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It's about time: perceived barriers to in-service teacher climate change professional development

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ABSTRACT

The pressing nature of climate change and its associated impacts requires a climate literate citizenry. Climate change education in K-12 settings may provide a unique opportunity to make inroads towards climate literacy. However, many K-12 teachers avoid teaching climate change because they are uncomfortable with the subject or do not see its relevance to their curriculum. Removing barriers to climate change professional development (CCPD) for teachers may help increase confidence in teaching about climate change. To understand the perceived barriers to participating in CCPD, a survey was conducted with 54 middle school science teachers who did not respond to a previous invitation to participate in a CCPD program. The most significant barrier was time to participate. The participants were also asked to rate their confidence about whether climate change is happening. The results were compared between teachers who were confident climate change was happening and those who were not to examine whether these beliefs influenced teachers' perceptions of barriers. Those who were confident climate change was happening were less likely to perceive administrative support, interest in the workshop, and knowledge of climate change content as barriers. However, both groups of teachers reported that time was the primary barrier rather than the topic. This suggests that, rather than developing unique strategies, existing best practices in teacher professional development can be used to support CCPD opportunities. Additional recommendations include thinking creatively about how to create time for teachers to attend and making the professional development directly relevant to teacher's local contexts.

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Teacher professional development; climate change; barriers; middle school

Climate change is currently one of the most serious environmental challenges society is facing due to its far-reaching effects on water availability, food resources, energy, transportation, and public health (IPCC 2018; US Global Change Research Program 2014). A climate literate public, or a society of people who accept, are concerned about, and have the skills and motivations to address anthropogenic climate change (US Global Change Research Program 2009), can help address and mitigate many of climate change's associated impacts.

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Unfortunately, efforts to increase climate literacy with adults have proven challenging. Decades of social science research offers evidence that climate change perceptions and actions are better predicted by factors such as cultural worldviews and political ideologies rather than scientific understanding (Kahan 2012; McCright and Dunlap 2011b). For example, McCright and Dunlap found an increase in the polarization of climate change views in America for those who identify as liberals and Democrats versus conservatives and Republicans (McCright and Dunlap 2011b) with conservative white males holding particularly strong climate denial beliefs (McCright and Dunlap 2011a). These social influencers of climate change beliefs and attitudes have been identified globally (e.g. Lee et al. 2015) and regionally in studies such as the 'Six Americas' report (Maibach, Roser-Renouf, and Leiserowitz 2009) and the 'British Social Attitudes 35th Report' (Fisher, Fitzgerald, and Poortinga 2018). To address these cultural barriers, climate change communication efforts typically must rely on tools such as strategic framing (Bales, Sweetland, and Volmert 2015; Bolsen and Shapiro 2017; Simon et al. 2014) or the use of trusted messengers (Moser and Dilling 2007) in hopes of engaging adults whose personal beliefs do not typically align with climate change acceptance or concern.

Climate change education among children may be a promising pathway to building climate literacy among current and future generations. Although climate change communication strategies can be useful in reaching adults, current research suggests youth may be more receptive than adults to learning about climate change, as they seem to parse scientific fact from its ideological context (Kahan 2012; Stevenson et al. 2014). Not only are youth more amenable to learning about climate science (Stevenson et al. 2014), but they may also influence their parents' perspectives on the subject (Lawson et al. 2019). This has been observed in other contexts where youth have been able to sway their parents into adopting a particular lifestyle such as recycling (Leeming et al. 1997) or purchasing specific grocery store items (Flurry and Burns 2005). In terms of climate change specifically, research by Lawson and colleagues (2019) showed that after participating in a climate change-based, wildlife environmental education curriculum at school, children increased their parents' levels of climate change concern at home. Additionally, adolescent-based climate education efforts may erase ideological rifts in concern about climate change among both youth (Flora et al. 2014; Stevenson et al. 2014) and parents (Lawson et al. 2019). Climate change education in K-12 settings may present an opportunity to reach a wide array of people of multiple generations.

Unfortunately, efforts to promote climate change-based education in K-12 schools face multiple implementation barriers due to a lack of teacher preparation and confidence to teach the subject (Wise 2010). Climate change is a major component of learning objectives for schools around the world such as the *Next Generation Science Standards* (NGSS Lead States 2013), *National Curriculum in England: Science Programmes of Study* (Department for Education 2015), and the UNESCO *Climate Change Education for Sustainable Development* (UNESCO 2010) which is used in several countries including Japan (Ministry of Education, Culture, Sports, Science and Technology 2012). Unfortunately, a 2020 report found that only 27 states in the United States scored a B + or higher rating for how their state science standards address climate change and six states received failing grades (National Center for Science Education & Texas Freedom Network Education Fund 2020). The climate grade report recommends that, in addition to revising standards, states must commit to professional development so that educators have the knowledge and skills to effectively teach about climate change so that they meet state standards (National Center for Science Education & Texas Freedom Network Education Fund 2020).

