Teachers' Experiences Integrating Data Sense-making and Computational Thinking into Science Instruction

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Comp Hydro Hypotheses, Inputs, Outputs

Career & Citizenship Skills
- Computer literacy
- Data literacy

Computational thinking supports principle- and model-based understanding of hydrologic systems

Thorny Local Phenomena
- Motivate, engage
- Extend, apply

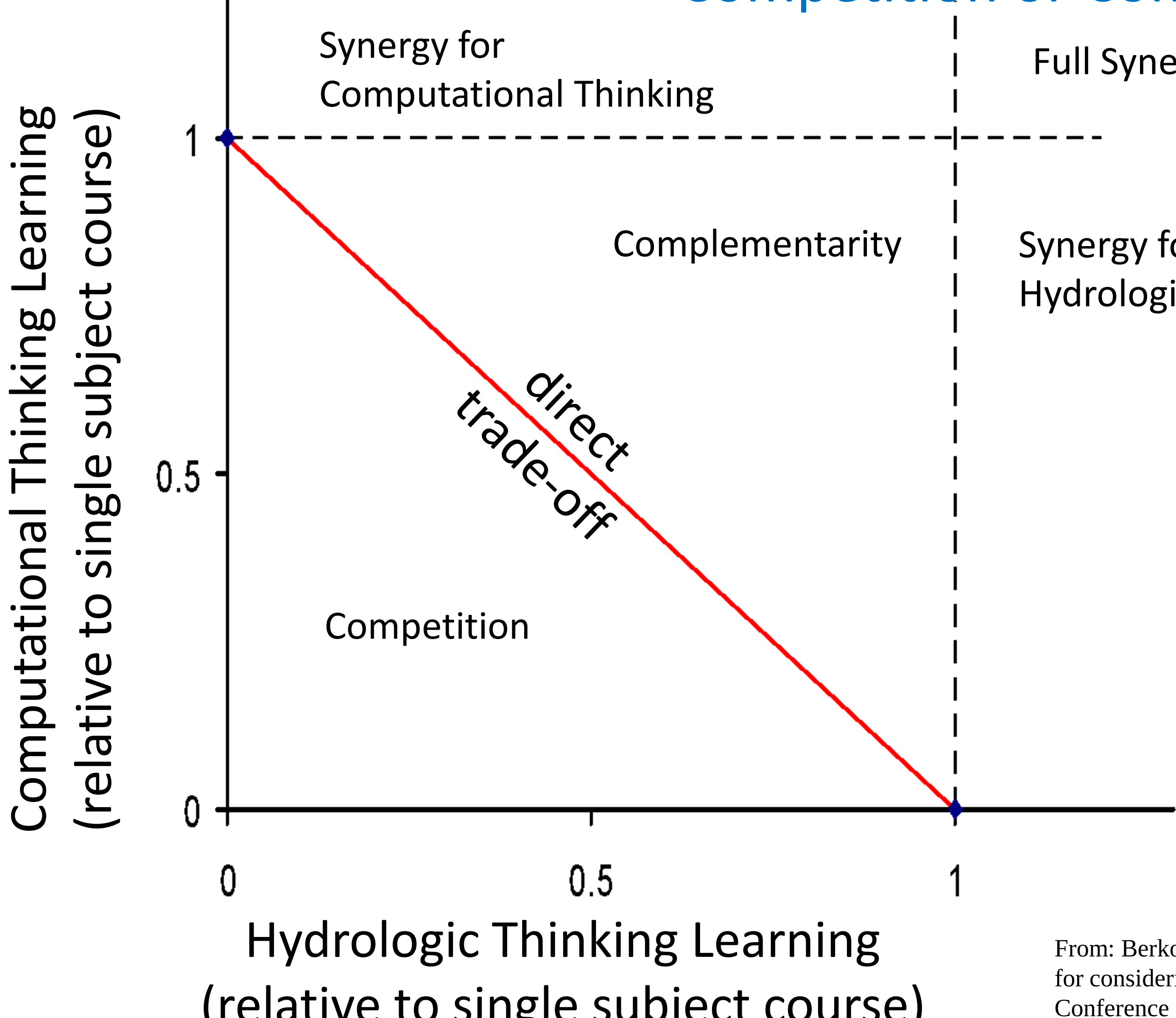
Computational Thinking
- Concepts
- Practices
- Habits of mind

