Designing and using multimedia modules for teacher educators: Supporting teacher learning of scientific argumentation

Citation
Marco-Bujosa, L., Gonzalez-Howard, M., McNeill, K., & Loper, S. (2017). Designing and using multimedia modules for teacher educators: Supporting teacher learning of scientific argumentation. *Innovations in Science Teacher Education, 2*(4). Retrieved from https://innovations.theaste.org/designing-and-using-multimedia-modules-for-teacher-educators-supporting-teacher-learning-of-scientific-argumentation/

by Lisa Marco-Bujosa, Boston College; Maria Gonzalez-Howard, University of Texas, Austin; Katherine McNeill, Boston College; & Suzanna Loper, Lawrence Hall of Science, University of California-Berkeley

Abstract

In this article, we describe the design and use of multimedia modules to support teacher learning of the practice of scientific argumentation. We developed four multimedia modules, available online for use in professional development or preservice classes, incorporating research-based features designed to support teacher learning of argumentation. Specifically, the features underlying the design of the modules include: (1) providing images of practice, (2) problematizing instruction, (3) offering the student perspective, and 4) encouraging teacher reflection. Each module supports teacher educators in engaging teachers in learning about argumentation through activities utilizing these features. We describe the rationale for designing multimedia teacher learning modules that incorporate these features. We also describe how these features are incorporated into learning activities by focusing on one session from one module. We then illustrate the utility of these modules by providing one example of how these resources can assist teacher educators to support particular district goals around argumentation by adapting and modifying the modules. This article features the ways these online modules are an innovative support for teacher learning, by providing multimedia resources and the opportunity for increased user flexibility. Finally, we discuss some preliminary findings around teachers' use of the features in these learning modules.

Introduction

The Next Generation Science Standards (NGSS) represent a new vision for science teaching and learning, requiring teachers to blend disciplinary core ideas, science and engineering practices, and crosscutting concepts (Pruitt, 2014). The focus of the NGSS is on providing students with more authentic experiences in science, with an emphasis on students using their understanding of disciplinary core ideas to make sense of the natural world (Schwarz, Passmore, & Reiser, 2017). This represents a departure from traditional science instruction that focuses more on

memorizing science knowledge and less on students engaging in science as a practice (Ford, 2015). However, the NGSS provide little guidance for teachers with respect to what these science practices should look like in science classrooms, or how teachers can design lessons to include them (Windschitl, Schwarz, & Passmore, 2014). Consequently, it can be difficult for teachers to incorporate science practices into their instruction.

In our work, we focus on one particular science practice, argumentation. A key aspect of argumentation is to promote student understanding of the nature of scientific knowledge and the culture of science (NRC, 2012), or science as knowledge and practice (Osborne, Erduran, & Simon, 2004). We conceptualize scientific argumentation as consisting of both a structural and dialogic component (McNeill, González-Howard, Katsh-Singer, & Loper, 2016). The structure of an argument consists of a claim about the natural world that is supported by both evidence and scientific reasoning (McNeill, Lizotte, Krajcik, & Marx, 2006). The dialogic component of argumentation emphasizes science as a social process in which students construct arguments through interactions with their classmates (Berland & Reiser, 2011). Although we describe structure and dialogic interactions as two different components of argumentation, they are often intertwined in classroom instruction. For instance, a student might critique the source of evidence a peer is using during a small group discussion.

Research has shown that scientific argumentation is difficult to implement in classrooms, particularly the dialogic component, which differs greatly from traditional, teacher directed, science instruction (Berland & Reiser, 2011). Studies around this science practice have shown that teachers' argumentation instruction is influenced by their pedagogical content knowledge (PCK) and beliefs. PCK refers to professional knowledge specific to teaching and learning about a particular science concept (Shulman, 1986). Recent studies have highlighted the importance of PCK for the science practices, such as argumentation (e.g., McNeill, et al., 2016). Teacher beliefs about argumentation, and the value of argumentation, can also influence how teachers incorporate this practice into their instruction (Sampson & Blanchard, 2012).