Even when climate change is included in state science standards, there are many barriers that can prevent climate change from being taught in schools. Some of these barriers stem from the socio-political context of climate change referenced above. For instance, one study found that textbooks promote discourses of doubt when describing climate change (Román and Busch 2016) and several researchers have documented how teachers' own ideologies (Plutzer, McCaffrey et al. 2016) have impacted how teachers approach climate change teaching

(Henderson and Drewes 2020). Other barriers relate to a lack of teacher preparation and confidence to teach the subject (Wise 2010). Research suggests teachers do not feel prepared to teach the content, worry about the political fallout, do not believe it fits into their curriculum, or worry about how to teach the arguments for and against climate change in a balanced way because they do not understand the scientific consensus (Hestness et al. 2014; Plutzer, McCaffrey et al. 2016; Waldron et al. 2019; Wise 2010). One way to maximize the opportunities provided by climate change education in K-12 settings is employing teacher professional development to reduce teacher hesitation in teaching climate change as a part of their curricular standards.

Teacher professional development

High quality, effective professional development (PD) can improve educator confidence and attitudes toward teaching science (NSTA 2006; Stein, Smith, and Silver 1999) and offer opportunities to learn science content related to climate change (Drewes, Henderson, and Mouza 2018). Increasing teacher knowledge and confidence can help them better understand the scientific consensus, gain confidence in teaching about climate change, address climate change misconceptions, and improve their teaching practices associated with the subject (Drewes, Henderson, and Mouza 2018; Hestness et al. 2014; Plutzer, Hannah et al. 2016).

To be effective, climate change PD must take into consideration the social context and policies of the school districts where teachers are located. Attending to these socio-political contexts at the local level allows the teachers opportunities to share best practices for navigating these contexts in regions that may be resistant to climate change education (Drewes, Henderson, and Mouza 2018). This approach can help alleviate some teacher concerns related to teaching about climate change. Additionally, situating climate change PD to include local issues related to climate change can help teachers connect to the content personally for themselves and their students. This approach can serve the dual purpose of making the content relevant to student and teachers' lives (Aikenhead 2003; Stuckey et al. 2013) and framing the issue in a way that those skeptical or unsure climate change is happening recognize and accept so they can think critically about how to address the issue (Busch 2016; Evans, Milfont, and Lawrence 2014). Further, highlighting local climate change impacts can help both teachers and students build an emotional understanding of the topic, which may lead to changes in behavior (Busch 2016; Drewes, Henderson, and Mouza 2018).

While research supports the need for teachers to participate in CCPD, there are few examples of highly effective CCPD (Drewes, Henderson, and Mouza 2018) and an increasing number of calls for more CCPD opportunities (Busch, Henderson, and Stevenson 2019). Organizations are responding to these calls to offer more CCPD through in-person workshops, online courses, or a hybrid between the two (Shea, Mouza, and Drewes 2016). Some examples include the 'Summer Climate and Global Change Professional Development Workshops' at the National Center for Atmospheric Research (Johnson et al. 2008), DataStreme Earth's Climate System from the American Meteorological Society (https://climate.nasa.gov/resources/education/edOpps/), and the Climate Academy (Drewes, Henderson, and Mouza 2018).

As the number of institutions offering climate change specific PD opportunities increases, it is worth examining the barriers teachers perceive to participating in such workshops. The socio-cultural complexities associated with climate change acceptance (e.g. worldviews and political ideologies, Kahan 2012; McCright and Dunlap 2011b) may indeed be a barrier to teachers participating in climate change specific PD. Around the world, studies have examined the barriers to teacher participation in traditional (non-climate change specific) PD opportunities (e.g. Badri et al. 2016; Geldenhuys and Oosthuizen 2015; Johnson 2006; Kwakman 2003; OECD 2009). Typical constraints that have been identified in these studies include conflicting work

schedules, cost, and lack of support from administration (OECD 2009). However, no research, to our knowledge, has investigated to what degree these barriers apply to climate change specific PD. As K-12 education is a means to reach children of all backgrounds, teaching climate change in the classroom is a critical. Therefore, an understanding what prevents teachers from participating in CCPD is needed.

Research questions

Given that climate change is included in science standards around the world and that research shows that educators do not feel confident teaching the content (Dawson 2012; Herman, Feldman, and Vernaza-Hernandez 2017; Sullivan et al. 2014; Wise 2010), we must examine why teachers are not taking advantage of this type of PD. It is possible that there are additional barriers to participation in climate change PD, such as teacher beliefs related to climate change, that are not found in other types of PD opportunities. Therefore, the research questions for this study were:

1. What barriers do teachers perceive to participating in a climate change specific professional development opportunity?
2. How do perceptions of these barriers differ between teachers who are confident in their understanding that climate change is happening versus those who are not?

