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What is motivating middle-school science teachers to teach climate change?*

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ABSTRACT

Adoption of science content standards that include anthropogenic climate change has prompted widespread instruction in climate change for the first time. However, the controversial nature of the topic can be daunting and many teachers share misconceptions that lead to weak treatment of climate change in classrooms. Nevertheless, numerous teachers have embraced the topic and are providing illustrations of deliberate climate change education. In this study we investigated teacher motivation using focus groups with middle school teachers who currently teach climate change. Qualitative analysis of the collective teacher voices yielded underlying motivations. Our findings suggest that these teachers' interest in environmentalism naturally translates to climate change advocacy and motivates teaching the topic. Their knowledge and expertise gives them confidence to teach it. These teachers see themselves as scientists, therefore their views align with the scientific consensus. They practice authentic scientific research with their students, thus confirming valued characteristics of their scientist identity. Finally, our findings suggest that teaching climate change gives these teachers a sense of hope as they impact the future through their students. This study contrasts with skepticism over the state of climate change education and contributes to an understanding of how climate change education is motivated in teachers.

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Introduction

Release of the Next Generation Science Standards (NGSS) occurred in the United States in 2013. These standards, informed by an internationally benchmarked study, are the most recent response to renewed calls for a scientifically literate citizenry (NGSS Lead States, 2013). For the first time in the history of US science curricula, the NGSS include performance expectations necessitating instruction in anthropogenic climate change (American Meteorological Society, 2013). These appear in the NGSS beginning in the middle grades, ages 11–14 (i.e. MS-ESS3-5. Ask questions to clarify evidence of the factors that

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have caused the rise in global temperatures over the past century) (NGSS Lead States, 2013). As states adopt and implement the NGSS, many middle-school science teachers are beginning instruction in climate change for the first time.

While 70% of middle-school science teachers in the United States currently provide instruction in climate change, the amount of time spent on the topic is minimal, typically only one hour of instruction per year (Plutzer et al., 2016). Teaching climate science can be difficult, involving challenging and complex science concepts. Teaching about climate change can necessitate debunking misconceptions and navigating a highly polarised social climate charged with political overtones. It is understandable that some middle-school science teachers may be hesitant to approach the topic with their students.

Nevertheless, numerous middle-school science teachers have embraced climate change education, providing illustrations for their colleagues and the science education community. These teachers are uniquely positioned to help us understand how to best motivate the topic of climate change and possibly sustain motivation to teach climate change among more hesitant teachers. In this work, we sought to investigate the motivations of current climate change educators from a social constructionist perspective that maintained the way in which classroom teachers collaboratively construct values about best teaching practices.

Background

Similar to Sputnik's stimulation of science education reform in the 1960s, climate change is a modern wake up call for science education, prompting the inclusion of new science content standards and advocating a focus on critical thinking and evidence-based reasoning. However, whereas Sputnik spurred scientific innovation (see Scott, 2007), climate change action suffers from ideological polarisation resulting from controversial social issues that are stalling efforts to solve problems.

Into this already tenuous situation, recent research has introduced justified skepticism regarding teachers' abilities to effectively deal with the challenges of teaching controversial science topics such as evolution and climate change. Both topics suffer from anti-science rhetoric related to low levels of science literacy and embeddedness in social communities that reinforce anti-science thinking (Gauchat, 2008). Thus, in addition to the climate change education literature, we looked to evolution instruction history as background for our study.

After investigating evolution instruction, Berkman and Plutzer (2015) suggest that teachers are 'enablers of doubt' (p. 253) in the science classroom. By treading lightly through evolution instruction and leaving space for alternate explanations, the majority of teachers in their study 'clearly allow doubt and uncertainty into their teaching of evolution and are weak advocates for evolutionary science' (p. 256). Following this study, Plutzer et al. (2016) used data from 1500 middle schools and high schools, to suggest that teachers are confused when it comes to the subject of climate change and that 'teachers' knowledge and values can hinder climate education' (p. 664).

The broader literature is laden with examples of this confusion in both the United States and other countries. Teachers confuse weather and climate (Lambert, Lindgren, & Bleicher, 2012; Papadimitriou, 2004; Wise, 2010), concluding, for example, that a particularly hot summer is evidence of climate change. Teachers also conflate the greenhouse effect and ozone depletion (Çimer, Çimer, & Ursava, 2011; Groves & Pugh, 1999; Lambert et al., 2012; Papadimitriou, 2004; Wise, 2010), imagining that greenhouse gases create a hole in the ozone layer allowing more solar radiation to penetrate the atmosphere. Often teachers are unaware of how carbon cycles through earth systems (Lambert et al., 2012) and cannot identify specific greenhouse gases other than carbon dioxide (Çimer et al., 2011; Papadimitriou, 2004). Preservice elementary teachers hold misconceptions regarding ways to mitigate global warming, including reducing nuclear stockpiles, protecting rare plants and animals, and keeping beaches clean (Groves & Pugh, 1999). Teachers implicate acid rain as both a cause and effect of climate change (Çimer et al., 2011; Groves & Pugh, 1999; Papadimitriou, 2004) and list recycling as a potential way to alleviate it (Papadimitriou, 2004).

While these misconceptions are concerning, we might hope that teachers with weak content knowledge seek the authority of experts. However, Plutzer et al. (2016) indicate that this may not be happening. Evidence suggests that up to 70% of middle-school science teachers in the United States are unaware of the deep consensus among climate scientists (>97%) over the anthropogenic nature of recent climate change. Instead, their work suggests that many middle-school science teachers believe that a scientific debate persists. This validates a rationale to teach both sides of the climate change controversy even among teachers who are convinced that climate change is human caused.

