective and unadulterated
  - Independent of the research
- "paradigm of maximal structural variation of perspectives" (Kleining & Witt, 2000)
- Methodological triangulation and data triangulation (Denzin, 1970)
- Member checking (with follow up interviews)

Overview of Data Sources

Year One			
Professional Development (Leadership Team Directed)		**Fellows Independent and Group Work**	
Activities	*Data Sources*	*Activities*	*Data Sources*
• Monthly Meetings • End of PLC presentations • Annual tri-site conference	• Fellow communications • Researcher notes • Presentations from fellows	• V-PLC debrief meetings • V-PLC lesson videos • Monthly reflections	• Videos • Meeting notes • Written reflections

Initial Findings

Professional Growth:

"Receiving feedback in our vertically aligned professional learning group enabled me to look at my teaching in a different way. I am not scared of inquiry as I once was. I was "forced" to try something I normally would not have previously attempted." (Elementary Fellow, V-PLC Debrief Reflection)

Support:

"Collaboration must involve a willingness to be an active participant in an external growth process involving ongoing critical reflection on classroom practices. The process requires infusing personal beliefs and values into ones shared and individual professional identity."(Elementary Fellow, January Reflection)

Development:

"Teachers at the elementary level often feel like we are teaching in a bubble because our schedules do not allow time for us to see our colleagues teaching and have time to debrief on the success of a lesson. This opportunity has allowed me to incorporate new ideas, strategies, and knowledge into my teaching practices." (Elementary V-PLC Debrief)

Collapsing findings into two themes

Theme 1: Self and Peer Guided Professional Growth

- A culture of mutual respect
- Questioning
  - Student (Classroom)
  - Teacher
- Feedback for teacher growth

Theme 1: In Fellow's Own Words

"We had a mutual respect for one another and the challenges each one of us faced when teaching our specific grade level." Claire (Personal reflection)

"I trusted that they were interested in my work and that they were giving feedback that was not only helpful to me and moved my practice forward but I also felt in some way that it would help move their own practice a bit. I often felt after our meetings that it gave my own work more traction." Mary (Post V-PLC Reflection)

"I found myself adjusting my lessons, and questioning based on what I was told. Additionally, I was able to see the other teachers in their classroom and apply their best practices." (Fellow Reflection)

*"I really appreciated the suggestions on a variety of ideas as to how students could extend their thinking."*Kiwa (Debrief Meeting Reflection)

Theme 2: The Use of Scientific Language

- Focus on the importance of scientific language in the science classroom

- Common understandings about the importance of content-specific language and teacher language in the science classroom

- Identifying the use of tech as a modality for increased language use and proficiency in the science classroom

- Identifying methods for incorporate Common Core and scientific language into teaching

Theme 2: In Fellow's Own Words

"Watching back video I was encouraged by student engagement and accountable talk using content specific vocabulary. As always, team feedback was greatly appreciated."
Andrea, (V-PLC debrief video)

"Science is a "new" language and there needs to be a big emphasis on language instruction by using different modalities. Tech can be one of these modalities." (Victor written debrief notes)

"It's important for teachers to build common language and understand what students are learning and will be learning in the future. Seeing the connection and deepening understanding helps teachers understand their part in the continuum." (Fellow reflection)

"As an elementary school teacher I am challenged to show how science can support students in reaching the Common Core Standards. There is a meaningful connection between those subjects and science. Science promotes authentic language use, particularly for ELLs." (Fellow reflection)

Conclusions and Implications

- The Importance of shared practice
- Personal teacher growth through the building of *knowledge of practice* Cochran-Smith and Lytle (1999), born from collegial interactions in vertical teams
- Power of V-PLCs for supporting elementary science teacher growth
- Looking forward:
  - More data analysis in progress
  - More interviews of fellows past and present

Future Directions and Discussion

- Inquiry across a district (H.S. teacher PD for E.S. teachers)
- Elementary science specialists
  - Teacher Preparation Programs
  - Sustained Professional Development
- Elementary science teacher support network
  - Science teacher socials
  - Person networks
  - Organized focus/study
- Future fellowship work and extended support networks
- Community outreach – Example: Family science learning nights

Questions?

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Inquiry at the Elementary Level

- Socio-dramatic play and the development of self-regulation (Vygotsky, 1978)
  - Zone of proximal development – learning at the edge of their capacities
  - Language as a tool of self-regulation - the process of transferring language from externally regulated to self regulated involves complex cognitive processes such as memory, self-direction, planning, attention *etc.*
  - Thus socio-dramatic play increases student learning while also increasing the capacity for future learning.
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