Current study

This study was conducted with middle school teachers in a southeastern state who chose not to participate in a climate change professional development (CCPD) opportunity with the goal of identifying perceived barriers to participation. We hypothesized that teachers would report the primary barrier to participation was that they believed the topic was too controversial. This hypothesis is derived from the fact that climate change is a socially complex issue and teachers may harbor concerns about the controversy associated with teaching the topic in the classroom (Wise 2010). We also hypothesized that teachers who were less confident in their beliefs that climate change is happening would perceive all barriers as more important than teachers who were more confident. The latter hypothesis emerges from psychology and health sciences literature that suggests that when learners are less confident about the value of a particular subject, then they are less likely to want to overcome barriers to participation than their confident counterparts (Gulliver, Griffiths, and Christensen 2012; Lovell, El Ansari, and Parker 2010).

Theoretical framework

There has been a renewed interest towards investigating teacher motivation for attending PD to allow organizations to improve the ways they attract teachers and increase persistence in their programs (Karabenick and Conley 2011). An individual's persistence, performance, and choices are influenced by his or her values and expectancies of future outcomes and this is often examined using expectancy-value theory (Eccles and Wigfield 2002). Karabenick and Conley (2011) developed a Professional Development Motivation Model using the expectancy-values framework to explore the factors influencing teacher's motivation to participate in traditional PD opportunities. The model includes five factors that drive teacher motivation to participate in PD. These factors include 'Motivation to teach Math/Science', 'PD Programmatic Features', 'Previous Experiences with PD in Math/Science', 'Perceived Social Support for PD', and 'Perceived PD Administrative Support' (Karabenick and Conley 2011, 14).

The first factor, motivation to teach science, includes teachers' beliefs about the value of teaching science, their perceived self-efficacy for teaching science, and any personal teaching goals they may hold (Karabenick and Conley 2011; Thomson and Kaufmann 2013). These beliefs contribute to a teachers' attainment value: the value they place on participating in the particular PD; intrinsic value: the enjoyment or interest they have for the subject of the PD; and the utility value: or whether the subject of the PD is related to their future goals. Additionally, a teachers' motivation to teach science influences their perceptions of cost based on their beliefs about the value of teaching science and whether the cost of participation is worth improving their teaching (Karabenick and Conley 2011). In this study, we apply these factors to teaching about climate change, specifically.

PD programmatic features also impact teacher motivation to participate in a PD opportunity. These include a teachers' understanding of the opportunity: any external requirements they need to participate; their beliefs about the benefits of increasing their content knowledge or pedagogical strategies; the cost to attend; time required to attend; any effort needed to participate; and penalties for nonparticipation. These features also include whether continuing education units or stipends are offered, the time needed to travel to the location, and the time needed to implement the new content in the classroom (Karabenick and Conley 2011). These wide range of features influence the intrinsic value, utility value, and cost perceptions the teacher may hold regarding a particular PD opportunity (Figure 1).

In addition to programmatic features, previous experiences with PD influence and social support for participating in PD influence whether or not teachers choose to participate in new opportunities in the future (Karabenick and Conley 2011). Teachers will consider whether previous experiences were good, bad, useful, time consuming, etc., when choosing future professional development. These previous experiences will influence the intrinsic value, utility value, and perceptions of cost that the teacher holds regarding new PD opportunities. Social support comes in the form of other teachers' participating (Karabenick and Conley 2011) or from support from individuals such as student's parents. Having social support to participate can lead to increases in intrinsic value, utility value, and decrease in the perceptions of cost. Social support can lead to increased motivation to participate in PD opportunities (Karabenick and Conley 2011).

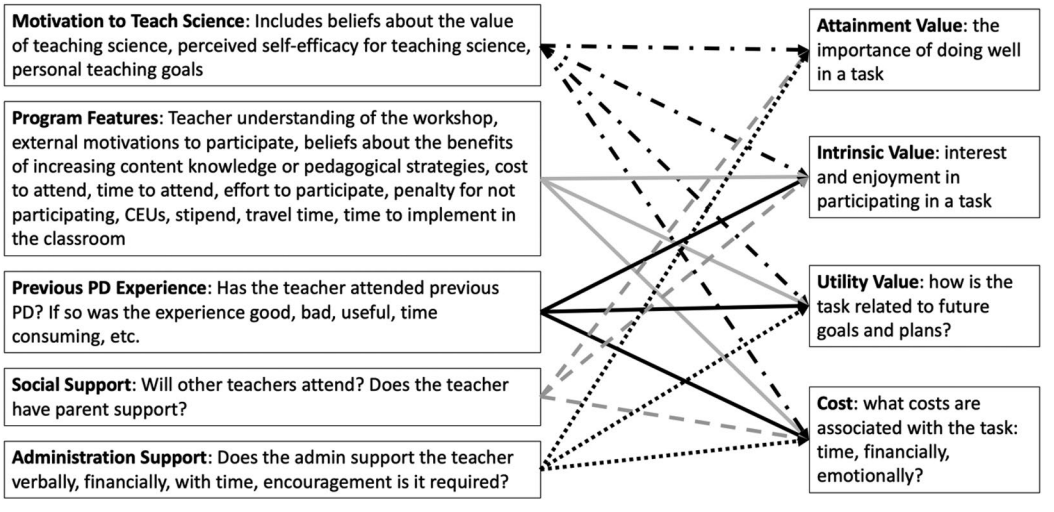

Figure 1. Factors that influence teachers' motivation to participate in professional development. Adapted from the Professional Development Motivation Model (Karabenick and Conley 2011) and Expectancy Value Theory (Eccles and Wigfield 2002).

