ARCTIC CLIMATE MODELING PROGRAM FINDINGS AND RESULTS

Because evaluation of this project was closely tied to the research conducted, the full evaluation report was prepared by Evaluator Angela Larsen in conjunction with Education Researcher Kathy Berry Bertram. Research was conducted by Bertram; Evaluator Larsen determined that the research was conducted effectively, appropriately, ethically and according to plan. The following excerpt pertains only to the research findings and results.

BRIEF INTRODUCTION

Connecting teachers and students with Arctic scientists and Native Elders is the heart of the Arctic Climate Modeling Program (ACMP), funded from 2005-09 by the National Science Foundation Innovative Technology Experiences for Students and Teachers (NSF ITEST ESI-0525277). For rural Alaskan teachers in the Bering Strait region, ACMP offered yearlong science, technology, engineering, and math (STEM) professional development focused on increasing student climate literacy and engaging youth in Arctic research workforce technologies.

The Framework for Culturally Responsive STEM Instruction established by ACMP was developed to bridge cultural and experiential differences among students and teachers in the Bering Strait School District. The framework advocates backward design to learning goals from two cultures—the western culture of non-Native teachers and the culture of indigenous students and their families. Guiding principles of STEM instruction and indigenous values were found to have common ground in that both recognize the importance of learning being place-based and unified in theme. By combining the goals of STEM literacy and indigenous ideology, the framework was able to successfully engage students in place-based Earth system research.

This summary provides the findings and results discussion of ACMP, examining the efficacy of the program's unique professional development framework and exploring its ability to provide Bering Strait teachers with the tools and knowledge they need to provide culturally responsive STEM instruction.

FINDINGS

Participation

Each grant year, not one school missed filing a monthly field-test report, which indicates consistent district-wide ACMP interest and involvement. Lead Teachers were responsible for overseeing and reporting on ACMP field-testing in their schools. At annual culminating workshops, Lead Teachers were able to ascertain how field-test input from teachers in their school and others across the district influenced ACMP curricular resource revision. Each grant year, the same 30 Lead Teachers (two from each school) participated in ACMP annual professional development events. This signifies substantial longevity for the Bering Strait, which had a 30% annual turnover rate (McDiarmid, Larson, & Hill, 2002). During ACMP enactment the BSSD teacher turnover rate dropped to 20% for the first time in decades (Hill & Hirshberg, 2008). Each grant year, Lead Teachers reported mentoring up to five other staff in their schools who were field-testing ACMP material, or a total of up to 150 of the Bering Strait school district's 165 teachers. Identifying the exact teachers who participated in field-testing each year is difficult because teachers within the district swap schools, teaching one year in Brevig Mission and the next year in Savoonga, for example. It is clear, however, that there was extensive, consistent district-wide teacher involvement in ACMP all grant years.

Each grant year, all 165 teachers attended ACMP introductory workshops. These workshops were one of a dozen offerings at the district's mandatory October in-service conferences held annually at district headquarters in Unalakleet, Alaska. Because such a large number of teachers annually signed up to attend ACMP introductory workshops, district administrators capped attendance so that other in-service sessions would have participants. ACMP offered additional evening workshops to ensure all 165 teachers could benefit. Evening workshops also attracted community members. During the first grant year, 100 community members attended; in the second, 650 attended; in the third, 400 attended. Considering that the total population in Unalakleet is 752, this annual average attendance of nearly 400 community members is substantial.

All 15 Bering Strait schools held ACMP Science Camps in their rural villages each grant year. ACMP provided manuals and supplies, but local Science Camps were organized and managed entirely by teachers in the village. Annually, 3750 local adults (250/school site) attended science expos, where students ran experimental stations. A Lead Teacher wrote:

> *At ACMP science camps, the kids do the interaction. The instruction was great for them because they were teaching the very lessons they learned in class. They were teaching it to their parents and to community members and to Elders. They came in and sat down with their grandchildren and great grandchildren and were working with them in understanding science concepts. It was very powerful for the teachers and the community to see the interaction of the students and the Elders working on ACMP projects together.*

Consistently high numbers of teachers and students interacted with scientist lectures each grant year. Lectures were video-broadcast live from UAF to all 15 Bering Strait schools simultaneously, recorded, and digitized. Teacher comments indicate that virtual scientist interaction contributed to teacher STEM knowledge and student STEM career focus. Teachers also contacted scientists through the online mentor network. Although the number of interactions was not tracked, any question posed to a scientist more than twice was posted on the ACMP "Question-and-Answer" portal. At grant end, the Q&A portal contained 70 questions.

