# Chapter 9
# Communities for Rural Education, Stewardship, and Technology (CREST): A Rural Model for Teacher Professional Development

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> *It's integrating technology completely. It's building a curriculum on the heritage and strength of our community. It's an example of how to engage kids in authentic learning. This is the biggest example we have of what education is supposed to look like.*
>
> Principal of a CREST school

**Keywords** Coastal ecology • Rural education • Sustainable learning communities • Place-based education

## 9.1 Introduction

Technology often provides an opportunity to engage student interest in self-directed learning. While technology can be a hook for students, a variety of obstacles such as a lack of technical expertise and lack of support often cause teachers to avoid using technology as an inquiry tool in the classroom (Groff & Mouza, 2008). This chapter examines a model for professional development created with the goals of building greater teacher IT fluency and of increasing student interest and awareness in STEM fields. This model was developed, implemented, revised, and evaluated through the Island Institute's Communities for Rural Education, Stewardship, and Technology (CREST) program, a 5-year project working with grades 6–12, funded by the National Science Foundation. CREST focuses on building curricular connections between schools and their communities while integrating technology in a nonhierarchical learning environment.

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The investigation detailed in this chapter identifies the theoretical frameworks guiding the CREST professional development model, examines the design principles, and describes how this methodology leads to geospatial technology integration in the science curriculum while providing concrete examples of project implementation using GIS in middle- and high-school science classrooms. Project outcomes and evaluation findings provide suggestions for best practices and identify areas for additional research.

## 9.2 Theoretical Framework

The CREST professional development model entails weaving (1) sustainable learning communities (SLCs), (2) integrated technologies, and (3) place-based education, into a highly effective pedagogy that addresses the STEM education needs of rural schools. This methodology was originally developed with 99 participants (44 teachers and 55 students), from Maine's island and remote coastal communities, and has grown to include more than 150 teachers and students from 16 schools. Participating schools range from unique one-room schoolhouses (with enrollments as small as eight students grades K-8) to more traditional regional schools with student populations of several hundred students grades 9–12. These 16 schools are spread across Maine's 5,300-mile coastline, and five are within island communities accessible only by boat. The CREST program model provides practical experience for delivering professional development effectively with rural school districts.

Maine's rural coastal and island schools are excellent collaborators for developing and piloting a professional development model because of their small school sizes, engaged teachers and students, and their close school and community connections. CREST's participating schools exemplify the strengths and challenges of working in rural districts. These strengths include a strong sense of community allowing schools to partner effectively with local leaders, provide students a chance to interact with people of all ages, and encourage individualized attention through small class sizes. Their small staff sizes and geographically isolated locations often make it more difficult for teachers and students to access professional development opportunities. While this model has proven successful in a rural environment, many of its core concepts are transferable across educational settings.

CREST focuses on delivering database development, GIS mapping, website design, and ethnographic research skills in an interdisciplinary approach that reconnects students to their communities and motivates teachers to integrate technology and create partnerships to work in interdisciplinary teams. The CREST framework is built upon four key theoretical constructs, focusing on integrated technologies, place-based education, resource stewardship, and nonhierarchical learning. The CREST professional-development model uses an integrated-technology approach that includes ethnographic research methods, website design and coding, and geographic information systems (GIS). This chapter will briefly describe the constructs of that approach and will present best practices and outcomes from the training and curricular integration using GIS, examples specifically.

### 9.2.1 Integrated Technologies

In recent publications, there is increasing recognition that the end result of IT literacy is not knowing how to operate computers but using technology as a tool for organization, communication, research, and problem-solving (Eisenberg & Johnson, 2002). The CREST program has three primary IT focus areas: geographic information systems (GIS) mapping, website development, and digital ethnography. Teachers learn to use GIS and incorporate Global Positioning System (GPS) technology to gather and analyze local community information. Through website development training, participants learn basic coding languages and create webpages as a platform for telling local stories. Digital ethnography creates skills in teachers and students to gather local data through interviews and original research and communicate that information through the creation of digital videos. While each technology area is different, all three require the acquisition and enhancement of database-management skills. The result is an integration of database-management competencies – the foundation of IT careers – with the capacity for creative inquiry. Teaching the technologies of GIS, website design, and ethnographic research methodologies, with a focus on database management, allows greater thought for data organization, storage, and easy retrieval of information to assist students in answering pressing community questions using the technologies. This integrated approach will serve both teachers and students well in the future as their level of IT literacy expands.