Finally, administrative support has been cited as one of the most important influencers of teacher motivation to participate in PD, even more important than district requirements (Karabenick and Conley 2011). Administrative support may be in the form of verbal, financial, time, or encouragement (Karabenick and Conley 2011; Thomson and Kaufmann 2013). It may also be simply requiring a particular PD opportunity (Karabenick and Conley 2011). When the administration supports a teacher in participating in a PD, it may increase their attainment value: the importance of doing well in the task; the utility value; and the perceptions of cost. Figure 1 shows the relationship between the factors influencing teacher motivation to participate in PD and the values and costs described in expectancy-value theory. While this framework has been used to examine teacher PD in general, we wanted to better understand how PD features, previous experiences, social support, and administrative support influenced the barriers teachers perceive to participating in a climate change specific PD opportunity. It is possible that teachers perceive the barriers to participation differently with ideologically fraught subjects such as climate change (e.g. Plutzer, Hannah et al. 2016; Waldron et al. 2019; Wise 2010).

Methods

The population of interest for this study included middle school science teachers who chose not to participate in a two-day CCPD workshop hosted by a public university. The workshop was designed to introduce middle school teachers to a new series of lessons focused on climate change and the impacts on their state. The choice of middle school teachers for the CCPD opportunity specifically relates to the age range of students that they serve. During middle school, students are at a point in development where they are capable of understanding a complex topic such as climate change (Mason and Scirica 2006), but are still malleable when forming their own perceptions on topics (Vollerberg, Iedema, and Raaijmakers 2001). Therefore, they are able to critically think about topics like climate change while being less burdened by the engrained socio-cultural and ideological biases faced by adults. These lessons specifically were developed to meet the state's middle school science standards. The workshop included several best practices in PD: it was focused on climate change content, it included active learning, collaboration between teachers, modeling of activities, as well as coaching and content experts (Darling-Hammond, Hyler, and Gardner 2017). For more detailed information on the PD, see Lawson et al. (2019).

To address traditional barriers to PD participation (OECD 2009), the workshop was held during the summer to avoid conflicting with school schedules and teachers were given a stipend, travel reimbursement, lodging, and meals. Information on the initial call to participate in the original PD opportunity can be found in Appendix 1. In spite of the resources offered to offset potential barriers to participation, there were still many teachers who opted not to participate in the CCPD.

Teachers initially recruited to participate in the summer PD were selected from a sample frame that included all middle school science teachers from coastal counties in a southeastern state in the United States. The study used a hierarchical sampling design by randomly selecting 60 schools from all public middle schools across the coastal counties and then randomly selecting science teachers from those schools to invite as participants in the PD ($n = 349$). Teachers were contacted via email and received up to 4 reminders about participating in the workshop. For further information about the specifics of the teacher recruitment process, see Lawson and colleagues (2019). For this study, only the teachers who declined or did not respond to the initial request to participate in the initial CCPD were contacted and invited to participate in this study.

In an attempt to reach more of the target population (i.e. the teachers who did not respond to the initial PD invitation), we used a multiple mode survey (Dillman, Smyth, and Christian 2014). First, we distributed an online survey through Qualtrics, with one initial invitation followed by two reminders. We sent the reminder emails at different times during the school week in

hopes of reaching more teachers. Of the 279 teachers emailed, 52 people took the survey and five opted out. To reach more of the non-respondents, 50 additional teachers were identified to be called by phone. These teachers were randomly selected using the random number function in Excel from the teachers who did not respond to the emailed survey. The teachers were initially called between 2-4 pm to reach them after school. Each teacher was called a maximum of three times. Eleven teachers were reached and nine completed the survey. The teachers reached by phone were read the online survey verbatim in order to decrease variability between the online surveys and phone surveys. Of the 279 individuals contacted, 62 took the survey either by email or phone for a response rate of 22.22%. This study was conducted under approval number 9400 from North Carolina State University's Institutional Review Board. The participants were provided an informed consent at the beginning of the survey and could only access the questions if they selected agree. For those participating via phone call, the informed consent was read and verbal consent was given before beginning the survey.

