

Multimedia Educative Curriculum Materials: Designing Digital Supports for Learning to Teach Scientific Argumentation

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Abstract: We report on work in progress from a research and development project in which we are designing digital supports to help middle school science teachers teach the practice of scientific argumentation. These supports include educative, teacher-facing videos embedded in a digital teacher's guide. In the first phase of the project we developed a framework to guide video development and produced twelve prototype videos. This paper describes the iterative design process for the framework and videos, in which we incorporated evidence from analysis of classroom video, teacher interviews, and teacher focus groups in order to create a design framework aimed to maximize the quality and practicality of the videos.

Introduction

Science education researchers and reform leaders are in alignment with recent U.S. policy documents (National Research Council, 2012) in a call to engage students more deeply and authentically in science practices such as scientific argumentation. Scientific argumentation is a practice that holds great promise for the way in which it draws together conceptual understanding and reasoning and communication skills that are an essential part of the construction of scientific knowledge (Osborne, 2010). Still, implementing the teaching of scientific argumentation poses a great challenge for science teachers (Sampson & Blanchard, 2012). New materials, professional development, and ongoing support are needed (McNeill & Knight, 2013).

Digital tools, including videos and other multimedia and interactive materials, offer potential to provide support for teachers (Lieberman & Mace, 2010). The research and development described in this paper focuses on supporting middle school science teachers in implementing instruction that emphasizes scientific argumentation. This support is provided by multimedia educative curriculum materials (MECMs), including teacher-facing videos that aim to help teachers expand their pedagogical content knowledge (PCK) around scientific argumentation.

Theoretical Framework

Argumentation and the Role of the Teacher

Argumentation has been a focus of research in science education for the past two decades, but has become more prominent in discussions about educational practice through its inclusion in recent standards documents. In our work, we emphasize both dialogic and structural aspects of argumentation. The dialogic aspect of argumentation involves the interactions between multiple individuals as they engage in construction and critique (Ford, 2012). The structural aspect focuses on the products of argumentation, in terms of how claims are supported with evidence and reasoning (McNeill & Knight, 2013).

The teacher plays an essential role in supporting students in argumentation (Zohar, 2008). Teachers' beliefs and PCK for argumentation impact their willingness to incorporate argumentation into instruction and their strategies to support students (Zemba-Saul, 2009). Teachers may lack PCK in how to support students in developing argumentation skills (Zohar, 2008). For example, teachers can struggle with the role of evidence in evaluating competing claims (Sampson & Blanchard, 2012) and they can have difficulty supporting students in classroom discussions in which students critique and question each others' arguments (Berland & Reiser, 2011). In addition, teachers struggle when assessing the strengths and weaknesses of student arguments and in determining strategies to support student learning (McNeill & Knight, 2013). Teachers lack pedagogical strategies, such as how to define an argument or how to provide content-specific examples (Zohar, 2008). In sum, to effectively integrate argumentation into their practice, teachers need greater support.

Digitally Enhanced Educative Curriculum Materials

Educative curricular materials (ECMs) (Davis & Krajcik, 2005) can have a positive effect on teacher knowledge, practice, and student outcomes. By design, ECMs tie new approaches to specific practices, activities, and learning objectives; ECMs thus have great potential for supporting change in teacher practice (Cervetti, Kulikowich, Drummond & Billman, 2013). Multimedia educative curricular materials (MECMs) that link text, representations of student work, and video clips demonstrating pedagogy in action in real classrooms,

hold even greater potential, particularly in an area such as argumentation that incorporates both oral and written modalities. Although there has been little work on the intersection of digital media with educative curriculum, our design of MECMs draws on previous work focused on multimedia representations of practice. *Multimedia representations of practice* can provide learning opportunities for teachers grounded in real life situations that utilize a rich and multi-layered approach to classroom teaching (van den Berg, Wallace & Pedretti, 2008). In particular, video cases specific to a teacher's curriculum can help support the development of pedagogical content knowledge (Roth, et. al, 2011). Multimedia representations of teaching can illustrate the intricacies and subtleties of effective teaching practices. This project builds on research on the affordances of digital curriculum materials, including the possibility for multimedia representations of teaching practice, to help teachers develop the beliefs and PCK that can support their enactment of argumentation instruction.

