Constructing and Critiquing Arguments in Middle School Science Classrooms: Supporting Teachers with Multimedia Educative Curriculum Materials

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How can multimedia educative curriculum materials (MECMs) provide support to middle school science teachers in implementing standards for *Constructing and Critiquing Arguments?*
In this five-year project (2011-2016) the Lawrence Hall of Science and Boston College are collaborating to develop and study MECMs to support middle school science teachers in teaching students to construct and critique scientific arguments. Educative curricular features will be embedded in a tablet-based teacher's guide that supports video, multimedia and text-based communications with teachers.

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How can multimedia educative curricular materials (MECMs) be designed to positively impact teachers' beliefs and pedagogical content knowledge about argumentation?

NEED

Science teachers need effective and scalable resources to support the challenge of teaching scientific practices like argumentation

- **Shortcomings in disciplinary literacy**—the specialized skills involved in reading, writing, and talking within a subject-matter discipline such as science—**impede learning**, particularly at middle school and above, and especially for academically vulnerable students (Lee & Spratley, 2010; Moje, 2007; Shanahan & Shanahan, 2008).
- **The prominence of disciplinary literacy in the Common Core standards movement, including a focus on argumentation, creates an opportunity to transform instruction in science (**Driver, Newton, & Osborne, 2000; Kuhn, 1993; McNeill & Krajcik, 2008; Pearson, Moje, & Greenleaf, 2010).
- **Widespread implementation of argumentation in science classrooms presents a serious challenge to science teachers (**Knight & McNeill, 2011; McNeill, 2009; Simon, Erduran, & Osborne, 2006; Zohar, 2008 **).**
- **Educative curriculum materials, particularly multimedia educative curricular materials, can provide a scalable solution.** (Ball & Cohen, 1996; Collopy, 2003; Davis & Krajcik, 2005; Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2008; Remillard, 2000; Santagata, Gallimore, & Stigler, 2005).

(please see handout for references cited)

GOALS

The intervention and assessment focus on two main **argumentation conceptions**, which were identified based on review of literature related to argumentation in education, analysis of videotapes of argumentation instruction, and interviews with teachers (McNeill, Gonzalez-Howard, Katsh-Singer, Price & Loper, 2013).

Conception #1 emphasizes the **structural** aspects of argumentation, and Conception #2 the **dialogic** aspects.

Conception 1 (STRUCTURAL): Students support their claims using scientific justifications

1A. Students use high-quality evidence to support their claims

1B. Students use scientific ideas or principles to explain the link between their evidence and claim (reasoning)

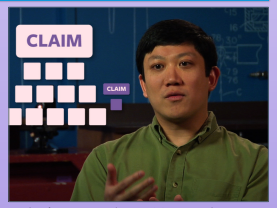
Conception 2 (DIALOGIC): Students engage in dialogic interactions in which they try to convince an audience of the strongest among competing claims.

2A. Students build off of and critique each others' ideas

2B. Students critique competing claims

Screen Capture from Example Videos

Activity: Science Seminar



Rationale: Argumentation as a Science Practice

DESIGN OF MEASURES

Measures of beliefs and pedagogical content knowledge (PCK) for argumentation were developed. The beliefs survey includes 22 Likert scale items and the assessment of PCK for argumentation includes 16 multiple choice and 4 constructed response items. The development process and some lessons learned are described below.

Step in PCK Assessment Development Process	Description
1. Conceptualization of the domain	Conducted a literature review to develop initial 4 argumentation conceptions for PCK items
2. Design of items (Version 1)	Developed 8 vignettes each with 5 items for a total of 40 items.
3. Pilot testing of items	Pilot tested 8 vignettes with 103 middle school teachers. Used data to select 6 vignettes for further development.
4. Cognitive interviews	Conducted cognitive interviews with 24 middle school teachers.
5. Revision #1: Items (Version 2)	Revised 6 vignettes using the data from both the pilot test and cognitive interviews.
6. Advisory board feedback	Selected 4 vignettes to receive feedback from the advisory board. Asked 10 advisors to provide the correct answer for each item, rate alignment of item with the conception and provide feedback.
7. Revision #2: Items (Version 3)	Revised 4 vignettes based on advisors feedback considering teacher data from Revision #1 to not contradict previous changes.