Of course, not all teachers hold misconceptions. Many teachers are aware of the scientific consensus and effectively manage the social issues surrounding controversy. Griffith and Brem (2004) describe three characterisations of high-school biology teachers in Arizona dealing with the pressure of teaching evolution: selective, conflicted, and scientist. Teachers in the selective group align with descriptions of some teachers in the Berkman and Plutzer (2015) and Plutzer et al. (2016) studies. They negotiate conflict though omitting elements of the curriculum, altering teaching styles to strategically timed lectures and creating highly structured classroom environments. Maintaining harmony in the classroom is very important to these teachers and thus, they construct a comfortable environment by limiting the expression of their students' thoughts and comments.

Teachers who are part of the conflicted group, however, take an opposite strategy altogether. Recognising the potential implications of evolutionary theory to their students' beliefs, they embrace exploration of the issues with their students and offer comfort and assurance that they are not attempting to change beliefs. These teachers recognise that they must teach evolution but also feel that 'it could have grave consequences' (p. 801) for students who experience unexpressed distress over conflicting beliefs.

Teachers in the scientist group express a deep love of science and a desire to share that love with students. Conveying their knowledge of science and the scientific process is, for these teachers, the most important part of teaching. They explicitly keep science separate from other contexts, especially religion. These teachers think 'that scientific knowledge is inherently different from religious knowledge, that you cannot "believe in evolution" because belief implies faith, and science does not rest on faith' (p. 796). In these teachers' classrooms, there is no room for anything but science.

Griffith and Brem's (2004) characterisation of teachers as scientists sparks visions of the type of science educators needed to engage with the topic of climate change. However, teachers must be sufficiently motivated to confront and surmount the challenges, real or imagined, that are associated with teaching controversial science topics. There is currently little understanding of how teachers are motivated to teach climate change and yet this understanding is vital to successful climate change education. Thus, in this study we investigate the motivations of a group of middle-school science teachers currently teaching climate change. These teachers are not experts in the science of climate change, we make no claims about their effectiveness in the classroom and they are not representative of middle-school science teachers as a whole. They are, however, sufficiently motivated to create opportunities for their students to learn about climate change, how to best mitigate it, and how to advocate for action. We seek to describe such teachers. In particular, we address the following research questions (RQ):

(1) What motivates these teachers to teach climate change?
(2) How do these teachers sustain their motivation to engage in climate change education?

The conceptual framework

For our study, we constructed a conceptual framework with elements of expectancy-value theory, social constructionism and predictors of teacher behaviour that characterised motivations, guided the methodology and produced a priori codes (see Figure 1). To facilitate understanding of the conceptual framework, a discussion of each component and rationale for inclusion follows.

Central to our investigation is an understanding of motivation. According to motivation theory in the expectancy-value tradition, two factors drive achievement motivation: one's expectancy of success at a task and how much one values the task (Wigfield & Eccles, 2000). These two driving factors of motivation, expectancies and values, are the foundation of our conceptual framework. Because a variety of social elements influence the development of these factors (Eccles, 1983; Eccles, Wigfield, & Schiefele, 1998; Wigfield & Eccles, 1992), we took a social constructionist perspective that promoted the use of focus-group discussions to collectively generate meaning and capture teacher perceptions. Collaborative expressions about the value of climate change education along with ongoing and expected successes in the classroom were considered a socially constructed reality of the focus-group teachers, distinguishable from those of other participants in climate change education (see Patton, 2014).

To this foundation, we added five components of expectancies and values and paired these with the predictors of teacher behaviours as shown in Figure 1. We derived the components of expectancies and values from the work of Eccles and colleagues (Eccles, 1983; Wigfield, 1994; Wigfield & Eccles, 1992, 2000). The components, part of a larger model of achievement motivation, were established in multiple studies with children and adolescents (Wigfield & Eccles, 2000). Because the components depict general aspects of motivation and have been applied successfully in other domains (e.g. Eccles & Harold, 1991; Fredricks & Eccles, 2002), they were considered appropriate for use in our investigation of teacher motivations to teach climate change.

The predictors of teacher behaviour stemmed from the work of Berkman and Plutzer (2015) and their investigation of high-school evolution instruction. In their work, Berkman and Plutzer found that the strongest predictors of how teachers will handle evolution instruction are their personal values, the deepness of their scientific knowledge and training, and the teachers' subjective assessment of their own expertise (Berkman &

