IMPROVING K-12 CLIMATE SCIENCE EDUCATION THROUGH COLLABORATIONS WITH SCIENTISTS

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1. INTRODUCTION

The Center for Remote Sensing of Ice Sheets (CReSIS) is a National Science Foundation Science and Technology Center based at the University of Kansas that concentrates its research on understanding the role of the polar ice sheets in sea level rise as a response to global climate change. Two primary objectives of the Center's Education Program are to excite K-12 students about science and to enhance K-12 foundational skills necessary to pursue further education in STEM fields. CReSIS' Education Team conducts a variety of outreach efforts. One particularly successful program is "The Heat is On! Confronting Climate Change in the Classroom" summer workshop for the professional development of K-12 science teachers. Participating teachers demonstrated significant gains in both climate science content knowledge and in their self-efficacy beliefs toward teaching climate science. Remarkably, when asked about the best part of the workshop, 20 out of 24 participants responded that the collaboration with scientists was the best part of the experience. These and additional evaluation results have contributed to new understandings about how to successfully integrate collaborative partnerships between scientists and teachers into a professional development program for K-12 science educators.

2. PROJECT DESCRIPTION

The summer workshop itself was designed, organized, and facilitated by the Education Team at CReSIS. This team consisted of the Education Director (a senior level research scientist whose specialty area is sea ice), the K-12 Outreach Coordinator (whose specialty area is elementary and middle school informal science programming), and two graduate students from the School of Education specializing in science education. The doctoral student, whose background includes 12 years as an elementary teacher, is the Education Team's Program Evaluator, while the master's student, whose background includes 4 years teaching physics and chemistry at the secondary level, was the primary organizer and coordinator for "The Heat is On!" teacher workshop. The workshop consisted of five primary components: 1) four weeks of online, pre-workshop assignments; 2) five days of face-to-face interaction between teachers, scientists, and workshop facilitators which included nine live lecture presentations from scientists at the various CReSIS partner institutions; 3) inquiry-based lessons developed by the CReSIS Education Team that address the workshop's science content; 4) four collaborative working groups of

teachers, each with a mentor scientist, to develop lessons based on the new science being learned during the lectures; and 5) lesson implementation in each teacher's classroom in the fall with written feedback provided to CReSIS regarding lesson evaluation and suggested modifications.

3. METHODOLOGY

Extensive data, both qualitative and quantitative, were collected as part of the evaluation of this professional development workshop for teachers. Formative assessment of content understanding was conducted during each scientist's presentation using a student response system (a.k.a. "clickers). Three types of quantitative data were collected to evaluate the summative success of the workshop: a pre- and post- climate science content assessment; a pre- and post- climate-teaching self-efficacy survey; and a Likert-scale evaluation survey administered at the end of the workshop. The 23-item, selected-response climate science assessment reflects the Climate Literacy principles developed by the National Oceanic and Atmospheric Administration (NOAA, 2008) and was developed in collaboration with CReSIS scientists [1]. Due to its alignment with NOAA's principles and the scientific accuracy conferred by our scientists, we are confident that this content assessment can be validly used to measure change in participants' level of climate science understanding. The self-efficacy instrument is a modified version of Enochs and Riggs' Science Teaching Efficacy Belief Instrument (STEBI). The STEBI has predictive validity for effective teaching and provides an indication of the effectiveness of a professional development program. [2]. The Workshop Evaluation Survey also provided qualitative data in the form of responses to open-ended questions on the final evaluation survey. All assessments and surveys were administered online using SurveyMonkey. Pre- and post- measures were analyzed for statistically significant differences using paired-samples t-tests and qualitative data were analyzed for recurring themes and commonalities. Unfortunately, although 24 participants completed the assessments, efforts to maintain anonymity for participants resulted in only 15 pre- and post- pairs being matched up for the paired-samples t-tests.

4. RESULTS

Both qualitative and quantitative evaluation results indicate that the workshop was particularly effective in increasing teachers' content understanding of climate change; increasing teachers' self-efficacy beliefs about teaching climate science; and creating meaningful connections between K-12 teachers and CReSIS scientists. The two quantitative evaluation instruments administered pre- and post- workshop, and the qualitative evaluation survey was administered at the end of the workshop.

