Piloting and Evaluating a Workshop to Teach Georgia Teachers About Weather Science and Safety

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ABSTRACT

A survey of 691 Georgia teachers suggested that their students generally were not prepared for severe weather. Teachers also were somewhat dissatisfied with the quality of the teaching resources on weather and weather safety. Only 46 (7%) of the teachers were aware of the American Red Cross Masters of Disaster (MoD) weather science and safety curriculum. We conducted a weeklong weather science and safety workshop for 49 Georgia teachers in the summers of 2008–2010 to introduce the MoD curriculum so that they could teach it to their students and share it with colleagues. Qualitative analyses of the teachers' and the authors' workshop goals revealed that teachers became more knowledgeable about weather science and safety and learned how to teach the MoD curriculum. Quantitative analyses of the teachers' pre- and postworkshop responses to the project measures revealed statistically significant increases at the workshop's conclusion in science teaching self-efficacy and in self-efficacy to teach weather science and safety. Teachers also evidenced statistically significant gains in their knowledge of weather science and safety concepts. A follow-up with teachers from the 2008 workshop revealed that they had shared the MoD curriculum with 77 teachers and had taught the curriculum to 724 students. We discussed the potential of the MoD curriculum to increase students' knowledge and preparation for weather hazards. In the supplemental materials, we provided a sample MoD lesson and alignments of the MoD curriculum with the Next Generation Science Standards. © *2015 National Association of Geoscience Teachers*. [DOI: 10.5408/14-069.1]

Key words: American Red Cross, geoscience education, Masters of Disaster, professional development, weather safety, weather science

INTRODUCTION

Background and Motivation

Our motivation for infusing weather science and safety content into the K–8 grades arose following the devastating impacts of Hurricane Katrina in 2005. The landfall of this major hurricane resulted in at least 1,987 deaths and property damages and losses that exceeded $108 billion (Knabb et al., 2011). The authors were impressed by the breadth and depth of Katrina's impacts upon society. People who either weathered the storm in place or who returned from evacuation shelters to witness the complete devastation echoed a recurrent theme: "I've never seen anything like this before, and I couldn't imagine it beforehand." The hurricane disrupted the beginning of the school year—from kindergarten through the college and university levels. Even in areas without major damage to school campuses, the loss of power, water, and other infrastructure necessary to operate schools meant that large numbers of K–12 students were unable to benefit from the stabilizing influences that accompany a structured school day and from the opportunities to give and receive social and emotional support from classmates.

More generally, a range of weather phenomena are responsible for deaths and damage in the United States. For example, preliminary 2014 statistics released by the National Weather Service (http://www.nws.noaa.gov/om/hazstats.shtml) revealed that from 2004–2013, an average of 109 Americans were killed annually by tornadoes, with 108 fatalities annually due to hurricanes, 75 due to flooding, and 33 due to lightning. The damage and losses from all weather hazards in the U.S., including heat, cold, and wind, as well as those mentioned previously, averaged more than $26 billion annually over this same period (http://www.nws.noaa.gov/om/hazstats/resources/weather_fatalities.pdf). These statistics suggested that for every Katrina that catches an entire region unprepared, there are numerous other weather events that surprise and disrupt lives on a smaller scale every year.

The weather therefore poses regular challenges to human health, safety, and daily functioning. Such challenges underscore the importance of educating K–12 students about weather science and safety. To some extent, the ever-present and universal elements of the weather make it tempting to assume that children will learn how to cope with weather conditions and to prepare for severe or extreme weather as part of building a general repertoire of life skills. We take exception to this assumption. A basic, systemic, and long-term effort is required to create a culture of weather safety among children and adults. The consensus from existing studies of responses to natural hazards suggests that providing education about the science, risks, and safety behaviors associated with such hazards is key in raising people's awareness levels and in effecting adaptive changes in their responses when hazards threaten (Liu et al., 1996; Balluz et al., 2000; Brown et al., 2002; Blanchard-Boehm and Cook, 2004). We believe, on the basis of our professional experience and conducting of the workshops described in this article, that both children and adults can benefit from an integrated curricular treatment of weather science and safety. The American Red Cross Masters of Disaster (MoD)

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curriculum, developed for the K–8 grades, integrates weather science with weather safety and was the focus of our research.

We pursued three goals in our work to share the MoD curriculum with teachers in Georgia:

1. To gain a better understanding of the extent to which K–8 teachers in Georgia believe that their students are sufficiently knowledgeable and prepared to deal with routine and severe weather.
2. To examine teachers' perceptions about the existing curricular resources that they could use to teach their students about weather science and safety.
3. To increase teachers' knowledge about weather science and safety through the introduction of the American Red Cross MoD curriculum in a weeklong professional development workshop. Related to this, we wanted the teachers' exposure to the MoD curriculum via our workshop to increase their sense of self-efficacy in teaching their K–8 students about weather science and safety.

We describe our pursuit of these project goals in the sections that follow, beginning with a review of existing weather-related educational resources for teachers. We then present the results of a needs assessment for our workshop, based upon a sample of teachers in Georgia. Following the needs assessment, we describe our weather science and safety workshop model and present data to evaluate both the teachers' extent of learning and benefit from the workshop immediately after its conclusion and, for the 2008 cohort of participants, the medium-term outcomes and effects of participating in the workshop.

Existing Instructional Materials and Activities

Given the ubiquity of the weather and the opportunities people have to experience many types of weather, both daily and seasonally, it was somewhat surprising to find that few systemic curricular resources exist for helping students learn about the weather, especially how to stay safe during severe weather. The American Meteorological Society (AMS) has developed Project Atmosphere to help teachers learn about the physical science of weather (Ginger et al., 1996). Project Atmosphere focuses upon teacher enhancement and professional development. This curriculum, perhaps the first of its kind, has benefitted many teachers who have used it. Similarly, the AMS DataStreme Atmosphere project aims to train weather education resource teachers so that they can assist teachers in local schools to incorporate further weather and climate-related instruction for students (http://www.ametsoc.org/amsedu/). These AMS resources provide thorough and scientifically current resources for instructing students about weather science. They place less emphasis on weather safety, however. More recently, Dupigny-Giroux et al. (2012) have developed the Satellites, Weather and Climate (SWAC) program for providing professional development instruction to K–12 teachers in Vermont. The summer workshops and supplemental contact that the workshop faculty has had with teachers throughout the year were intended to increase their competency in conveying basic atmospheric science concepts to students.

Other resources and materials focus on observing various parts of the atmosphere. For example, the Global Learning and Observations to Benefit the Environment (GLOBE) project relies upon a learning-by-doing approach to help students learn how to observe the natural world and to take precision measurements of atmospheric variables (http://www.globe.gov; Butler and MacGregor, 2003). The Students' Cloud Observations On-Line project was created, in part, through the National Aeronautics and Space Administration (NASA) and involves the real-time reporting of cloud conditions by students. Such observations help NASA scientists to verify the cloud retrieval and processing algorithms of weather satellites (https://scool.larc.nasa.gov/; Chambers et al., 2003). Finally, the Oklahoma Climatological Survey, with its dense mesonet of automated weather stations in that state, has developed the EarthStorm project to allow the use of real-time data in K–12 classrooms (https://www.mesonet.org/index.php/earthstorm; McPherson and Crawford, 1996). Teachers also may draw upon the rich variety of atmospheric science online topics that are offered through the Cooperative Program for Operational Meteorology, Education, and Training program through the University Corporation for Atmospheric Research (https://www.meted.ucar.edu/; Jackson and Carr, 1995).