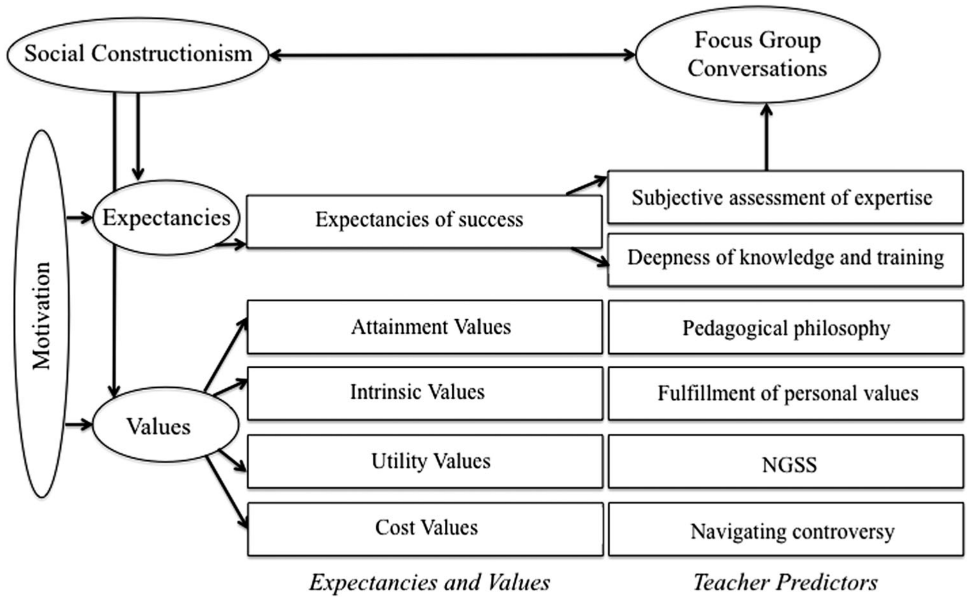

Figure 1. The conceptual framework used in this study.

Plutzer, 2010). Further analysis of data revealed that a teacher's pedagogical philosophy also plays a critical role (Berkman & Plutzer, 2015). By applying these predictors to climate change education, we extended their use to a different controversial topic and applied research from evolution education.

Together, the components of expectancies and values, paired with predictors of teacher behaviour (Figure 1) provided a lens through which we viewed teacher motivations towards climate change education. Components and predictors were paired according to the following rationale:

(1) Expectancies of success, encompassing perceptions of current and future competence at a given activity (Wigfield & Eccles, 2000), were paired with two predictors of teacher behaviour that influence this component: teachers' subjective assessment of their expertise, and deepness of knowledge and training. First, Berkman and Plutzer (2015) found that teachers who perceived themselves as lacking expertise felt more concerned about navigating controversy and doubted the validity of the science. Additionally, Berkman and Plutzer's (2015) work clearly shows that teachers with graduate-level science training felt that they had a 'good and accurate understanding of evolution' (p. 258) and this translated into more class time devoted to the topic and instruction consistent with the scientific consensus.
(2) Wigfield and Eccles (2000) describe attainment values as 'the relevance of engaging in a task for confirming or disconfirming salient aspects of one's self-schemata' (p. 119). We paired this component of motivation with Berkman and Plutzer's description of teachers' pedagogical philosophies as revealed through their primary identification as educators or scientists. Specifically, professional identity as an educator favours the

use of classroom management strategies such as teaching both sides of a controversy to appeal to fairness over evidence-based approaches typical of scientists (Berkman & Plutzer, 2015).

(3) Tasks that are intrinsically valued are motivating because they have psychological consequences that fulfil personal interests (Wigfield & Eccles, 2000) and create joy. Conversely, tasks that conflict with aspects of personal values are uncomfortable and often evaded. We paired intrinsic values with fulfilment of personal values as a predictor of teacher behaviour. In Berkman and Plutzer's (2015) work, a 'love of nature' (p.261) stoked teachers' interest in biology; however, perceived conflicts between teachers' faith and evolution created value judgments about evolution that characterised instruction. In the context of climate change, the satisfaction that teachers feel when supporting valued causes, such as environmental action, is motivation for including it in the classroom. However, political ideologies and value commitments that support rejection of sound scientific conclusions powerfully predict teacher approaches towards climate change instruction (Plutzer et al., 2016).

Since Berkman and Plutzer (2015) determined four predictors of teacher behaviour, to complete the pairing with the five components of expectancies and values, we added two of our own predictors of teacher behaviour unique to this study.

(4) Eccles (1983) describes utility values as extrinsic motivators determined by how instrumental a task is to the process at hand. Middle-school science teachers have varying, but limited control over the science content they teach. State or district mandated curricula standards usually delineate student performance expectations, and alignment to the standards may be imposed through required curricular materials and standardised testing. With the ongoing adoption and implementation of the NGSS, we hypothesised that the prospect of implementing the NGSS (or state-specific standards similar to the NGSS) is a potential extrinsic motivator for inclusion of climate change instruction for middle-school science teachers.

(5) Finally, cost value influences motivation as one considers what must be forfeited and the effort required to complete a task (Wigfield & Eccles, 2000). Here we added navigating controversy as a potentially costly factor for teachers as they consider how the topic of climate change might be accepted in their student population and the potential forfeiture of classroom harmony. As such, cost value creates a negative effect on motivation in our study.

Taken together, the six predictors are the a priori codes that we used to analyse the data. The codes were intended to identify components of these teachers' behaviour that characterise motivation from the perspective of expectancy-value theory, both their expectancies of successfully teaching climate change and the extent to which they value climate change education. Examples of how we applied the codes are in Table 1.

Methods

The research design draws from a phenomenological approach because we sought to understand the essence of the lived experiences of teachers engaged in the process of

Table 1. Examples of how representative statements were coded.