To use it effectively in the classroom, teachers must feel comfortable seeing technology as a tool in their toolbox, not an add-on, but an effective means for fostering inquiry-based learning to be integrated seamlessly into the curriculum. The curricular outcomes of CREST, technology, and place-based projects offer an effective pedagogy that allows teachers to draw on technology as appropriate in their day-to-day instruction. Students become experts in technology, allowing the teachers to focus on how the concepts can be applied to their curriculum. In this way, implementation becomes meaningful for all. Students are empowered to become technology leaders in the classroom while teachers are free to guide the learning process by framing inquiry-based questions (Kerski, 2008).

One participating teacher has a unit designed to help students better understand the state's resource-based economies, which are heavily reliant on fishing and farming. In the past, this may have included completing research from online and printed materials culminating in a written paper. Following participation in CREST, the teacher recognized the potential to integrate the technologies as effective learning tools for this unit. Students met the same learning goals by creating maps to analyze patterns of the state's agricultural land, digitally recording interviews with local business owners and creating short video vignettes, and writing an accompanying narrative. All three pieces were then integrated into a completed website to share the findings from this unit. Student leaders who had attended CREST summer institute were integral in teaching their peers how to use the technology to complete the assignments central to completing the unit.

This chapter focuses primarily on the outcomes from the GIS portion of the CREST professional development model. In practice, many participating teachers learn each of the three different technologies offered through CREST by participating in different training sessions each year during the annual summer institutes, while some decide to focus on learning one technology more deeply. In this way, educators expand the technology tools available in their toolbox, and are able to integrate them as appropriate. This method encourages participants to develop new ways of teaching with, rather than about, technology.

### *9.2.2 Place-Based Education*

CREST's place-based education strategies provide youth and adults – teachers and students – with opportunities to connect with their communities and public lands through hands-on, real-world learning experiences on community-based projects (Conservation Study Institute, 2006). At the project's core are the assumptions that (1) schools and young people are among our most important community resources, (2) CREST's place-based education projects must begin locally (they are not prepackaged), and (3) all project results must answer questions that are relevant to that community.

All of CREST's place-based activities reflect the desired outcomes common to most place-based education strategies: enhanced community and school connections, increased understanding of and connection to the local place, increased understanding of ecological concepts, enhanced stewardship behavior, increased academic performance in students, improvement of the local environment, improvement of schoolyard habitat and its use as teaching space, and increased civic participation (Powers, 2004). In addition, a place-based education program, such as CREST, enables rural communities to meet needs and solve problems by using the total community environment and its human resources (Young, 1980). CREST's place-based education projects are informed by research such as that completed by the Harvard Graduate School of Education (Bryant et al., 1999, Abstract) that validates the power of this approach to transform schools and communities "by grounding students' education in the local community and intentionally moving away from didactic approaches to standardized schooling," concluding that "as schools and communities work together to design curricular goals and strategies, students' academic achievement improves, their interest in their community increases, teachers are more satisfied with their profession, and community members are more connected to the schools and to students."

CREST projects are carried out inside and outside of the classroom and encourage teachers to invent new ways of engaging students in the education process through combining the power of the school's technology infrastructure and the store of local knowledge found among students' families, friends, and neighbors. CREST's 16 participating schools have partnered to create authentic learning experiences with over 70 organizations, from community groups such as local historical societies to state agencies such as Maine's Department of Marine Resources.

CREST's approach to place-based education uses Orion's recommendations for engaging a broader student audience in science education by the following: (1) placing learning in an authentic and relevant context, beginning with concrete concepts and moving toward more advanced and abstract thinking, (2) creating opportunities to make connections through a variety of learning styles, (3) integrating the outdoor environment as a key component in the learning process, and (4) relating to both the cognitive and emotional aspects of learning. Using the community as a resource and an outside classroom fosters a more holistic approach to teaching and learning about science, and it helps students become better prepared citizens (Orion, 2007).

