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An Investigation of Science Educators' View of Roles and Responsibilities for Climate Change Education

J. RANDY MCGINNIS[*], CHRIS MCDONALD, EMILY HESTNESS, WAYNE BRESLYN[†]

ABSTRACT: This exploratory study investigates what science educators from differing groups (outside of higher education – informal and formal (K-12) and inside of higher education – content and pedagogy experts) believe are the roles and responsibilities (and what actions these might involve) in climate change education for: 1) their group of educators, and 2) other groups of educators, for climate change. A hybrid theoretical perspective (interactionism and social constructivism) was used. Written data were analyzed using a delimited discourse methodology to make sense of the participants' thinking of roles and responsibilities for climate change education. The psychosociological construct *diffusion of responsibility* provided a useful interpretative lens. Findings suggest that science educators from different groups hold differing views of roles and responsibilities for climate change education, which may lead to a damaging diffusion of responsibility for effective climate change education. Recommendations for effective professional development in climate change education are suggested to ameliorate the potential for a diffusion of responsibility.

KEY WORDS: Science Education; Professional Development Program; Climate Change Education; Socio-scientific Issues

INTRODUCTION

This exploratory study investigates the perspectives of science educators concerning personal and others' roles and responsibilities (and what actions these might involve) on climate change education. Specifically, the study focused on the written words of an unusually diverse group of science educators (informal and formal K-12science educators and higher education science content and pedagogy instructors) in a professional development academy on climate change. The research question is: What do science educators from differing groups (outside of higher education – informal and formal (K-12) and inside of higher education – content and pedagogy experts) believe are the roles and responsibilities in climate change education for: 1) their group of educators, and 2) other groups of educators, for climate change?

[*]Corresponding author: jmcginni@umd.edu
[†] University of Maryland, College Park, United States of America

RATIONALE AND REVIEW OF RELEVANT LITERATURE

There is a growing need to examine broadly the perceptions of science educators regarding the topic of global climate change. Climate change is an increasingly salient topic in science education in the US and worldwide, as well as a potentially sensitive socio-science issue topic (Feierabend & Eilks, 2010). In this study we explored the perceptions of a diverse community of science educators regarding their own and others' roles and responsibilities for teaching the topic of climate change. Recent policy changes in U.S. science education have sought to catch up with the international science education community by including the topic of climate change as a topic that science educators will now need to consider in their practices. The2013 release of the Next Generation Science Standards (NGSS Lead States, 2013), preceded by the 2012 Framework for K-12 Science Education (NRC, 2012), marks the first set of U.S. national science standards to explicitly address climate change (other countries have previously included the topic in standards documents).

The NGSS have garnered increased attention for climate change education and have the potential to catalyze climate change education efforts in the years to come. However, questions remain regarding how climate change education can be implemented most effectively. One potential threat to effective implementation of climate change education may arise if science educators who are situated in differing professional appointments (i.e., level and type of instruction)"do not take responsibility for action because they assume others are acting or have already acted" (Rushton et al, 2014, p. 390). This phenomenon of an individual in assuming others will take responsibility for needed actions and therefore the individual does not have to take action is known as the sociopsychological construct *diffusion of responsibility* (Banyard, Plante, & Moynihan, 2004). Confronting this condition, should it exist in climate change education, by prompting self-awareness by educators is of high importance for accomplishing effective climate change education.

CONTEXT OF THE STUDY

The context of this study was a voluntary, week-in-duration, residential Professional Development Program at Climate Literacy Academy. The professional development consisted of four facets: science content, learning theory, pedagogical enhancement (including educational technology integration), and educational policy. Each participant was expected to utilize knowledge gained from the Academy to develop a learning segment (3 to 5 hours of concentrated or spread apart instruction), which they would implement and reflect upon in their teaching context. Learning segments were expected to incorporate learning progressions as a tool for gaining insight into students' understanding of climate change. Previous reports by our research team detailed the planning for the Academy (Hestness, McDonald, Breslyn, McGinnis, Mouza, 2014a) and the Academy's outcomes in multiple dimensions (Hestness, et al., 2014b; Shea, Mouza, & Drewes, 2016).

The workshop was a component of a larger project (MADE CLEAR, funded by the National Science Foundation ‡ , ClimateEdRearch.org, madeclear.org) focused on the implementation of a comprehensive climate change education plan for the U.S. Mid-Atlantic region. Participants (N=33) in the Academy (including 5 project personnel members) were middle school (n=16), high school (n=6), higher education (n=7), and informal science educators (n=4) from two adjoining Mid-Atlantic States in the U.S. (approximately half of the sample came from each state). Throughout the week, climate change content experts and experts in learning theory delivered presentations. Participants engaged with vetted classroom resources related to climate change education, examined Next Generation Science Standards (NGSS) information relevant to the climate change topic.