Participant-reported Impact

Likert-style Responses

Table 5 shows anonymous STEM workshop survey responses to the ten questions asked of participants each grant year. Responses indicate overwhelming satisfaction with the annual STEM workshop.

Table 5
STEM Workshop Survey Results by ACMP Program Year

External Evaluator Survey Question	**% of teachers who agreed or strongly agreed**		
Program Year (PY) & Teacher Number*	**PY1 (n=44)**	**PY2 (n=39)**	**PY3 (n=29)**
Workshop was of high quality	100%	100%	100%
Activities were carefully planned	100%	100%	100%
Presentation objectives were clear	100%	100%	97%
Time was used effectively	100%	100%	97%
Presenters were effective instructors	100%	100%	97%
Presenters were well prepared	100%	100%	100%
Presentations held my interest	96%	97%	93%
My questions or concerns were addressed	100%	100%	100%
Presentation was balanced with teacher interaction	96%	100%	90%
Facilities were conducive to learning	97%	97%	93%

*There are more than 30 teachers in years 1 and 2 because the district permitted a limited number of non-Lead teachers (from larger schools) to attend.

Open-ended Responses

Analyses of open-ended responses support and clarify Likert-style survey findings. Open-ended comments were derived from three sources: Lead Teacher field-test reports (FT), case study interviews (CS), and STEM workshop surveys (SW). All are displayed in Table 6. Responses for all years are combined in each database. The field-test report database contains 497 entries, well over the expected amount (6 mos x 3 yrs x 15 schools = 270 reports). In some months, enthusiastic Lead Teachers filed two reports. The database of case study interviews contains 342 paragraphs, and the database of open-ended responses collected from annual STEM workshop surveys totals 128.

As shown in Table 6, the primary purpose of 79.23% of the 967 comments in combined databases is to indicate that ACMP involvement improved teachers' K-12 STEM classroom instruction or increased student learning outcomes. Of the remaining open-ended comments, 17.05% pertain to teachers receiving or giving mentoring support, and 3.72% contain participant recommendations for revising ACMP professional development training or curricular resources.

Primary Purpose of ACMP Participant Open-ended Comments by Database

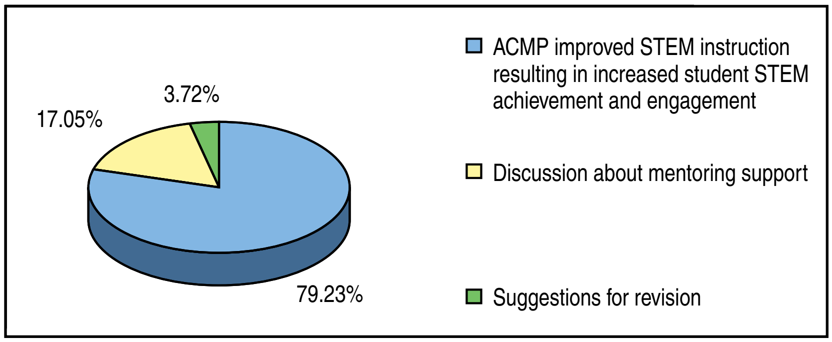


Table 6
Primary Purpose of ACMP Participant Open-ended Comments by Database

Category Comment Classification, by Database	FT	CS	SW	Total Comments	% Total
Sample Size (number of entries analyzed)	**497**	**342**	**128**	**967**	**(100)**
Improved K-12 STEM classroom instruction	178	190	105	473	48.86%
Increased student STEM achievement & engagement	178	116	0	294	30.37%
Discussion about mentoring support	110	32	23	165	17.05%
Suggestions for revision	31	4	0	35	3.72%

