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"When Scientists Look at Their Data, They Don't Know the Answer:" Talking Science in a University Introductory Science Course

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"*When Scientists Look at their Data, they Don't Know the Answer*":
Talking Science in a University Introductory Science Course

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STEM-SOTL Conference
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Overview

- Course background
- Course Tools – *Science Talk* and *STEM Writing Heuristic*
- Data review
- Discussion about Data
- Implications to K-12 education, teacher education, and higher education
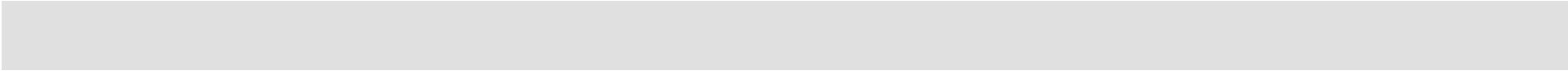- Application to instruction

Session Goals

By the end of this session, participants will have tools that focus on how knowledge gets built through **collaboration** and application to their own instruction

Background

- required upper-level (PHSC 4010/5010) for middle grades education majors and graduate students/practicing teachers

- support for models-based approach – funds from STEM Mini-Grant Program – Georgia College Presidential STEM Initiative

- resistance to required class in science

- Fall 2013 section consisted of 13 junior middle grades candidates, 2 science majors

- 3 men, 10 women in 2014

What is a Science Talk?

- Building knowledge through conversation
- Uncover misconceptions
- Knowledge that is greater than the sum of what any individual knows
- Non-competitive discussion
- Role of instructor is to facilitate

Science Talk

- Student have common experiences, investigations

- Traditional Science Talks:
  - open-ended conversations in which the instructor serves as facilitator to keep talk flowing, but does not serve as authority
  - open-ended discussion of science ideas on a topic initiated by instructor. For example, "How does a *Solar Radiometer* work?"
  - pedagogical approach is not about technology – rather, it is about talking in order to evaluate what students know

- **Our Science Talks:**
  - focus on inscriptions and representations of data
  - focus on the drawings that students generate
  - student-generated inscriptions are the ones that matter
  - we look to see if these inscriptions will allow students to connect information coherently

Adapted from Rosebery and Warren, 2008

THE STEM WRITING HEURISTIC

- In a lab notebook, record steps 2-9. These are in the form of notes. They must be comprehensible to someone else reading them, but need not be formal.

- **Beginning ideas** – What are my questions? Brainstorm several questions you have that can be answered by testing. These should **not** be yes or no questions. Choose one question out to try to answer.

- **Tests and Experiments** – What did I do? What do you have to find out in order to conduct these tests in a meaningful way? What sort of equipment might be available that will help you answer the question you have chosen?

- **Observations** – What did I see, hear, smell, feel? How did I measure what I observed?

- **Claims** – What can I claim as a result of my observations?

- **Evidence** – How do I know your claims are true? Why am I making these claims?

- Conferences, Science or Math Talks, Reading and Instruction – How do my ideas compare with other ideas?

- **Reflection** – How have my beginning ideas changed?

- **Redesign or Extension** – How can I use my new ideas to improve my design (engineering) or investigate something new?

THE STEM WRITING HEURISTIC

- **Report:** Prepare a report of your investigation which includes the following formal steps which are the way scientists communicate:

  - Description of the problem

  - Question you investigated

  - What materials you used to investigate your question?

  - A step-by-step description of your procedure. The purpose of this description is so that another investigator could use it to do the experiment the same way you did, and thus verify your results

  - A description and display of your data

  - What claim you make as a result of your investigation, and why your evidence supports this claim. This is commonly called a conclusion.--Hand, Prain & Wallace (2003:21)

Newton's Law Learning Progression

- Newton's Cars/STEM Writing Heuristic
- Read the textbook
- Attend Supplemental Instruction sessions
- Rock on a String – homework/class discussion
- Science Talk
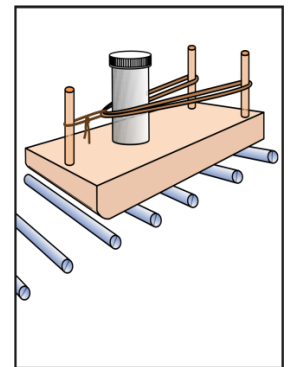- Exam
- Rotocopter design activity
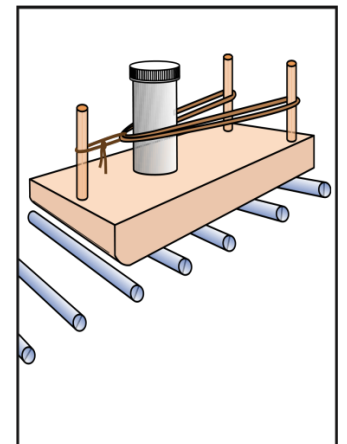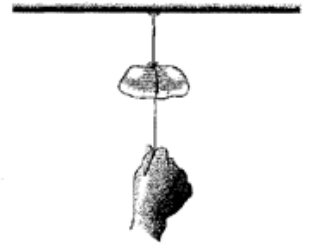
Experience before instruction - goal to accumulate background knowledge prior to *Science Talk*
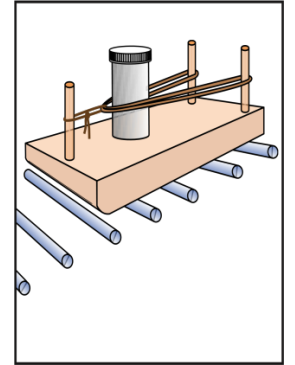
What it Looked Like
"Why did the car move?"