Place-based education strategies lend themselves particularly well to incorporating geospatial technology, as GPS units become tools for data collection within the students' backyards and GIS software facilitates inquiry and analysis of local community data. In one example from a CREST high school, participating teachers partnered with a local marine nonprofit organization to teach broad ecological concepts linked to local resources. They connected with one of the driving forces of Maine's economy – the lobster-fishing industry. This made the learning more relevant to the students, empowering them to act as consultants to fulfill a real-world need identified by a local lobster hatchery. The hatchery raises and releases larval lobsters into the local embayment to promote a healthy lobster population. Students worked with the lobster-hatchery manager and local lobstermen to identify habitat areas that are particularly favorable for larval lobster settlement. Students used GIS to analyze bottom type, bathymetry, and water-temperature data to locate these important lobster settlement areas and inform the hatchery manager as to where to best release their larval lobster stock.

This student-led project enabled teachers to meet state and national science learning standards while empowering students to use geospatial technology for fully interdisciplinary learning. Students learned science content while becoming more informed citizens with a deeper understanding of their local environment and maritime industries – a driving force behind the local economy.

### *9.2.3 Resource Stewardship*

The third essential design component of the CREST project is the continual provision of opportunities for participants to develop a sense of resource stewardship. As a measure of this intent, all CREST place-based IT projects have a focus in resource conservation, entrepreneurial economic efforts, preservation of local history, and other community- development activities, all of which are considered an intrinsic part of the resource-stewardship approach (Sobel, 2004). CREST's hands-on digital-ethnography, GIS-mapping, and website-design projects have begun to reconnect students with their communities and have helped them develop a deepened appreciation for the natural resources around them and the value of preserving fragile ecosystems and seafaring traditions.

As students and teachers complete research that help to manage and conserve their local resources, their capacity to become deeply engaged can have a significant impact on their educational and career-path decisions. This becomes particularly relevant in rural areas where natural resources are often the mainstay of local economies, for it heightens the need for students to understand the degree of interrelatedness – the mixing of societal functions and natural processes (Orr, 1992).

The CREST principle of guiding students toward a sense of resource stewardship adapts Hungerford and Volk's research that identifies a linear progression of three categories that contribute to environmentally responsible behavior (1990). This progression begins with understanding an issue and imparting content knowledge. Understanding is followed by ownership, where students become personally invested in the problem. The third variable in this progression is empowerment, when students have a strong understanding of the issue and believe that they have the power to make a difference (Hungerford & Volk, 1990). Within the CREST program, teachers and students work together to identify a local community question that is of interest to students and that allows teachers to meet the requirements of content knowledge. Once the question has been identified, students become leaders within the learning process, using technology to gather information, engage in a cycle of inquiry, and become a community resource by finding and suggesting solutions to local community problems.

In an example from one CREST school, students were interested in learning why their local clam flats were closed and how the flats could be reopened for harvesting. To answer these questions, students mapped historic clam flat locations, completed population-dynamic field studies using GPS to plot inventory locations, and identified potential sources for clam flat contamination. At the same time, students interviewed old-time clammers and scientists from the state's Department of Marine Resources to learn why the flats were closed and to better understand the clamming industry's past, present, and possible future. Students created maps and videos of their findings, which they presented to the community, identifying the reasons and action steps for reopening local clam flats. Students made important connections with their community through this process while meeting national science-education standards.

### *9.2.4 Nonhierarchical Learning*

The focus on place-based education and resource stewardship has been especially effective when combined with the fourth of CREST's design components: a nonhierarchical learning environment. Each participating CREST school forms a sustainable learning community (SLC) comprised of teachers, students, and community members. SLC members receive technology training and meet regularly to plan for curriculum integration. The SLC structure takes to heart Mitchell and Sackney (2000) observation that, within a learning community, the learning of the teachers is every bit as important as the learning of the children and that a learning community consists of a group of people who take an active, reflective, collaborative, learning-oriented, and growth-promoting approach toward both the hidden dynamics and the problems of teaching and learning. They experience and express different forms of leadership, confronting uncomfortable organizational truths, and they search together for shared solutions (Hargreaves, 1994).

The CREST project focuses on creating a learning environment that enables both students and teachers to learn and ask questions freely, working together in school-based SLCs to formulate project ideas, and provide a network for local technical support. During the Summer Institutes, CREST staff members facilitate activities designed and structured to promote participant interaction on a peer-to-peer level: teachers become students and students become teachers. This design principle embodies Senge (2000) findings for the need to see the "learning organization" approach to education as more than just talking and working in groups, but instead a process that involves everyone in expressing their aspirations, building their awareness, and developing their capabilities together. Through the creation of this nonhierarchical learning environment, the enhanced sense of "buy-in" to the learning process and the increased level of student empowerment lead to a shift in interpersonal dynamics as teachers discover the wealth of knowledge and resources that their students bring to the table.