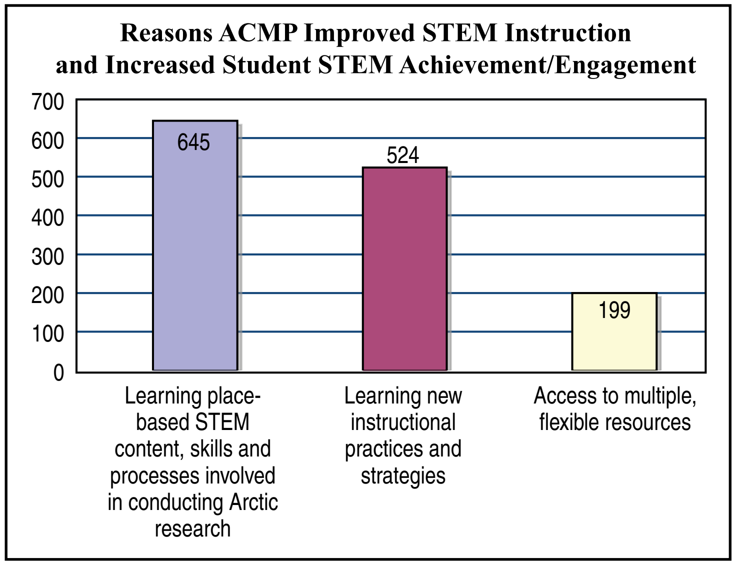
Reasons ACMP Improved STEM Instruction and Increased Student Achievement

Table 7 shows a breakdown of the 767 entries in the combined databases whose primary purpose is to describe that ACMP improved K-12 STEM classroom instruction or increased student STEM achievement. Many of these entries were two or more sentences long. For this reason, reviewers gave more than half (56.07%) of these entries two codes. Therefore, the sample size used in Table 7 reflects the total number of codes assigned to database entries, rather than the total number of entries.

Table 7
Reasons ACMP Improved STEM Instruction, and Increased Student Achievement and Engagement

Summary Codes	FT	CS	SW	Total Codes	% Total
Sample Size (number of codes analyzed)	**806**	**650**	**128**	**1368**	**(100)**
Learning place-based STEM content, skills and processes involved in conducting Arctic research	357	218	70	645	47.15%
Learning new instructional practices and strategies	254	251	19	524	38.30%
Access to multiple, flexible resources	85	98	16	199	14.55%

Learning place-based STEM content, skills and processes related to Arctic research is the most frequently given reason for how ACMP involvement improved classroom instruction and increased student STEM achievement (see Table 7). Many teachers report that ACMP training in scientific content and processes helped them guide student inquiry and experimentation in their classrooms. Examples (1) and (2) are typical of such entries.



(1): As for keeping students engaged, ACMP training in scientific content and processes has been wonderful and use of ACMP curricular resources shows results. Students get excited when you say: "Okay we will be doing an ACMP lesson tomorrow." The reply is usually: "Cool, those are fun." More important is that students are learning scientific content and processes and retaining the knowledge. The ACMP hands-on science experiments guide students from the ground up, and I believe this helps to instill in students a sense of ownership.

(2): Oobleck is a fascinating, hands-on lesson in ACMP that really helps kids with the questioning and hypotheses aspects of scientific experimentation. It creates real fascination as they cannot easily classify the substance and they've never seen/experienced anything like it. They really seemed to feel like scientists and better understood the idea of classification, which is useful in so many areas.

The open-ended comments emphasizing increased use of technology and math skills in the classroom often underscore virtual interaction with scientists during monthly online lectures. Scientist lectures were provided by live video-broadcast to all Bering Strait schools. During these lectures, students interacted with scientists using Skype, a free online communication service. Classes could later view a recorded lecture online from the ACMP website, or on DVD, as is expressed in Example (3). Example (4) describes how ACMP helped teachers incorporate technology skills in other subjects.

(3): My students like to watch the lecture live, but I have had classes watch the lecture on DVD after the fact. I like to do the DVD version so we can pause the DVD to discuss how the lecture relates to what we have been doing in class. The lectures often are directly related to the standards that we have been studying. Thus, they make a good tie-in and a way for the students to hear it from another source, namely an expert.

(4) ACMP has some great Internet and technology lessons. There was like a scavenger hunt in one of the lessons, and that gave me the idea to do scavenger hunts on the Internet in other subjects. I hadn't really thought about it before, and it went off really well.

Learning new instructional practices and strategies is the second most popular reason given for why ACMP involvement improved classroom instruction and increased student STEM achievement, followed by the ability to use multiple, flexible resources in the comprehensive ACMP curriculum (refer to Table 7). Access to multiple, flexible resources for transfering STEM training to classroom instruction was cited in 14.55% of the entries in combined databases whose primary purpose describes how ACMP improved K-12 STEM classroom instruction or increased student STEM achievement. Example (5) is typical of entries that explain how ACMP training and curricular resources met the needs of a variety of students.

