Science Discourse and Inquiry

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Agenda:
What is the role of discourse/argumentation in science?
What does it look like?

How do the new standards (Common Core, Next Gen Science Standards) view discourse?

What’s the research on science talk?

How can we hold science “talks”?
Turn and Talk: What is the role of talk in science classroom?

| LISTEN: Ideas and Info | REFLECT what you do or think should be done | SHARE. What your partner thinks and how you concur/diverge |
Peer Discourse and Science Achievement

Complete study at
www.newhavenscience.org/peerdiscourse

- Observed 6 classes, both class lesson, then 1 small group per class designing the acid rain experiment.
- Coded class observations and group talk observations
- Teacher survey and student survey (all students in each class)
- Got Inquiry scores for quarter one and quarter two assessments
- Got Inquiry scores for quarter three assessments
- Used student numbers to match and find correlations
Variety of classrooms….
The “best” had trained students on how to talk with each other in groups, and practiced sharing..
See field study memo
### Complete Data, Discourse, and Assessment by class

<table>
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<th>Class</th>
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<th>Talk 0</th>
<th>Talk -</th>
<th>Class Task (CT)</th>
<th>Class Und (CU)</th>
<th>SSurv Task (ST)</th>
<th>SSurv Und (SU)</th>
<th>TSurv Task (TT)</th>
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*Note.* <sup>a</sup>n=28. <sup>b</sup>n=18. <sup>c</sup>n=9. <sup>d</sup>n=18. <sup>e</sup>n=19. <sup>f</sup>n=20. <sup>g</sup>n=978. <sup>h</sup>n=1053
## Correlations among discourse factors and student achievement

| Measure                      | M   | SD  | 1  | T+ | 2  | T0 | 3  | T- | 4  | ST | 5  | SU | 6  | TT | 7  | TU | 8  | CT | 9  | CU | 10 | Q1 | 11Q3 |
|------------------------------|-----|-----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|
| **GroupTalk**                |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 1. TalkPos                   | 2.18| 1.30| -- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 2. TalkNeut                  | 2.19| 1.10| .54*| -- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 3. TalkNeg                   | 1.40| .91 | .09 | .11| -- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| **Survey**                   |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 4. Student Task             | 3.72| .76 | .21 | .29| -.44| -- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 5. StudentUnder             | 3.73| .76 | .15 | .29| -.32| .94**| -- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 6. Teacher Task             | 3.32| .67 | .32 | .37| -.29| .31**| .30**| -- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 7. Teacher Under            | 3.46| .80 | .30 | .23| -.32| .28**| .27**| .89**| -- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| **Class Observed**          |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 8. Class Task               | 2.10| .73 | .41*| .66**| .11| .17 | .18 | .38**| .43**| -- |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 9. Class Under              | 2.02| .28 | .40*| .53*| -.15| .27**| .29**| .62**| .66**| .89**| -- |    |    |    |    |    |    |    |    |    |    |    |    |
| **Student Achievement**     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| InqScore                     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| 11. Quart3                  | .492| .270| .46 | .24| .29 | .26**| .30**| .18 | .25**| .21**| .39**| .66**| -- |    |    |    |    |    |    |    |    |    |    |    |
| InqScore                     |     |     |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |
| Significance with Q3        | .067| .362| .258| .006| .001| .067| .009| .025| .00002| .00001| -- |    |    |    |    |    |    |    |    |    |    |    |    |

**Note.** a.n=17. b.n=110. c.n=1053.

*Correlation is significant at the 0.05 level (2-tailed).

**Correlation is significant at the 0.01 level (2-tailed).
Complete study at [www.newhavenscience.org/peerdiscourse](http://www.newhavenscience.org/peerdiscourse)

- Observed 6 classes, both class lesson, then 1 small group per class designing the acid rain experiment.
- Coded class observations and group talk observations.
- Teacher survey & student survey (all students in class).
- Inquiry scores for q 1 & q 2 assessments compared to q3
- Used student numbers to match and find correlations
Findings:

- Student talk does correlate with achievement, even when prior achievement is factored in especially in science inquiry.
- Classroom observations are good data, as are student group observations.
- Students have some knowledge of understanding linked to group talk and scores.
- Teachers may not know of the benefit of group talk as much.