Participants were presented with a draft hypothesized learning progression on sea level rise, a locally relevant impact of climate change, developed by the project's learning scientists. They utilized the draft hypothesized sea level rise learning progression as they developed their learning segments, and were asked to consider collecting information during the coming year about their students' understanding of sea level rise. In this way, it was intended that the teachers would take the role of co-researchers in helping to test and validate the draft hypothesized learning progression on sea level rise.

During the Academy, we sought to connect seamlessly professional development to our research activities. We carefully considered the burden on participants who were learning new content, while also participating in research that required data collection. To lessen the time burden on participants, we chose to collect handwritten data for our research question, as opposed to other data collection methods such interviews.

THEORETICAL FRAMEWORK AND DESIGN

Our research employed a hybrid theoretical perspective that consisted of interactionism (Cobb & Baursfeld, 1995), while also drawing upon tenets of social constructivism (Bruffee, 1986). Interactionism posited that individuals communicate meanings of experiences by inventing symbols within a cultural context (Cobb & Baursfeld, 1995). Invented symbols included units of communication called speech, talk, discourse, or registers (Roth & Tobin, 1996). These symbols sustained and contributed toward defining and conducting social life within a defined population (Alasuutari, 1995). Social constructivism asserted that the construction of understanding of experiences was a socially-mediated act (Bruffee, 1986). As such, our hybrid theoretical perspective

‡For more information about the project see www.ClimateEdResearch.org and www.madeclear.org).

focused on documenting and making sense of the perspectives among differing self-defining groups within a community.

The methodological model for our study is based upon an emerging body of literature on the use of written communication to elicit science educators' perspectives of topics in science education. This approach may be particularly valuable for diverse science educator communities collaborating in large-scale science education professional development settings (McGinnis, 2003). Researchers interested in investigating the perspectives of varying subgroups within a community seek typically to collect data that document the diversity of thinking on a topic within the community. Goals of such research include first, to acknowledge, and secondly, to understand more accurately the images held by individuals (Mura,1993;1995) of selected items of interest. Ultimately, the goal is for such information to be used strategically in decision-making regarding how to interact productively with groups of individuals in a community, such as in a professional development workshop for educators.

In addition to this body of literature on eliciting educator perspectives, our investigation within a professional development program was supported by the work of Luft and Hewson, 2014 and City, Elmore, Fairman, and Teitel (2009). In particular, City et al. identified a set of key obstacles for realizing professional development program goals, including a lack of a common instructional vision applied to daily instructional practice in schools. We sought to remain cognizant of this type of obstacle in our investigation of diverse science educators' perspectives on climate change education roles and responsibilities (and what actions these might involve).

The study design employed a qualitative case study methodology (Stake, 1995) to address our research question: What do science educators from differing groups (outside of higher education – formal (K-12) and informal; inside of higher education – content and pedagogy experts) believe are the roles and responsibilities in climate change education for: 1) their group of educators, and 2) other groups of educators? As Stake defined it, a case study may be bounded by time or activity. Our case is bounded by the week-in-duration, voluntary summer Climate Literacy Academy and an activity, a written reflection of participants' perceptions of roles and responsibilities for climate change education.

During the Academy, participants engaged in a writing activity that asked them to reveal their perceptions of their own and others' roles and responsibilities (and what actions these might involve) for climate change education. We customized the activity for the two major subgroups of our research sample: science educators outside of higher education (formal and informal science educators), and science educators within higher education (science content specialists and science pedagogy experts). See Figure 1 for an overview of the participant groups and subgroups.

We administered our researcher-crafted instrument at the start of the Academy and at the end. Participants were given 30 minutes to write their responses to the questions (see Table 1). Responses were collected and not shared with the participants until the last morning of the Academy when the participants were presented with their original responses. At that point, they were asked to review and revise them as necessary to reflect their most current thoughts after interacting throughout the Academy with a diverse group of science educators (i.e.,in planned small group and whole group activities, as well as in informal interactions).