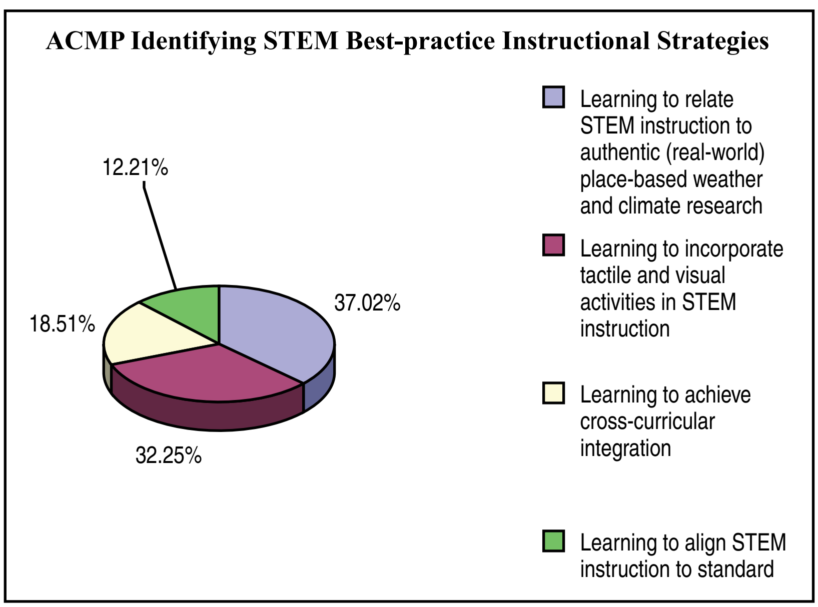
(5): ACMP is helpful for instruction because it contains venues for reaching so many different learners. For the students who need kinesthetic hands-on, there are tactile activities. The Climate Change DVD with the Yup'ik words helps me reinforce the Native language students learn in their homes and in Bilingual/Bicultural classes. This is good for the auditory learners. Also, the pictures on the Climate Change DVD, which related directly to this community, are good for visual learners.

Table 8 shows a further breakdown of the 524 codes that attribute improved classroom instruction and increased student STEM achievement to ACMP training in STEM best-practice instructional strategies. The four instructional strategies most frequently mentioned by teachers include: (a) learning to relate STEM instruction to authentic place-based weather and climate research; (b) learning to incorporate tactile and visual activities into K-12 classroom STEM instruction; (c) learning how to achieve cross-curricular integration; and (d) learning how to align STEM instruction to Alaska education standards.

Table 8
Teachers Identify STEM Best-practice Instructional Strategies

Summary Codes	FT	CS	SW	Total Codes	% Total
Sample Size (number of codes analyzed)	**254**	**251**	**19**	**524**	**(99.99)**
(a) Learning to relate STEM instruction to authentic place-based weather and climate research	131	63	0	194	37.02%
(b) Learning to incorporate tactile and visual activities in K-12 STEM classroom instruction	75	90	4	169	32.25%
(c) Learning to achieve cross-curricular integration	37	54	6	97	18.51%
(d) Learning to align STEM instruction to standards	11	44	9	64	12.21%

(a) Learning to relate STEM instruction to authentic (real-world) place-based weather and climate research is the specific instructional strategy cited most frequently in teacher comments. As illustrated in Example (6), teachers stated that learning how to relate STEM instruction in the classroom to local weather and other topics of community interest is an effective way to engage indigenous students in STEM studies. Because Bering Strait schools are located in Alaska Native communities, teacher comments on local relevance also refer to learning how to include Native culture or language in STEM classroom instruction.



(6): Weather is an important science concept that affects students' lives here, so lots of real-world applications and high student interest in ACMP. We did the weather charting activity, but have not stopped. They enjoy it so much the kids won't let me stop working with ACMP.

(b) Learning to incorporate tactile and visual activities into STEM instruction is the second most frequently cited instructional strategy in teacher comments. Example (7) illustrates how ACMP training helped one teacher integrate hands-on activities into classroom instruction.