Code	Example
Subjective assessment of expertise	I have a science background so I can usually pick out the junk from the internet, but that's a big source of information.
Deepness of knowledge and training	We've been working a lot on analysing albedo in general. Specifically, what I do with my gifted and talented students, I have them using Image J software to look at Arctic sea ice extent. We looked at data sets of that where they could actually map out the region of sea ice and then analyse and predict and project into the future.
Pedagogical philosophy	I'm a scientist first. Then he just said to me, well take this stuff and play with it and see if you can get kids to think like you do.
Personal values	You guys have said it before … I want them to be informed. I want them to be science literate. I want them to appreciate what's happening to our planet on a local and global scale.
NGSS	But for the state as a whole, again, it's hit or miss. It really depends on the teacher and what enthusiasm he or she might have for that particular topic.
Navigating controversy	The best way to convince hesitant students is by getting them involved in collecting their own data and doing their own research so that they can see the trends and the effects for themselves.

teaching climate change and the motivations that drive them (Creswell, 2013; Feig, 2011). Data were generated from middle-school science teachers who met in online focus groups using web conferencing software. Each focus group met once and consisted of five to eight participants who were drawn from different states and schools. We generated data from the conversations and artefacts shared during the focus-group meetings. The first author acted as moderator of each focus group as well as a participant due to her 14 years' experience as a middle-school science teacher with experience in climate change instruction.

Research perspective

We used focus groups because focus groups take advantage of the communication between participants to generate data, explicitly promoting group interaction as part of the method. Focus groups can be used to reveal not only what people think, but also how they think and why they think what they do (Kitzinger, 1995).

We referred to Millward's (2006) approach to focus group inquiry from a social constructionist perspective. Thus, we empowered the participants to converse with one another, co-construct meaning, and produce a collective rhetoric derived from reflections on mutual values and experiences. We consider each conversation a collaboratively produced reality (see Millward, 2006) of the teachers participating in the focus groups as framed by the conceptual model. Because we sought a concerted voice, we consider the unit of analysis to be one focus group and the sample size to be three total focus groups (Creswell, 2013). Therefore, although the statements came from individuals, we analysed them as collective statements of their entire focus group to reflect their collaborative nature as evidenced by verbal consensus, head nodding, thumbs up, and facial expressions of agreement.

Participant recruiting

We purposely targeted a criterion sample via email invitation using professional contacts, listserves, and snowball recruiting (Creswell, 2013). Middle-school teachers with over two years' teaching experience and currently teaching climate change were specifically invited. All potential participants who responded and met the criteria were accepted. During the period that the focus groups were conducted, 11 states in the United States had adopted the NGSS and 2 additional states adopted the NGSS during the course of the study (Academic Benchmarks, 2015). Six teachers came from three states that had adopted the NGSS at the time of the focus-group meetings. Table 2 provides additional information on participants by focus group.

Data collection

After determining that focus groups held online are methodologically sound (Murray, 1997; Turney & Pocknee, 2005; Tuttas, 2015), we closely followed techniques outlined by Tuttas (2015) for using an online web conferencing service to conduct the focus-group meetings. This provided a cost-effective way to convene a group of geographically dispersed teachers who otherwise may not have met. After reviewing several web conferencing software and services and testing a sample of these, we used Zoom web conferring services for all of the focus-group meetings. The meetings were video recorded through the Zoom service, which captured body language, facial expressions, and shared artefacts in addition to the verbal conversation. Methods for fostering a collaborative environment in which participants co-construct meaning evolved from techniques described by Krueger and Casey (2008). In particular, participants used the share screen function to collectively review material, share resources, and record synthesising ideas. Despite the virtual environment, the teachers embraced discussion, readily shared lesson ideas, and were eager to learn from each other.

Each focus group lasted approximately 80 minutes and began with a 'share and tell' that served as an icebreaker intended to quickly prompt conversation. This provided a rich picture of current trends and variations in climate change education practices while highlighting teachers' values and interests. We prepared a set of questions to stimulate and sustain conversation; however, it was not expected that all of the questions would be used or that each participant respond to every question. Rather, the questions were prompted to elicit discussion that could be captured by the a priori coding scheme, generally and address the RQ, specifically. Questions evolved and varied with each focus group. Typically, they were:

(1) What compels you to teach climate change and what provokes your interest? (RQ 1)
(2) Where do you get your climate change knowledge and how do you stay current on climate change science? (RQ 1)
(3) What keeps you going? What sustains your teaching of climate change? (RQ 2)

Table 2. Participant information by focus group.

Date	Focus group 1 March 2015	Focus group 2 July 2015	Focus group 3 October 2015
Number of participants and gender[a]	5 females	5 total, 4 females and 1 male	8 total, 3 males and 5 females
States represented (**Bold** indicates an NGSS state at the time of the meeting)	Arizona, **California**, New Hampshire, Texas, and **West Virginia**	**California**, Massachusetts, and **New Jersey**	**California**, Florida, Massachusetts, and Tennessee

[a]Because the moderator assumed a participatory role, she is included in the participant count for each focus group.

(4) Have you experienced controversy and if yes, how do you navigate controversy? (RQ 2)
(5) Does your administration support you teaching climate change? What professional development is offered/in what do you participate? (RQ 2)

Data analysis

Following the data analysis spiral described by Creswell (2013), after each focus group we transcribed the entire conversation from the video recording of the meeting, read and reread the transcript and highlighted meaningful chunks of text. The first and second authors coded the transcripts by sorting the highlighted text using the six a priori codes established in our conceptual framework; in some cases more than one code was assigned to the same text. Initially we completed this process by hand; however we subsequently converted to qualitative analysis software (QSR International's NVivo 11 Software). Six external auditors each individually repeated the coding process with subsets of the data.