Data
Systems
Models

Hydrologic Thinking
- Concepts
- Practices
- Habits of mind

Hydrologic systems provide a real-world context for understanding and building proficiency with computational thinking.

Computation + Science
Competition or Complementarity?



From: Berkowitz, AR. 1997. A simple framework for considering the benefits of SSPs. National Conference on Student and Scientist Partnerships: Conference Report. Cambridge, MA: TERC.

Comp Hydro's approach to integrating science (hydrology, H), data (D) and computational thinking (C)

- Real world phenomena in the local environment
- Data in 2-dimensional representations - maps, cross-sections, signature graphs
- Physical models
- "Be the computational model" - enact simulation
- Computational models - Net Logo
- Proposing model-based solutions to real world problems in the local environment

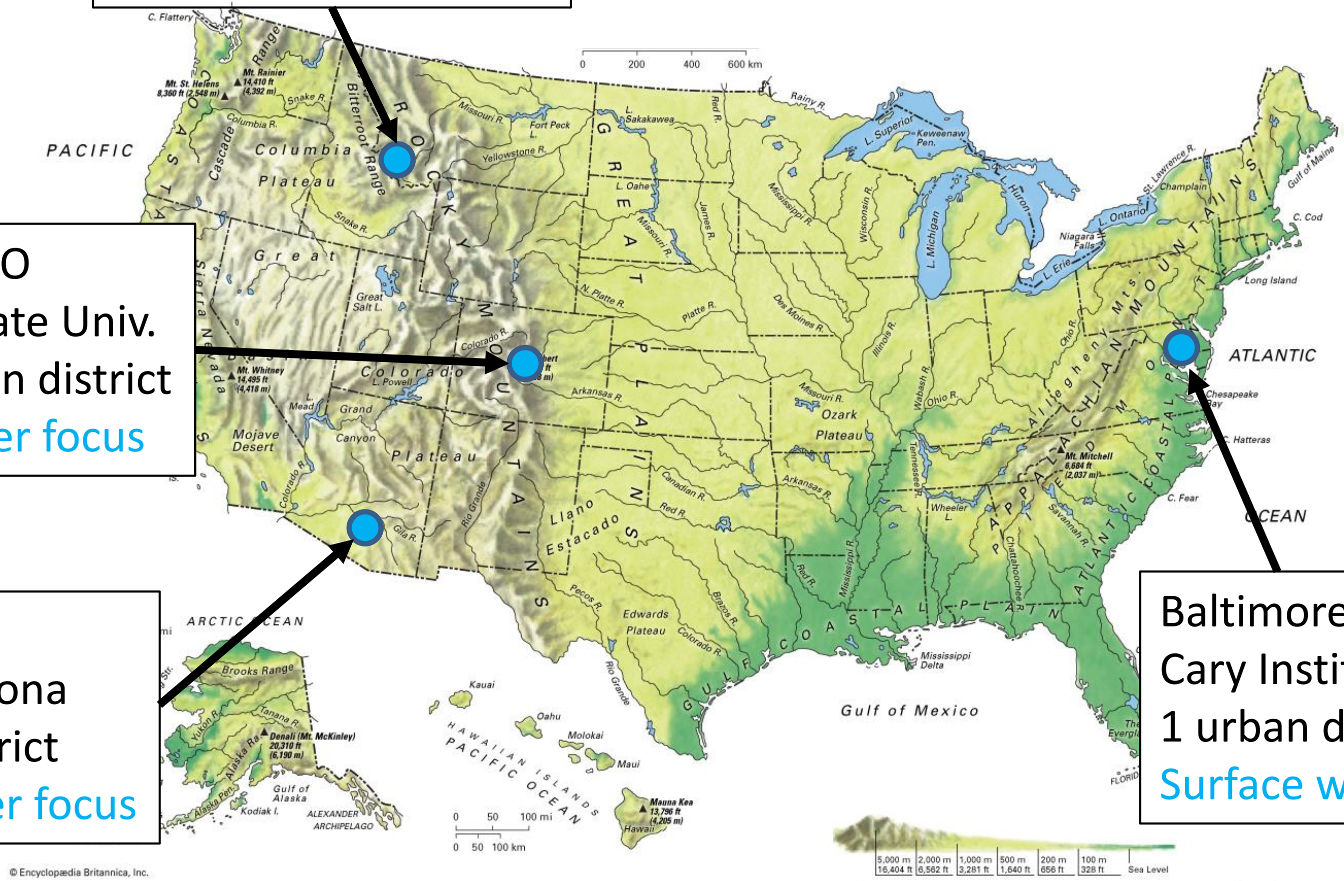
4 Corners of Comp Hydro

Missoula, MT
Univ. of Montana
2 rural 1 urban district
Groundwater focus

Ft. Collins, CO
Colorado State Univ.
1 small urban district
Surface water focus

Tucson, AZ
Univ. of Arizona
1 urban district
Groundwater focus

Baltimore, MD
Cary Institute
1 urban district
Surface water focus



Comp Hydro's approach to supporting teachers in integrating H, D + C

– Strong focus on teacher knowledge (H, D and C)