> *(7): Before I used ACMP, I taught from a book. I was actually dumbing down a college book. My mom sent up my college book and I started doing that sort of thing. And even the general science that I was teaching just went from a book, and I'd say, "read this and do these questions next," because I didn't know any better. That's what I came from. When ACMP came along I was like "Oh! I could, oh I never thought about doing that!" Now I do hands-on things with the kids. The ACMP lessons have science background. So now, it is usually, "we're going to read about this, and then we're going to do something. We'll build something."*

(c) Learning to achieve cross-curricular integration is the third most frequently cited instructional strategy learned through ACMP. Example (8) is typical of entries that explain how ACMP training and use of curricular resources facilitated the integration of STEM with other subject areas (such as art, reading, history, language, and music).

> *(8): I used the ACMP DVD in my social studies classes to demonstrate changes over time and to illustrate the land bridge. We used the ACMP Climate Change DVD to study Beringia and the geologic timeline. The students loved the interactive science games and it was extremely helpful for them to be able to look at some of the fossils on their desks and then look at the epoch periods on the DVD to see when they came about. Before they could see it happening on the DVD, the kids didn't get it.*

(d) Learning to align STEM instruction to standards is the fourth most frequently cited instructional strategy learned through ACMP. During the grant period, all Bering Strait teachers were required to meet the Alaska standards that underpin annual student standard-based testing. Examples (9) and (10) are typical of entries that explain how ACMP training and use of ACMP curricular resources helped teachers meet these standards.

> *(9) Teachers are constantly looking for material to cover the standards, so having this ACMP material and training has given teachers a progressive curriculum and standard-aligned resources they can use and that is really a plus for everyone.*
>
> *(10) Using ACMP resources has really streamlined the learning process for the kids. I didn't have to reach for straws or go out of the lesson to make it a perfect fit to the standards required by the district. Using standard-aligned material also makes it easy to rationalize… to defend it to yourself and to anyone who would say, "Why are you doing this?" It is really easy to say about the ACMP resources, "here's what we would do, here are the objectives, here's what we were learning, here's how it is useful, and here's how it meets our district standards and GLEs."*

Student Outcomes

Despite challenges in maintaining a consistent pool of students from which random selection was possible, 867 students completed pre- and post-tests over the three-year grant period, as is indicated in Table 9. All students took pre-tests the first year. Students randomly selected in the final year were tested in three different groups (according to grade level). Analysis revealed significant student improvement from pre-test to post-test for all groups and overall. Overall, students' average improvement was 74.9% ($n = 867$); a significant improvement ($Z = 25.201$, $P < 0.001$). In the first program group, students' average improvement was 83.1% ($n = 299$); a significant improvement ($Z = 14.874$, $P < 0.001$). In the second group, students' average improvement was 68.7% ($n = 382$); a significant improvement ($Z = 11.687$, $P < 0.001$). In the third group, students' average improvement was 74.3% ($n = 186$); a significant improvement ($Z = 11.687$, $P < 0.001$).

Table 9
ACMP Project Student Pre/Post Test Wilcoxon Signed-rank Analysis Results

Group	Number of Students	Average Pre-Test	Pre-Test Standard Deviation	Average Post-Test	Post-Test Standard Deviation	Average Improvement	*Z* Score	*P*
K-4	382	25.2%	32.1%	93.9%	10.7%	68.7%	16.678	<0.001
5–8	299	13.7%	26.6%	96.8%	14.1%	83.1%	14.874	<0.001
9-12	186	19.3%	27.7%	93.6%	12.1%	74.3%	11.687	<0.001
Overall	867	20.0%	29.8%	94.9%	12.3%	74.9%	25.201	<0.001

Qualitative data supports pre- and post-test student achievement results. In open-ended comments, teachers attribute improved student performance on End-of-Level (EOL) science tests to teacher involvement in ACMP. All Bering Strait students must pass EOLs in order to progress to a higher level of instruction. “Everyone (teachers and administrators) realizes that students are passing EOLs at an accelerated rate after their teacher has been involved with ACMP,” a Lead Teacher stated in a monthly report. Example (11) is an open-ended comment typical of those in the field-test report database describing student achievement.

> *(11): Student achievement has increased using ACMP. Although I do not have direct scores, I do have a class that did not get any ACMP lessons last year and one that did. The one that did, they seem to be more natural at problem solving and working towards an answer. The class that has worked with ACMP lessons this year – they have progressed rapidly in the scientific process area, which is where they previously were very weak. In this class, 12 of 14 were Proficient or Advanced on their Level 3 process test this year. Before ACMP, I had no proficient student; no one scored above 40%.*

Examples (12) and (13) typify comments in the case-study database describing how ACMP involvement increased student achievement.