The existing resources cited here all share the characteristic of being designed to supplement or enhance teachers' knowledge of atmospheric science concepts and their use of the data products available from different state or federal agencies in the United States. Similarly, none of the resources reviewed here is intended to function as a standalone curriculum, either for the purpose of training teachers or for teachers to use in providing weather and climate-related instruction to their K–12 students. Invariably, the resources that these interesting and valuable programs offer are more well suited to be integrated into the curricular framework that teachers already are using (i.e., adopted textbooks for Earth Science) or to be supplemental inquiry-based activities that may help to meet performance standards. In this regard, no information could be found that showed the alignments of the different programs or projects with state educational standards, with the exception of the SWAC project (Dupigny-Giroux et al., 2012). Finally, and perhaps most significantly, none of these resources provided significant coverage of safety concepts when faced with routine or severe weather events. These programs primarily emphasized science rather than the use of what is known about routine or severe weather to prevent property losses or to ensure personal safety. Associating science with its use for preparation and safety purposes is essential in creating a weather-ready nation, which is a recent initiative of the National Weather Service to help communities and individuals prepare and respond effectively to severe and extreme weather (Lindell and Brooks, 2013; http://www.nws.noaa.gov/com/weatherreadynation/). Given the availability of the aforementioned resources and the MoD curriculum, we were interested in assessing teachers' needs and perceptions of materials for instructing their students about weather, especially severe weather.

Georgia Teachers' Needs for Weather Science and Safety Curriculum Materials

We explored the extent to which Georgia teachers were satisfied with the existing weather science and safety curricular materials and whether the teachers were familiar with the MoD (at least the earlier versions of it). In fall 2007,

TABLE I: Demographic statistics for needs assessment and workshop participants.

Variable	Respondents to Needs Assessment (n = 691)		Workshop Participants (n = 49)	
	n	%[1]	n	%[1]
Gender				
Women	539	78	42	86
Men	152	22	7	14
Grade levels taught				
K–2	98	14	7	14
3–5	192	28	24	49
6–8	198	29	16	33
9–12	197	29	2	4
Subjects taught				
Science	352	51	40	82
Language arts	290	42	26	53
Math	288	42	28	57
History	262	38	23	47
Reading	249	36	24	49
Health	138	20	3	6

[1]Because the needs assessment respondents and workshop participants typically taught multiple subjects, the percentages do not sum to 100%.

we conducted an online survey of 691 teachers in Georgia using the Weather Safety Education Questionnaire (WSEQ), which the authors created for this purpose. This online study was reviewed and approved by the University of Georgia Institutional Review Board (IRB). The authors used publicly available e-mail addresses from the Georgia Department of Education (DoE) and county school districts to invite teachers throughout the state to complete the survey. The authors used the Statistical Analysis System (SAS), version 9, statistical software to conduct the analyses for this article (SAS Institute, 2004). The authors used t-tests of independent means to examine whether groups of teachers (e.g., those who were providing science instruction compared to those who were not) differed on variables of interest. SAS was used to evaluate the distributional and variance homogeneity assumptions of the t-test. When group variances and sample sizes differed, the Welch-Satterthwaite t-test was used.

Demographic statistics for the respondents are provided in Table I. The responding teachers reported a mean (M) of 13.7 y and a standard deviation (SD) of 9.1 y of work experience. Beyond the demographic items, the remaining WSEQ items and a summary of the teachers' responses to them appear in Table II. The teachers indicated that their students generally were not prepared for severe or extreme weather (M = 43% prepared or M = 57% unprepared). Those who taught science (either exclusively or with other academic subjects) provided significantly lower estimates of student preparedness for severe weather than did teachers who taught subjects that did not include science, t (688) = 3.39, $p < 0.0001$ (Table II).

Teachers reported spending a mean of 9.5 h/y teaching their students about weather and climate concepts. Teachers who provided science instruction reported that they spent more time teaching students about weather than did those whose teaching load did not include science, t (661) = 7.70, $p < 0.0001$. The teachers indicated a mean of 4.3 h were devoted to weather safety education. Again, respondents whose teaching loads included science spent more time on weather safety than did teachers who did not provide science instruction, t (587) = 3.38, $p = 0.001$. In using a 1 (not important at all) to 5 (maximally important) rating scale, teachers reported that it was very important to them to teach their students about weather safety. The respondents whose teaching involved science placed slightly but significantly greater importance on weather safety compared to their colleagues who did not provide science instruction, t (668) = 3.72, $p < 0.0001$ (Table II).

We asked teachers to use a 5-point rating scale (1 = very dissatisfied to 5 = very satisfied) to evaluate their satisfaction with weather-related teaching resources. Overall, teachers were somewhat dissatisfied to neutral regarding the quality of the teaching resources on weather and climate in general and with teaching resources regarding weather safety. As shown in Table II, those who taught science were significantly more dissatisfied with resources for teaching students about weather safety compared to teachers of other academic subjects, t (667) = 2.71, $p = 0.007$.

Despite its availability since 2001, only 46 (7%) of the 691 Georgia teachers were aware that the MoD curriculum existed; more than half of those who were aware of the MoD curriculum were teachers who provided science instruction. Of the teachers who knew that the MoD curriculum existed, most indicated they had no or only slight familiarity with the curriculum. Consequently, it is not surprising that only 2% of the teachers had taught one or more lessons from the MoD curriculum within the past academic year. Approximately 72% of the survey respondents were interested in learning how they could obtain a copy of the MoD curriculum materials. Furthermore, 157 (23%) of 691 Georgia teachers were interested in attending a professional development workshop on the MoD curriculum and in disseminating and promoting the curriculum to their fellow teachers.

TABLE II: Descriptive statistics for items from the WSEQ.

WSEQ Item	Respondents to Needs Assessment (n = 691)						Workshop Participants (n = 49)	
	Teachers of Nonscience Subjects (n = 354)		Teachers Whose Subjects Included Science (n = 337)[1]		All Teachers (n = 691)			
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
What proportion of your students would you estimate are adequately prepared to deal with hazardous weather events at this time?	47.0%[2]	32.6	38.9%[2]	30.2	43.1%[3]	31.7	21.5%[3]	23.2
How many hours would you estimate that you spend during the school calendar year in teaching your students about weather concepts in general?	5.6 h[2]	12.5	13.6 h[2]	14.7	9.5 h[3]	14.2	30.7 h[3]	44.3
How many hours would you estimate that you spend during the school calendar year in teaching your students about weather safety?	3.3 h[2]	6.6	5.4 h[2]	9.8	4.3 h	8.4	10.8 h	18.3
To what extent do you think it is important to teach your students about weather safety? (1 = not important, 5 = maximally important)	3.7[2]	0.8	3.9[2]	0.6	3.8[3]	0.7	4.3[3]	0.6
How satisfied are you with the current educational resources that are available for your use in teaching students about weather concepts in general? (1 = very dissatisfied, 5 = very satisfied)	2.9	0.8	2.9	0.9	2.9	0.8	2.5	0.9
How satisfied are you with the current educational resources that are available for your use in teaching students about weather safety? (1 = very dissatisfied, 5 = very satisfied)	2.8	0.8	2.7	0.9	2.7[3]	0.8	2.3[3]	0.8

[1]These are teachers who indicated that, among other subjects they taught, they also taught science. This number (337) includes 88 teachers who indicated that they only taught science and no other subjects. The statistics in this table thus represent a mix of classroom formats in which some teachers provided instruction in self-contained classrooms, whereas other taught a single subject (e.g., science).
[2]Differences in mean values for those who provided science instruction (n = 337) and those who did no (n = 354) were assessed with t-tests, correcting for unequal group variances. To control from Type I error, we employed the Bonferroni correction (0.05/6 = 0.0083) in evaluating the significance of the statistical tests. Means marked with the superscript were significantly different.
[3]Differences in mean values for all teachers who participated in the online needs assessment survey (N = 691) and teachers who participated in the workshop (N = 49) were assessed with t-tests, again using corrections for unequal group variances and the Bonferroni correction. Means marked with the superscript were significant different.

The Curriculum—The American Red Cross MoD

Background

Our project focused upon the American Red Cross MoD curriculum. Work to develop the initial version of the MoD curriculum began in 1999 after the Red Cross discovered that a comprehensive K–8 curriculum on the science and safety of natural hazards did not exist. A number of state and federal agencies and private organizations provided technical support, feedback, and review of the curriculum (e.g., NOAA/National Weather Service, NOAA/National Severe Storms Laboratory, The Weather Channel, and U.S. Geological Survey). The MoD curriculum was pilot tested, disseminated, and then reviewed and revised in 2007.