– Active learning through the curriculum
– Ready-to-use curriculum with all requisite models, supplies
  - educative for teachers
  - engaging and accessible for students
– Supports for attending and responding to student thinking
– Teachers as collaborators in learning with us and each other
– Actively help teachers fit CH into their curriculum
– District and administrator support and resources

(Desimone 2009, Garet 2001, Yoon et al. Gerard et al. 2011)

Questions

1. How do our mix of teachers perceive, understand and value the integration of science, data and computational thinking, and how does this vary with their context?
2. How do teachers enact the Comp Hydro curriculum, and what lessons can we learn about the possibilities and challenges for this kind of instruction?
3. How do teachers respond to the supports provided by the project, and what lessons can we learn?

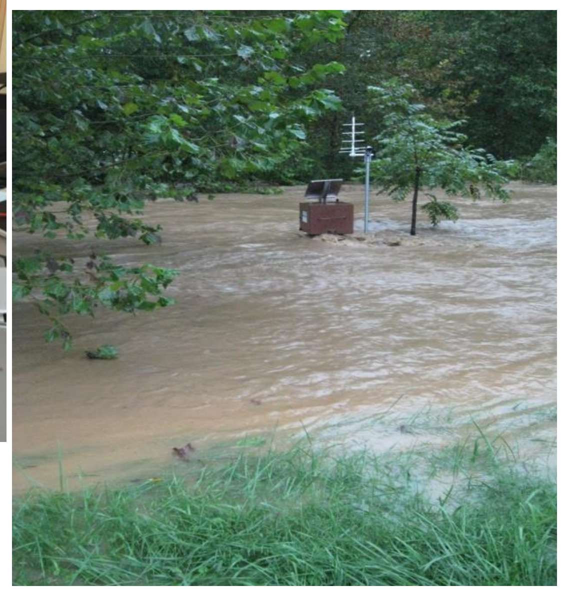
Data Sources

- Application forms (MT, AZ, MD, CO)
- Focus group interviews (MT, AZ, MD)
  - Year 1 - pre, during and post-implementation
  - Year 2 - during and post-implementation
  - Year 3 – pre (MT, MD), during and post-implementation
- Curriculum implementation feedback forms (AZ, MD)
- PD leader reflections (MT, AZ, MD, CO)
- Comp Hydro assessments (MT, AZ, MD, CO)