> *(12) On the “Earth and Universe” End of Level science test, students are asked to pick 3 things that affect the Earth and explain how it applies to their communities. Before ACMP, students could not answer this question. We would feel extremely lucky if even one student picked one thing to write about. And, if they did write, it would be one or two sentences on the topic. This year, directly because of working with ACMP, all my high school students passed their “Earth and Universe” EOL science test. These kids all wrote on three topics related to climate and weather concepts they had learned in ACMP, pretty difficult concepts— such as the effect of the global ocean conveyer belt, ocean levels rising, and thawing permafrost— and they were able to apply these complex thoughts to effects in their local communities. And, the kids did not write just one or two sentences on each topic. Each kid wrote a book. It was amazing. ACMP really got them thinking.*
>
> *(13) Just look at this example of an EOL. Now, that is student engagement. Because of ACMP involvement, when students come to the EOL test they are more comfortable because in ACMP they have done scientific experiments, they have seen the local impact of climate change, and they say, “Oh, this is a piece of cake.” All five students who took the EOL this week got the answer about global warming right. One is an 8th grader, another a 9th grader, another a 10th grader, and two seniors. After work on ACMP, they thought the question was “easy.” Prior to ACMP, none of them felt that way.*

Finally, Example (14) typifies teacher open-ended comments on student achievement found on STEM workshop surveys. This comment refers to students looking forward to studying the ACMP unit on permafrost in the program extension year.

(14) Two of my classes actually asked if they could work longer on their End of Level tests so that they would be sure to pass. The reason? They told me, "If we pass, then we can go on to the next level and learn about permafrost next year, right?"

Unanticipated Outcomes

Both monthly reports and case study interviews described ways in which ACMP was useful to the community. Many teachers said local residents were interested in ACMP technology, as was evident in the Bering Strait village of Shishmaref. The owner of Shishmaref's only grocery store retrieved data from the ACMP school weather station daily and accessed online satellite imagery to examine weather patterns and near real-time sea ice movement influencing the region. A data display in the grocery store helped others in the community determine when local weather and sea ice conditions were favorable for engaging in subsistence hunting activities central to the Native village culture. In the Bering Strait community of Savoonga, local airlines used data from the school weather station to determine when flying out of the village was possible.

Example (15) is typical of comments that detail community use of ACMP resources.

(15) Information from the school weather station put in by ACMP is actually being used by the airline agents here because the main weather station is not working. So that is making ACMP known throughout the village.

DISCUSSION

High levels of participation, teacher feedback, survey results, and student learning outcomes indicate that the ACMP "curriculum resource-based professional development" model provides a feasible alternative to the ITEST model for offering STEM professional development in rural areas. Participant-reported impact indicates that each facet of ACMP's year-round mix of in-person, long-distance, online, and local training was beneficial for rural teachers.

Venues for Professional Development

In-person Training

Survey results from each grant year indicate extremely high satisfaction with ACMP's main in-person event for Lead Teachers (the 4-day intensive STEM workshop). All grant years, Lead Teachers gave high ranking to all 10 facets of workshop instruction. Scientific findings and methods related to annual ACMP Arctic research themes were presented during these workshops, along with instruction on implementing newly created curriculum. Teachers' open-ended comments reveal that the workshop enhanced their knowledge of scientific processes and prepared them to incorporate research-affiliated technology into classroom instruction. Teachers also believed the workshop increased their ability to mentor others, and that standard-aligned, comprehensive resources were useful for instructing multiple levels and students with diverse learning styles and abilities. In three grant years, the external evaluator noted only one unfavorable qualitative open-ended comment.

Long-distance Training

Teacher feedback indicates high teacher satisfaction and support of ACMP field-testing, the main venue used for long-distance training. Throughout the three-year grant, Lead Teachers oversaw field-testing in their rural schools far from ACMP staff in the UAF Geophysical Institute. The persistent emailing of monthly reports from Lead Teachers in all schools each grant year demonstrates consistent long-distance involvement. The majority (72%) of monthly reports, and the majority (90%) of case study interview entries describe specific reasons why teachers believed ACMP involvement was either improving their ability to provide STEM instruction in local classrooms, or enhancing student-learning outcomes.