The MoD curriculum consists of a series of ready-to-go lesson plans for grades K–2, 3–5, and 6–8. The major content of the MoD curriculum includes preparing for any disaster with Be Disaster Safe; coping with tough issues like terrorism, war, and pandemic flu with Facing Fear; recovering and rebuilding from any disaster with In the Aftermath; preventing injuries that happen at home with Home Safety; and keeping safe from fire with Fire Prevention and Safety. The principal content we used in our workshops included the four weather science and safety modules—Hurricanes, Floods, Lightning, and Tornadoes—and focused upon these as meeting the performance standards in Georgia.

The revised curriculum package is approximately the size of a portfolio folder. The kits contain the lessons, teaching guides, activity sheets, and other consumable materials on a CD. Lesson-related videos are contained on a DVD. In addition, Spanish-language materials have been included in the revision. The educator version of the MoD kit costs $30.80 at the time of this writing. A home-schooling–based MoD kit for families can be purchased for $24.00. The kits are available for order through local American Red Cross chapter offices (http://www.redcross.org/find-your-local-chapter).

MoD Curriculum Features

Each module (i.e., Hurricanes, Floods, Lightning, or Tornadoes) consists of an average of three to four lessons made up of activities that each can be completed within approximately 20–45 min. In a typical module, approximately two lessons are dedicated to helping students learn about the science of the weather hazard while the remaining lessons are devoted to associated preparations and safety practices. The lessons within each module are designed to be used separately or together, as required by time or curricular guidelines. In our experience, most teachers devoted 1–2 weeks to the curriculum.

Each MoD lesson has been designed using an inquiry-based approach, because this is one of the most effective means of helping to increase students' knowledge (i.e., learn by doing, National Research Council, 2007; National Science Teachers Association, 2007). In this regard, each lesson has at least one activity that students can perform, working individually or in groups, to achieve the lesson objectives to learn about some aspect of weather science or safety. The lessons are organized with a uniform format that consists of key terms and concepts, lesson purposes and objectives, activities, wrap-up, and linking across the curriculum. The latter two components (wrap-up and linking across the curriculum) are designed to consolidate and review students' learning by fostering discussions of the main points of the lesson and by linking aspects of the lesson to other academic subjects such as math, language arts, and communication. In addition, each lesson plan has a Home Connection activity that gets safety and preparedness information into students' homes and an assessment component that helps teachers assess students' learning through activities and/or discussions. We provide a sample lesson, taken from the grade 3–5 MoD curriculum (reproduced with permission of the American Red Cross), of the hydrologic cycle in the supplemental materials of this article (available online at http://dx.doi.org/10.5408/14-069s1).

Content Limitations of the MoD Curriculum

Although the MoD curriculum provides comprehensive coverage of the science and safety concepts for lightning, tornadoes, hurricanes, and floods, it does not cover other aspects of atmospheric science, such as air masses, fronts, or weather forecasting. Basic observational concepts are conveyed in the lessons; however, coverage of radar and satellite technologies and their role in the global observing and forecasting system are not emphasized. In addition, the MoD curriculum does not provide instruction on aspects of the climate that are necessary for developing climate literacy.

Alignment With Performance Standards

An essential feature for our project concerned the extent to which the MoD modules met the Georgia Performance Standards for Science (GPSS). In preparing our Teacher Quality–funded workshops in 2008 and 2009, we established the extent to which the MoD Hurricane, Flood, Lightning, and Tornadoes modules met and aligned with the GPSS. We demonstrated these curriculum alignments to the Georgia DoE, which then reviewed the curriculum. We obtained a letter of support from the director of science at the Georgia DoE. Thus, the use of the MoD curriculum in this project was consistent with and supportive of the school districts' mission to meet the GPSS. Table S1 in the supplemental materials for this article (available online at http://dx.doi.org/10.5408/14-069s2) provides the alignments of these MoD lessons with the Next Generation Science Standards. Table S2 (available online at http://dx.doi.org/10.5408/14-069s2) illustrates the ways in which the MoD lesson that we emphasized (Lightning, Floods, Hurricanes, and Tornadoes) met the GPSS in the strict sense of satisfying one or more content standards and one or more characteristics of science standards.

Workshop Design, Organization, and Goals

We designed our workshop to be responsive to what is known about best practices for teacher professional development (Garet et al., 2001; American Federation of Teachers, 2002; Borko, 2004; American Educational Research Association, 2005; Ingvarson et al., 2005; National Research Council, 2007; Darling-Hammond and Richardson, 2009). The main design features included (1) helping teachers understand how the MoD curriculum met the GPSS; (2) building teachers' knowledge of weather science and safety concepts as these are contained within the MoD; (3) active learning about the MoD lessons through discussion, demonstration, and performance of lesson plans in the curriculum (Crawford, 2000); (4) discussing how to adapt and to use the curriculum with their particular students; (5) building a sense of teaching self-efficacy and commitment to the curriculum by learning about the MoD curriculum with teachers in their school district and the local area; and (6) following up with teachers during the subsequent academic year to address questions that they may have and challenges that they experienced or to learn about what aspects of the curriculum worked particular well for them.

Science teaching self-efficacy played an important role in our project. It is related to how much teachers take professional development experiences from the workshop and use them their classrooms (Puchner and Taylor, 2006; Mintzes et al., 2013) . Learning new concepts and skills is one professional development component that can enhance teaching self-efficacy. Perhaps more important is the opportunity to practice and enact what one has learned in a supportive environment so that the new learning (here, about weather science and safety concepts) can become a more enduring part of the teachers' geoscience repertoire. Thus, throughout the workshop and afterward, we were interested in increasing teachers' beliefs that (1) weather science and safety concepts can be taught in general and (2) they can teach their students about weather science and safety.

Our workshop design, along with the results of our survey of Georgia teachers, helped us to formulate specific goals for our workshop. These goals were as follows:

1. Educate science teachers about the needs and benefits for providing safety education for weather and other natural hazards.
2. Teach science teachers about the American Red Cross MoD curriculum and how it can be used in their classrooms.
3. Build teacher commitment to the use the MoD curriculum in their classrooms and to the promotion of its use by colleagues.

We organized the workshop to be responsive to these goals. One of the first decisions we had to make was about the length of the workshop training, given the amount of material that we thought necessary to cover so that the teachers would become familiar with the MoD curriculum. We wanted the teachers to have enough exposure to the curriculum to increase their knowledge. We also wanted the teachers to have the opportunity to prepare a lesson with the MoD materials so that they would be able to integrate the practical aspects of the curriculum into their teaching, consistent with a lesson study approach (Lewis, 2002; Puchner and Taylor, 2006). These considerations suggested to us that a weeklong workshop would provide the most suitable time frame. Teachers would obtain 40 h of in-workshop instructional time. In addition to the activities of the workshop week, teachers completed an online orientation task to the MoD curriculum and the workshop ahead of time. Postworkshop follow-up conference calls also occurred during the following school year, which gave a total workshop time frame of approximately 50 h. Such a scope and format is common in teacher quality workshops (Ingvarson et al., 2005) . The postworkshop conference calls were especially important in helping us to further teachers' interests and efforts to use the curriculum during the subsequent school year and are a recognized best practice in teacher professional development (Darling-Hammond and Richardson, 2009). Because of the local school calendars in Georgia, we offered the workshop during the last 2 weeks in May.