Comp Hydro Teachers
34 High School Teachers

Course for Comp Hydro	MT	AZ	MD	CO
Earth Science	11	3		
Environmental Science	1		3	1
Integrated Science		2		
Biology		2	4	
Computer Science			2	
Engineering			3	
Physical Science	1			
Math			1	

1. Teachers' perception, understanding and value of integrating C, D + H?



Motivations for Comp Hydro

Teacher: Pedagogy	**16**	**Student: Learning**	**11**
Hands on, field	5	Local, real	8
Integrate comp, hydro	3	Water	3
Fit, NGSS	3	Data	2
Technology	2	Impacts	2
Project-based	1	Interest in science	1
Hard to see	1	Achieve equity	1
Big Datasets	1	Computer jobs	1
Generic	1	Modeling, critical thinking	1
Teacher: Content	**6**	**Teacher: Resources**	**3**
Local issues	3	**Teacher: Social**	**1**
Hydrology	2		
Remote sensing	1		
Sustainability	1		
Love topic	1		

Number of teachers mentioning each reason on application forms

Focus Groups: Perception of H+D+C integration

- Teachers discuss H, D and C separately, with fewer mentions of actual integration
- Most focused on H, with C and D contributing to H
  - Data learning, including BIG data!
  - Visualize invisible parts of system (GW sites only)
- Appreciated the lessons that integrated H, D and C
- D important for some teachers (in standards)
- C emphasized only by teachers already teaching it
  - MD engineering and computer science teachers
  - CO teacher with 2+ years experience with NetLogo

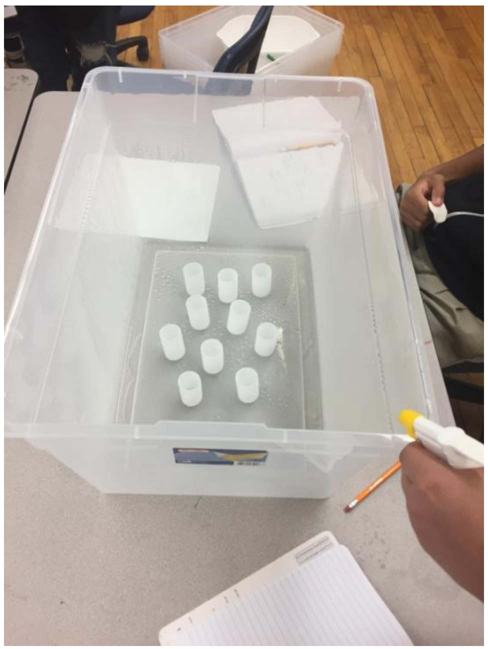
Focus Groups: Perception of H+D+C integration

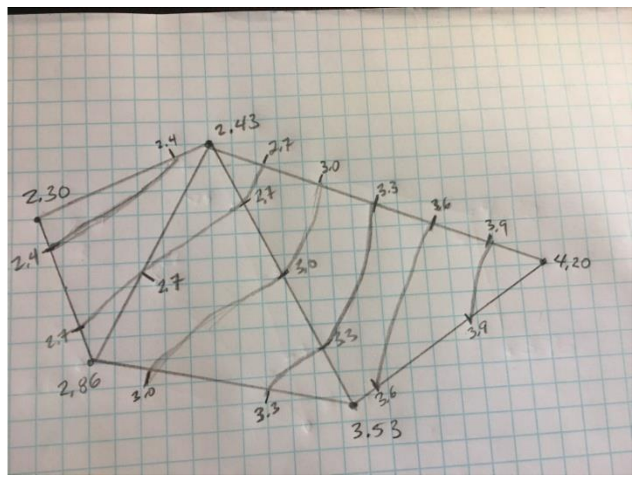
- MD teachers appreciated being in a group with a mix of expertise among themselves as an important strength for their own integrated learning.
- Some MD teachers co-taught computation, science parts of unit.