Implications:
- Teachers should scaffold and teach group talk, experiment design.
- Less emphasis on task completion, content as part of lab design talk.
- Social roles matter, and students can become aware of their roles.
- Teachers need to find opportunities to observe group talk (video, peer observ, etc).
Practice Observing a science “talk”

Rock Cycle “Chaos in the Corridor” from:

Intro Video: 8th Grade class, given instruction on igneous, metamorphic, sedimentary rocks. Some practice with “science talks” (how rocks are formed). Rules for science talks include to be a good listener, but teacher admits that often just meant be silent till you can talk/question.

Task: Day one, discuss with groups, Day two: build model of rock cycle

Teacher is helping a more organized group in classroom, this group is in the hallway.

2 min in: What suggestions should she give the group? What do you think about how she intervened?

7 minutes in: What do you think of the students’ summary/progress?

11 min in: What about her explanation with shoe? Do you think that science talks could help you as a teacher figure out students’ learning?

How can you structure science talks?
Talk is important for sharing, clarifying, and distributing knowledge among peers.

Asking questions, hypothesizing, explaining, and formulating ideas together are all important mechanisms during peer discussions.

Writing is an important tool for transforming claims and evidence into knowledge that is more coherent and structured.

Talk combined with writing appears to enhance the retention of science learning over time. (Rivard and Straw, 2000)
What’s Common Across ELA, Math, and Science?

-adapted from Sarah Michaels (Clark University)

“Making Thinking Visible” in the Service of Evidence-Based Argument
ALL the standards — math, ELA and science — require that teachers focus more attention on reasoning and “thinking practices.” These high level “thinking practices” require that students participate in making their thinking public and cogent.

• Students will have to participate, with guidance, in making their thinking visible,
  • public,
  • available to others,

in talk and in writing.
Teachers will have to help all students:

- Externalize their thinking;
- Listen carefully to one another and take one another seriously;
- Dig deeper into the data and evidence for their positions;
- Work with the reasoning of others.
There’s a common core in all of the standards documents (ELA, Math, and Science)

- At the core is:
  - Reasoning with evidence.
  - Building arguments and critiquing the arguments of others.
  - Developing rigorous, conceptually strong, evidence-based thinking practices.
  - Participating in reasoning-oriented practices, with others.
An Examination of “Practices”

- **Science and Engineering Practices**
  1. Asking questions and defining problems
  2. Developing and using models
  3. Planning and carrying out investigations
  4. Analyzing and interpreting data
  5. Using mathematics, information and computer technology, and computational thinking
  6. Constructing explanations and designing solutions
  7. Engaging in argument from evidence
  8. Obtaining, evaluating, and communicating information
An Examination of “Practices”

Mathematical Practices
1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.
Let’s look in detail at shared elements in the Standards documents

- **Math Practice #3:**
  - Construct viable arguments and critique the reasoning of others

- **Science and Engineering Practice #7:**
  - Engaging in argument from evidence
Argumentation

○ Construction

○ Critique

○ Creating Common Ground
A few more of these practices seem to relate explicitly to sense-making and discussion:

reasoning,

in the service of arguments.
Where do we see “sense-making” in the math CCSS?

Mathematical Practices

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning.
Where do we see “sense-making” in the science Framework practices?

- Science and Engineering Practices

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information
But what about ELA? Are the same reasoning practices common here as well?

The ELA standards emphasize “processes” of communication –
• reasoning
• critiquing arguments with evidence
• communicating with others
Instead of “practices,” the ELA Standards identify the “capacities” of the literate individual:

**Students Who are College and Career Ready**

in Reading, Writing, Speaking, Listening, and Language

The descriptions that follow are not standards themselves but instead offer a portrait of students who meet the standards set out in this document. As students advance through the grades and master the standards in reading, writing, speaking, listening, and language, they are able to exhibit with increasing fullness and regularity these capacities of the literate individual.