In our previous work (McNeill, et al., 2016), we explored teachers' beliefs around argumentation in three areas related to their classroom instruction: 1) students' backgrounds, 2) learning goals and 3) self-efficacy. In terms of students' backgrounds, some teachers believe argumentation is too hard for some students (Sampson & Blanchard, 2012) or that argumentation may create confusion and lead to student misconceptions about science concepts (Osborne et al., 2004). Research also indicates that teacher beliefs about student ability to engage in argumentation vary based upon factors such as the socioeconomic status of their students (Katsh-Singer, McNeill, & Loper, 2016). In addition, teachers' understandings of argumentation, and their beliefs about how knowledge is created and used in the classroom, can influence the ways teachers plan for and teach argumentation activities in the classroom (McNeill, et al., 2016; Marco-Bujosa, McNeill, González-Howard, & Loper, 2017). These learning goals play an important role in teachers' approach to argumentation instruction. For example, in a study of the impact of teachers' beliefs on instruction of scientific argumentation, Zohar (2008) found teachers who believed that the goal of science instruction was to provide content knowledge

only rarely engage students in activities requiring critical thinking, an essential aspect of scientific argumentation. Finally, teacher beliefs about themselves have been shown to influence their instruction (Bryan, 2012). For example, in prior work we found that teachers' confidence in their ability to teach argumentation can influence their instruction (McNeill, et al., 2016). These kinds of beliefs may cause teachers to undermine the goals of argumentation by placing an instructional priority on transmitting knowledge.

Teachers need support to develop their PCK and beliefs about argumentation. To do so, teachers need to see the practices in action, and understand how they are different from traditional approaches to science instruction (Hanuscin, Arnone, & Bautista, 2016; Osborne, 2014). The challenge for teacher educators is that most science teachers, or prospective science teachers, received little support to develop knowledge of the science practices in their science education experiences or teacher preparation programs (Osborne, 2014). Consequently, teachers may be unfamiliar with the science practices, both as a science learner and as a teacher, and will need support to incorporate the practices into their science teaching. Additionally, research has shown that considering *how* teachers learn is important in supporting teachers to teach science practices (Allen & Penuel, 2015; Hanuscin, Arnone & Bautista, 2016) and argumentation in particular (Marco-Bujosa, et al., 2017). Thus, teacher learning experiences about the science practices, such as argumentation, may need to shift to better support teacher learning. This has implications for curriculum, learning structures, and strategies used in teacher preparation and professional development (Bybee, 2014; Hanuscin et al., 2016).

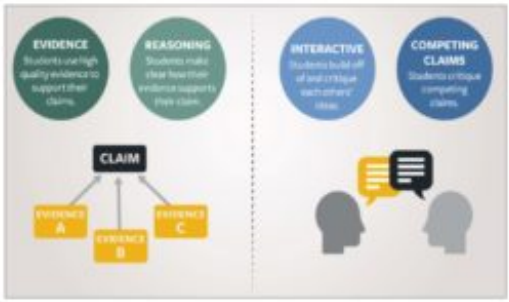
We developed multimedia modules about scientific argumentation to change teacher beliefs about argumentation in three ways that have been shown to support teacher instruction of this practice: beliefs about student abilities to engage in this scientific practice; beliefs about the importance of teaching argumentation (learning goals); and beliefs about their ability to teach argumentation (self-efficacy). In this paper, we focus on the features of the multimedia modules, which are designed to help teacher educators support teacher learning of scientific argumentation. In particular, these online modules were developed to incorporate the lessons emerging from research on supporting teachers to learn about the science practices. Specifically, four features provided the backbone of our module design approach: (1) providing images of practice, (2) problematizing instruction, (3) offering the student perspective, and 4) encouraging teacher reflection. These features are based upon research and best practices (e.g., van den Berg, Wallace & Pedretti, 2008; Zhang, Lundeberg, Koehler, & Eberhardt, 2011), as well as our personal experience working with teachers and teacher educators around argumentation. Additionally, creating these modules in an online platform offered an innovative means by which to support teacher learning through the use of multimedia supports. Furthermore, the online platform permits flexible use by teacher educators, specifically allowing for customization and adaptation to their needs, as well as the needs of the schools and teachers they serve. In the next section, we describe the context of our work – a research and development project around the practice of scientific argumentation – that provided the impetus for the development of these modules.

Context of our Work

We developed the teacher learning modules as a part of The Argumentation Toolkit, (http://www.argumentationtoolkit.org/), an online collection of resources designed to help teachers understand and teach scientific argumentation, which we will refer to as "the toolkit" for the remainder of the article. The toolkit was developed as part of a research and development project to support middle school teachers in integrating argumentation into their science instruction. This project is a collaboration between the Lawrence Hall of Science at the University of California, Berkeley and Boston College.