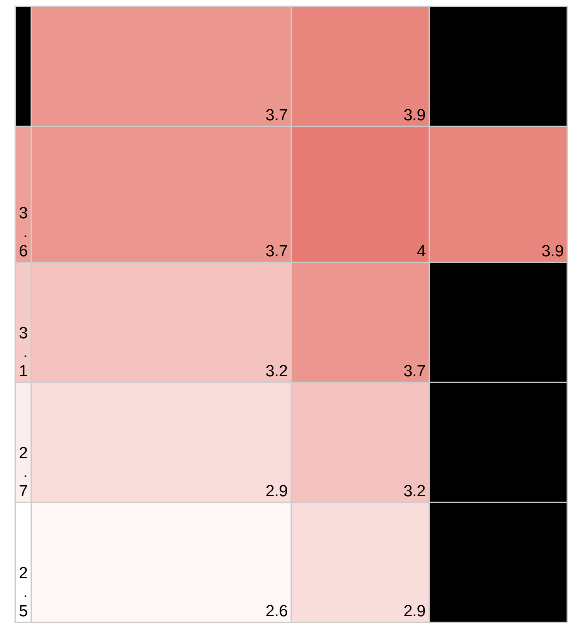
Focus Groups: Perception of student benefits

- Appreciated the real-world context as a major motivator for relevance of both H and C
  - human health and GW contamination (MT, AZ)
  - flooding impacts on people (MD)
  - increase interest in science and citizenship from H
- Some appreciated that D and C engaged students
  - Visualizing conditions where groundwater can move up
  - Sense making while rasterizing and contouring
  - Variety of representations for the system
- Some mentioned the career and college readiness
  - C skills per se (MD teachers)
  - Water modeling (CO teacher)

2. Teachers enactment of the Comp Hydro curriculum?







Comp Hydro Enactment

	MT	AZ	MD	CO
Implementation				
Lessons completed	100%	100%	33% comp 100% hands on	100%
Curriculum				
Lessons (actual)	15 (15)	10 (17)	9-17 (14)	~15
Focus	E. Helena GW	Tucson GW	Flooding	Water Budget
Computers				
Type	Desktops + Chromebooks	Indiv. Chromebooks	Desktops	Indiv. Laptops
Availability	Somewhat ltd	Good	Very ltd.	Excellent
Other Challenges	Internet, Tech support	Teacher comfort, not 100% reliable	Internet, Downloading NetLogo	None

Focus Groups: Enactment

- CO, teacher implemented his unit with very high fidelity
- MT, all the teachers completed all of the lessons
  - relatively high fidelity
  - limited use of the pre- and post-assessments
- AZ, all the teachers completed all of the lessons
  - Implementation was often procedural
  - Implementation of the NetLogo and hands-on lessons staff supported
- MD, implementation varied by type of lesson and teacher
  - Implementation was procedural
  - 100% of the hands-on activities were implemented
  - All teachers struggled with implementation of the data-rich lessons – rainfall contouring, hydrographs
  - Only ENG, CS teachers one Env Sci teacher taught the NetLogo lessons
  - 3 teachers made use of the pre-assessment

