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Abstract

4-H and Extension educators who work with youth are uniquely positioned to help them meaningfully learn about global climate change (GCC) in a way that connects to their everyday lives and interests. Yet we don't have a baseline understanding of these educators' knowledge of GCC or how they teach about it. This paper presents brief findings of a study intended to fill that gap in knowledge. Educators from six states responded to an online survey in 2020. GCC knowledge varied by topic and by educator instructional focus, with STEM and Civic Engagement educators scoring highest. Questions about greenhouse gasses and long-term air temperature changes had the lowest number of correct answers. Responses to open ended questions in the survey indicated a moderate number of educators believed that GCC is anthropogenic. Most educators avoided teaching about GCC or touched on it briefly. Those that did teach about GCC indicated their main motivation is that such instruction benefits youth, followed by care for the earth. Recommendations for professional development, such as making opportunities contextualized to the instructional focus and the geographic location are shared.

Keywords

climate change, informal educators, youth, 4-H, Extension

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Abstract

4-H and Extension educators who work with youth are uniquely positioned to help them meaningfully learn about global climate change (GCC) in a way that connects to their everyday lives and interests. Yet we don't have a baseline understanding of these educators' knowledge of GCC or how they teach about it. This paper presents brief findings of a study intended to fill that gap in knowledge. Educators from six states responded to an online survey in 2020. GCC knowledge varied by topic and by educator instructional focus, with STEM and Civic Engagement educators scoring highest. Questions about greenhouse gasses and long-term air temperature changes had the lowest number of correct answers. Responses to open ended questions in the survey indicated a moderate number of educators believed that GCC is anthropogenic. Most educators avoided teaching about GCC or touched on it briefly. Those that did teach about GCC indicated their main motivation is that such instruction benefits youth, followed by care for the earth. Recommendations for professional development, such as making opportunities contextualized to the instructional focus and the geographic location are shared.

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Introduction

Extension Education provides opportunities for adults and youth to learn about the phenomenon of global climate change outside of the formal schooling system, in informal settings (Banks, et al., 2007; Falk & Dierking, 2000; Hofstein & Rosenfeld, 1996). In keeping with the mission of Land Grant Universities, Extension systems are an integral part of local and global communities. They provide a unique opportunity for contextualizing learning about complex science phenomena such as global climate change (GCC), and prepare youth, especially in marginalized communities, for global leadership and decision making. Enhancing the capability of such programs becomes especially critical in the context of climate literacy where public opinion about the basic science of GCC remains confounded with political debate (Nisbet & Mooney, 2007), even with scientists' consensus about it. Research studies note that even the use of various strategies for curriculum and instruction (Monroe et al., 2019) comprehending the basic science of GCC remains challenging for students (Boyes & Stanisstreet, 1997; Shepardson, Choi, Niyogi, & Charusombat, 2011), their teachers (Boon, 2010; Herman, Feldman, & Vernaza-Hernandez, 2015), and practitioners in both formal and informal settings.

Instructional decisions - what and how they teach - of educators are complex. They are influenced by their given curriculum as well as their beliefs about the content, the learners they work with, their goals for them, conceptions of the subject matter, and the complexity of the content (Shavelson, 1983; Tran, 2007).This would suggest that better understanding educators' beliefs and knowledge of a socially and scientifically complex topic such as GCC would lead to a better understanding of their instruction, in particular their decision whether or not to teach about GCC.

4-H is a nationwide youth development and outreach program through Extension that provides experiential education to youth in grades K-13. Programs for youth in urban, suburban, and rural settings programs include afterschool, special interest groups, and overnight or day camps. Because of their accessibility, these programs have the potential to involve a large number of youth in conversations about GCC, climate justice, and environmental sustainability. With its roots in agricultural education, 4-H's perceived scope is limited, however it encompasses a wide variety of interests including those within science, technology, engineering and mathematics (STEM). The professionals, paraprofessionals and volunteers who help run these programs might not be aptly trained or have expertise in teaching science about global climate change. Therefore, they need professional development and support for building their instructional capacity.