- video
- transcripts

The Newton's Car *Science Talk* ACTIVITY

- **Form groups**
- **Review transcript**
- **Discuss the following:**
  - What accurate conceptions did you see?
  - *What misconceptions do you see students have even after SI and reading text?*
  - Can you infer where this (these) misconception(s) came from?
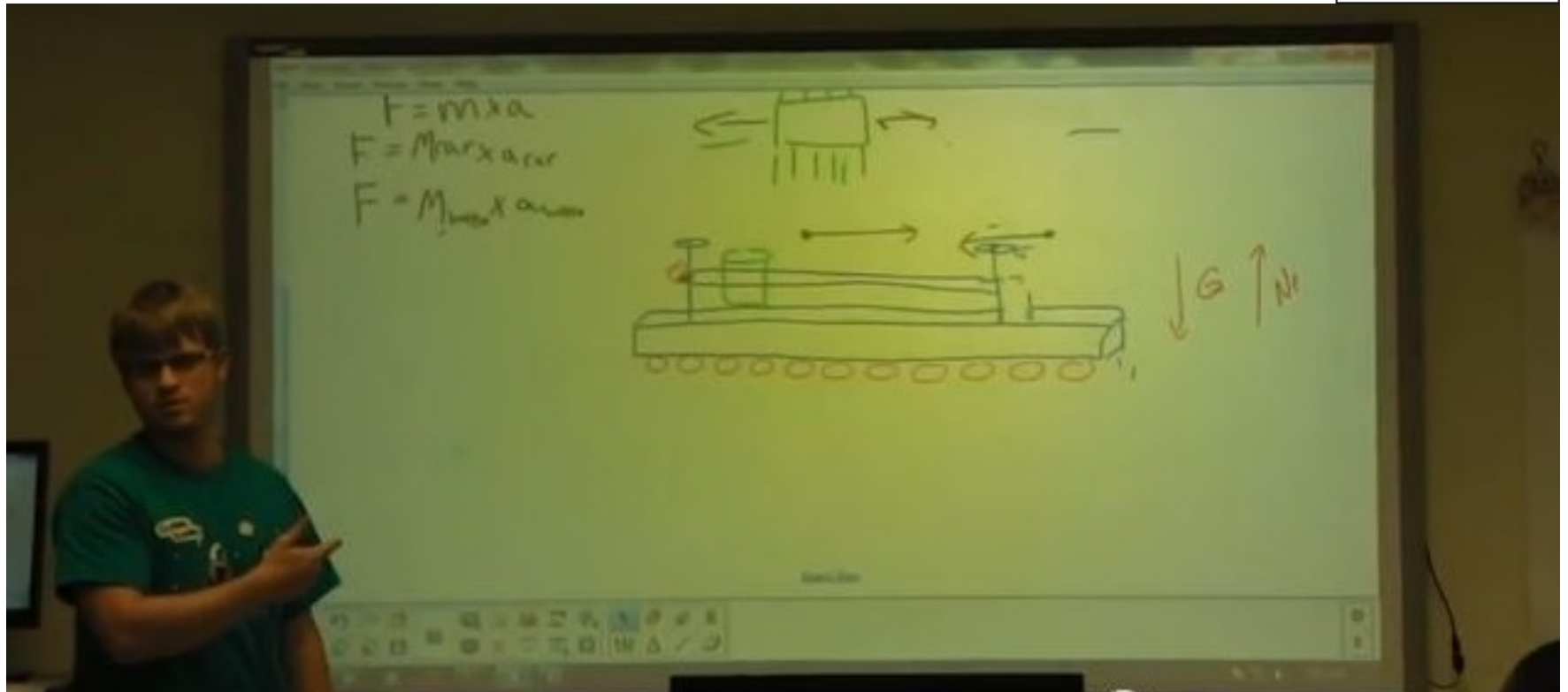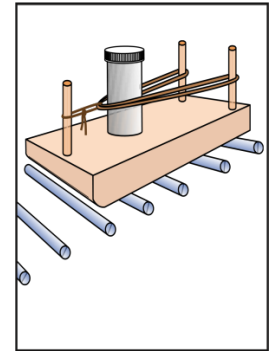- **Debrief**