Instrument development

To better understand why respondents chose not to participate in the PD, a survey was developed based on expectancy-value theory in the context of teacher PD. Questions were developed to examine the five factors from the Karabenick and Conley (2011) model. To examine these five factors, we asked teachers, 'Why did you choose not to participate?' (in the CCPD opportunity). We then listed eight potential barriers to participation based on the factors in the model (Table 1). Barriers based on motivation to teach science included: 'I was not interested in the subject', 'I don't know enough about climate change' and 'Climate change is too controversial'. Barriers based on the PD features as well as prior PD experiences included 'I do not have time to teach the curriculum', 'I do not have time to attend the professional development' and 'I was already familiar with the content'. Barriers examining social support included 'I do not have parental support' and administrative support included 'I do not have administrative support'. These barriers were identified from previous teacher PD research (e.g. Badri et al. 2016; Geldenhuys and Oosthuizen 2015; Johnson 2006; Kwakman 2003; OECD 2009). We asked teachers to indicate their level of agreement that those items were barriers to participation on a Likert scale ranging from strongly disagree to strongly agree. We also solicited information on the teachers' climate change beliefs through a multiple-choice question utilized in the 2011 nation-wide climate change survey (Leiserowitz, Smith, and Marlon 2011). In this question, the teachers were asked whether they believed climate change was happening and how confident they were in their answer. While we acknowledge current concerns about the term 'belief' when examining climate change perceptions, the 'Six Americas' Survey (Leiserowitz, Smith, and Marlon 2011) is a commonly used tool in assessing perceptions of climate change (Monroe et al. 2019) and allows for comparison with other studies (Busch, Henderson, and Stevenson 2019). The final survey was

Table 1. Relationship between factors that influence teacher motivation to participate in professional development and the barriers included in the teacher survey.

Factor	Barrier to participation
Motivation to Teach Science (influences attainment value, intrinsic value, utility value, and cost)	I was not interested in the subject. I do not know enough about climate change. Climate change is too controversial.
Program Features and Prior PD Experiences (influences intrinsic value, utility value, cost)	I do not have time to teach this curriculum. I do not have time to attend the PD. I am already familiar with the content.
Social Support (influences attainment value, intrinsic value, and cost)	I do not have parental support.
Administration Support (influences attainment value, utility value, and cost)	I do not have administrative support.

reviewed by a panel of science education researchers for comprehension, clarity, and validity. It had an acceptable level of internal consistency, as determined by a Cronbach's alpha of .70 (Gliem and Gliem 2003).

Data analysis

We conducted data analyses using STATA 16.0. Descriptive statistics were determined for the variables that included belief in climate change, causes of climate change, and whether or not teachers remembered receiving the email invitation to participate in the study. We also calculated descriptive statistics for each of the perceived barriers to CCPD participation. Because data were not normally distributed, we used the non-parametric Wilcoxon-Rank Sum to test for differences in perceived barriers to CCPD participation between teachers who were confident about their belief that climate change is or is not happening and teachers who were not confident about their beliefs. Data is available upon request from the corresponding author.

Results

After cleaning the data, a total of 54 teachers had completed the entire survey either via email or over the phone. When asked whether they believed the climate was changing, most of the teachers (64.81%, $n = 35$) were confident that climate change is happening but 31.37% ($n = 16$) were not confident, and 5.56% ($n = 3$) chose not to respond.

Perceived barriers to CCPD participation

To examine the factors that influenced teachers' decisions to participate in climate change PD, the survey first asked the teachers why they did not attend the workshop. The biggest perceived barrier to CCPD participation was lack of time for PD, with a mean of 4.07 out of 5.00 possible points (SD = 1.10; Figure 2). Lack of time was the largest perceived barrier to CCPD participation for teachers who were both confident in their belief that climate change was happening as well as those teachers who were not confident (Figure 3). Lack of time to teach climate change related content and considering oneself already familiar with climate change pedagogy were

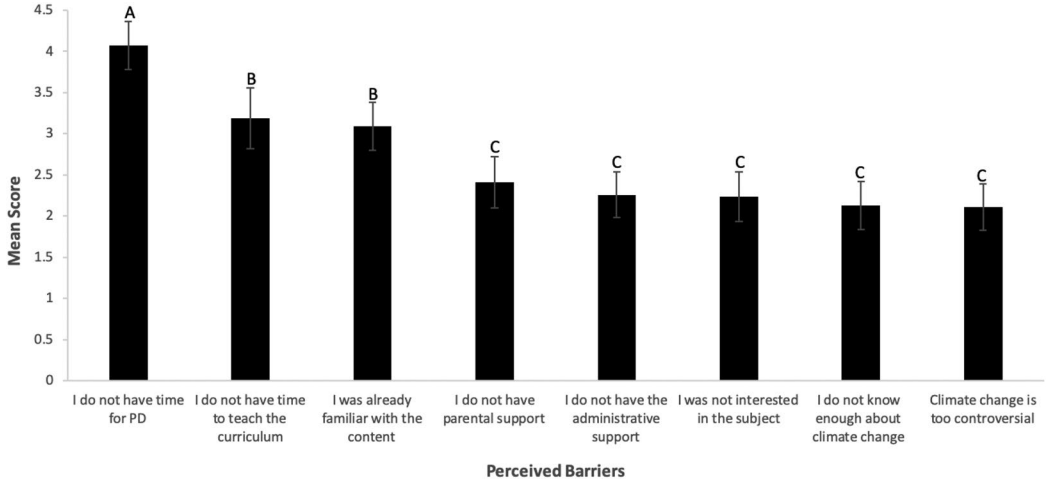

Figure 2. Teachers' mean response to whether or not factors were seen as a barrier to participating in a climate change professional development opportunity. Error bars represent 95% confidence intervals.