**They demonstrate independence.**

Students can, without significant scaffolding, comprehend and evaluate complex texts across a range of types and disciplines, and they can construct effective arguments and convey intricate or multifaceted information. Likewise, students are able independently to discern a speaker’s key points, request clarification, and ask relevant questions. They build on others’ ideas, articulate their own ideas, and confirm they have been understood. Without prompting, they demonstrate command of standard English and acquire and use a wide-ranging vocabulary. More broadly, they become self-directed learners, effectively seeking out and using resources to assist them, including teachers, peers, and print and digital reference materials.

**They build strong content knowledge.**

Students establish a base of knowledge across a wide range of subject matter by engaging with works of quality and substance. They become proficient in new areas through research and study. They read purposefully and listen attentively to gain both general knowledge and discipline-specific expertise. They refine and share their knowledge through writing and speaking.

**They respond to the varying demands of audience, task, purpose, and discipline.**

Students adapt their communication in relation to audience, task, purpose, and discipline. They set and adjust purpose for reading, writing, speaking, listening, and language use as warranted by the task. They appreciate nuances, such as how the composition of an audience should affect tone when speaking and how the connotations of words affect meaning. They also know that different disciplines call for different types of evidence (e.g., documentary evidence in history, experimental evidence in science).

They comprehend as well as critique.

Students are engaged and open-minded—but discerning—readers and listeners. They work diligently to understand precisely what an author or speaker is saying, but they also question an author’s or speaker’s assumptions and premises and assess the veracity of claims and the soundness of reasoning.

They value evidence.

Students cite specific evidence when offering an oral or written interpretation of a text. They use relevant evidence when supporting their own points in writing and speaking, making their reasoning clear to the reader or listener, and they constructively evaluate others’ use of evidence.

They use technology and digital media strategically and capably.

Students employ technology thoughtfully to enhance their reading, writing, speaking, listening, and language use. They tailor their searches online to acquire useful information efficiently, and they integrate what they learn using technology with what they learn offline. They are familiar with the strengths and limitations of various technological tools and mediums and can select and use those best suited to their communication goals.

They come to understand other perspectives and cultures.

Students appreciate that the twenty-first-century classroom and workplace are settings in which people from often widely divergent cultures and who represent diverse experiences and perspectives must learn and work together. Students actively seek to understand other perspectives and cultures through reading and listening, and they are able to communicate effectively with people of varied backgrounds. They evaluate other points of view critically and constructively. Through reading great classic and contemporary works of literature representative of a variety of periods, cultures, and worldviews, students can vicariously inhabit worlds and have experiences much different than their own.
In the fine print:

… “construct effective arguments,” “request clarification,” “ask relevant questions,” “build on others’ ideas,” “articulate their own ideas,” “question assumptions and premises,” “assess the veracity of claims,” “assess the soundness of reasoning,” “cite specific evidence,” “make their reasoning clear,” “constructively evaluate others’ use of evidence,” “evaluate other points of view critically and constructively,” “express and listen carefully to ideas,” “cite specific textual evidence to support conclusions,” “delineate and evaluate the argument and specific claims in a text including the validity of the reasoning as well as the relevance and sufficiency of the evidence,” “participate effectively in a range of conversations and collaborations with diverse partners, building on others’ ideas and expressing their own clearly and persuasively.”
Speaking and Listening Standards!

Not to Mention......
Making Thinking Visible
-to self and others -

through language
(talk and text)

is at the core,
in science, math, and ELA.
Through talk, joint attention, and shared activities, students and teacher can create common ground.

To do this, they have to talk about what’s in the common ground.
“Reasoning practices” have to be enacted, and for learners, most are enacted socially, through talk and writing.

“SOCIAL” does not just mean student-led group work.