Research and Development Process

The work described here is part of a five-year project in which we are designing and researching MECMs to support teacher learning of argumentation. We focus here on our early design phase. Our question in this phase was, *How can multimedia educative curricular materials (MECMs) be designed to positively impact teachers' beliefs and pedagogical content knowledge about argumentation?* In this design work, our two main considerations were practicality and quality (Doyle & Ponder, 1978); in other words, we sought a design framework that would support the development of videos likely to be accessed by teachers and to have an impact.

In order to pursue these goals of quality and practicality, our development followed an iterative process (see Figure 1), with input at multiple timepoints from a number of sources. Through this process we created a MECM Design Framework to guide the development of prototype videos. The framework has three components: (1) Learning Goals (our goals for teacher learning); (2) Teacher Needs (types of needs that videos could address); and (2) Video Specifications (guidelines for length, setting and participants, and other elements to be included in the videos). The Learning Goals were derived from review of literature and input of expert advisors, described in more detail in McNeill, Katsh-Singer, Gonzalez-Howard, Price & Loper (2013). The Teacher Needs and Video Specifications were developed based on two main sources of evidence; (1) analysis of videotaped lessons and teacher interviews; and (2) teacher focus groups. These evidence sources are described below.

Evidence Sources

Videotaped Lessons and Teacher Interviews

In 2011-12, we collected data from ten teachers implementing a field trial version of an earth science curriculum with a specific focus on argumentation. For each teacher we collected videotapes of two argumentation lessons and conducted follow-up interviews. Interviews focused on the teachers' instructional practices in relation to the original curriculum and their rationales for instructional decisions specifically around argumentation. Interviews were audio recorded and transcribed and a coding scheme was developed from both our theoretical framework and an iterative analysis of the data (Miles & Huberman, 1994). The findings from this study informed the development of the Learning Goals and Teacher Needs and are reported in more detail in McNeill, Gonzalez-Howard, Katsh-Singer, Price & Loper (2013).

Teacher Focus Groups

In 2012-13, we conducted a series of teacher focus group sessions to inform our development of the MECM Design Framework and the prototype videos themselves. Five teachers were selected from a list of teacher contacts in the local area. These five teachers represented a range of school settings (suburban and urban;