In order to effectively teach argumentation, teachers need an understanding of this science practice and of instructional strategies to engage and support students. Thus, we developed the toolkit to support both teacher understanding of argumentation and to provide teachers with classroom strategies. The toolkit was developed around four elements of scientific argumentation that are particularly challenging for teachers and students. Two of these elements relate to the structural component of argumentation – 1) evidence, and 2) reasoning – while two correspond to the dialogic aspects of this science practice – 3) student interaction, and 4) competing claims (Figure 1).

Figure 1 (Click on image to enlarge). Argumentation elements.



In our work developing resources for teachers, we found that teacher educators also require resources and support to facilitate their professional development efforts around argumentation. We approached this need through the development of multimedia modules for scientific argumentation, which were added to the toolkit website to provide support for teacher educators using the toolkit resources. The following sections describe our design approach, specifically illustrating the utility of particular features in a multimedia format that guided our development of the modules. Additionally, we provide an illustration of the first author's use of these multimedia learning modules during professional development for science teachers. This example is intended to highlight how the flexibility of these modules allows teacher educators to modify and adapt them to their own setting.

Module Design

We developed four multimedia teacher learning modules around scientific argumentation. The four modules consist of an introductory module, which introduces teachers to argumentation using the four common student challenges previously described, and three advanced modules, which provide teachers with additional depth and practice related to teaching argumentation. More information about these modules is provided in Table 1, and on the toolkit website under the "Teacher Learning" tab (http://www.argumentationtoolkit.org/teacher-learning.html). Each module consists of four sessions, which can be presented all at once in a 3 hour long session, or as individual, 45 minute sessions. Modules provide teachers with the opportunity to engage in a variety of argumentation activities, review student artifacts and student talk (e.g., writing and video), and design or revise their own argumentation lessons. Additional information about the design and organization of the modules is provided below in the section of this article entitled, "Using the Module."

Table 1 (Click on image to enlarge)

Description of Teacher Learning Modules

Module Name	Goal	Session Description
Introductory Module on Scientific Argumentation	Introduces the four argument elements.	Sessions address argument structure (the role of evidence and reasoning) and dialogic interactions (how competing claims support student use of evidence, and supporting student interactions with peers)
Advanced Module - Science Seminar	Introduces the science seminar, a dialogic argumentation activity.	Sessions provide more information about a science seminar, how to prepare students for a science seminar, tips for teachers to conduct a science seminar, and supporting student writing after a seminar.
Advanced Module - Designing Rich Argumentation Tasks	Introduces four criteria and other considerations when designing rich argumentation tasks.	Sessions introduce design criteria, strategies to support students in evaluating the quality of evidence and revising their thinking given new evidence, and provides participants with an opportunity to design an argumentation task.
Advanced Module - Evidence and Reasoning	Supports teachers in helping students overcome common challenges in using evidence and reasoning in scientific arguments.	Sessions distinguish between evidence and reasoning, explores how to support student use of evidence and reasoning in an argument, and provides tips for planning activities to support student use of evidence and reasoning.

Each module, and its corresponding sessions, was designed to incorporate four features intended to support teacher learning of the science practices: (1) providing images of practice, (2) problematizing instruction, (3) offering the student perspective, and 4) encouraging teacher reflection. Table 2 provides a summary and a description of how each feature is incorporated in the modules.

Table 2 (Click on image to enlarge)

Module Design Features to Support Teacher Learning

Design Feature	Description in Modules
Providing images of practice	Most sessions feature videos of teachers and students engaged in argumentation activities, which are meant to offer teachers with insight into what it looks like when argumentation is a part of classroom instruction.
Problematizing instruction	Each session is framed with a guiding question to support teachers in noticing how argumentation instruction differs from their current instruction. During each session, teachers engage in activities, discussion, and reflection addressing the guiding questions. Additionally, the modules are organized around four elements of argumentation that are challenging for teachers and students: evidence, reasoning, student interactions, and competing claims.
Offering the student perspective	Sessions engage teachers directly in the practice of argumentation through argumentation activities and tasks from the perspective of students. Teachers are then prompted to reflect on the experience through discussion, and by making connections to their students' needs and challenges.
Encouraging teacher reflection	Sessions encourage teachers to reflect on their current practice while learning about argumentation. This supports teachers in making connections between new tools and strategies learned in the modules and current instruction. Additionally, if taught as four separate sessions, an optional "Try it with your students!" activity is presented at the end of each session, which facilitates teacher reflection between sessions. This provides teachers with an opportunity to put new skills into practice and reflect upon them individually and with the learning group.