Four Lessons Learned from PCK of Argumentation Assessment

(McNeill, K. L., González-Howard, M., Katsh-Singer, R. & Loper, S., 2014)

- For MC items, distractors should focus on the targeted scientific practice (not other areas of science instruction).
- Difficult to assess a deep understanding of the scientific, but still have a clear correct answer.
- Using vignettes is both a strength and weakness in the design of the items
- Dialogic conception more challenging to develop high-quality items

Example Item

Mr. Cedillo's students are analyzing the data table from an investigation they conducted that answered the question: Which type of material will allow a car to travel the fastest? The students timed how long it took for a toy car to travel 1 meter over a rug, wood floor, rubber mat, and ice.

Surface	Distance Traveled (meters)	Time (seconds)
Rug	1	10
Wood Floor	1	5
Rubber Mat	1	7.5
Ice	1	4

Mr. Cedillo next asks his students to engage in argumentation where they debate their ideas about the relationship between surface material and speed. The excerpt below is from the beginning of their conversation.

Maya: My claim is that rough materials cause cars to go faster.

Elana: I think the data table shows that rough materials make cars go slower.

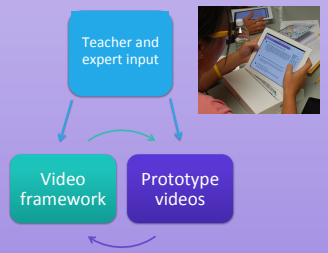
Ben: Well, I think there are lots of reasons a car would go faster or slower.

2. Mr. Cedillo should speak up and encourage the students to:
   a. Raise their hands before sharing their ideas
   b. Focus on the scientifically accurate claim
   c. Review the vocabulary from the content wall
   d. **Persuade each other of the strength of their claim[1]**

[1] Correct answer choice is bolded

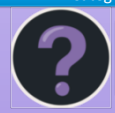
DESIGN OF INTERVENTION

Multimedia supports, including educative videos, are embedded in a digital Teacher's Guide for three Earth & Space Science units



- 24 educative videos were developed in an iterative process involving input, refinement of framework, and creation and revision of prototype videos
- *Video Framework* elements included learning goals (based on the Conceptions), video categories, and video specifications
- Other elements of the MECMS include interactive reflection questions and other digital resources such as slideshows, student work examples, and extended video segments

Categories and Video Titles



Rationale Videos
- Argumentation as a Science Practice
- Argumentation and the Standards
- Argumentation for Deeper Learning

Approach Videos
- Argumentation Overview
- Competing Claims
- Evidence
- Reasoning
- Beyond Right Answers
- Argumentation is Interactive

Activity Videos
- Argumentation Tools & Activities
- Science Seminar
- Reasoning Tool
- Evidence Gradient
- Evidence Card Sort

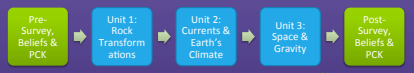
Strategy Videos
- Revising Claims With the Anticipation Guide
- Gathering Evidence from Text
- Culture of Argumentation: Supporting Discussions
- Culture of Argumentation: Taking Risks and Stepping Back
- Writing an Argument Using the Reasoning Tool
- Discussing Evidence Quality Using the Gradient Tool
- Encouraging Reasoning During a Card Sort
- Promoting Student Interaction in Science Seminars
- Writing for a Hypothetical Audience
- Stepping Back During Science Seminars

NEXT STEPS

In 2014-15 a randomized control experimental study will be conducted with 100 teachers:

- 50 Treatment Teachers will receive a Teacher's Guide that includes MECMs
- 50 Control Teachers will receive a Teacher's Guide without MECMs, including text-based supports only.

The lessons and student materials are identical for both groups



Back-end data collection on teacher usage

Observations in subset of classrooms conducted by external evaluator

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