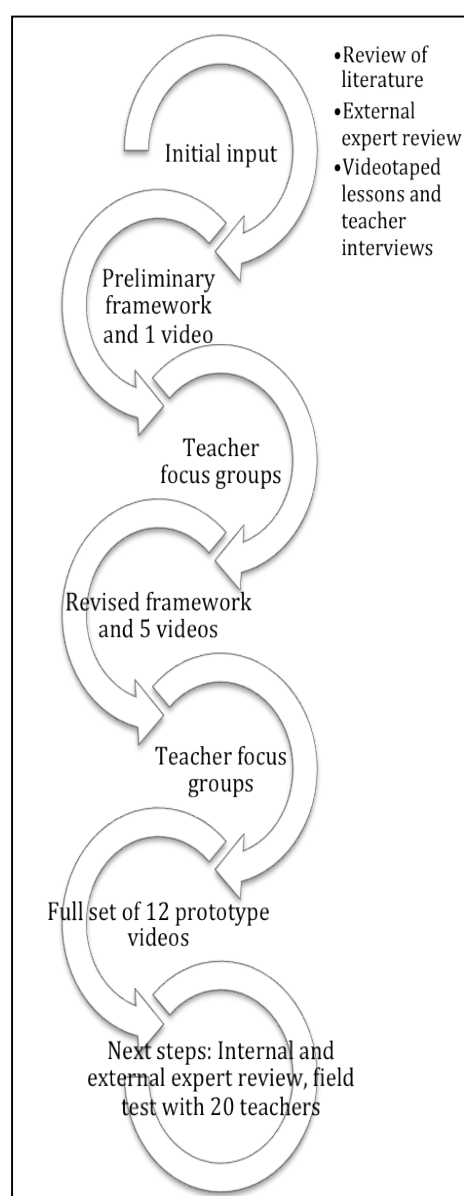


Figure 0. Iterative development of framework and prototype videos

parochial, charter, and public), years of experience teaching in the classroom (2-30 years), and prior experience participating in pilot and field trial studies with our group.

Four focus group sessions were conducted over a period of seven months. First, each teacher participated in an individual interview at their school site. The remaining sessions were conducted as group sessions, with two sessions occurring in face-to-face meetings and one session conducted via web-based conference and the use of Google Docs. Data collected included audio recordings, field notes, research memos and participant artifacts. The data was coded in a recursive and comparative manner (Charmaz, 1994) into categories of findings. The findings from these focus groups informed both the development of the Teacher Needs and the Video Specifications.

Results: Iterative Development of MECM Design Framework

Findings from the evidence sources were used in the iterative development of the MECM Design Framework, which includes three elements: 1) Learning goals, 2) Teacher needs, and 3) Video specifications.

Learning Goals

We identified three critical learning goals for teachers based on our evidence sources (McNeill, Katsh-Singer et. al, 2013; McNeill, Gonzalez-Howard, et. al, 2013) that focus on both the structural and dialogic aspects of argumentation. The phrasing of the goals was refined, based on feedback from the teacher focus groups, to make them clear and appealing to teachers. For example, while these are goals for teacher learning, focus group teachers recommended that the goals nonetheless be phrased to emphasize student achievement. Focus group participants felt that teachers are motivated by a focus on supporting their students, as opposed to a focus on themselves as learners.

Table 1: Learning Goals

Teachers will learn how to...

1. Improve students' use of high-quality evidence.
2. Help students to strengthen their arguments by articulating reasoning (connections between evidence and claims)
3. Create conditions that support student-driven argumentation.

Teacher Needs

Following a design based research approach, three Teacher Needs were developed as an “embodied conjecture” (Sandoval, 2004) drawing on literature review, expert advisor input, and our other evidence sources. For example, in the analysis of videotaped lessons and teacher interviews, we found that different teachers enacted the same lesson plan in very different ways, and yet all felt that they were implementing the lessons faithfully (McNeill, Gonzalez-Howard, et. al, 2013). This suggested a need for a type of video that provides ‘images of practice’ to help teachers better envision the intent represented by the lesson plans. Two other needs were identified: ‘meta-level’ videos that provide teachers with foundational information about what argumentation is and why it is important; and ‘strategy’ videos that provide teachers with concrete actions they can use in the classroom. Based on input from the teacher focus groups, we developed teacher-facing labels for three types of videos addressing each of these needs. Table 2 lists the three categories of videos, with the associated Teacher Needs. The teacher-facing labels for the videos are in quotations.

Table 2: Video Categories and Associated Teacher Needs

1. **Meta-Level Videos (“Building Blocks”)**: Teachers need to understand the elements of scientific argumentation (for example, the components of an argument, or what counts as scientific evidence) and the rationale for incorporating argumentation into science instruction.
2. **Images of Practice (“In the Classroom”)**: Teachers need an image of what an instructional practice looks like in the classroom, and increased confidence that it can be enacted with real students.
3. **Strategy Videos (“Strategies”)**: Teachers need concrete tools, activities and strategies that they can take into the classroom and try right away.

Video Specifications

The teacher focus groups were our primary evidence source for constructing a set of Video Specifications, designed to help us maximize the practicality of the videos, in particular the likelihood that teachers would actually use them (Doyle & Ponder, 1978). We sought input from teachers about their preferences for the elements included in the videos and how they believed they would use the videos. Themes that emerged from the teacher focus groups fell into three categories: 1) Access Options and Potential Uses, 2) On-Screen

Participants and Settings, and 3) Video Details and Supporting Media. These findings from the focus groups resulted in the development of a list of Video Specifications, excerpted in Table 3.