We next describe and illustrate each of these design features using examples from one session, the fourth session from the Introductory Module on Scientific Argumentation, entitled, "How do we support students in interacting with peers during argumentation?" (The agenda for this session is provided in the Appendix, and can also be accessed on the toolkit website.) This session was designed to help teachers develop an understanding of argumentation as a social process in which students question and critique claims using evidence and reasoning.

Design Features to Support Teacher Learning

Providing images of practice

To incorporate the first feature, *providing images of practice*, the modules make rich images of classroom enactment of science argumentation available to teachers. Images of practice serve as useful instructional models for teachers in preservice classes and professional development, particularly for those who are unfamiliar with the practice and lack context for how argumentation activities may differ from traditional science instruction (Reiser, 2013). In our learning modules, these images are incorporated through videos of teachers and students engaging in argumentation activities.

As compared to text-based supports, these videos provide teachers with real world examples of argumentation in science classrooms. The videos feature footage of real classrooms with teachers enacting a curriculum on argumentation with their students. The teachers in the videos were using a curriculum with a strong focus on scientific argumentation. This context was used with the hope that it would provide strong examples of what argumentation may look like in a classroom. Each video was created with a particular goal for teacher learning. For instance, while some videos provide an overview of the elements that are particularly challenging for teachers and their students, other videos highlight classroom activities and strategies to support engagement in argumentation. For each video, specific clips were selected to illustrate the

particular goals of the video. Further, the videos are edited and have voice overs to emphasize particular goals, and teachers reflect on challenges and successes of implementing these activities in their classroom.

The fourth session begins with an activity "Video & Discussion." This video supports the dialogic elements of argumentation, and is specifically focused on encouraging student interaction (Figure 2). The videos support teacher learning by providing an overview of the practice, a rationale for supporting student interaction in the science class, and footage of students in actual science classes critiquing each other's ideas across different types of argumentation activities (e.g., pair feedback on written arguments). These videos also provide a vehicle for helping teachers see the interconnectedness of argument structure and dialogic interactions. For example, in this video, students draw upon evidence to convince their peers.

Figure 2 (Click on image to enlarge). Image of practice and problematizing instruction.

Problematizing instruction

The second feature, *problematizing instruction*, helps teachers recognize how their current instruction may be different from instruction authentically incorporating the science practices, such as argumentation (Osborne, 2014). As mentioned earlier, our four modules were explicitly designed to address four elements of argumentation that research has found to be particularly challenging for teachers and students (evidence, reasoning, student interactions, and competing claims) (McNeill et al., 2016). Across the four modules, each session title is a key question of practice related to an argumentation challenge, which serves as a guiding question for session activities. The question both identifies the argumentation focus for the session, and also encourages teachers to make connections between this science practice and their current instruction. For example, the fourth session in the Introductory Module is entitled, "How do we support students in interacting with peers during argumentation?" This question focuses on the challenge of student interactions, and all activities are around helping teachers provide support for student interactions in their science class.

Moreover, discussions following different activities in this session prompt teachers to consider challenges their students face. For example, in a discussion following the first activity, "Video & Discussion: Encouraging Student Interactions," participants are asked: "What are the benefits to

having students interact with peers during argumentation tasks?" Questions like these encourage teachers to consider the ways in which incorporating argumentation into their instruction supports student learning (Figure 2).