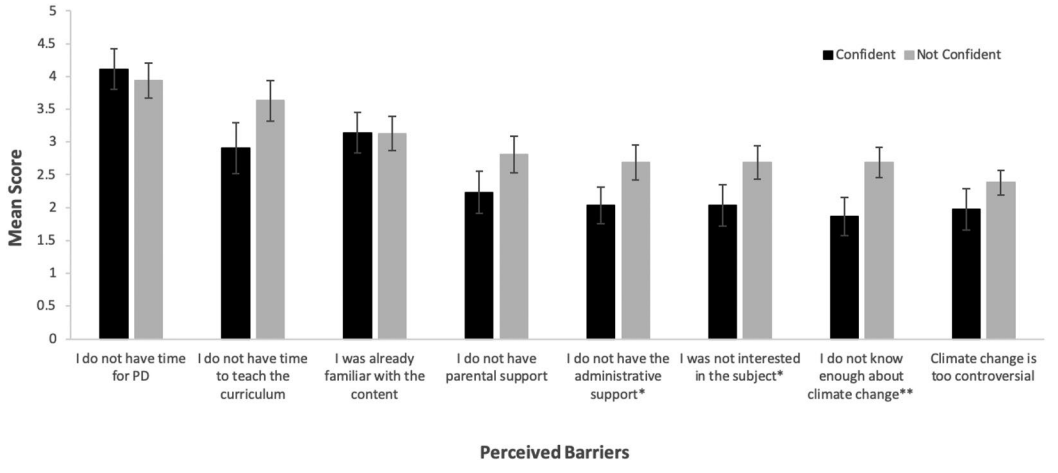

Figure 3. Teachers' mean response to whether or not factors were seen as a barrier to participating in a climate change professional development opportunity, separated by whether or not they were confident or not confident about their climate change beliefs. Error bars represent 95% confidence intervals. Statistically significantly different factors are indicated by an *. * $p < 0.05$, ** $p < 0.01$.

Table 2. Teachers' mean level of agreement as to whether these statements were barriers to participating in a climate change professional development opportunity.

Barrier	N	M	SD	Lower 95% CI	Upper 95% CI
I do not have time for professional development	54	4.07[A]	1.10	3.78	4.36
I do not have time to teach the curriculum	54	3.19[B]	1.39	2.82	3.56
I was already familiar with the content	54	3.09[B]	1.10	2.80	3.38
I do not have support from parents	54	2.41[C]	1.17	2.10	2.72
I do not have support from administration	54	2.26[C]	1.05	1.98	2.54
I was not interested in the subject	54	2.24[C]	1.13	1.94	2.54
I did not know enough about climate change to feel comfortable teaching about it	54	2.13[C]	1.08	1.84	2.42
I feel climate change is too controversial	54	2.11[C]	1.06	1.83	2.39

Note.[A, B, C] Statistically significant groupings of barriers. Groups indicated by letter.

identified as the second group of barriers to CCPD. These two items ranked as neutral in terms of whether teachers saw them as barriers to participation. Finally, five items fell into a third group of barriers to CCPD. These included lack of support from parents, lack of support from administration, lack of interest in the subject, lack of enough knowledge to feel comfortable teaching the subject, and feeling as though climate change is too controversial. These five items were all below three, or neutral, meaning teachers disagreed that these items were barriers to participating in the CCPD (Table 2).

To examine whether there were differences between teachers who were confident climate change is happening and those who were not confident, we compared the two groups for each of the eight barriers (Table 3). Of the eight barriers listed in the survey, teacher responses varied significantly for three items. These included lack of support from the administration (Confident in their beliefs about climate change: $M = 2.03$, SD = 1.04; Not Confident in their beliefs about climate change: $M = 2.69$, SD = 1.01; $p = 0.044$), lack of interest in the subject (Confident: $M = 2.03$, SD = 1.18; Not Confident: $M = 2.69$, SD = 0.95; $p = 0.028$), and lack of enough knowledge on climate change to feel comfortable teaching about it (Confident: $M = 1.86$, SD = 1.09; Not Confident: $M = 2.69$, SD = 0.87; $p = 0.006$; Figure 3). While there is a significant difference between groups for these three items, both groups still tended to rank them as 'disagree' meaning they did not see them as a barrier to participating in the PD.

Table 3. Teachers' mean level of agreement as to whether these factors were barriers to participating in a climate change professional development opportunity, based on whether or not they were confident or not confident in their climate change beliefs.