Objective

With the objective to better understand 4-H and Extension educators' knowledge, beliefs, and instructional practices regarding GCC, researchers from three
institutions have collectively engaged in the design, implementation and subsequent analysis of an exploratory study. Our guiding questions for this study are:

1. How do 4-H and Extension educators conceptualize the phenomenon of GCC?
2. What beliefs, motivations, and teaching practices do 4-H and extension educators demonstrate about GCC?

Methods

To answer these questions, we adapted a global climate change (GCC) survey instrument previously used with formal agriculture educators (Wang et al., 2019). That instrument was modified to more accurately reflect the work that 4-H and Extension educators do outside of the classroom (Appendix A). For example, the knowledge and feelings about GCC scales were kept intact, but items were added to the teaching about GCC scale to ask about which program focus educators worked with - community service, science, technology, engineering and mathematics (STEM), or healthy living. The resulting 23 question survey consisted of multiple choice, Likert-type, and open response items eliciting 4-H educators' understanding, beliefs, motivations, and their instructional practices about GCC. The modified survey was reviewed by Extension staff familiar with 4-H and then distributed virtually via the Qualtrics survey software. We chose to distribute the surveys virtually a) to broaden the sample across states; b) the distributed nature of 4-H and Extension educators within each state; and c) at the time of data collection, the COVID-19 pandemic limited face-to-face interactions. We used a convenience sample of 4-H departments with which the authors had professional relationships through current or former colleagues (IN, MI, MN, NE, NJ, and PA). Leaders of those departments distributed the survey link to educators in their programs, either through email or listservs. Though convenience sampling does somewhat limit the generalizability of results, it is an accepted method for studies with limited resources or of an exploratory nature (Etikan, Musa, & Alkassim, 2016)

We received 106 responses, 87% of which were women. Respondents identified as 4-H staff (45.37%), Extension educators (46.3%), or other (8.33%). Due to the nature of the survey distribution in each state, it was not possible to calculate a response rate. Quantitative analysis of the data was completed using

SPSS (version 26). Responses from the open-ended items and were coded independently by two authors, then recoded after discussion. The final interrater agreement (calculated using Excel software) was 91.96% on the question "*How would you describe the phenomenon of global climate change in your own words?*" and 82.09% on the question "*What motivates you to teach about climate change*".

Results

Demographics

In total, 106 Extension educators (46.3%), 4-H staff (45.37%), and educators in other Extension-related roles (Interns, GreenCorps Members, Senior Extension Educators, Assistants, and Professors, 8.33%) participated in the study. Participants were from Michigan (40), Minnesota (24), Nebraska (18), Pennsylvania (11), New Jersey (9), and Indiana (4). Most of the participants had Masters degrees (48.15%) and Bachelors degrees (37.04%) degrees. A minority held doctorate (3.7%), associates (9.26%), and high school (1.85%) degrees. Degree areas were diverse, including education (30.56%), science (26.85%), social sciences (8.33%), business (6.48%), arts (4.63%), humanities (1.85%), health science (0.93%), and others (Family and consumer science, journalism, early childhood education, environmental studies, recreation therapy, community health, agriculture, art education, outdoor education, animal science, administration) (20.37%).

The participants had worked with youth for a mean of 12 years, distributed across age groups - 22.82% taught 5-7 years old, 25.24% taught 8-10 years old, 24.03% taught 11-13 years old, 23.06% taught 14-18 years old, and 4.85% taught other ages of learners. Participants identified themselves as working in rural (46.96%), suburban (25.97%) and urban areas (20.99%). The largest group of participants primarily work in 4-H STEM programs (42.59%), followed by civic engagement (12.9%), and healthy living (10.19%). Again, other programs accounted for a meaningful portion of participants (e.g., animal science, college & career readiness, leadership, environmental education, workforce development, career development, financial literacy, expressive arts, STEM, livestock, positive youth development) (34.26%).

Knowledge of the participants

Participants were asked five questions based on their current knowledge of climate change. Participants were given multiple choice options, as well as a choice of "I

don't know", which was added to account for participants guessing rather than knowing the answer. Table 1 describes the patterns for these closed-response items. To more fully understand educators' conceptions of global climate change, we examined open responses to the question "How would you describe the phenomenon of global climate change in your own words?" Of the 89 responses to the question, 25.94% of couldn't or didn't describe climate change, consisting of punctuation (e.g. "?" or "N/A"), single words (e.g. "shocking", "confusing"), or responses that did not provide an explanation such as "I do not believe in it and have seen no proven research to support this idea. I am not even sure it is mandated to teach this in [State] curriculum" or "This is a topic I don't know much about other than my own observations to the changes in my area."