Offering the student perspective

Teachers are given the opportunity to engage in numerous argumentation activities during sessions from the *student perspective*. Research has shown it is important for teachers to develop knowledge of how students learn (Lee & Luft, 2008; Park & Oliver, 2008). One way to support teacher understanding of how students learn about argumentation is to have them engage in argumentation activities as a learner themselves. This feature addresses the lack of familiarity and experience many teachers have with argumentation, and allows them to understand the challenges students may encounter. For example, session four in the Introductory Module introduces teachers to the experience of student interactions by having teachers work in groups to collaboratively analyze data from three different studies related to a claim about metabolism (Figure 3). Teachers are encouraged to interact around evidence by asking each other questions, building off of one another's ideas, critiquing each other's claims, and persuading one another—all key dialogic aspects of argumentation. Following the activity, teachers are prompted to reflect on their experience of having engaged in this argumentation task as a student ("What did you talk about when you engaged in this task? How did interacting with others influence the argument you developed?"). Afterwards, they shift back to a teacher perspective to discuss instruction, particularly the supports they anticipate their students may need to productively interact with their peers in this argumentation activity ("What types of supports do you think your students might need to engage in this element of argumentation?").

Figure 3 (Click on image to enlarge). Student perspective.

Lung Test

Average Results

Twins A (normal exercise: 3 hours per week)	Lung Test (in liters)		Twins B (more exercise: 12 hours per week)	Lung Test (in liters)
Average	3.1		Average	3.8

Full Results

Twins A (normal exercise: 3 hours per week)	Lung Test (in liters)		Twins B (more exercise: 12 hours per week)	Lung Test (in liters)
Twin A1	3.1		Twin B1	4.0
Twin A2	3.2		Twin B2	3.9
Twin A3	2.9		Twin B3	3.6
Twin A4	3.3		Twin B4	3.8
Twin A5	3.0		Twin B5	3.9
Twin A6	3.3		Twin B6	4.1
Average	3.1		**Average**	3.8

Encouraging teacher **reflection**

The fourth feature we incorporated into the modules is *encouraging teacher reflection*. Research has shown that professional development supporting teachers' PCK should provide teachers with opportunities to both enact instructional strategies and opportunities to reflect on those enactments, both individually and as a group (Van Driel & Barry, 2012). Thus, in each session, multiple opportunities for discussion among teachers are provided. Questions prompt teachers to reflect on their own instruction after different activities, such as after viewing a video or engaging in an argumentation task. In the example discussed earlier, numerous opportunities are provided for teachers to engage in sustained reflection on how to support student interactions in their science classroom. For instance, all sessions include an optional extension, which can be used to encourage teachers to further reflect on their argumentation instruction. Session four in the Introductory Module begins with a debriefing of an argumentation task teachers were asked to try with their students following session three. Teachers are encouraged to reflect on a lesson they developed addressing reasoning with their peers, specifically discussing what went well and what was challenging, as well as sharing student writing (Figure 4).

Figure 4 (Click on image to enlarge). Teacher reflection from extension discussion.

Teachers also engage in a reflective discussion following "Activity: Analyzing data with peers." Specifically, they are prompted to consider, "What type of supports do you think your students might need to engage in this element of argumentation?" Additionally, in a culminating activity for the module, "Discussion: Connections between argumentation elements," teachers make connections across all four argumentation elements introduced in the session, and consider the

strengths of science instruction incorporating these elements, as well as any challenges students may encounter. Such a discussion is meant to support teachers in considering the needs of their students in planning for instruction.

As these examples from just one session illustrate, the four design features underlying this module (providing images of practice, problematizing instruction, encouraging teacher reflection, and offering the student perspective) are synergistic, working together to support teachers in developing their understanding of argumentation and how to incorporate it into their instruction. In particular, the videos (which offer teachers an image of practice) provide the teacher educator with a natural vehicle to facilitate teachers' ability to engage in two other features, problematizing their instruction and reflecting on their practice. Moreover, although each session focuses on one particular challenge identified in the question framing the session (evidence, reasoning, student interaction, or competing claims), the other challenges are interwoven across different session activities. For example, the focal session described above addressed the challenge of supporting student interactions, but activities also incorporated the structural elements of argumentation, notably student use of evidence and reasoning.

Using the Module

Our experience leading professional development and working with other teacher educators guided our approach to the development of these modules. Though the modules were developed as self-contained units, the fact that these modules are provided online enable these resources to be flexibly used and easily customized.

The first author used the modules to prepare a professional development (PD) session about scientific argumentation for a school district. The district requested a PD session specifically focused on the structural elements of argumentation (i.e., how a claim is supported by evidence and reasoning). The district had a particular goal to better support student writing of science arguments, and requested a focus on reasoning, which they found had been an area of challenge for both teachers and students. Furthermore, because this PD request was designed to support a new district initiative that encompassed a goal for vertical alignment, the audience included teachers of science from grades 4-12 (most of whom were new to argumentation). As such, the goal of the PD was to introduce teachers to argumentation, and to begin the process of modifying instruction to incorporate more opportunities for authentic student argumentation.