4.1. Content Knowledge Assessment

The first quantitative measure was the pre- and post- assessment of teachers' climate science content knowledge. As shown in Table 1, participants' mean score on the pre-test was 8.8 items answered correctly out of 23. The mean score on the post-test increased to 14.4. A paired-samples t-test showed this increase to be significant with a respectable Cohen's *d* effect size of .57, $p < 0.05$.

	n	*df*	**Pre-Workshop**		**Post-Workshop**		*t*	*Effect Size*
			Mean	*SD*	*Mean*	*SD*		
Content Assessment	15	14	8.8	4.21	14.4	3.71	2.14*	0.57

Table 1: Content Assessment results show significant gain in content knowledge, where *n*=sample size, *df* = degrees of freedom, and *t* = two tailed *t*-test. * = $p \leq 0.05$

4.2. Climate Science Teaching Efficacy Belief Instrument (C-STEBI)

Participants' scores also increased significantly on the C-STEBI that measured teachers' efficacy beliefs about teaching climate science and the outcome expectancy they hold for student achievement. Our results indicated that the teachers participating in the workshops showed significant increase in personal climate science teaching efficacy and outcome expectancy, both at the $p \leq 0.05$ level. Therefore, it is reasonable to claim that the workshop was successful in increasing teachers' efficacy beliefs about teaching climate science as well as their outcome expectancy of their students. The Cohen's *d* effect size for the change in self-efficacy beliefs nearly doubles that for outcome expectancy. It is also interesting to note that gains in content knowledge and teaching efficacy appeared to be independent of each other. Although it seems logical to think that changes in efficacy beliefs may have been caused by gains in content knowledge, our results show low correlation between these two factors. This suggests that another factor, such as collaboration with the scientists or the inquiry-based lesson demonstrations may have played an important role in increasing teachers' climate teaching efficacy beliefs.

	n	*df*	**Pre-Workshop**		**Post-Workshop**		*t*	*Effect Size*
			Mean	*SD*	*Mean*	*SD*		
Personal Climate Science Teaching Efficacy (C-PSTE)	15	14	46.47	6.60	53.00	4.77	2.14*	0.49
Climate Science Teaching Outcome Expectancy (C-STOE)	15	14	33.50	6.81	37.20	6.61	2.14*	0.26

Table 2: C-STEBI results show significant gain in C-PSTE and C-STOE scores, * = $p \leq 0.05$

4.3. Workshop Evaluation Survey

The results of the post-workshop survey dramatically demonstrated the success of the workshop from the teachers' point of view. They overwhelmingly (96%) found the workshop effective, with 58% strongly agreeing that overall the workshop was effective. A similarly strong percentage (92%) felt that the workshop improved

their ability to communicate climate change and 88% agreed that they are confident enough to "confront climate change in the classroom." Analysis of the responses to the open-ended questions revealed the most striking qualitative evaluative outcome. When asked *What did you like best about the workshop?,* the teachers overwhelmingly replied that the contact and collaboration with the scientists throughout the workshop was the highlight of the workshop. In fact, 20 out of the 24 responses to this question (83%) indicated a very successful experience with the scientists during the presentations and working groups with comments such as: *"Being able to interact with the professionals at this high of a level is not an opportunity that is available to us in the classrooms of school very often. Thank you!"*

5. CONCLUSIONS

Climate change is one of the major challenges facing society today. More effective education of the public on this topic certainly is necessary and K-12 teachers play an important role in climate change education. It is therefore necessary to find ways of training teachers in the science behind climate change and equipping them with effective strategies for confronting it in their classroom. One method of teacher training is through the use of summer institutes and workshops, in which teachers spend a significant amount of time in professional development and in interactions with scientists.

The evidence presented here shows the workshop titled "The Heat is On! Confronting Climate Change in the Classroom" was effective at significantly increasing participating teachers' climate science teaching self-efficacy as well as their knowledge and understanding of climate science. Equipped with new resources, higher efficacy, and greater content knowledge, it is likely that the teachers will implement changes in their classes. In fact, several participating teachers have since communicated with members of the CReSIS Education Team about workshop-inspired lessons they had implemented in their classes during this past school year.

With such positive evaluation results, we can be confident that the workshop made an impact on the practice of the participating teachers. Perhaps it would be worthwhile—it would certainly be interesting—to administer the efficacy and content knowledge assessments to the teachers one more time after another year has passed. If the gains of efficacy and content knowledge persist, one could be quite confident in claiming that the workshop had not only a significant impact on participating teachers, but a lasting one as well.

6. REFERENCES

[1] National Oceanic and Atmospheric Administration (NOAA). (2008). *Climate Literacy: The Essential Principles of Climate Sciences.* Retrieved on December 9, 2009 from http://www.climate.noaa.gov.

[2] Enochs, L.G. and Riggs, I.M. Further development of an Elementary Science Teaching Efficacy Belief Instrument: A Preservice Elementary Scale. *A paper presented at the annual meeting of the National Association of Research in Science Teaching, Atlanta GA, April 8-11, 1990.*