Trustworthiness

We referred to Lincoln and Guba (1985) and took several measures to establish the trustworthiness of the results. We used moderator techniques (see Krueger & Casey, 2008), bracketing (see Creswell, 2013) and the explicit recognition of the moderator as participant and participants as co-constructors of meaning to ensure that the conversation truthfully represented the teachers' socially constructed reality. In particular, we sought to mitigate concerns that the moderator or a participant might lead the conversation and bias the results. As a result, each focus-group conversation took a slightly different path, following what drew the participants' attention, thus providing evidence of authenticity.

To establish the credibility of statements made by individuals and groups, the first author used informal member checks (Lincoln & Guba, 1985) during the focus groups. This gave participants the opportunity to provide clarifying statements and volunteer additional thoughts. Lincoln and Guba (1985) highlight the importance of prolonged engagement to establishing credibility, specifically the development of a rapport to establish trust and facilitate the co-construction of meaning. The first author's extensive experience as a middle-school science teacher effectively established her as 'one of them' and fostered this relationship.

Transferability to similar contexts was established through a thickly described account of the contexts from which the data were drawn. This account, presented in our results, was derived from the detailed descriptions of the participants' experiences, both verbally and visually, along with the vivid and engaged conversations recorded in the transcripts. Finally, dependability of the results was established through external audit of the coding process, which produced a 95.11% agreement averaged across all auditors and the three transcripts. We sought additional dependability by collaborating with these auditors during our interpretation of the focus-group transcripts.

Results and discussion

We situated our analysis within the conceptual framework to align our interpretations with expectancy-value theory, maintain a social constructionist perspective, and assess the validity of the teacher predictors in the context of climate change education. Following this framework, we explain and discuss the results below using the component-predictor pairs outlined in Figure 1.

Expectancies of success-subjective assessment of expertise

Berkman and Plutzer (2015) claim that a lack of subject matter expertise leads to a de-emphasis of the topic. However, in our focus groups, even teachers with less expertise were motivated to teach about climate change. Two factors potentially explain this difference. First, several teachers were actively working in conjunction with university outreach programmes or research scientists, providing them with a sense of expertise that they otherwise might not have developed. An illustrative case involved a teacher who described personal high-school experiences discouraging her pursuit of science because of her gender and ethnicity. Later, as a middle-school teacher, she established a relationship with a marine scientist through a programme connecting teachers with researchers. This collaboration included oceanographic research near Antarctica that spawned classroom activities on carbon sequestration. The following quote describes her experience and exemplifies the mindset shared by teachers in Focus Group 1 (FG 1):

> It made so much difference to me, having been there to see what was going on and it opened up a total different world. It changed my way of thinking. I found myself trying to gobble up everything I could on oceanography, climate change, polar science, and I think that that really made a difference.

Second, these teachers were characterised by a 'can do' attitude that supplanted any perceived lack of expertise. This attitude was captured well in the following statement made during Focus Group One (FG1):

> I refuse to bring a group of seventh graders into the classroom and say, 'They probably can't do this.' Like I'm just going to say, 'You guys are doing this and we're just going to all dive in together and we'll figure it out as we go.' They amazingly rise to the occasion. (FG1).

Thus, we submit that these teachers scaffold their expertise through work with scientists and ambitious attitudes that increase their expectancy for success and motivate them to undertake impressive climate change projects with their students. Examples include taking measurements of snow cover to evaluate albedo, collecting seawater samples to study biogeochemical cycles, and relating stream pH and temperature to trout population health.

Teachers without such scaffolding of expertise may understandably feel intimidated by the subject of climate change. While discussing ways to motivate such teachers, Focus Group Two (FG2) offered the following:

> Encourage them [the other teachers] to do it [teach climate change] and not be nervous to do it because it is an excellent way to teach science in multidisciplinary ways and to do science in a very relevant and current way using whatever current issues and current events. (FG2)

Focus Group Three (FG3) suggested that not having all of the answers is inherent to being a scientist:

> A lot of people don't know this information either and so don't be afraid to be a scientist yourself. Don't necessarily have all the answers, but, allow them [the students] to come out with the discussion. (FG3)

Expectancies of success – deepness of knowledge and training

Expectancies of success are also informed by teachers' deepness of knowledge and training. Considering that content mastery is variable, but controllable through institutional requirements and personal initiative (Berkman & Plutzer, 2015), there exists a documented lack of earth science training among middle-school science teachers (Lewis, 2008). Of middle-school science teachers holding science degrees, most have degrees in biology. Among 8th grade teachers who identify as earth science teachers, only 19% majored in the geosciences, whereas 21% have degrees in elementary education (Lewis, 2008). Compounding the problem is the reality that for many middle-school science teachers, they completed content studies prior to the advent of anthropogenic climate change as a high-profile topic in earth science and thus have little first-hand experience upon which to model their own instruction.

Of the middle-school science teachers in our focus groups, four reported majoring in the geosciences, specifically geology, oceanography and environmental science. As a group, the participants provided the following as sources of content knowledge (in random order):

- National Science Teacher Association (NSTA) conference workshops
- Collaboration with other teachers
- Professional development
- Internet/newspaper/books
- Personal science background
- Collaboration with scientists
- Personal research experiences

The teachers in FG1 were actively involved in multiple continuing education and professional development opportunities such as:

- Online courses through the American Museum of Natural History
- Field testing with the Lawrence Hall of Science
- Global Learning and Observation to Benefit the Environment (GLOBE) training
- Polar Teachers and Researchers Exploring and Collaborating (PolarTREC) training

Overall, the focus-group conversations yielded evidence of high expectancies of success resulting from their knowledge of climate change. Teachers in FG1 talked about coastal ecosystems and eutrophication, along with algal growth in sea ice and the migration of low latitude soot to the Arctic. The conversation in FG2 included topics ranging from beach profiling to microscopic analysis of diatoms in core samples. The teachers in FG3 were interested in ocean acidification, the extent of Arctic sea ice, and phenology. Like subjective assessments of expertise, a portion of the overall content knowledge resulted from work with researching scientists and encouraging this type of collaboration may be one avenue for increasing both levels of knowledge and motivation among less motivated teachers. Collaboration, both between teachers and researchers and researchers and students is important. It increases knowledge levels, enhances motivation, and is exciting.