Because no individual module aligned with the district's request and goal of focusing solely on the structural components of argumentation (evidence and reasoning), I identified sessions across the four learning modules that provided a variety of activity types for teachers to learn about evidence and reasoning and consider implications for their instruction. (See the Teacher Learning tab on the toolkit website for more information: http://www.argumentationtoolkit.org/teacher-learning.html). Specifically, I used the first session and the third session from the Introductory Module (What is the role of evidence in a scientific

argument? and What is the role of reasoning in a scientific argument?) to introduce teachers to evidence and reasoning. Then, to support teachers in identifying opportunities in their current curriculum and instruction to support student argumentation, I drew upon sessions from different advanced modules, specifically session 3 from the Advanced Module on Evidence and Reasoning (How can you support student use of reasoning in a scientific argument?) and session 1 from the Advanced Module, Designing Rich Argumentation Tasks (How can you design rich argumentation tasks to encourage student use of evidence and reasoning?). Even though the selected sessions and activities were designed to support teacher learning about argument structure, the videos included in these sessions also provided footage of students engaged in argumentation activities. Videos encouraged teachers to problematize their instruction and reflect on their practice to incorporate the dialogic components of argumentation, notably student interaction. For example, the video in the session introducing reasoning not only provides examples of classroom activities that can support student use of reasoning, such as group work, but also provides teachers with footage of students using reasoning in real classrooms engaged in argumentation activities. The discussion questions following this video ("How do the activities featured in the video encourage students to use reasoning?" and "What challenges do your students encounter using reasoning?") encourage teachers to reflect on this practice and the implications for their own instruction.

As illustrated in this anecdote showing how the modules can be used, the online platform makes them flexible and easily modified to serve different purposes and audiences. For example, the modules are flexible with respect to time, since each module can be delivered as one 3 hour session, or four separate 45 minute sessions, depending upon the timing and format of the PD session. If presented as four separate sessions, optional "extension" activities are included to provide connections across session topics. Furthermore, though designed for a middle school audience, the sessions can be utilized with teachers across grades K-12, and even with a preservice audience. This flexibility is facilitated with references and supports around science content to enable teachers to engage in the argumentation activities regardless of their content knowledge.

Additionally, the modules can be used in any desired combination or order. They were designed to be presented as stand-alone learning experiences, or as a series, with an introductory module and several options for more advanced practice on argumentation. Or, as illustrated by the previous example, teacher educators can organize the learning experience based upon the needs and interests of their audience. Each session is cross referenced by the argumentation element (evidence, reasoning, student interactions, and competing claims) and by the argumentation activity focused on in the session (Figure 5) to facilitate teacher educators in customizing the learning experience.

Figure 5 (Click on image to enlarge). Argumentation element and activity.

Finally, each session can be viewed in one of two ways to allow teacher educators easy access to resources for planning and presenting. Specifically, each session can be displayed on the website as either 1) a scrollable lesson plan, which provides an outline of all activities, with links to session resources, or 2) as a slideshow, which includes any videos at the bottom of the page. Both views offer the same learning experiences to teachers. Additionally, an agenda is provided for each module, which includes tips for facilitators, and time estimates. This document can be edited, allowing facilitators to customize the lesson plan for their session.

Evidence of Success: Teacher Beliefs and Understanding of Argumentation

There is evidence that the types of supports included in our learning modules are desired by teachers and teacher educators who are interested in incorporating the scientific practice of argumentation into classroom teaching. This demand is evident in the number of hits the modules have received. Specifically, since we posted the first module in June 2016, we have had 10,508 unique page views for the teacher learning modules in just over six months (as of January 2017). The last module was posted in late December 2016.

Although we have not yet collected data from teachers who participated in PD using these modules, we can report data about changes in teacher beliefs about argumentation from a pilot of resources for teachers provided in the toolkit, including the videos featured in the teacher learning modules. We explored teacher beliefs about scientific argumentation through a survey consisting of 22 items measuring three aspects of teacher beliefs (self-efficacy, learning goals, and beliefs about student background and ability) after using a web-based teacher's guide that included videos and other supports. Sample items and consistency ratings for these three scales are reported in Table 3.