The Newton's Car *Science Talk* ACTIVITY

- **Discuss the following:**
  - Where do you exactly see students building a conception of equal and opposite reaction?
  - *What did the instructors have to pay attention to?*
  - What opportunities might the instructors have missed?
- **Debrief**
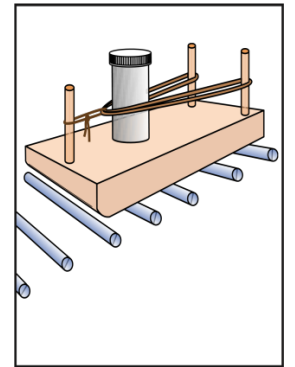
What it Looked Like
"Where is the force applied?"

What do you think we were thinking when we asked them to go to the board and draw?

What it Looked Like
"Where is the force applied?"

video

What is the rationale for public and collaborative inscriptions?
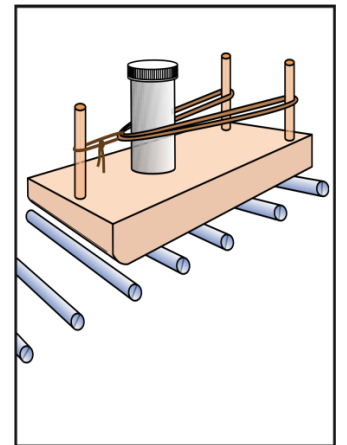
Building on Students' Strengths

- *Science Talks* began to break out spontaneously.

- Parachute example (Paul's experience with skydiving)

- Beyond a flipped classroom – learning in this environment

The Scientific World View

Scientists expect the world to be understandable. That's a value. That's what they're going forward with...This aroused much emotion amongst the students, and it's always stayed with me. Because. They really just couldn't conceive of a world where that's what you're expecting. And certainly not in science. Like in the rest of the world they expect their world to make sense. But in science, it's just like, why would scientists expect it to make sense? It doesn't.

– Dr. Karynne Kleine, Dean, Young Harris College

They really just couldn't conceive of a world where understanding of phenomena is what you're expecting.

Conceptual Change Model

- Inadequate to explain our findings
- Next step in our research

Implications for K-12 Students

Science Talk in a Middle Grades Classroom:

- open-ended conversations in which the teacher serves as facilitator to keep talk flowing, but does not serve as authority

- open-ended discussion of science ideas on a topic initiated by teacher. For example, "How do you think the movement of the Newton Cart demonstrates Newton's third law of Motion?"

- pedagogical approach is not about technology – rather, it is about talking in order to evaluate what students know.

Our Science Talks:

- Evidence of students acquiring knowledge from one another to build an understanding of science concepts.

- Evidence of student's use of prior knowledge to build concrete understanding of a concept.

- Evidence of student's developing a respect for one another as science learners and contributors to new knowledge and ideas.

Implications for Science Teacher Education

- we expect pre-service teachers with a science background to come to class with data analysis ability
- what we assume is obvious is not
- we miss finding out if pre-service teachers understand concepts when we accept facts as evidence of understanding
- we need to think carefully about how we teach students to make connections in science
- science teachers model their teaching practices from higher ed
- we must hold students accountable for thinking *through ideas* and providing explanations
  - giving partial credit for incomplete explanations encourages this
  - providing exams that do not ask for explanations encourage this
- Science Talk can be re-characterized as any "***Discipline***" *Talk*

Implications for University Science Classes

— Science Autobiography

  • students remember content related to whether or not they liked the teacher and if it was "fun" or "gross"

  • students consider science as what is done in science class

  • school science is not what scientists do

— Argumentation: arguing to learn (Andriessen, 2006)

— Faculty in any discipline can use the principles
of Science Talk: can be re-characterized
as "**Discipline**" *Talk*
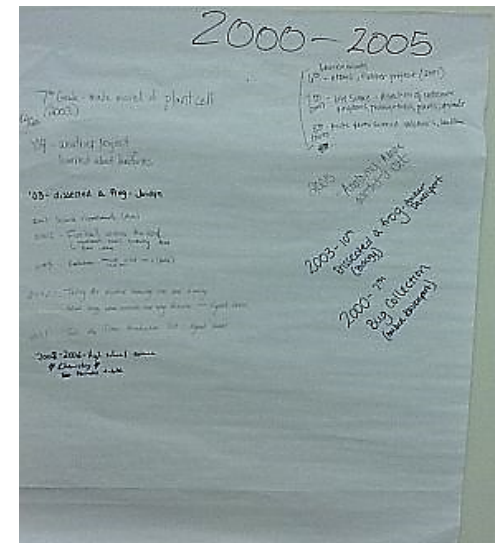
We argue that when students have continued experiences in communal, collaborative learning (versus competitive learning), they are better able to extract the content in a course

Acknowledgements

Session Participants

PHSC Students

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