The workshop training schedule is provided in Table S3 of the supplemental materials for this article (available online at http://dx.doi.org/10.5408/14-069s2) and provides a description of the way that we structured the 40 h of workshop time. We found that the participants were the most engaged in the workshop (i.e., asked questions, engaged in discussions, and shared teaching ideas with other participants) when we interspersed presentations about the science or safety aspects of the MoD curriculum with opportunities for the teachers to experience the curriculum through demonstrations, much in the same manner that their students would when they delivered various MoD lessons. This provided teachers with a change of pace and helped them to see how the hands-on, inquiry-based activities about weather could be performed. Anecdotal comments from the workshop evaluation form, especially for the 2009 and 2010 workshops, suggested that the participants liked and benefitted from a variety of activities and presentation formats (e.g., listening to, watching, and trying or doing various weather science and safety activities). These demonstrations and activities also facilitated informal discussions about ways that the curriculum activities could be supplemented or modified for their own classrooms and students. We scheduled a field trip on the fourth day of the workshop to help teachers learn more about weather data gathering, forecasting, and information dissemination, primarily because issues of weather forecasting are not emphasized in the MoD curriculum as much as the science of the hazardous weather in each module. Finally, we devoted the last day of the workshop to lesson study in which teachers would prepare and deliver, often working with teachers of the same grade level, a MoD lesson that they would use in the upcoming school year.

METHODS

Before the conduct of the workshops, the authors obtained the approval of the University of Georgia (IRB) to conduct the workshop-related assessments on the participating teachers. We conducted three Weather Science and Safety Workshops from 2008–2010 with 49 teachers in Georgia. We evaluated teachers at the beginning and at the conclusion of the workshop to assess the extent to which we had achieved the workshop goals. In addition, we conducted a longer-term follow-up with the 2008 workshop participants.

Workshop Recruitment

The workshop recruitment occurred between the months of January through May in 2008–2010. The recruitment of participants from the county school districts surrounding Athens-Clarke County occurred via e-mails to the district's professional development coordinators, superintendents, and assistant superintendents. In some cases, hard copies of the workshop announcement and application form were distributed to principals of local school districts. Recruitment for the first 2 y included e-mails to teachers who had responded to our needs assessment survey and who indicated interest in the workshop. To reach a geographically broader pool of potential participants, the workshop was announced through the e-mail list of the Georgia Science Teachers Association in 2009 and 2010. In addition, we set up a booth to display the MoD curriculum and the workshop during the daylong WeatherFest for science educators that occurred as part of the annual meeting of the AMS in Atlanta in 2010.

The workshop application asked potential attendees to describe the reasons for and basis of their interest in the workshop, what they hoped to learn by attending, and how they anticipated using the curriculum materials in their teaching. The application also emphasized that teachers would be expected to be adopters of the MoD curriculum and to function, to the extent possible within their schools, as ambassadors to get their colleagues to at least examine the curriculum and ideally teach lessons from it.

Participants

The workshop participants were 49 teachers who attended the weeklong Weather Science and Safety Workshop on the campus of the University of Georgia. The workshop enrollment varied from 14 participants in 2008 to 20 in 2010. Within each workshop year, approximately 60% of the attendees were Caucasian American and 40% were

African American, Asian American, and Hispanic American. The teachers represented 18 public school districts that were geographically dispersed within the state of Georgia. Table I provides a summary of the demographic statistics for the workshop participants. Although all participants reported that they provided science instruction, eight participants (16%) taught science exclusively in the 6–8 grade levels, whereas only two participants (4%) in grades 3–5 taught science exclusively.

Data Analysis

The data analysis for the workshop pre- and post-measures was similar to that employed for the needs assessment described earlier; the authors used SAS to complete the statistical analyses. The authors used repeated measures analyses of variance to examine whether the teachers' responses on the project measures (i.e., mean values) changed over the course of the weeklong workshop. SAS was used to evaluate the distributional and variance homogeneity assumptions of the *F*-tests.

Workshop Faculty and Materials

The workshop organizers and presenters included (1) a doctoral-level science educator, (2) a doctoral-level meteorologist with extensive experience in K–12 and postsecondary weather education (second author), (3) a doctoral-level psychologist who completed an undergraduate certificate in atmospheric science (first author), and (4) one of the designers and developers of the MoD curriculum (third author). Each organizer developed and presented lectures for the workshop based on their areas of expertise with the purpose of providing the participants with information about the MoD curriculum and ways in which their students might best learn the curriculum lessons. The faculty presentations and learning materials were designed to help the participants feel prepared to teach the subject in their classroom (i.e., to increase their knowledge and sense of efficacy in teaching science).

The participants received five copies of the MoD curriculum kits for their use and to distribute to their colleagues. We printed workshop binders for the teachers that contained the workshop schedule, alignments of the MoD curriculum with the GPSS (K–8 grades), and full printouts (made from the MoD curriculum CD) of the Lightning, Tornado, Hurricane, Flood, In the Aftermath, and Be Disaster Safe modules. The binders were specific to the teacher's reported grade level (i.e., K–2, 3–5, or 6–8).

Measures

The workshop measures were chosen to be responsive to the goals of imparting the participants with an increased knowledge base about weather science and safety and building a sense of self-efficacy in delivering instruction from the MoD curriculum to their students. At the start of the workshop, the participants were asked to complete a preworkshop assessment packet, which included questions regarding their attitudes and beliefs about the teaching of the curriculum (the WSEQ) and a set of items intended to assess workshop training goals. The participants completed a goal-attainment scaling procedure in which they articulated up to three of their own goals for the workshop and then rated the degree of importance for achieving each goal (Kiresuk et al., 1994). They also indicated the perceived importance for pursuing the three workshop goals that were part of the workshop curriculum (i.e., receiving instruction about the needs and benefits of providing weather safety education to their students, learning about the MoD curriculum and how it can be used in the classroom, and building commitment to use of the MoD curriculum and promote its use by colleagues).

The next pair of measures assessed the teacher's efficacy-related beliefs about providing instruction in science. The teachers completed the Science Teaching Efficacy Belief Instrument (STEBI, 25 items; Riggs and Enochs, 1990). The authors chose the STEBI because it has found wide use in evaluating teachers' perceptions about the outcomes and sense of efficacy in providing science instruction (e.g., Ellins et al., 2013; Thomas et al., 2013). The first author created an adaptation of the STEBI that was specific to providing instruction in weather science and safety, called the Weather Science and Safety Teaching Efficacy Inventory (WSSTEI, 20 items). The primary reason for creating the WSSTEI stems from self-efficacy being specific to particular realms of activity or endeavor rather than being a global trait that people possess (Bandura, 2006). The STEBI and the WSSTEI are based upon the social cognitive theory of Bandura (1977, 1997, 2006), in which people's beliefs about their capabilities and sense of agency in bringing about a desired outcome affect the extent to which they behave in a manner to actually produce the outcome. This choice of measures was meant to assess the participants' general science teaching efficacy (STEBI), along with the efficacy associated with conveying particular content (WSSTEI). Both of these measures assessed outcome expectations (Can a task be performed?) and efficacy expectations (Can I perform the particular teaching task?).

An example item from the STEBI designed to assess science teaching outcome expectations is "The teacher is generally responsible for the achievement of students in science." Science teaching efficacy expectations are assessed by items such as "I know the steps necessary to teach science concepts effectively" (Riggs and Enochs, 1990, 635). The content of the WSSTEI focused specifically on weather science and safety education. An example of an outcome expectancy item on the WSSTEI is "Students can learn how to respond safely when lightning occurs." An example item assessing efficacy expectations about teaching weather science is "I believe that I can teach my students the science concepts associated with hurricanes."

The scores on the STEBI range from 0–125, with higher scores indicative of greater self-efficacy in providing science instruction. The WSSTEI scores range from 0–80, with higher scores suggestive of greater self-efficacy in providing weather-related instruction. The preworkshop administrations of the STEBI ($\alpha = 0.88$) and the WSSTEI ($\alpha = 0.97$) revealed that each instrument possessed good levels of internal consistency as assessed via Cronbach's alpha.