	Confident		Not Confident	
Barrier	M	SD	M	SD
I do not have time for professional development	4.11	1.16	3.94	1.00
I do not have time to teach the curriculum	2.91	1.46	3.63	1.15
I was already familiar with the content	3.14	1.17	3.13	0.96
I do not have support from parents	2.23	1.21	2.81	1.05
I do not have support from administration	2.03	1.04	2.69*	1.01
I was not interested in the subject	2.03	1.18	2.69*	0.95
I did not know enough about climate change to feel comfortable teaching about it	1.86	1.09	2.69**	0.87
I feel climate change is too controversial	1.97	1.18	2.38	0.72

Note. $^{*}p < 0.05$, $^{**}p < 0.01$

The same trend existed for additional barriers, even though they were not significantly different for the two groups of teachers. Teachers who were not confident in their beliefs about climate change, were more likely to perceive three of the remaining five choices as barriers as opposed to those who were confident about their beliefs in climate change. The lack of significant differences between the two groups could be due to small sample size in this study (see Table 3). The two barriers that did not exhibit differences between groups were time to participate and whether the teachers felt they were already familiar with the content of the PD.

Discussion

Climate change education has been identified as an important tool for increasing climate literacy among young people (Stevenson, Peterson, and Bondell 2018) and the general public through intergenerational learning (Duvall and Zint 2007; Lawson et al. 2019). However, even though climate change is included in the standard course of study in many countries (e.g. NGSS Lead States 2013; Department for Education 2015; UNESCO 2010), teachers may shy away from teaching about it in their classes. This study sought to add to the literature surrounding general teacher PD by specifically examining what barriers teachers may perceive to participating in climate change specific PD. Having teachers who are prepared and willing to teach about climate change is vital but first we must understand whether they will choose to attend a PD opportunity designed to support them in teaching this subject.

Time as a barrier

This study examined teacher barriers to participating in a CCPD using the Professional Development Motivation Model developed by Karabenick and Conley (2011) and expectancy-value theory (Eccles and Wigfield 2002). Of particular interest were the portions of the model focusing on teacher motivation to teach science (which includes self-efficacy and future goals), the features of the PD opportunity (which includes teacher beliefs about the relevance and cost of participating in the PD), previous experiences with PD, and perceived support which influence teachers' attainment value, intrinsic value, utility value and perceptions of cost when deciding whether or not to participate in PD. When examining the data, features of the PD opportunity were listed as the biggest barrier to participation. While we had initially hypothesized that controversy associated with the topic of climate change would be the primary barrier to CCPD participation, time to participate was the primary barrier reported by teachers in the study.

This included both those teachers who were confident that climate change was happening as well as those who were not confident. This finding suggests that rather than developing new strategies specifically for CCPD, CCPD providers can focus on addressing common barriers to participation in teacher PD using established research-based practices for high quality teacher PD (e.g. Badri et al. 2016; Geldenhuys and Oosthuizen 2015; Johnson 2006; Kwakman 2003; OECD 2009).

The concerns reported about time to participate suggest that teachers are not avoiding CCPD opportunities due to the topic. As a whole, teachers disagreed with the statements that they did not participate because the topic was too controversial or because they did not know enough to teach the subject. For organizations who hope to offer climate change specific PD opportunities, this suggests PD efforts should focus on minimizing time requirements for training. Embedding CCPD within school-based professional development would be one option to reduce time constraints. Additionally, advertising the potential long-term time saving strategies that would be offered during the PD (e.g. plug and play lessons) during recruitment may help teachers see the time saving value of the PD.

While both groups of teachers agreed that time was the main barrier to participation, the differences that existed between teachers with differing climate change beliefs suggests that PD efforts should also consider obtaining support from school administration and focusing the climate change content on local contexts. Research on climate change perceptions suggests that climate change beliefs drive our perceptions of the world around us. This includes how we interpret scientific information to form our climate change concern (Hamilton 2011), our concepts about what policy steps should be taken (Leiserowitz, Maibach, and Roser-Renouf 2009), or even how our perceptions of the severity of specific weather events form (Cutler 2016). Understanding local audiences' beliefs about climate change in order to properly frame the content and focus on local contexts is vital for developing effective PD opportunities (Brownlee, Powell, and Hallo 2013). Applying these techniques to recruiting materials may increase the chances that teachers who hold a variety of climate change beliefs may attend. They may also ensure that the workshops themselves are more effective at engaging teachers in the material, subsequently increasing the quality of climate change education in the classroom.

Addressing barriers

The results of this study suggest that the barriers teachers perceive to participating in a climate change specific PD opportunity are very similar to those barriers for other types of PD. When planning climate change PD, organizations need to remember that there is no one solution that will meet the needs of every teacher (Fields et al. 2012) and a wide range of tactics may be needed to successfully recruit teachers to attend the PD opportunity. Teachers are busy and often overworked so they are less likely to choose to spend their time on PD if they do not see the relevance (Timperley et al. 2007). Organizers must help teachers understand that the CCPD opportunity is meaningful, usable, and practical so that teachers see the value in committing time to the PD (Timperley et al. 2007). This study suggests efforts to reduce barriers to CCPD may be more important in areas where teachers are less confident that climate change is happening.