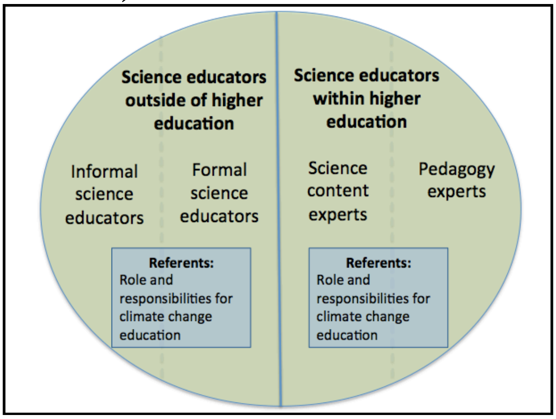

Figure 1. Science Educator Groups and Subgroups

Table 1. Questionnaire Items Relevant to the Present Study

Questions for participants representing higher education contexts (*content and pedagogy experts*)	Questions for participants representing contexts outside of higher education (informal and formal K-12 educators)
1. What are higher education science educators' (your) role and responsibilities for promoting understanding of climate change? 2. What are science educators' outside of higher education's role and responsibilities for promoting understanding climate change education	1. What are science educators' (your) role and responsibilities for promoting understanding of climate change? 2. What are scientists' unique responsibilities for promoting understanding of climate change?

We collated participants' responses by major community group (science educators outside of higher education; science educators within higher education) and then by subgroup (informal science educators or formal (K-12) science educators; content experts or pedagogy experts). We then reviewed the final version of the comments and looked for trends both within and between the groups. We found that nearly all the participants maintained their original responses. Only two participants made any changes, and in those instances, they only added slightly more details, which did not alter their original responses. Based on this result, we gained confidence in our belief that the participants' perceptions on this topic were deeply held ones. All responses were then word processed, with any post-administered revisions noted. We used a delimited written discourse analysis (see, McGinnis, 2003) to analyze our data to detect patterns of responses that would lead us to insights (Huberman & Miles, 1994; Merriam, 2009).A delimited discourse analysis focuses on making sense of respondents' thinking by examining their written communication, concerning only a selected topics of interest. Since the delimited discourse analysis methodology is in its early stage of development it remains uncertain as to which data interpretative methods or strategies offer more or different insight than others. For this reason, we decided to be expansive in how we analyzed the data from differing subgroups in our community. As a means to address issues of trustworthiness, reliability, and bias, we engaged in the following procedures: checking for rival (counter or negative) explanations, maintaining a chain of evidence researcher negotiation, and researcher negotiation (Yin, 2009).

ANALYSIS AND INSIGHTS

We believe our data analysis was appropriate for our exploratory study in this early stage area of research(i.e., delimited written discourse methodology),which remains open for experimentation. For our purposes, this approach was coherent, complete, and aligned with the research question investigating the potential diffusion of responsibility in climate change education (Rushton et al., 2014).

The analysis was undertaken on the collation of each subgroup's responses to the two relevant questions. Trends of individuals' responses within each of the four subgroups, and the main two groups (see Figure 1),led us to compile insights. For the first phase of our analysis of the data, we conducted analyses of each of the separate data sets by subgroups in the community. In each we examined the data differently to see if we could make meaning of the data. For the second phase of our analysis, we looked across the subgroups' data for insights.

PHASE ONE ANALYSIS

During this phase, we examined the data from each subgroup of science educators participating in the Academy: science educators outside of higher education (informal science educators, formal (K-12) science educators) and science educators within higher education (content experts and pedagogy experts). We present our strategies for examining the data for each of these groups, as well as initial insights from the data. Group: Science educators outside of higher education**.** For this group, we began by examining the informal science educators' responses to the instrument. In this analysis strategy of the data, patterns emerged from multiple readings.

Subgroup: Informal science educators. For the question "What are science educators' outside of higher education's (your) role responsibilities for promoting understanding of climate change?", we noted that participants considered the question at various levels. We labeled these emergent levels as: (a) personal, (b) pedagogical, and (c) institutional. Personally, informal science educators believed it was their responsibility to educate themselves about climate change, and be aware of and able to access a variety of climate change education resources. Pedagogically, this group emphasized communicating climate science content in ways that learners and the public could understand; communicating the importance of understanding climate change; engaging students in active learning related to climate change; educating students and the public about where to find reliable resources for continued learning about climate change; and portraying climate change as a science topic still being investigated (i.e. "science in the making" (Kolsto, 2001). Institutionally, informal science educators believed it was their responsibility to integrate climate change into existing curricula (e.g., programs already being taught at their informal science education sites).