Finally, the teachers completed a Weather Science and Safety Content Test (WSSCT) to assess their amount of available knowledge before beginning the workshop week. The WSSCT consisted of 22 multiple-choice, true–false, and short-answer items. Approximately half of the measure was devoted to weather science, while the other half assessed content pertaining to weather safety practices. The workshop faculty developed an initial pool of items (nearly 50 in all) and then placed half of the items on the WSSCT as a pretest. The other half of the items were chosen for the posttest, which was a parallel form of the WSSCT pretest measure. We constructed the WSSCT to be on par with what university students might encounter in an assessment for an introductory-level undergraduate atmospheric science course. The test was intended to be somewhat difficult so that the participants could realize that they had gaps in knowledge that the workshop would address. Examples of items from the WSSCT include "The rise of the sea preceding a storm, usually a hurricane, due to the winds of the storm is called ___________," "What is the Hands-in-Lap Rule and where is its use the most important?" "Most deaths from a hurricane are due to ___________," and "An isolated lowering base of a thunderstorm, which can be especially threatening if it is rotating, is called a ___________."

We assessed the parallel forms correlation of the pre- and posttest versions of the WSSCT in a small IRB-approved study involving 38 students who were taking an introductory course in atmospheric science. The students responded to the 44 items of each measure that we presented in an even–odd format (i.e., items from each measure were alternated successively from 1–44 items). The two forms were modestly correlated, $r = 0.53$, $p = 0.0007$. In addition, the mean proportion of correct scores (i.e., overall test difficulties) did not differ significantly across the two forms. We interpreted these results as an indication that the two forms of the WSSCT were roughly comparable.

The teachers completed a packet of measures on the last day of the workshop. Again, we used the STEBI ($\alpha = 0.86$ at posttest) and WSSTEI ($\alpha = 0.98$) to assess changes in general science teaching self-efficacy and in weather science and safety instruction. The teachers also completed the parallel version of the WSSCT to assess changes in their weather science and safety knowledge as a result of the workshop. We provided the participants with copies of the goals that they stated for themselves at the beginning of the workshop week. At posttest, the participants rated the extent to which they had achieved their own goals, along with the workshop goals. Finally, the participants completed an overall workshop evaluation form in which they rated the quality of the instructional activities, the workshop faculty, and the physical accommodations and environment.

RESULTS

Weather Safety Education

The teachers in the workshop produced some noteworthy responses to the WSEQ when compared to the sample of Georgia teachers who completed the measure as part of our needs assessment survey; see Table II for descriptive statistics and results of statistical tests. The teachers who attended the workshop believed that a much smaller percentage of students on average (M = 22%) were adequately prepared for hazardous weather compared to the larger sample of all teachers who completed the needs assessment (M = 43%); this was a statistically significant difference, as noted in Table II. The workshop participants reported spending significantly more time on weather during the academic year (M = 30.7 h) compared to teachers in the needs assessment (M = 9.5 h). The workshop teachers indicated that it was more important to teach students about weather safety (M = 4.3) than did the teachers who responded to the survey (M = 3.8); this difference was statistically significant. Finally, the workshop teachers (M = 2.3) were significantly less satisfied with curricular materials for teaching weather safety compared to the teachers in the needs assessment (M = 2.7).

Teacher and Workshop Goal Attainment

The goal attainment scaling assessment involved both workshop goals that teachers generated for themselves and three goals that the authors set for the workshop. We content coded the teachers' goals to better understand the categories of objectives the participants had for the workshop. Three people content coded each of the teachers' goals into one or more of eight categories. The consistency of the content coding was evaluated using Krippendorff's alpha (Hayes and Krippendorff, 2007). This statistic ranges from 0–1, with higher values indicating greater consistency among raters. The Krippendorff α for our content coding was 0.85, with a 95% confidence interval ranging from 0.81–0.89. The raters conferred to discuss goals for which they assigned discrepant codes. The 49 teachers expressed a total of 127 goals (M = 2.6 goals per teacher). For both the goals that the teachers specified and those that were set by the workshop authors, the teachers used a 10-point rating scale for indicating the extent to which it was important for them to achieve the goal. For this scale, 1 indicated not very important and 10 indicated very important. At the conclusion of the workshop, the teachers used a similar 10-point scale to assess the extent to which the goals had been met (1 = not met at all and 10 = met completely). Table III shows the descriptive statistics for the teachers' content-categorized goals in descending order of the frequency with which goal content was mentioned. The table also shows descriptive statistics for authors' goals for the workshop.

The teachers most frequently articulated workshop goals for themselves pertained to learning more about weather, the science of meteorology, storms, weather safety, and various kinds of weather phenomena. Related to this goal was the second most mentioned objective of improving their teaching around weather and weather-related geoscience topics. Teachers seemed to believe that by learning more about the weather, they would be more knowledgeable teachers and better able to help their students learn. The third most frequently articulated teacher goal pertained to the safety and prevention component of the workshop: helping students and their families, schools, and communities to become better prepared for severe and extreme weather. Three of the goals, mentioned somewhat less frequently than the others, pertained to pragmatic concerns at their schools: sharing their workshop experiences and materials with teachers at the schools, learning about the alignment of the MoD curriculum with the GPSS, and earning professional learning units (PLUs) for maintaining their teaching certification in Georgia.

Overall, the teachers indicated that it was very important to meet their goals at the beginning of the workshop (M = 9.4 on the 10-point scale). At the workshop's conclusion, the teachers indicated that their goals had been achieved (overall M = 9.2). The outcome was somewhat more modest for the eight teachers who had goals of finding ways to stimulate their students' interests and curiosities about the weather (M = 7.4). With respect to the authors' goals of educating teachers about weather science and safety to help them become more familiar with the MoD curriculum and to build commitment to use the curriculum in the class, the teachers agreed that these were goals that were generally very important to meet (M = 9.2 on the 10-point scale). The teachers also were in agreement that the authors' workshop goals were rather completely met (M = 9.7). We observed that the authors' goals for the workshop were perceived to be met to a significantly greater degree, statistically speaking, than were the workshop goals that the teachers developed, F (1, 39) = 10.26, p = 003. This result suggested that although the teachers perceived that their goals and those of the organizers were generally met, the organizers' goals were met to a reliably greater degree than their own.

Teaching Self-Efficacy

An enhanced sense of science (general) and weather-related instructional self-efficacy underlies a greater likelihood of using the MoD curriculum subsequently and sharing it with students and colleagues. Table IV provides descriptive statistics for the project measures and results of statistical tests assessing changes in the participants' scores on the measures from pre- to posttest. At the workshop's inception, the teachers produced a modest mean score on the STEBI (M = 78.0). This value represented about 62% of the possible maximum score and suggested that the teachers possessed moderate levels of general science teaching self-efficacy beliefs. At the workshop's conclusion, the mean value of the STEBI total score increased by approximately 5% (M = 82.9; Table IV). Although still in the moderate range of science teaching self-efficacy, the increase in total STEBI scores at the conclusion of the workshop was statistically significant. With respect to the STEBI efficacy and outcome subscales, we observed a statistically significant increase in teachers' efficacy beliefs about teaching science. Although there was a slight numerical increase in teachers' outcome expectations (that their students could learn from the instruction they provided), this increase was not statistically significant.

Regarding weather science and safety efficacy, the workshop participants produced a mean total score at the beginning of the workshop that was 88% of the full scale of the WSSTEI (M = 70.4). A ceiling effect on this measure may have occurred, possibly due to the enthusiasm of the participants about weather while in the workshop or due to the need for additional items in the WSSTEI. Regardless, the scores on weather-related self-efficacy instruction had increased significantly by the conclusion of the workshop. We observed statistically significant increases in WSSTEI subscales assessing both efficacy expectations of being able to provide weather science and safety instruction and outcome expectations that students would be able to learn from the instruction teachers provided.

Weather Science and Safety Content Test

We assessed the teachers' factual knowledge about weather science and safety through the 22-item multiple-choice test. Before beginning the workshop, the teachers' correct answers to questions produced scores that were 42% of the maximum possible (M = 9.3). At the conclusion of the workshop, the scores increased approximately 23%, but were still far less than the maximum possible (M = 14.3). This represented a statistically significant increase (Table IV). Because we used different item sets for the two content measures and sought to increase the teachers' knowledge of weather, the two content measures were not significantly correlated, $r = 0.24$, $p = 0.10$.