The teachers in FG 1 summarised their commitment to continue learning with:

> You continue to learn and you hope to pass that on to your kids. There's no age mark. You don't quit learning when you leave college. It should be a beginning. And that's one of the things to motivate students with. (FG1)

As anticipated by the teacher predictors, these teachers' deeper levels of knowledge and training equip them to offer a more rigorous treatment of climate change in their classrooms and enhance their expectancies of success, suggesting that this is an influential component of their motivation.

Attainment values – pedagogical philosophy

According to Eccles (1983), the attainment value of a particular task is high when the task affirms critical components of one's self-concept. Berkman and Plutzer (2015) found that teachers' pedagogical philosophies, particularly how they identify as educators and scientists, play a critical role in evolution instruction. Specifically, their surveys with practising teachers found that 14–21% of teachers in their study endorsed nonscientific alternatives to evolution (Berkman & Plutzer, 2010). Additionally, the preservice teachers they interviewed proposed dealing with potential controversy using effective classroom management rather than using science knowledge. Strategies included downplaying controversial aspects of evolution and appealing to standards as rationale for including instruction in evolution. The authors observed that these teachers' primary identification as educators rather than as scientists does not promote advocacy for evolutionary theory using scientific arguments.

We contrast this with the characterisation of biology teachers as scientists by Griffith and Brem (2004) for whom conveying science knowledge and the scientific process is the most important part of teaching. Their classrooms are strictly places for science without room for nonscientific or alternate explanations of evolution.

With these two portrayals, we sought to characterise a representative sample of our participants' statements on a continuum beginning with affirming roles as educators, progressing to educator-scientists and ending with scientists (Figure 2). Specifically, we characterised statements appealing to standards or indicating reliance on classroom management as affirming roles as educators. We characterised statements illustrating the use of science knowledge to inform pedagogy as affirming roles as educator-scientists. We characterised statements demonstrating participation in the scientific process as affirming roles as scientists. As Figure 2 makes evident, the teachers' statements cluster towards the end of the continuum that characterises statements as affirming roles as scientists.

Essentially, the teachers in our focus groups identify as scientists as strongly as they do educators and this promotes pedagogies that model the practices of researching climate scientists. This has implications for teacher training programmes and science methods classes. What are the barriers that prevent many science teachers from seeing themselves as scientists? How might science methods classes be structured to facilitate a scientist identity? We suggest that for the teachers in our focus groups, the process of engaging their students in real scientific work helps to confirm their identification as scientists and enhances their overall motivation to teach climate change.

Figure 2. Characterisation of statements as affirming roles as educators, educator-scientists, or scientists (in random order). The teachers' statements cluster towards the end of the continuum that characterises statements as affirming roles as scientists.

Intrinsic values – fulfilment of personal values

In its simplest form, intrinsic value refers to the fulfilment of personal values (Wigfield & Eccles, 2000). For example, the personal enjoyment one gains from doing a task such as teaching, the nourishment of important psychological needs such as advocating for a cause, and the creation of positive emotions such as hope, all fulfil personal values. It is important to recognise that outside their role as educators, the teachers in our focus groups value environmental sustainability and have a sense of social consciousness that was evident throughout their discussions. Likewise, Griffith and Brem (2004) reported that one of the teachers they characterised as a scientist was seen as a maverick by fellow teachers, indicative of a willingness to advocate for a cause, in this case evolution. This contrasts with Berkman and Plutzer's (2015) characterisation of the preservice teachers in their study. Recognising that many college students see themselves as future members of advocacy coalitions, Berkman and Plutzer (2015) found that 'none of the preservice teachers related to larger political movements or controversies in this way' (p. 264). Here, we consider how the personal values of the teachers in our focus groups are fulfilled by teaching climate change, which in turn further fuels their motivation.

Analysis of the focus-group conversations suggests that these teachers have a love of learning science in general (and climate change in particular) that brings them joy and enhances motivation. The participants in FG2 enthusiastically supported this comment:

> I'm having a blast because I don't have a formal science background, so some of this stuff is a little bit hard to grasp. I'm thoroughly enjoying myself and learning all sorts of new things and coming up with lots of new ideas. (FG2)

The collective joy that these teachers feel over learning about and teaching climate change was palpable. Comments such as 'I get so passionate' (FG 1) and 'I'm excited about how can we teach them to problem solve' (FG 3) characterised the conversation.

Their joyful expressions became muted however, when they discussed stewardship of local environments. They bemoaned how disconnected we have become from the consequences of our daily lives and their desires to create awareness of climate change. These two comments from FG3 are typical of all three discussions:

> I just love the outdoors and I'm concerned about the direction that we're headed and frustrated by the lack of recognition on the part of our political leaders. (FG3)

> I was an environmental science major so I've been aware of this for quite a long time and I really got into teaching because I wanted to help educate kids on this issue and also other issues around climate and around the environment. (FG3)

Collectively, these teachers were united by common personal values relating to larger environmental and political causes. These teachers feel that climate change 'is the major issue of our time' (FG2) and that it is their 'job to educate the kids … so that they'll be informed when it's their turn' (FG3).