Table 3: Video Specifications

<p><i>Access Options and Potential Uses</i></p> <ul style="list-style-type: none"> • Flexible access system, including both lesson-specific links and top-level menu structures <p><i>On-Screen Participants and Settings</i></p> <ul style="list-style-type: none"> • Diverse classroom settings; avoid classrooms that appear unusually ‘high-resourced’ • Include extended student dialogue • Teacher voices are more desirable than scientists or curriculum developers <p><i>Video Details and Supporting Media</i></p> <ul style="list-style-type: none"> • Video length 3-6 minutes • Include reflection questions for teacher • Include annotation or call-outs to help scaffold teacher interpretation of student footage • Include explicit connections to state and national standards

Development of Prototype Videos

The MECM Design Framework was used to guide the creation of twelve prototype videos, listed in Table 4.

Table 4: Titles of 12 prototype videos

Learning Goal	Building Blocks	In the Classroom	Strategies
1: High quality evidence	• <i>What Is Evidence?</i>	• <i>What Does Evidence Look Like?</i>	• <i>Strategies for Working with Evidence from Text</i>
2: Reasoning	• <i>Why Is Reasoning Important?</i>	• <i>What Does Reasoning Look Like?</i>	• <i>Strategies for Supporting Reasoning with Questioning</i>
3: Student-Driven Argumentation	• <i>Why Argumentation?</i> • <i>What Is a Science Seminar?</i>	• <i>What Does a Culture of Argumentation Look Like?</i> • <i>What Does Working with Multiple Claims Look Like?</i>	• <i>Strategies for Adapting Activities for Argumentation</i> • <i>Strategies for Conducting Science Seminars</i>

The videos contain a mix of classroom and interview footage, text, and voiceovers. Video scripts were developed in an iterative process involving preliminary script development, collection of footage, culling of footage, and revision of scripts based on footage availability. Four filming days were conducted, with two days focused on classroom footage and two days focused on interviews with teachers, scientists and curriculum developers. For each classroom filming day, we spent 1-2 days prior to filming working with the students to prepare them for the activities that would be filmed. Working with a video production company specialized in educational media, we created draft videos that went through several rounds of input and revision.



Figure 1: Frames from *Why Is Reasoning Important?* and *What Does Working with Multiple Claims Look Like?*

Figure 2 shows sample frames from two of the videos. The frame on the left-hand side is from a “Building Block” video. In this case, the video is annotated to help the viewer link the students’ words to the components of an argument. The frame on the right-hand side is from an “In the Classroom” video focused on student-driven argumentation. Here the text at the bottom of the screen highlights this characteristic of argumentation as the viewer observes students engaging in these important interactions.

Discussion

Previous technology innovations have not become widespread in K-12 schools, in part because of their lack of focus on systemic issues such as usability, scalability and sustainability (Fishman, Marx, Blumenfeld, Krajcik & Soloway, 2004). In our work on the development of MECMs to support teachers' learning of argumentation, we take this issue seriously. Our current MECM design framework suggests the importance of focusing on both *quality* and *practicality*: creating materials that could have the desired impact, and developing them in a way that teachers would see as useful and appealing. For example, in the creation of the learning goals, we utilized the current research literature (e.g. McNeill & Knight, 2013; Ford, 2012) and our evidence sources to identify high *quality* learning goals addressing both structural and dialogic aspects of argumentation. Then we modified the language of those learning goals to target supporting students, instead of teachers, because in terms of *practicality* the focus group teachers found these more appealing. We feel that both quality and practicality are essential characteristics of MECMs to support greater scalability. The prototype videos are currently being revised based on further input, and their impact will be investigated in a randomized experimental study.

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