For the question "What are scientists' unique responsibilities for promoting understanding of climate change?", we noted four broad themes in the informal science educators' responses. First, they perceived scientists as responsible for communicating scientific information to the public by: sharing the results of current scientific studies; using accessible language understandable to those outside of the scientific community, presenting climate change in ways that are relatable to people's lives; and presenting findings objectively, in a non-confrontational manner. Second, they viewed scientists as responsible for collaborating with science educators and science communicators to develop clear messages about climate change, and in some cases, co-develop teaching and learning resources. Third, some of the informal science educators saw scientists are responsible for educating students and the public about climate change. Finally, the believed scientists were responsible for promoting scientifically informed citizenship by helping citizens understand, and possibly take action, related to climate change.

Subgroup: Formal (K-12) science educators. We also examined formal (K-12) science educators' perspectives regarding climate change education roles and responsibilities. For this analysis, we decided to create an inventory of the frequencies of common terms that the participants included in their responses (see Table 2). Through this process, we interpreted that many of the formal science education teachers saw themselves using the data produced by scientists to *inform* students and their decision-making.

A theme that emerged from this group's responses was the view that teachers should present the data (from the scientists) and teach the students how to analyze and interpret the data objectively, so that their students could make up their own minds. That it is, the scientist was the source, the student was the consumer, and the teacher was in the middle. However, we also noted that while this was a common perspective, a few of the K-12 formal science teachers stated different ideas. For example, one K-12 formal science teacher stated,

> It is my role to teach science as science. Climate science should be data driven through experimentation & allow students to make their own conclusions. They should compare & communicate results with the scientific community….Scientists must keep information regarding current and as unbiased as possible. All evidence supporting hypotheses should be accessible and transparent. (Formal (K-12) Science Educator12)

Table 2: Key Terms from K-12 Science Educators' Responses to the Instrument

Term	Frequency in K-12 science educators' responses
Data	12
Informed	7
Citizen	6
Communicate	5
Impact	5
Greenhouse	3
Lives	3
Curriculum	3
Literacy/literate	3
Steward	2
Materials	2
Classroom	2
NGSS	2
Political, politics	2

In this rival example, the K-12 science educator saw the students, not the scientists, as the generator of data through experimentation. Additionally, scientists were not placed in the role of passing down their findings, but rather in the role of supplying additional data for the students to analyze and evaluate on their own, in order to draw their own conclusions.

Group 2. Science educators within higher education.To analyze the perspectives of science educators within higher education (content and pedagogy experts), we looked for patterns of how this group of participants viewed their roles and responsibilities for climate change education.

Subgroup: Science content experts. A review of the data from the small sample suggested that the content experts thought that their primary roles and responsibilities were to deliver to learners (in higher education and in community settings) evidenced-based scientific information in a way that others could model teaching the topic. As one scientist stated,

> It is important to be a role model for best practices and provide information that will inform decision makers. We also help train the next generation of citizens to be critical thinkers and to interpret information and understand the consequences of their choices. (Scientist2).

We also examined how the higher education content experts viewed the role and responsibilities of science educators outside of higher education (informal and formal (K-12) science educators). A review of the data from the small sample suggested that this group emphasized that in order for the country's citizenry to be accurately informed, it was essential for science educators outside of higher education (informal and K-12) to teach the topic of climate change to their students. They also emphasized the importance of being careful to teach about climate change in an effective manner. They suggested, for example, that the purpose of scientific information was to be prepared to make informed decisions, and that good teaching required the teacher to make the topic relevant to learners' lives. As stated by one content expert,

> More importantly K-12 science educators should provide basic background information as best as they can, focus on and understand local issues, and help kids associated with the [illegible] issues to effectively teach climate change (Scientist 2).

Subgroup: Science education pedagogy experts. A review of the data from the small sample of higher education pedagogy experts suggested that these participants thought that their primary roles and responsibilities were twofold. First, they believed they should teach accurate science content knowledge as delimited by the science standards, and second, they believed they should teach effective pedagogy (theory and methods) for this topic. As one science methods instructor stated,

> Our roles and responsibilities include working with formal and informal educators to incorporate climate change into their teaching in a thoughtful way that encourages learners to understand its complexities and to appreciate how climate science knowledge has been constructed. Also, it is important to promote climate change teaching that is relevant to learners lived experiences as a way to motivate learners to want to learn more about climate change. Our responsibilities also include producing original research concerning learner thinking, learner motivation, curriculum, instruction, assessment, and other aspects related to climate change education (Pedagogy expert1).

Regarding the question of the roles and responsibilities of science educators outside of higher education (informal and K-12), the pedagogy experts responded similarly to the content experts. They expressed the view that teaching about climate change in K-12 and informal science education settings is crucial for developing scientifically-informed citizens who are able to make informed decisions about climate change. Likewise, they emphasized the important role that educators outside of higher education can play in presenting climate change to learners in ways that are relevant to their lives.