Additionally, these teachers' belief that they are positively impacting the sustainability of the planet by promoting scientific thinking and practices with their students is highly motivating for them. The teachers in FG1 feel rewarded by seeing their students as future scientists:

> I can see them growing into being actually, you know really, real scientific, real STEM based learners, which is great. (FG1)

Several teachers in FG2 taught in areas that were substantially impacted by Hurricanes Sandy and Irene and their students' ability to deal with future challenges is a primary motivator:

> Until Hurricane Sandy, we had four classrooms out on the beach … so one of our main issues was rising sea level and coastal change. So that's been a big part of it that whole time. (FG2)

The ability of students to think independently using evidenced-based thinking is motivating for the teachers in FG3:

> [They are] using their intelligence in practical ways and they are not just relying on other people's opinions. They are making their own judgments based on what they find out there in the world. I'm very proud of what they're doing and I hope that maybe a tiny bit of that may be what we are providing in our science classrooms. (FG3)

> Some of my students were really starting to talk about how they're making different choices than their parents and they're ok with that. And that's something that they want to do. It's not always easy but they're doing that. (FG3)

Their students' burgeoning abilities to think scientifically, critically evaluate information and plan for a sustainable future fill these teachers with hope:

> So I am also hopeful, cautiously optimistic is what I am. I think kids are seeing it [climate change] more and more and that this is the generation that is really going to notice it as they are growing up and it's going to be more front and center for them. (FG3)

> I hope in the future. And based on former students that I see coming back, things look good. I actually have some hope. (FG3)

Given that these teachers are already concerned about climate change and advocate for solutions, understandably, they are motivated to raise awareness and take actions within their realm of influence and feel rewarded as a result. Hope for a sustainable future is a powerful motivator for them. However, for middle-school science teachers who do not personally value environmental stewardship to the same degree, or are less convinced that human impacts to the climate are problematic, the intrinsic value of teaching climate change does not align with their personal values and thus this important motivational component is diminished.

Utility values – NGSS

The work of Plutzer et al. (2016) provides evidence that the majority of middle-school science teachers include climate change in their curriculum although the situational impetus for its inclusion remains unknown. Our investigation with middle-school science teachers in our focus groups suggests that neither the NGSS nor the prospect of adopting the NGSS is motivating components of their climate change instruction. Throughout the conversation in FG1, none of the participants (including the moderator) referenced curricular standards as a reason for teaching climate change, suggesting that this does not figure highly for these teachers. Although curricular standards were mentioned in the other two focus groups, as a whole, these teachers did not emphasise standards as a factor in their personal motivation to teach climate change and indicated that inclusion of the topic among their colleagues was spotty and dependent on the interests of the teacher:

> It's hit or miss. It really depends on the teacher and what enthusiasm he or she might have for that particular topic. (FG2)

> Honestly, within our district, and I suspect it's true for other districts, they haven't provided any curriculum, there's no resources provided. It's up to the individual teachers. (FG3)

For the teachers in our focus groups, the scarcity of reference to the NGSS or other standards as a current or future reason to include climate change instruction suggests that for them, the personal and intrinsic value of climate change education overwhelm any extrinsic motivation that might extend from the utility value of the NGSS. This prompts questions about how compelling such extrinsic motivation, if it did exist, would be for teachers less intrinsically motivated. This is a question that remains for future research.

Cost values – navigating controversy

Controversy can be handled in a variety of ways; indeed teachers may avoid controversy or introduce it intentionally to generate particular learning situations as illustrated by the Griffith and Brem (2004) example. The teachers in our focus groups align most closely with the teachers in Griffith and Brem's (2004) scientist group who do not acknowledge explanations outside those that science offers. In our focus groups, there was little reference to dealing with the controversial nature of climate change, which we consider to negatively affect motivation to teach climate change. When the topic was introduced, it seemed to be of little significance for these teachers, who responded with, 'Gosh, as far as controversy, we're not running into that' (FG1) and 'I really don't think that it would be an issue. I would be shocked' (FG2).

Our analysis of the focus-group conversations imply that through skilfully weaving together data-driven inquiry activities in which students draw their own conclusions and consider local impacts that hold personal meaning for the students, these teachers successfully circumvent controversy. We claim that they circumvent controversy because they go beyond simply denying alternative explanations. This was articulated well in FG1 and FG2:

> The best way to convince hesitant students is by getting them involved in collecting their own data and doing their own research so that they can see the trends and the effects for themselves. (FG1)

> You really need to personalize it with the kids. All climate change issues have to be local … otherwise it just doesn't mean anything. (FG2)

Hurricane Sandy served to mitigate controversy especially for teachers in FG2, several who lived along the eastern seaboard:

> It's been a lot easier to discuss all this after Hurricane Sandy because everyone at every level in the state except perhaps the governor has been working toward mitigation and planning for the next storm and talking about how much worse the next storm will be. (FG2)

Our findings indicate that these teachers provide students with concrete and tangible opportunities to make sense of evidence that supports scientific claims. They give students ideas that they are compelled to think about rather than dispute. Whereas the ability among these teachers to circumvent controversy was compelling, we suspect that it is uncommon and could be quite challenging for teachers with less interest, experience and motivation to teach climate change. Such teachers would likely view the cost values of their efforts as high.