Well-structured social interaction builds in time to think as an individual–making thinking available.
Because these “thinking practices” are inextricably linked to content, and to core ideas,

participating in productive talk is not an add-on.

It’s fundamental to the learning goals in each set of standards.
Students have to be inducted into these “thinking practices” socially.

They have to be guided to participate in them — through well-structured discussion; through “productive talk.”
Bottom Line:

- Well-structured talk — discussion or guided, scaffolded reasoning talk — will have to become the new foundation for the common core.
What is “productive talk?”

What does it look like and sound like?

What do YOU think??
Demonstrated Successes:

- Well-structured discussion practices have been shown to result in robust gains in academic achievement for students from a range of socioeconomic and linguistic backgrounds.

- There are a small number of carefully controlled, large-scale studies that show that well-structured talk actually “builds the mind,” with achievement gains transferring to other domains, and persisting over years.
Summing up the Research:

This body of work demonstrates that productive discussion, well-structured talk produces robust learning. It actually helps “build the mind” — with long term benefits for thinking and achievement, which show up in standardized tests, transfer to other content domains, and persist over years.
The bad news:

While there is typically lots of talk going on in classrooms, it is often not “productive” talk.

- Teachers rely on recitation

  *(Initiation – Response – Evaluation - the IRE)* and a few reliable talkers.
The bad news:

- The dominant forms of talk in classrooms — recitation and direct instruction — do NOT support reasoning.
- They do NOT support the building of arguments with evidence.
- They do NOT support students to do the heavy lifting of explaining, critiquing, and building common ground.
More bad news:

- Teachers are not well-prepared (from their own experiences in school) to lead academically productive, reasoning-oriented discussions.

- They often rely on group work, hoping that the hands-on activities, in small groups, will teach the students what they need to learn.
More bad news:

- Even in good, NSF-funded science curricula, where the curriculum calls for “making meaning” discussions,

- teachers have a hard time running the discussions. Discussions are often skipped. “...We just didn’t have time.”
The Good News:

- “Reasoning” practices are common to all 3 sets of standards. Big bang for the buck.

- The practices of discussion transfer from one content domain to another.

- We now know a great deal about how to induct students, from all backgrounds, into these reasoning practices, through rigorous, content-rich, teacher-guided discussions.
In the past ...

- We’ve told teachers to:
  - ask higher-order questions,
  - use Bloom’s taxonomy,
  - refrain from “known-answer” or “test questions,”
  - step to the side and get the students to talk to one another.
None of these “rules of thumb” is at the right level for teachers — on the fly.

What they need are moment-to-moment moves to help students externalize, clarify, and extend their own reasoning, and to build on and critique the thinking of others.
Goals for Thinking and Discussion:

1. Helping individual students to externalize their thinking— to share their reasoning out loud.

2. Helping students to orient to others and listen to what others say.

3. Helping students to work on deepening their own reasoning.

4. Helping students to respond to the reasoning of others.
Here are some examples where talk tools are integrated into content domains:

Math K-6
[http://www.mathsolutions.com]

Math K-6
[http://www.mathsolutions.com]

Math, ELA, and science, K-12
[http://inquiryproject.terc.edu]

ELA K-3
[http://discussions4learning.com]

Science 3-6
[http://ifl.lrdc.pitt.edu/ifl]
Talk Science 3-5 (web-based)
Components of Cooperative Learning

1. Positive Interdependence
2. Individual Accountability
3. Social and Communication Skills
4. Promotive Interactions
5. Group Processing
In order to facilitate a productive discussion, a teacher has to think deeply about:

- the disciplinary content,
- the learning goals of that lesson,
- the demands and affordances of the task or problem at hand, and
- the students as learners, what they know or might think they know, or might need to know.
Talk Moves in Action

- “Say More”
- Wait Time
- So, are you saying...?
- Who can restate?
- Provide evidence
- Do you agree/respond?
- Who can clarify, add on?
Needs...

- Talk about it!