Table 3 (Click on image to enlarge)

Teachers' Beliefs About Scientific Argumentation

Sub-Scale	Number of Items	Sample Item	Cronbach's Alpha	
			Pretest	Posttest
Teacher Self-Efficacy*	8	I feel confident facilitating students' critiques of arguments.	0.93	0.88
Learning Goals*	7	Engaging students in argumentation is an important part of learning science.	0.87	0.77
Student Background and Ability^	7	Tammy has an IEP for challenges she experiences with reading. Tammy's mother says she likes science and watches TV shows about the environment at home, but is easily frustrated at school.	0.83	0.89

*Response options: 1 = Strongly disagree, 2 = Disagree, 3 = Agree, 4 = Strongly Agree

^Response options: 1 = Not capable, 2 = Somewhat capable, 3 = Capable, 4 = Very Capable

Overall, we found significant increases in teachers' self-efficacy, their learning goals for their students, and beliefs related to student background and ability as a result of learning about argumentation using these supports (Table 4).

Table 4 (Click on image to enlarge)

Changes in Teachers' Beliefs About Scientific Argumentation

	T	Pretest		Posttest		Paired Samples t-test
	N	Mean (se)	SD	Mean (se)	SD	Sig †
Self Efficacy	46	3.06(.08)	0.57	3.43(.06)	0.39	-4.94	<.001
Learning Goals	46	3.55(.06)	0.41	3.82(.04)	0.27	-4.95	<.001
Student Background	46	3.04(.06)	0.43	3.31(.09)	0.58	-3.44	<.01

Interviews with teachers about how they used these videos in preparing for instruction offered insights into how teachers interact with these features, resulting in instructional changes. In interviews following their instruction of a focus lesson on argumentation, teachers were asked to comment on how they used the resources to prepare their argumentation instruction. Several teachers commented on the benefits of the videos in helping them develop their own understanding of argumentation and of what it looks like in the classroom. One teacher described how the videos were helpful in providing a clear explanation of the structure of a scientific argument.

> *[I] watched the video… just to go over what a claim is, because I think I've had different definitions of it over, you know, different iterations, the definition over the past three years and these definitions seem very tight, and there's not a lot of wiggle room with what it means, so that was my biggest concern, is talking about the evidence and talking about the process of making an argument.*

Another teacher found the videos to be particularly helpful in supporting her understanding of what argumentation looks like in a science classroom, and instructional strategies that can facilitate student engagement in the dialogic components of this science practice.

> *So I did watch the video, and it was more specific in terms of language than the previous ones I had looked at had been, so I did take the time to watch it a second time and freeze the screen and write down some of the questions because it was new language to me, and I just wanted to integrate it more and to, so that I would be able to reinforce it as I was talking to individuals.*

As such, the videos that we included in our teacher learning modules have shown promise in

supporting changes in teachers' beliefs about argumentation, as well as shifts in their instruction around this science practice. This suggests that the modules themselves may have promise to support changes in teachers' beliefs.

Conclusion and Implications

Our work contributes to bridging the gap between teacher education and the classroom, specifically in helping teachers incorporate the science practice of argumentation into their science classes. Our modules provide teacher educators with a tool to better support teacher learning around argumentation in their professional development efforts. Specifically, in this paper we described the research-based features we incorporated in our design of the modules, and offered contextualized examples of what each of these features look like. Research on argumentation, and personal communication from teacher educators, reveal there is a need for these types of resources. Our teacher learning modules, freely available online, are both flexible and easy to access and use with a variety of teacher audiences, easily modified for particular instructional goals related to argumentation, and engage teachers in meaningful, reflective activities to support their understanding of argumentation.

Supplemental Files

Appendix.docx

References

References
Allen, C. D., & Penuel, W. R. (2015). Studying teachers' sensemaking to investigate teachers' responses to professional development focused on new standards. Journal of Teacher Education, 66, 136-149.

Berland, L. K., & Reiser, B. J. (2011). Classroom communities' adaptations of the practice of scientific argumentation. Science Education, 95, 191 – 216.

Bryan, L. A. (2012). Research on science teacher beliefs. In B. J. Fraser, K. Tobin, & C. J. McRobbie (Eds.), Second international handbook of science education (Vol.1, pp. 477-495). Dordrecht: Springer.