It might be contended that controversy surrounding climate change did not exist in the populations that these teachers serve. Evidence contrary to this claim exists in the following individual statements:

> We're in West Virginia where there is like a ton of coal being burned.

> I'm in a state where our governor forbade employees to use the term [climate change] for a while.

> Grandparents were simply saying, you know, 'I don't believe in climate change. This isn't happening. This is just a made up thing'.

These teachers teach in areas where climate change sensitivity is high and yet, their ability to move their students past a point of disagreement and to a place of reasoned logic and understanding diminishes, if not eliminates, the cost value and potentially demotivating power of the climate change controversy for them. Especially impressive is their ability to guide students to make their own conclusions rather than ask them to believe what they are told:

> I'm sort of constantly asking them to look at lots of sources of information and evaluate what they know, so that I'm not in a situation where I'm saying, 'This is how it is and you either believe in me or you don't.' I don't want to be in that spot as a teacher. (FG3)

Conclusions

The nature of this study, particularly its focus on middle-school science teachers, is limited in its ability to generalise. The intent is to characterise a small group of climate change educators and investigate their motivations, thus informing climate change education as we move forward. As such, the results may be transferrable to and descriptive of likeminded teachers in similar contexts; however, the conclusions that follow characterise the teachers in the current study only and we consider implications outside of this study as suggestive.

Our findings suggest that the participating teachers' knowledge of climate science and their self-assessment as capable climate change educators impart the confidence necessary for forthright climate change instruction that rests on the scientific consensus. Their strong identification as scientists supports pedagogies that model authentic science practices, specifically involving students in collecting and analysing data and drawing conclusions. These practices are instrumental in developing their students' understanding of climate change using scientific evidence while circumventing controversy. Their personal values regarding environmental sustainability and advocacy for climate change action promote the inclusion of climate change education in their classrooms without the need for external stimuli such as curricular standards or administrative directives. Thus, we submit that the predictors effectively capture the values and practices of these teachers in the context of climate change education.

When examining our original RQ, we look to understand how to best motivate the topic of climate change and sustain the commitment to teaching climate change among those teachers who may be more hesitant. Our findings suggest that for our focus-group teachers, preexisting interests in science and environmental advocacy foster their interest in climate change education. We recognise that not all middle-school science teachers have these inherent interests and that in some cases teacher interests are significantly rooted in value commitments that are tied to political ideologies (Plutzer et al., 2016). This is potentially problematic to motivating the topic, but does not diminish the power of the focus-group teachers' example nor the impact they may make through their students.

The focus-group conversations reveal that these teachers feel a heavy responsibility to prepare their students for the future, especially their ability to evaluate claims, analytically look at data and think from a scientifically literate perspective. These are likely goals of all middle-school science teachers. Appealing to the idea that teaching climate change is 'an excellent way to teach science' (FG2) may be one avenue for encouraging its inclusion among hesitant teachers.

We found that the teachers in our focus groups perceive success in the form of increased student motivation, development of independent, critical thinking and the ability to construct arguments from evidence. This gives these teachers great satisfaction and fills them with hope for a sustainable future. They also enable hope in their students for whom 'it was way scary and … a foregone conclusion that we can't do anything about it' (FG3). As their students negotiate society, these teachers anticipate that their students' hope will offset doubt and that they too will advocate for climate change action. Ultimately, this is what sustains these teachers' motivation to teach climate change. Enabling hope among their colleagues by sharing their experiences and advocating for climate change education within their education communities also holds promise for motivating hesitant teachers.

In this study, we applied expectancy-value theory to understand the motivations of a small group of middle-school science teachers who currently teach climate change. Our findings suggest that these teachers' personal interests and experiences enrich their expectations of success and motivate teaching climate change in their classrooms. Because they value science and advocate for environmental sustainability, climate change education is interesting and enjoyable for them, further increasing their motivation. Additionally, teaching about climate change provides important psychological benefits for them. It brings them joy and gives them hope for the future, the ability to overcome 'the really terrifying factor of it' (FG3) and 'a sense that it wasn't too big and too overwhelming, that [we] could actually do something that matters' (FG3). Finally, these teachers' identification as scientists motivates them to create and conduct science research in their classrooms. By practising authentic research with their students, they confirm valued characteristics of their ideal identities.

This work adds to the climate change education literature by identifying how these teachers are motivated to teach climate change. It also juxtaposes illustrations of current climate change education with existing literature citing evidence of teachers' confusion and misconceptions, and suggestions that teachers enable doubt and hinder climate change education. Certainly both ends of the spectrum exist. Recognising and bridging disparities is essential to improving climate change education and advancing our understanding of how to do so. Mentoring relationships between active climate change educators and hesitant teachers capitalise on the professional rapport found in education communities and are potentially effective (Wise, 2010). As one example, a teacher in FG3 described working collaboratively on an interdisciplinary, project based, climate change unit at her school. She was excited about the change that she witnessed in a colleague as they worked together on the unit:

> There was a … teacher and she knew very little about climate change. She was really taken aback by it. And it really impacted her, so it was really eye opening for her. (FG3)

When teachers are directly encouraged to teach climate change by other teachers in their professional communities, their own climate change instruction is enhanced (Wise, 2010). Promoting mentoring relationships between active climate change educators and hesitant teachers could potentially improve the quality and quantity of climate change education, an area ripe for additional research.

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