Focus Groups: Constraints 1

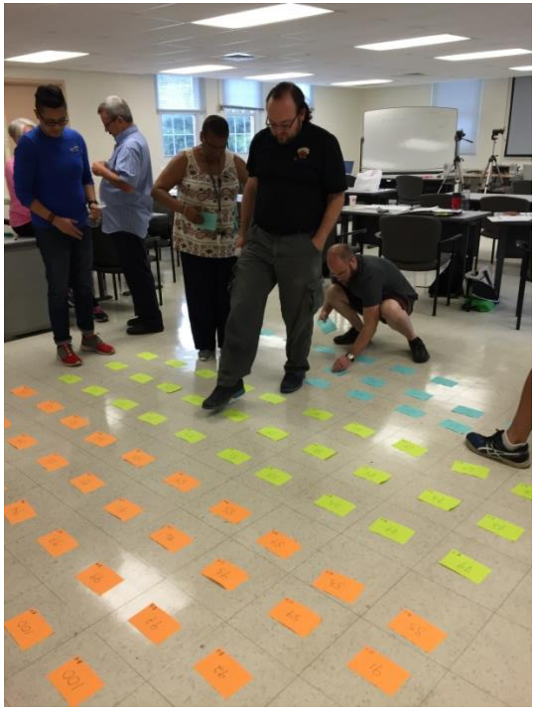
- Computer access and technology
  - Lack of computers and internet access (all but CO)
  - Intermittent challenges with the technology
    - Chromebooks for all only worked 80% of the time
    - Technical assistance my common request of staff
- Curriculum
  - Many requests for more scripting, student handouts
- Teacher time/expertise
  - Learning and building expertise in C or H
  - [From PD leaders}] Developing pedagogy for integrated teaching

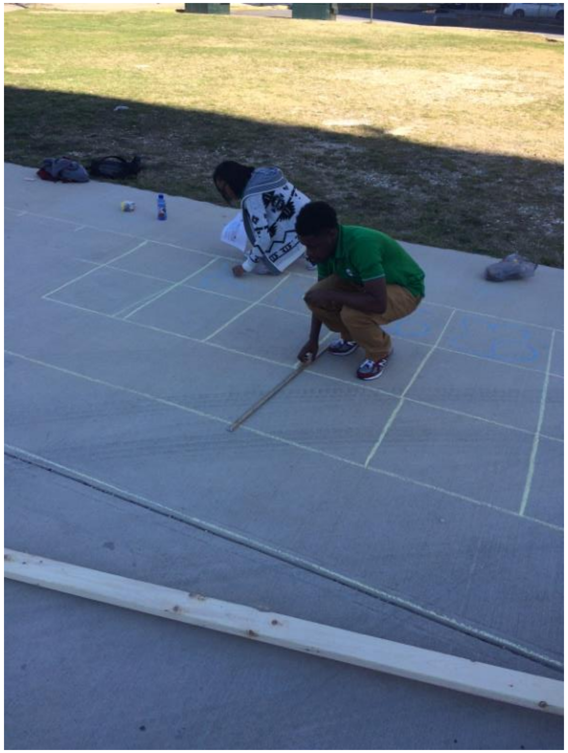
- Teacher comfort improved in years 2 and 3

Focus Groups: Constraints 2

- Focus of instruction and fit with curriculum
  - H sense making >> C
  - D mixed
  - C only for the MD CS or ENG teachers and CO teacher
  - Biology teachers struggled to dedicate time beyond H
- Student response
  - Certain local issues – flooding in MD – are not as compelling nor familiar to students as we had expected
  - Other issues - GW contaminant plume in MT – did not need to be local to be engaging
  - Student management was a challenge – AZ and MD