Overall Evaluation of the Workshops

The final portion of the assessment administered at the workshops' conclusion contained items assessing the teachers' overall evaluations of the workshop faculty, the MoD curriculum, and the physical training environment (in the College of Education, University of Georgia campus). Table V presents the items and descriptive statistics for the overall evaluation. The teachers provided uniformly positive evaluations of their experiences with the workshop faculty and their instructional material. A significant component of the last 2 d of the workshop involved teachers preparing a lesson from the MoD curriculum and delivering it to the workshop cohort and faculty. The teachers agreed that this activity was helpful and that it would increase the likelihood of the MoD curriculum's use in their classrooms. Similarly, we asked the participants to plan how they would use the MoD curriculum in their schools and implement it on a wider basis among their colleagues. The teachers agreed that developing and sharing implementation plans was helpful and that it would make it more likely that they would use the curriculum. Overall, we were pleased to receive the consistent and uniform feedback that the workshop made it both more likely that teachers would use the curriculum and that they would recommend the workshop to their colleagues when it was offered again.

Follow-Up With the 2008 Workshop Participants

In September 2009, we conducted a follow-up survey of the 14 participants in the 2008 cohort of the workshop. We wanted to assess the teachers' sense of self-efficacy after having implemented the curriculum. We also wanted to assess the extent to which the teachers shared the curriculum with other teachers, and we asked the teachers about their sharing of the curriculum with other teachers, their use of the MoD curriculum, and the numbers of students that they estimated had been exposed to some aspect of the curriculum. The follow-up measures included items of the WSSTEI and eight additional open-ended questions that asked participants to supply factual and objective information regarding the dissemination of the MoD curriculum. To help ensure the most complete response as possible, the participants were first telephoned to alert them that the measurement packet was being sent; they also were given an opportunity at this time to complete the instruments over the telephone. Follow-up phone calls were made after 3–4 weeks to remind participants to complete the measures. Of the 14 workshop participants, 11 teachers completed the measures. One teacher had moved and was unavailable, while two other teachers were unable to complete the measures during the planned or intended time frame.

The teachers' responses to selected WSSTEI items suggested that they maintained high levels of both outcome and efficacy expectations regarding the use and impacts of the MoD curriculum. Specifically, the participants believed that their students could learn from the MoD curriculum how to behave safely when severe weather threatens them (M = 4.72, corresponding to agree to strongly agree on the 5-point scale; SD = 0.47). They also continued to feel efficacious regarding their role in using the curriculum to

TABLE III: Descriptive statistics for the teachers' and authors' goals for the workshop.

Teachers' Workshop Goals (Content Coded)	Frequency of Goal, *n* (%)	Importance of Achieving the Goal —Before the Workshop, M (SD)[1]	Degree to Which Goal Was Met —After the Workshop, M (SD)[2]
1. Desire to learn more about weather and weather safety. Ex: *To become more personally weather educated*.	43 (34.1%)	9.4 (1.0)	9.3 (1.4)
2. Desire to improve teaching about weather or weather safety. Ex: *To communicate weather information to my students effectively*.	28 (22.2%)	9.6 (0.7)	9.0 (1.3)
3. Desire to help students, families, school, or community to prepare for severe weather or natural disasters. Ex: *To help my school develop a severe weather plan*.	18 (14.3%)	9.1 (1.0)	9.6 (0.7)
4. To learn how the MoD curriculum aligns with the GPSS. Ex: *To find out which MoD modules satisfy which of the GPSS*.	9 (7.1%)	9.2 (1.0)	9.1 (2.0)
5. To earn PLUs for certification. Ex: *To obtain the necessary PLUs to renew my certification*.	9 (7.1%)	9.6 (0.9)	10.0 (0.0)
6. To obtain ideas of how to make geoscience education something that stimulates interest or curiosity in students. Ex: *I would like to learn fun, exciting ways to teach my 3rd graders about weather*.	8 (6.4%)	9.6 (0.7)	7.4 (1.9)
7. To share their workshop experiences and/or materials with other teachers. Ex: *To provide other science teachers with information from this workshop*.	6 (4.8%)	8.8 (1.3)	8.2 (3.5)
8. To learn about hands-on activities for teaching students about weather. Ex: *To find creative, hands-on ways of helping students learn*.	5 (4.0%)	10.0 (0.0)	9.0 (2.2)
Mean (SD)		9.4 (0.9)	9.2 (1.5)

TABLE III: continued.

Authors' Workshop Goals	Importance of Achieving the Goal —Before the Workshop, M (SD)[1]	Degree to Which Goal was Met —After the Workshop, M (SD)[2]
1. Educate science teachers about the needs and benefits for providing safety education for weather and other natural hazards.	9.3 (1.0)	9.8 (0.4)
2. Teach science teachers about the American Red Cross MoD curriculum and how it can be used in their classrooms.	9.4 (0.8)	9.9 (0.5)
3. Build teacher commitment to the use the MoD curriculum in their classrooms and to the promotion of its use by colleagues.	8.9 (1.2)	9.5 (0.8)
Mean (SD)	9.2 (1.1)	9.7 (0.6)

[1]For both the teachers' and the authors' prospective ratings of goals, a 10-point rating scale was used, with 1 = not very important and 10 = very important.
[2]For evaluating the degree to which that the goals were met, a 10-point scale also was used, with 1 = not met at all and 10 = met completely.

teach their students (M = 4.72, SD = 0.47). The 2008 participants were satisfied that the MoD curriculum enabled them to teach the students about both weather science (M = 4.45, SD = 0.69) and weather safety (M = 4.36, SD = 0.81). These follow-up statistics were quite consistent with the teachers' responses to the same items in immediate postworkshop assessment.

With regard the dissemination of the curriculum following their participation in the workshop, the teachers in the 2008 cohort reported that they had discussed the MoD curriculum with approximately 129–139 adults, of whom 73–77 were teachers. This means that, on average, each responding participant discussed the workshops with about 12 adults, seven of whom were other teachers. The participants reported that they most frequently discussed their MoD curriculum with their colleagues when a severe weather outbreak occurred near their schools or at some other location. They also reported discussing the curriculum with colleagues during weather safety awareness weeks. The participants indicated that they had used the MoD curriculum with approximately 559–724 students who were in their classes. All but one teacher had given away the extra MoD kits with which they were supplied at the conclusion of the 2008 workshop to total of 38 teachers. The participants estimated that as a result of their distribution of the kits to their colleagues, 1,035–1,525 additional students were exposed to the MoD curriculum. The respondents to the follow-up indicated that, overall, between 1,490 and 1,870 students were impacted in some way by the MoD curriculum as a result of their attending the 2008 workshop. Although encouraging, these numbers represent rough estimates of the workshop's secondary effects.

DISCUSSION

Attainment of Workshop Goals

Our outcome data provide support that the project goals were generally accomplished, with some qualifications. With respect to our first goal of educating teachers about the needs and benefits of providing weather safety instruction to their students, data from the goal attainment scaling activity suggested that teachers saw this as an important goal and that the workshop achieved this goal. Fourteen percent of the goals that the teachers supplied themselves involved helping their students, schools, or communities to become more prepared for extreme weather. The teachers also indicated, via the workshop goals that the authors provided, that this goal had been satisfied. Related to this, approximately half of the items on the WSSTEI pertained to assessing teachers' outcome and efficacy expectations regarding weather safety. The significantly higher postworkshop scores on the WSSTEI provided an indication that the teachers believed that students could learn about weather safety (outcome expectations) and that they, as a result of the workshop, could provide such instruction to their students (efficacy expectations).

The teachers' expressed goals of learning more about weather science and safety so that they could provide instruction to their students (56% of teachers' expressed

TABLE IV: Pre- and posttest descriptive statistics on project measures.