Table 1

Patterns of response on GCC knowledge items (% choosing that response). The correct response is provided in italics.

		Correct Response	I don't know
1.	Which of the following is the best definition of a greenhouse gas? *"An atmospheric gas that absorbs solar radiation"*	40	22
2.	How has the amount of carbon dioxide in the atmosphere changed since the start of the Industrial Revolution 150 years ago? *"It has increased"*	82	15
3.	Which is the best description of the differences between climate and weather? *"Climate changes over long periods of time and weather changes over short periods of time."*	91	7
4.	Which of the following statements about global climate change over the past 50 years is most accurate? *"Global climate change over the past 50 years is slightly due to natural processes and mostly due to human activity."*	74	11
5.	Which of the following statements about air temperature over the past million years is the most accurate? *"Air temperature changes over the past million years is slightly due to natural processes and mostly due to human activity"*	44	25

Note: Correct response is provided in italics below the question.

Table 2
Patterns of correct responses by educators' focus area (%, n=106).

	GH Gas Definition	CO2 since Ind. Rev.	Climate & Weather	GCC past 50 years	Cause of air temp changes of 1MY
STEM	48.7	87.2	94.9	79.5	41.0
Healthy Living	11.1	66.7	100	55.6	33.3
Civic Engagement	11.1	88.9	88.9	88.9	55.6
Other	46.9	78.1	84.4	68.6	50.0

A modest number of responses (34.83%) identified GCC as human-caused. Some of these included mechanisms of the human influence, such as industrialization: "Climate around the world has shifted since humans have ramped up industrial capacity. This has shifted our weather patterns, increased the temperature of our air and oceans, and caused biomes to alter their boundaries." Other blamed humans more generally:

> Global warming is the Earth's temperature rapidly increasing, caused by us humans not taking better care of our environment. As the Earth's temperature gets hotter the glaciers start to melt, sea levels rise, animals start to die, it messes with our weather, etc. It basically causes a ripple effect.

The most common impacts cited were increased temperatures, weather changes, and rising sea levels.

Practice of participants

When asked how often each program area taught about global climate change, the most frequent responses across program areas were "I avoid it" or "I mention it briefly" (Figure 1). For STEM and civic engagement, educators it is avoided frequently. For the category "other" participants responded that they "did not have resources", "did not avoid it, but did not choose it" or "did not feel comfortable teaching it". Among GCC topics, there were few topics that were taught extensively, and that was infrequent (Table 3). Some, such as changes in the prevalence and distribution of disease were frequently avoided.

Analysis of the open-response question "*What motivates you to teach about climate change*" provided further illumination of why 4-H and Extension educators did teach about GCC. Three main themes of these responses were 1) teaching GCC

benefited the youth they worked with (22%); 2) teaching about GCC was rooted in an ethic of care for the environment
and the world (16%); and 3) such teaching was for the future of all (14%). For example, in the category of benefits for youth one educator replied that they taught GCC because "Our world is changing around us and the youth need to understand why." Another said "I believe it is critically important for youth to understand the complexities of environmental science and their impacts and agency related to their actions."

Responses that aligned with caring for the earth included responses such as "To help children understand the importance of caring for the environment" and "Help the decrease in the footprint on the environment." For example, one educator said this:

> Climate change is, in many ways, an existential threat to humanity and in order to make change and work towards creating a just and habitual future, educating on climate change is deeply necessary. For me, clean water and air, healthy food are all foundational to creating vibrant and resilient communities. For youth to truly thrive, their needs must be met first and foremost. And climate justice work can be an incredible and intersectional model and framework to educate through.

The last theme, that teaching about GCC was for the future of all, is reflected in this passage:

> It [GCC] is the human challenge of our time. The consequences of inaction will affect every single person on this planet, with those lower on the economic ladder being affected disproportionately. We as a human race have it within our power to slow and reverse climate change, but it will take collective action to do so.