In addition to helping teachers see the value of committing time to the PD, organizers should help school districts understand the value of participation. Time is often the most significant cost associated with professional development for districts (Gulamhussein 2013) and obtaining administrative support may be crucial to getting teacher participation (Fields et al. 2012; Timperley et al. 2007; Whitworth and Chiu 2015). This is particularly important as political barriers such as district buy in and administrative support are the most difficult for teachers to overcome (Johnson 2006). International research on teacher PD has found that school administrators not only need to offer time for PD but also to develop a school culture that offers social support from the administration and among the teachers (Evers, Van der Heijden, and Kreijns 2016). PD

organizers should take opportunities to build relationships with the school systems they hope to serve in order to increase administrative support.

Limitations

The greatest limitation to this study is the sample size and geographic restrictions as this was limited to nonrespondent, middle school science teachers in coastal counties of a southeastern state. There is a need to conduct this study with a larger population over a greater geographic region. Additionally, demographic data for teachers was not collected to preserve their anonymity. This prevents the data from being analyzed by gender, socioeconomic status, political ideology, and other social factors that influence climate change beliefs. Care should be taken when generalizing this study for other populations.

Conclusion

K-12 climate change education is considered imperative in moving towards a climate literate society, therefore preparing teachers to effectively teach their students about the subject is key. This study examined the barriers perceived by teachers who chose not to participate in a CCPD opportunity that sought to mitigate many of the barriers traditionally expressed by teachers (a stipend, meals, travel, and taking place outside of the school year). To better understand the barriers teachers perceive surrounding climate change specific PD, we recommend similar studies should be conducted with a larger sample of teachers in a wider geographic range. To gain more information on teacher motivation, additional research should investigate how teacher agency and social cultural barriers may influence teacher participation in CCPD. Future research should also explore how changing time and location affects participation as well as examine the effectiveness of online asynchronous climate change PD opportunities in increasing teacher participation.

Teachers have a vital role to play in creating a climate literate public. By educating youth in climate issues and solutions, it may be possible to reach adult decision makers (Duvall and Zint 2007; Lawson et al. 2019). Youth are better than adults at separating out facts about climate science from socio-ideological biases (e.g. worldviews, political ideologies, gender identities (Flora et al. 2014; Kahan 2012; Stevenson et al. 2014). Therefore, climate change education in schools may have the opportunity to make real inroads in achieving a climate literacy society where other approaches have not been as successful. However, this study suggests teachers who are not confident climate change is real perceive barriers to CCPD as more difficult to overcome than other teachers do. Thus, success of climate change education relies in part on helping these teachers prepare to teach the subject and states must commit to professional development in support of this goal (National Center for Science Education & Texas Freedom Network Education Fund 2020).

Organizations offering CCPD opportunities must find ways to address the barriers to participation teachers are facing. Increasing the characteristics that teachers find appealing in PD opportunities as well as designing PD that is locally relevant may increase participation particularly for teachers who are not confident in their beliefs about whether climate change is happening. Developing climate change education programs that are focused on connecting participants to the information by making it meaningful and relevant has emerged as an important theme in research assessing the success of climate change education (Monroe et al. 2019). To help educators connect with the content, researchers and organizers should identify pre- and post-workshop activities to help the participants further engage with the content as well as ways to support participants during the implementation of the new content (Lauer et al. 2014). Additionally, in classroom support has been identified as a method for improving teachers' practice with new content and pedagogical skills (Johnson 2006; Maeng et al. 2020) and so

researchers and institutions offering CCPD should explore ways to include classroom coaching as part of their PD offerings.

Current research shows that time is the major barrier to participation in teacher PD no matter the topic (e.g. Badri et al. 2016; Geldenhuys and Oosthuizen 2015; Johnson 2006; Kwakman 2003; OECD 2009). Therefore, organizations offering climate change specific PD should further investigate techniques to boost PD participation and think creatively about how to create time for teachers to attend their PD opportunities. To identify the appropriate length for the PD as well as to guide the scope of the workshop, researchers and organizers of CCPD should consider the use of a needs assessment to best meet the needs of their participants (Lauer et al. 2014).

The results of this study also suggest administrative buy in is an important first step for decreasing the barriers perceived by teachers who were not confident in their beliefs about whether climate change is happening. Increasing administrative support is necessary in terms of both time and money. School districts need to recommit to supporting teacher PD both in terms of time and financial support. A 2012 study found that PD is often the first item cut during budget cuts with 69.4% of school districts saying PD is the first line item they reduce in times of shortage (Ellerson 2012). However, a report by the Center of Public Education found that districts may not need to spend more money on PD for teachers but rather they need to identify how much they are currently spending and examine ways to restructure current funds (Gulamhussein 2013).

Teacher professional development is important for teachers in all stages of their careers (NSTA 2006). The National Science Teaching Association recommends finding ways to help PD accommodate teachers' busy schedules through opportunities offered at a variety of times including in school, after school, as well as during the summer (2006). Finally, organizations offering PD must help teachers understand the value of their opportunities and adhere to best practices in PD implementation (NSTA 2006). By collaborating with local school districts, organizations offering climate change specific PD may be able to better recruit and sustain teacher's participation leading to more teachers who can effectively communicate climate change science to their students.

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