Online Training

Use of technology skills topped the list of the reasons most frequently given for why ACMP involvement increased teacher STEM instructional ability or student learning outcomes. The technology skills theme code was applied to the variety of online ACMP training options available, including student and teacher interaction with Scientist Lectures, multimedia Climate Change in the Arctic interactive units and activities, the ACMP website, SNOW portal, access to Alaska satellite imagery, and computer modeling.

Local Training

Local training depended mainly on Lead Teacher mentorship of other staff in their schools. ACMP Science Camps were the outgrowth of local mentorship. The fact that every Bering Strait school held an ACMP Science Camp each grant year speaks volumes to the success of this mentoring hierarchy. Lead Teachers received supplies from the Geophysical Institute, but the Science Camps were staged entirely by teachers and students in local villages. High attendance at science camps in each village every grant year also indicates high levels of community interest in ACMP.

Sustainability

Community interest and high teacher enthusiasm provide a foundation for ACMP sustainability. The need to forfeit the experimental design so more teachers could field-test ACMP, the school district's need to cap teacher attendance at ACMP workshops, and qualitative comments from monthly reports and case study interviews indicate consistently high teacher enthusiasm for ACMP training, and for curricular resources designed to sustain ACMP for future teachers. For example, in the final grant year, the technology workshop focused on data collection from ACMP instruments that would remain in villages after grant end. More than 100 teachers (61% of all) signed up for the workshop, but the district capped attendance at 60.

The three-year grant ended in 2008; however, teachers throughout the Bering Strait continued to use online ACMP lessons and instruments installed near their school for at least one full school year after the grant ended. During this year, one teacher commented,

As long as I am able, I am going to use ACMP. As long as I am in the Arctic, it absolutely has direct connections to student lives, great connections. If I go further south, yeah I would have to start juggling, but it still is going to have a direct impact on the students. I can make those real connections work. Absolutely, I am going to continue using this.

Limitations

To reduce bias, four people twice reviewed the codes for every entry in all three qualitative databases. Even so, assigning codes is a subjective process, and it is possible that other reviewers could have detected other patterns. Because the STEM content portrayed in ACMP mirrors Arctic research skills and techniques, it is probable that qualitative analysis underrated teacher appreciation for the place-based nature of ACMP. Only comments that specifically referred to how ACMP incorporated local knowledge and culture received the "locally relevant" theme code. Arguably, every comment referring to Arctic research-related science and technology could have fallen into this theme category.

Because ACMP was designed to advance 21st century technology and workforce skills and to promote understanding of scientific content and processes related to Arctic research, it is not surprising that most teacher comments address these themes. Because research-based instructional skills for engaging Native students were used as the basis for lesson creation, it follows that teachers referred to ACMP's emphasis on tactile, inquiry-based experimentation, and found diverse resources useful for cross-curricular integration and for meeting multiple student learning styles, abilities, and levels.

Implications

The volume of curricular resources created during the program, and the diverse, flexible opportunities for teacher engagement made it difficult to determine which aspect of ACMP was most critical in its success. Two findings stand out, however, and each has implications for policy, practice, and potential future research. First, ACMP kept teachers engaged. ACMP did not battle against attrition, as so many programs do. Teachers were motivated to use ACMP classroom activities, experiments, and inquiry related to authentic scientific research throughout the grant, and to organize annual ACMP Science Camps (largely on their own volition) for local residents. Even after the three-year grant period, teachers continued using ACMP curricular resources.

Second, teachers were enthusiastic about long-distance interaction with scientists. Rural Bering Strait teachers did not need to interact with scientists in person or to attend two-week institutes to benefit from STEM instruction. This may be the most critical finding considering in-person encounters are exclusive—they exist within a defined time frame, are limited to teachers who can be physically present (Falk & Drayton, 1997), are labor intensive for the scientist, and are expensive to conduct (Loucks-Horsley, et. al, 1998).

Based on these results and implications, the PI created Investigations in Cyber-enabled Education (ICE), an NSF Discovery Research K-12 grant (DRL-0918340). ICE will explore the research question: Under what circumstances can cyber-enabled collaboration between scientists and educators enhance teacher ability to provide STEM secondary education? The research goal is to clarify the constructs of a framework for promoting virtual scientist-teacher collaboration that is sustainable, affordable, replicable, and broadly accessible to teachers in all parts of the U.S., including those in rural and disadvantaged areas far from research centers.

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