Figure 1
How often do you teach about climate change?

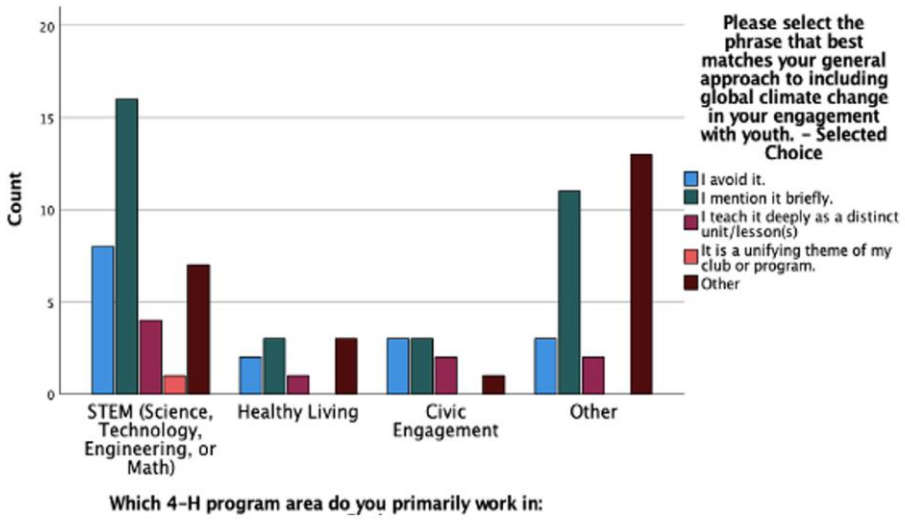

Table 3
Global Climate Change Topics Taught Extensively and Avoided Most Frequently

	Topic	%
Teach Extensively	Impacts on Food Supplies	17.24
	Impacts on Water Sources	15.52
	Impacts on Local Weather Patterns	14.29
Avoid Teaching	Prevalence and Distribution of Disease	66.67
	The Disruption of the Carbon Cycle	59.26
	Social & Political Considerations	46.43

Discussion

We know that youth can be effective disseminators of GCC beliefs (Lawson, et al., 2019), and potentially action (Lawson, et al., 2018) through intergenerational learning. This, and preparing youth to be active citizens in a society facing ever-increasing impacts of GCC, calls for GCC education in multiple settings, in and out of school. To understand the education happening outside of schools, we must first understand the knowledge, beliefs, and practices of the

educators in those spaces. This research sought to understand the GCC knowledge and teaching patterns of 4-H and Extension educators across several states.

Results indicate that knowledge among these educators is variable. It is low to moderate on some topics (e.g. nature of greenhouse gasses and long-term changes in atmospheric temperature remain poorly understood) and high on others (e.g. the difference between weather and climate). In addition, educators whose work focused on STEM and Civic Engagement had the highest levels of knowledge on four out of five of the questions, suggesting that there is greater need for professional learning in Healthy Living and general/other focus educators.

Open responses to a question asking educators to explain GCC reinforced the finding that professional learning is necessary. Nearly 26% of educators could not or would not explain GCC, and only 35% attributed it to human causes. This contrasts with a large national study that found that 59% of Americans believe that GCC has anthropogenic causes, but more closely aligns with the rates found among farmers (Arbuckle, et al., 2013; Rejesus, et al., 2013) and Extension professionals (Monroe, et al., 2015). Monroe and colleagues found that of Extension educators who work with 4-H, over 30% fell in the dismissive, doubtful and disengaged categories of GCC concern. This prompts the question of how to improve 4-H and Extension educators' understanding of the anthropogenic nature of GCC and its impacts in a way that aligns with their beliefs. We agree with Monroe and colleagues (2013) in that reframing GCC as "changing weather patterns" may be an entry into engaging those that do not believe in GCC or its anthropogenic nature.