Project Measure	Pretest Scores		Posttest Scores		*F*-Test Statistic
	Mean	SD	Mean	SD	
STEBI—Total score	78.0	11.7	82.9	10.1	F (1, 39) = 15.77, p = 0.0003
STEBI—Efficacy expectations	40.2	8.9	43.2	7.3	F (1, 41) = 14.50, p = 0.0005
STEBI—Outcome expectations	38.3	4.8	39.7	5.6	F (1, 44) = 2.92, p = 0.0948
WSSTEI—Total score	70.4	8.7	74.1	9.1	F (1, 43) = 9.00, p = 0.0045
WSSTEI—Efficacy expectations	34.7	4.5	36.9	4.6	F (1, 43) = 8.14, p = 0.0066
WSSTEI—Outcome expectations	35.7	4.8	37.2	4.7	F (1, 43) = 6.60, p = 0.0138
WSSCT	9.3	3.2	14.3	2.8	F (1, 45) = 83.79, $p < 0.0001$

TABLE V: Descriptive statistics for evaluating the workshop faculty, curriculum, and physical setting.[1]

Item	M	SD
The faculty's workshop content was well presented.	4.9	0.3
The faculty's demonstrations and activities were helpful.	4.8	0.3
Developing and presenting the implementation plan was helpful.	4.8	0.5
Developing and delivering the lesson plan was helpful.	4.8	0.5
The implementation and lesson plan activities will make it more likely that I will deliver the MoD curriculum in my classroom.	4.7	0.5
I believe that the MoD curriculum meets the GPSS.	4.7	0.8
As a result of this workshop I am more likely to use MoD	4.8	0.5
As a result of this workshop I am more likely to recommend that my colleagues use the MoD.	4.9	0.3
I would recommend this workshop to my colleagues.	4.9	0.4
The training environment was satisfactory.	4.8	0.5
The food and refreshments were satisfactory.	4.8	0.4
Access to the building/classroom was satisfactory.	4.8	0.6
Information about the workshop was communicated effectively.	4.9	0.4

[1]The ratings for the items in this table were made using a 5-point scale, where 1 = disagree and 5 = agree. The median rating for all items in the table was 5, corresponding to agree.

goals) aligned well with our second project goal of teaching teachers about the MoD curriculum and how it could be used in their classrooms. The increases in teachers' knowledge about weather science and safety on the WSSCT, along with their high levels of agreement that the lesson preparation and delivery activity was helpful, provided additional support that this goal was accomplished.

We view this outcome as particularly significant because many K–5 teachers in Georgia regularly have self-contained classes, meaning that they need to provide instruction in multiple content areas, including science. The Georgia Professional Standards Commission (http://www.gapsc.com) formerly stipulated that early childhood education (ECE) teachers (grades K–5) must have at least two science classes as part of their undergraduate degree; this requirement has since been relaxed. Anecdotally, most teachers from the ECE grades in the workshop felt that science was not a relative teaching strength for them. Thus, when our outcome data indicated increases in science teaching self-efficacy, both generally and with respect to weather, we were encouraged that the teachers felt more empowered in their approaches to geoscience in the ECE grades.

It was also encouraging to observe in the follow-up data from the 2008 participants that the teachers' sense of efficacy in teaching science and safety concepts was maintained over 1 y after participating in the workshop. Data from the 2008 follow-up also suggested that teachers were using and disseminating the curriculum and that this resulted in more than 1,000 students being exposed to the MoD curriculum. These results suggested that our goal of enlisting the teachers to use and to promote the curriculum was met to some extent.

Workshop Features That Enhanced the Teachers' Experiences

Several features of the workshop seemed to accentuate the teachers' learning experiences. The first of these was the preworkshop assessment of the teachers' knowledge of weather science and safety. We deliberately constructed this test to be difficult—making it on par with what one might encounter in an introductory undergraduate course in atmospheric science. We reviewed the answers to the pretests as soon as the preworkshop measurement component was completed. There were two purposes for using this pretest. One was to engage the teachers by demonstrating how seemingly straightforward or commonsense approaches may produce wrong answers (e.g., it is not safe to seek shelter from a tornado while in a car by finding a highway overpass). This had the effect of the teachers remembering what they answered correctly and incorrectly and stimulating discussion about the science or safety behind the topic when we discussed it during the week. Another purpose was that a difficult pretest helped teachers to understand that they had a lot to learn and that the workshop was, therefore, going to take them beyond their customary levels of knowledge about weather science and safety.

We also built engagement and buy-in of the MoD curriculum at the beginning of the workshop by showing how the different content areas (floods, hurricanes, lightning, and tornadoes) aligned (by grade level) with the GPSS. Although we focused primarily upon science, we also provided examples of standards in other content areas that the curriculum would meet (i.e., mathematics). Then, we revisited applicable standards that were satisfied when we demonstrated particular lessons. The teachers' workshop binders contained a section that cross-referenced individual MoD curriculum lessons by grade with the GPSS, similar to what we provided in Table S1 (supplemental materials).

Another helpful component that contributed to the building of commitment to use the MoD curriculum began during our inaugural year of the workshop in 2008. This involved the teachers recalling significant weather events that had affected their cities, towns, or neighborhood. For example, one teacher from Bibb County showed a set of pictures following the August 2005 tornado that struck Macon, Georgia. Viewing the photos during the workshop led teachers to share accounts of the storm and tornado—what they did while at school and what effect the tornado had upon them and their students in the days afterward. In this respect, severe weather, along with less dramatic changes in the routine weather (e.g., from a dry to a rainy period), becomes an attention-maintaining natural laboratory for both teachers and students.

Finally, the teachers' presentations of how they planned to use the MoD curriculum at their schools and their delivery of an actual lesson they prepared from the curriculum yielded at least two benefits. One was the opportunity for us as workshop presenters to observe how the teachers understood and operationalized the materials in the curriculum; their lesson delivery provided an in vivo assessment of their learning. The teachers generally performed remarkably, which was inspiring for us as workshop faculty. More importantly, delivering a lesson in front of peers helped them to build their confidence levels and to have the experience of "I can do this!" Because teachers left the workshop with at least one lesson already prepared, we believed that this increased the likelihood that teachers would use the curriculum in the upcoming school year. Teachers frequently commented that this exercise significantly helped them to get into the curriculum later during the school year.

Recommendations

We have two recommendations based upon our experiences with this project. First, we echo the existing recommendations that increased emphasis be placed on science education during teacher preparation programs, especially those that train elementary and middle school grades (Epstein and Miller, 2011; Milner et al., 2012; Bybee, 2013; National Science Teachers Association, 2014). If students are to be prepared for the increased emphasis on science, technology, engineering, and mathematics in later grades, it follows that teachers, especially those in the K–5 grades, should receive a level of science training that equips them with background content, pedagogical skills, and a sense of science instruction self-efficacy that is up to the task. Our teachers were interested in science and had particular enthusiasm about weather, yet many of them expressed reservations about having what it takes to teach science well. What might this imply about teachers who do not have as high a level of interest in science or science education?

Related to this recommendation, others working in teacher professional development could readily adapt our workshop model to train teachers about weather science and safety. One of our subsequent goals for this project involves training others on how to conduct the weeklong workshop so that the training model can be scaled up to reach a larger number of teachers who provide science instruction. That is, we want to train others in how to provide weather science and safety professional development for teachers. We are also interested in assessing the effects of the workshop on student learning and the associated effects on the students' families. This will be a focus of our subsequent research efforts.

Our second recommendation pertains to teacher enhancement and professional development programs. We recommend that those who develop or continue to offer professional development in the areas of weather or climate show how their curricular materials align with educational performance standards at the state or national levels. Increasingly, teachers seem hesitant to incorporate curricular materials into their instruction, no matter how well developed they are, unless demonstrable links to the standards exist. Although some teachers are willing to do the work to show the links with the standards, we also know that many teachers want these links to be readily evident or provided for them. In this regard, the work of Dupigny-Giroux et al. (2012) is exemplary. A number of excellent teacher enhancement programs exist (e.g., Project Atmosphere, DataStreme Atmosphere, and GLOBE). We contend that such programs may see wider dissemination and application if teachers can see how they are responsive to the standards.