Bybee, R. W. (2014). NGSS and the next generation of science teachers. Journal of Science Teacher Education, 25, 211-221.

Ford, M. J. (2015). Educational implications of choosing "practice" to describe science in the next generation science standards. Science Education, 99, 1041-1048.

Hanuscin, Arnone, & Bautista (2016). Bridging the 'Next Generation Gap' – Teacher Educators Enacting the NGSS. Innovations in Science Education, 1(1).

Katsh-Singer, R., McNeill, K. L., & Loper, S. (2016). Scientific argumentation for all? Comparing teacher beliefs about argumentation in high, mid, and low socioeconomic status schools. Science Education, 100, 410-436.

Kazemi, E., & Hubbard, A. (2008). New directions for the design and study of professional development attending to the coevolution of teachers' participation across contexts. Journal of Teacher Education, 59, 428-441.

Lee, E., & Luft, J. (2008). Experienced secondary science teachers' representation of pedagogical content knowledge. International Journal of Science Education, 30, 1343 – 1363.

Marco-Bujosa, L. M., McNeill, K. L., González-Howard, M., & Loper, S. (2017). An exploration of teacher learning from an educative reform-oriented science curriculum: Case studies of teacher curriculum use. Journal of Research in Science Teaching, 54, 141–168.

McNeill, K. L., González-Howard, M., Katsh-Singer, R. & Loper, S. (2016). Pedagogical content knowledge of argumentation: Using classroom contexts to assess high quality PCK rather than pseudoargumentation. Journal of Research in Science Teaching, 53, 261-290.

McNeill, K. L., Lizotte, D. J., Krajcik, J., & Marx, R. W. (2006). Supporting students' construction of scientific explanations by fading scaffolds in instructional materials. Journal of the Learning Sciences, 15, 153–191.

National Research Council. (2012). A framework for K-12 science education: Practices, crosscutting concepts and core ideas. Washington, DC: The National Academies Press.

Osborne, J., Erduran, S., & Simon, S. (2004). Enhancing the quality of argumentation in school science. Journal of Research in Science Teaching, 41, 994 – 1020.

Osborne, J. (2014). Teaching scientific practices: Meeting the challenge of change. Journal of Science Teacher Education, 25, 177-196.

Park, S., & Oliver, S. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. Research in Science Education, 38, 261 – 284.

Reiser, B.J. (2013). What professional development strategies are needed for successful implementation of the next generation science standards? Invitational Research Symposium on Assessment, K-12 Center at ETS. Retrieved from: http://www.k12center.org/rsc/pdf/reiser.pdf

Sampson, V., & Blanchard, M. R. (2012). Science teachers and scientific argumentation: Trends in views and practice. Journal of Research in Science Teaching, 49, 1122-1148.

Schwarz, C. V., Passmore, C., & Reiser, B. J. (2017). Moving beyond "knowing about" science to making sense of the world. In. C. V. Schwarz, C. Passmore, & B. J. Reiser (Eds.). Helping students make sense of the world using next generation science and engineering practices (3-21).

Arlington,

VA: National Science Teachers Association.
Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. Educational Researcher, 15(2), 4–14.

van den Berg, E., Wallace, J., & Pedretti, E. (2008). Multimedia cases, teacher education and teacher learning. In Voogt, J. & Knezek, G. (Eds.), International Handbook of Information Technology in Primary and Secondary Education (pp. 475-487). New York, NY: Springer.

Van Driel, J. H., & Berry, A. (2012). Teacher professional development focusing on pedagogical content knowledge. Educational Researcher, 41(1), 26 – 28.

Windschitl, M., Schwarz, C., & Passmore, C. (2014). Supporting the implementation of the next generation science standards (NGSS) through research: Pre-service teacher education. Retrieved from: https://narst.org/ngsspapers/preservice.cfm

Zhang, M., Lundeberg, M.A., Koehler, M.J., & Eberhardt, J. (2011). Understanding affordances and challenges of three types of video for teacher professional development. Teaching and Teacher Education, 27, 454-262.

Zohar, A. (2008). Science teacher education and professional development in argumentation. In S. Erduran & M. P. Jimenez-Aleixandre (Eds.), Argumentation in science education: Perspectives from classroom-based research (pp. 245–268). Dordrecht: Springer.