Educators in this study teach about GCC infrequently, avoiding it or touching on it briefly. Responses indicate that they feel unprepared to teach it or lack the resources necessary. When they do teach about GCC, they focus on the daily impacts that are meaningful to the youth they work with and align with Extension goals - its impacts on weather, water sources, and the food supply. They avoid teaching its effects on the prevalence and distribution of disease, its effects on the carbon cycle, and the social and political considerations. This reflects Stylinski, et al.'s (2017) work with informal educators on climate change education. In that study, educators identified climate change as one of many environmental issues that are "briefly addressed", and only teach about GCC 0-3 hours per week, with 44% not teaching it at all. They identified several needs for including GCC in their teaching, which echo barriers educators in this study cited: materials and resources and training in GCC education and GCC science.

We asked, in an open response question, for educators' motivation to teach climate change. We received far fewer responses to this question, which aligns with the finding of low instruction levels. That 22% of those that responded cited that such instruction benefits youth should come as no surprise, since positive youth development is a core value of their work. While motivation to teach GCC topics has been studied in teachers (e.g McNeal, et al., 2017; Wise, 2010) and college

professors (e.g. Kirk, et al., 2014), primarily with science educators, it has not been undertaken with 4-H and Extension educators, who teach a much broader array of topics, so this study serves as a beginning point for such research. McNeal and colleagues (2017) found that middle school teachers who identified with environmentalism reported this as a motivation to teach GCC, which is echoed in our finding that 16% of educators cited care for the earth/world as a motivator for instruction. They also found that science teachers' identity as scientists promoted GCC instruction. Since not all 4-H and Extension educators teach about STEM topics, there are multiple possible identities and alignments possible for these educators. Here we return to the questions of how to promote professional learning opportunities for educators broadly, so that they do not just attract those educators already interested in GCC or who are already teaching. Bowers, et al. (2016) suggest that alternate framing of GCC as a) part of caring for the earth or b) minimizing negative economic impact may be helpful in reaching educators who are hesitant or uninterested about teaching about climate change.

This survey study is limited in helping us understand the underlying motivations and practices for these decisions, but they bear further study. Research that builds upon the findings shared here that identifies the greatest barriers that 4-H and Extension educators perceive and the motivation of both engaged educators and those who do not teach about GCC will help effectively shape the professional learning opportunities provided. This is best accomplished through in-depth work with educators to understand how they relate to GCC personally and professionally and how they see it related to their work. We believe that, because the contexts of 4-H and Extension educators vary greatly by county, state, and country, in-depth work must take place in a variety of settings within and beyond the United States.

When professional learning is provided, it is important to remember that as learning occurs in context, so should professional learning opportunities. We know from this study that 4-H and Extension educators as a group do not have a strong understanding of greenhouse gasses and the origin of air temperature changes over geologic timescales. Yet simply providing them this information is unlikely to have a strong effect. The 3H learning model proposed by Sipos and colleagues (2018) is both promising and aligns well with the 4-H model of Hands, Heart, Head, and Health. The 3H learning model proposes that teaching that involves the Hands (experiential learning and opportunities for action), Head (cognitive learning) and Heart (affective learning) leads to transformative education. If we keep that in mind for providing professional learning for informal educators, we can tie the learning securely to their particular context by providing experiences that involve learning through teaching and opportunities to work with the community on GCC related projects (hands on), that addresses knowledge of local and global impacts of GCC (heads on) and that meets them where they are emotionally and belief-wise with regards to GCC and helps them identify how it aligns with their values (VonBergen

& Manon, 2020; hearts on). The result of this is that one national curriculum that is decontextualized and does not speak to local interest, impacts, and values will not create a long-lasting change in educator practice. Professional learning for 4-H and Extension educators in Michigan will look very different than it would in New Jersey or Indiana. Globally, more than 80 countries have 4-H type youth development programs. Regardless of where a 4-H program exists in the world, focused education to introduce and strengthen skills featured in this study can help to shape the way how non-formal educators around the world teach GCC.

There is no easy solution to the problems of climate variability and agricultural sustainability. However, educators can incorporate climate information, issues, and potential solutions into their teaching and this helps youth understand the challenges that in order to maintain a healthy life, human have a dilemma that needs to resolve between facing a variable climate and trying to manage a sustainable agricultural system. We now know that 4-H and Extension educators need professional learning programming in GCC, specifically in how to teach it, but we need to understand more about their personal and professional motivations and beliefs. Doing so will better prepare researchers to further explore their practice and providers of such programming to better plan. Further research is warranted in these areas.

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