A few alternatives to this general view also emerged amongst the higher education pedagogy experts. One pedagogy expert emphasized the importance of climate change education for examining how scientific knowledge was formed, and how to use such knowledge to take action.

> Once learners are motivated and see climate change as relevant to their lives, educators should help learners explore the complexities of climate change, including an understanding of the way that climate change science knowledge has been constructed. K-12 science educators also have a responsibility to help learners make decisions about how to act on their understanding of climate change (e.g., participating in recycling programs) (Pedagogy expert2).

PHASE TWO ANALYSIS

In the next phase of our data analysis, we examined, in totality, the patterns of responses we identified in our phase one analysis while placing attention on the two main groups of science educators (i.e., inside higher education and outside higher education). Two key insights emerged upon researcher negotiation when we compared the two subgroups that constituted each major group.

First, the science educators within higher education(content and pedagogy experts) evidenced more similarity in how they viewed the roles and responsibilities for science educators outside of higher education (i.e. for others) than for themselves. That is, the content experts thought that their primary roles and responsibilities were to deliver evidenced-based scientific informationin a way that could usefully model how to teach the topic. Pedagogy experts differed by thinking that their primary roles and responsibilities were to teach science content knowledge in a pedagogical manner as presented in the science education standards. For other groups of science educators outside of higher education (informal and formal (K-12) science educators), the higher education content and pedagogy experts emphasized the essential need for these educators to teach the topic if the country's citizenry were to become accurately informed. The content and pedagogy experts also emphasized that it is crucial for K-12 and informal science educators to teach about climate change in an effective manner (e.g., the purpose of scientific information is to be prepared to make informed decisions, and good teaching requires the teacher to make the topic relevant to learners' lives).

Our second insight was that for the formal K-12 science educators, a theme that emerged was that they believed that they should present climate change data (from scientists) and teach students how to analyze and interpret the data objectively, so that their students could make up their own minds. That is, they projected the belief that the scientist is the source, the student is the consumer, and the teacher is in the middle. In contrast,for the informal science educators (outside of higher education)a theme that emerged was their high concern for science communication. They believed that the most current, evidence-based information from the science community is valuable. They emphasized the importance of informal science educators to communicate information that is understandable to the general public by avoiding use of technical language and in ways that help people see the relevance of science to their everyday lives.

CONCLUSIONS

Within this discussion, we believe attention is warranted withregard to diffusion of responsibility (Banyard, Plante, & Moynihan, 2004). As suggested by our findings, a possibility is that science educators may assume others in the field are teaching learners what they need to know about climate change, whilein fact, no group of science educators is taking on that responsibility.

Our insights do not refute theoretical constructs, since diversity of perspectives by subgroups in a speech community is an accepted norm. However, we believe our insights add to foundational studies on the perceptions of climate change education by science educators. Specifically, our findings acknowledge and recognize the diversity of subgroups in the science educators' community as a way to lessen the complexity of delivering effective professional development to science educators. As a result, we believe our exploratory study may offer to interested readers new considerations in two areas:(i) use of a research methodology to identify and compare perspectives in select topics of interest held by diverse groups in a professional development community, and(ii) designing and implementing professional development in climate change education for a diverse science education community. A key implication of our study is that the findings from our study may assist professional development leaders to promote a common instructional vision for professional development(City, Elmore, Fairman, & Teitel, 2009). We believe this has the potential to decrease the development of a diffusion of responsibility in climate change education.

Strategies to employ in professional development might include providing opportunity for the differing groups in the community of participants to share with each other and with other groups their views of their roles and responsibilities (and what actions these might involve). Another suggested strategy was the potential value of including in professional development information on effective science communication among science educators, with learners, and with the general public. Finally, our study suggests the potential value of professional development that includes discussion of actions that individuals could consider taking (personal and societal) in response to their understanding of climate change.

LIMITATIONS

In our study, participants were given ample opportunity (both at the beginning and the end of the Academy) to express their perspectives on a topic that typically does not come up in casual conversation among professional science educators. However, they were not given opportunity to hear how others responded to the questionnaire on the items of interest to this study. Such an opportunity would have provided more interaction of the participants on the topic. It was possible, too, but unlikely, since this particular sample was literate and skilled in written expression, that individual interviews rather than the paper-and-pencil instrument would have resulted in richer data collection from the participants. We also acknowledged that a number of potential rival interpretations of the data might be possible. However, we reduced this outcome by appeal to evidence-based methodology and to researcher negotiation in which we came to consensus of our interpretations.

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