3. Teachers' response to the supports provided by the project?

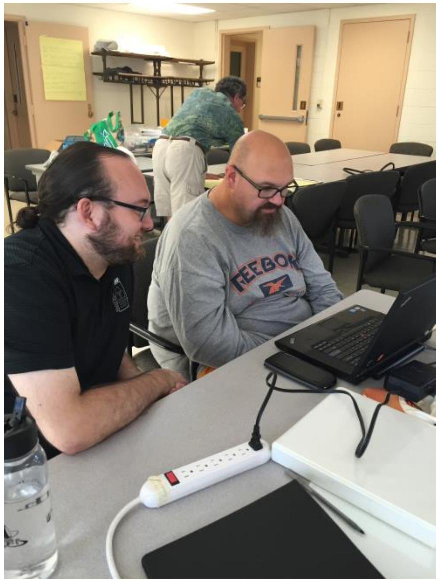


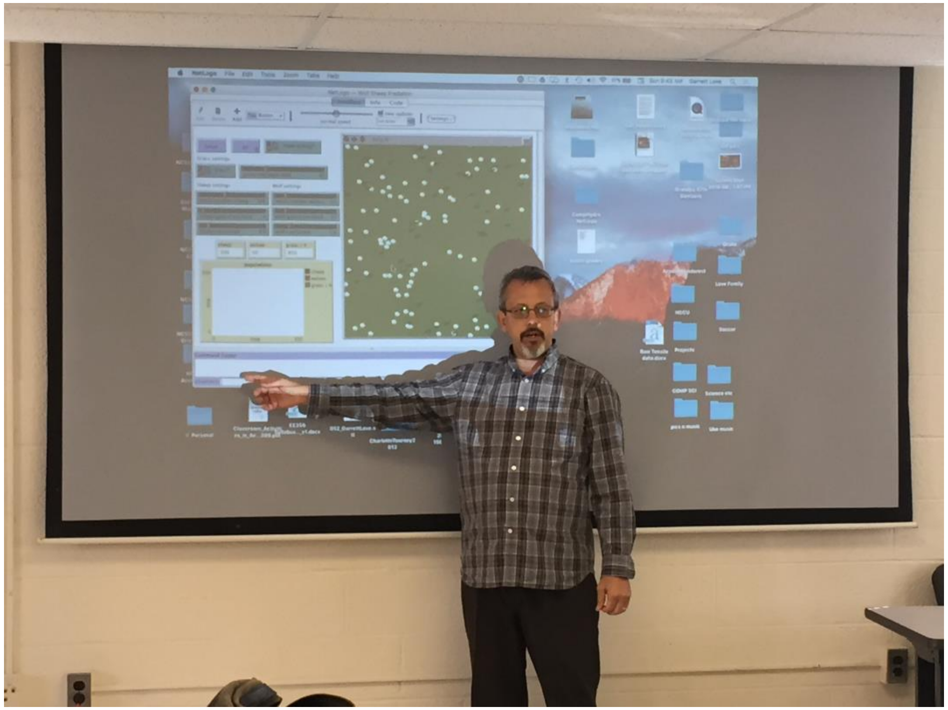


Focus Groups: PD Supports

- Curriculum development with frequent input from teachers before, during and after implementation
  - Teachers appreciated the responsiveness to their input
  - Sense of pride and ownership
- Collaboration and diverse inputs
- PD mix of goals and activities appreciated for
  - Practical implementation focus
  - Troubleshooting, addressing concerns
  - Building H, D, C and investigation skills
  - NetLogo experts from project
- Focus on research and attention to student perceived as mixed
- On-going support perceived as essential

Implications





Implications

- Teacher perception of C, D, H integration
  - H, D and C all are new and challenging
  - The diversity of teacher goals could be an asset
  - Need for evidence that C and D support H learning
- Enactment of integrated instruction
  - Context constrains and shapes implementation
  - Students don’t always respond to ‘thorny local issues’
  - Teachers might not have the capacity, support or resources to re-create Comp Hydro-like units on their own
  - Deep, phenomena based units may not sustain teacher interest year-to-year
- PD supports
  - How to move teachers beyond procedural implementation

Comp Hydro Conceptual Framework

Career & Citizenship Skills
- Computer literacy
- Data literacy

Computational thinking to Hydrology
- Confirm system structure
- Visualize phenomena
- Test scenarios, understanding

Local Phenomena/Issues
- Groundwater flow and contamination
- Urban runoff and flooding

Computational Thinking
- Concepts
- Practices
  - Abstraction
  - Automation
  - Analysis
- Habits of mind

Data Representations
Maps
Physical models
Computer models

Hydrologic Thinking
- Concepts
- Practices
  - Define problems
  - Argue from evidence
  - Construct explanations
- Habits of mind

Hydrology – to – Computational Thinking
- Discretize the problem/system
- Parameterize
- Define rules, algorithms
- Set and specify rules for boundaries