Limitations

Our project has at least two limitations. The first involves the restricted nature of our sample of workshop participants. All of our participants were from the state of Georgia and self-selected to attend the workshop based upon their interests in weather and how they might teach weather in their classes. Thus, most of the results we have reported here may not generalize to other geographical areas or to teachers who do not possess an interest in weather. A second limitation concerns the follow-up with the workshop participants; rather than an in-person meeting, the follow-up was limited to conference calls. A third limitation is that despite the positive outcomes we reported here, we are not able to make any statements about how the teachers' workshop experiences translated to what their students learned about weather science or safety. The impact of the workshop on student learning and the associated effects on the students' families is the focus of our subsequent research efforts.

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REFERENCES

American Educational Research Association. 2005. Studying teacher education: The report of the AERA panel on research and teacher education. Cochran-Smith, M., and Zeichner, K.M., eds. Mahwah, NJ: Lawrence Erlbaum Associates.

American Federation of Teachers. 2002. Principles for professional development. Report 39-0176. Washington, DC: American Federation of Teachers.

Balluz, L., Schieve, L., Holmes, T., Kiezak, S., and Malilay, J. 2000. Predictors for people's response to a tornado warning: Arkansas, 1 March 1997. *Disasters,* 24:71–77.

Bandura, A. 1977. Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review,* 84:191–215.

Bandura, A. 1997. Self-efficacy: The exercise of control. New York: W.H. Freeman.

Bandura, A. 2006. Guide for constructing self-efficacy scales. *In* Pajares, F., and Urdan, T., eds., Self-efficacy beliefs of adolescents. Greenwich, CT: Information Age Press, p. 307–337.

Blanchard-Boehm, R.D., and Cook, M.J. 2004. Risk communication and public education in Edmonton, Alberta, Canada on the

10th anniversary of the "Black Friday" tornado. *International Research in Geographical and Environmental Education,* 13:38–53.

Borko, H. 2004. Professional development and teacher learning: Mapping the terrain. *Educational Researcher,* 33(8):3–15.

Brown, S., Archer, P., Kruger, E., and Mallonee, S. 2002. Tornado-related deaths and injuries in Oklahoma due to the 3 May 1999 tornadoes. *Weather and Forecasting,* 17:343–353.

Butler, D.M., and MacGregor, I.D. 2003. GLOBE: Science and education. *Journal of Geoscience Education,* 51:9–20.

Bybee, R.W. 2013. The case for STEM education: Challenges and opportunities. Arlington, VA: NSTA Press.

Chambers, L.H., Young, D.F., Costulis, P.K., Detweiler, P.T., Fischer, J.D., Sepulveda, R., Stoddard, D.B., and Falcone, A. 2003. The CERES S'COOL project. *Bulletin of the American Meteorological Society,* 84:759–765.

Crawford, B. 2000. Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching,* 37:916–937.

Darling-Hammond, L., and Richardson, N. 2009. Teacher learning: What matters? *Educational Leadership,* 66(5):46–53.

Dupigny-Giroux, L., Toolin, R., Hogan, S., and Fortney, M.D. 2012. The Satellites, Weather and Climate (SWAC) teacher professional development program: Making the case for climate and geospatial literacy. *Journal of Geoscience Education,* 60:133–146.

Ellins, K.K., Snow, E., Olson, H.C., Stocks, E., Willis, M., Olson, J., and Odell, M.R. 2013. The Texas Earth and Space Science (TXESS) revolution: A model for the delivery of Earth Science professional development to minority-serving teachers. *Journal of Geoscience Education,* 61:187–201.

Epstein, D., and Miller, R.T. 2011. Slow of the mark: Elementary school teachers and the crisis in STEM education. *Education Digest: Essential Readings Condensed for Quick Review,* 77:4–10.

Garet, M., Porter, A., Desimone, L., Birman, B., and Yoon, K. 2001. What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal,* 38:915–945.

Ginger, K.M., Moran, J.M., Weinbeck, R.S., Geer, I.W., Snow, J.T., and Smith, D.R. 1996. Project ATMOSPHERE: 1995 teacher enhancement programs. *Bulletin of the American Meteorological Society,* 77:763–769.

Hayes, A.F., and Krippendorff, K. 2007. Answering the call for a standard reliability measure for coding data. *Communication Methods and Measures,* 1:77–89.

Ingvarson, L., Meiers, M., and Beavis, A. 2005. Factors affecting the impact of professional development programs on teachers' knowledge, practice, student outcomes and efficacy. *Education Policy Analysis Archives,* 13:1–26.

Jackson, V.C., and Carr, F.H. 1995. A mesoscale meteorology course for university faculty. *Bulletin of the American Meteorological Society,* 76:2459–2462.

Kiresuk, T. J., Smith, A. and Cardillo, J. E., eds. 1994. Goal Attainment Scaling: Applications, Theory, and Measurement. Hillsdale, NJ: Lawrence Erlbaum.

Knabb, R.D., Rhome, J.R., and Brown, D.P. 2011. Tropical cyclone report: Hurricane Katrina, 23–30 August 2005. Available at http://www.nhc.noaa.gov/2005atlan.shtml (accessed June 2014).

Lewis, C. 2002. Lesson study: A handbook of teacher-led instructional change. Philadelphia, PA: Research for Better Schools.

Lindell, M.K., and Brooks, H. 2013. Workshop on weather ready nation: Science imperatives for severe thunderstorm research. *Bulletin of the American Meteorological Society,* 94:ES171–ES174.

Liu, S., Quenemoen, L.E., Malilay, J., Noji, E., Sinks, T., and Mendlein, J. 1996. Assessment of a severe-weather warning system and disaster preparedness, Calhoun County, Alabama. 1994. *American Journal of Public Health,* 86:87–89.

McPherson, R.A., and Craford, K.C. 1996. The EarthStorm Project: Encouraging the use of real-time data from the Oklahoma Mesonet in K–12 classrooms. *Bulletin of the American Meteorological Society,* 77:749–761.

Milner, A.R., Sondergeld, T.A., and Demir, A. 2012. Elementary teachers' beliefs about teaching science and classroom practice: An examination of pre/post NCLB testing in science. *Journal of Science Teacher Education,* 23:111–132.

Mintzes, J.J., Marcum, B., Messerschmidt, C., and Mark, A. 2013. Enhancing self-efficacy in elementary science teaching with professional learning communities. *Journal of Science Teacher Education,* 24:1201–1218.

National Research Council. 2007. Taking science to school: Learning and teaching science in grades K–8. Duschl, R.A., Schweingruber, H.A., and Shouse, A.W., eds. Washington, DC: National Academies Press.

National Science Teachers Association. 2007. NSTA position statement: The integral role of laboratory investigations in science instruction. Available at http://www.nsta.org/about/positions/laboratory.aspx (accessed June 2014).

National Science Teachers Association. 2014. NSTA position statement: Early childhood. Available at http://www.nsta.org/docs/PositionStatement_EarlyChildhood.pdf (accessed July 2014).

Puchner, L., and Taylor, A. 2006. Lesson study, collaboration and teacher efficacy: Stories from two school-based math lesson study groups. *Teaching and Teacher Education,* 22:922–934.

Riggs, I., and Enochs, L. 1990. Towards the development of an elementary teacher's Science Teaching Efficacy Belief Instrument. *Science Education,* 74:625–637.

SAS Institute. 2004. SAS/STAT user's guide, version 9.1. Cary, NC: SAS Institute.

Thomas, J., lvey, T., and Puckette, J. 2013. Where is Earth Science? Mining for opportunities in chemistry, physics, and biology. *Journal of Geoscience Education,* 61:113–119.