This structure not only leads to student empowerment but also helps teachers experience the power of collaborative learning, through the discussion and reflection of new ideas found within a learning community. Having teachers experience first-hand an effective learning community is a necessary step to allow them to see the value in creating and sustaining these structures within their own classrooms (Whitehouse, Breit, McCloskey, Ketelhut, & Dede, 2006). Particularly as the CREST and SLCs work together to integrate innovative technologies in the classroom, teachers take on the role of facilitators guiding the inquiry questions, while students lead the integration of the technology and become self-directed learners. When teachers become comfortable in this new role of facilitators, it enables them to become lifelong learners and imparts the same qualities to their students while creating a collaborative atmosphere of professionalism in the classroom (Holland, Dede, & Onarheim, 2006).

Once CREST students and teachers have learned new IT skills and concepts side by side during the Summer Institutes and regional trainings, they continue to gather regularly in their school-based SLCs throughout the school year to engage in an ongoing cycle of inquiry, gathering data, examining student and professional work, and giving and receiving meaningful feedback. Students whose ancestors settled Maine's islands bring to the table a vast store of collective knowledge and can contribute equally with teachers to the research, development, and execution of projects. Not only do students bring the enhanced value of local knowledge to their learning; they also become technology coordinators in the classroom. Throughout the process of technology integration, students provide training and tech support in the classroom, taking on leadership roles and helping teachers feel more comfortable with integrating technology in their day-to-day classroom instruction.

As one example of this process in action, many CREST schools have created annual geohunts (GPS-assisted treasure hunts) around their local school campus or within their neighboring community. Students who have received training in using GPS units during the summer create small geocache experiences for younger grade levels in their school. Students become leaders among their peers, teach other students GPS technology, and create experiences for younger students to learn more about their local school grounds and/or surrounding community.

## 9.3 Structure for CREST Professional Development

The CREST professional development (PD) model consists of a series of dynamic technology trainings, college and career-awareness events, and nonhierarchical team-building activities that occur over a 5-year period. The longevity of the program is an important aspect to its overall success in increasing teacher IT fluency and student interest in and awareness of STEM-related fields. Professional development experiences are more effective when delivered over a long-term period and coupled with a variety of training opportunities tailored to different needs and learning styles (McClurg & Buss, 2007). As such, the CREST program developed a series of iterative events throughout the 5-year program designed to provide intensive technology training, foster inquiry-driven learning, promote healthy SLC structures, raise awareness of and interest in STEM-related careers and college opportunities, and offer a consistent support mechanism for schools throughout project implementation.

At the core of the PD model are the annual Summer Institutes, where the most intensive trainings occur. These are weeklong workshops where participants receive structured training in one technology focus area (GIS, ethnographic research methods, or website-design coding), engage in team building, and plan curriculum. This approach provides participants with the necessary technology skills and allows them to work together as a team to develop the curriculum plan for how the technology will become integrated in individual classes. CREST Summer Institutes support a nonhierarchical learning model in which both teachers and students attend the workshops together as SLC teams and learn side by side. Individual SLC members select a technology focus area to become an expert within their team; this method grows the technology capacity of the group through the knowledge of its individual members.

The Summer Institutes' structure, however, places as much emphasis on transferring technology skills as on forming strong sustainable learning communities, through team building and curriculum planning time. For example, participants receive intense technology training in the morning and in the afternoon have time to process how their new skills will be used in the classroom during curriculum planning time. Curriculum planning time is structured in a variety of ways throughout the week including time for individual planning, collaborative work with SLC teachers and students together, and workshops spent with technology trainers to brainstorm integration strategies. In this way, CREST works to increase technology integration and inquiry-driven learning while giving participants the freedom and support to design their own curriculum within which integration takes place.

In order for teachers to feel comfortable in this nontraditional role as facilitators – not deliverers – of knowledge, they need a professional development model that prepares them for this role. Through a variety of team-building activities, student-led goal-setting protocols, and shared responsibilities during the implementation phase, teachers learn how to step back and let the students drive the learning.

During the Summer Institutes' technology training, teachers and students work together to learn geospatial skills through hands-on, collaboratively applied activities. These learning activities follow project-based learning (PBL) models, allowing participants to apply new technology skills within a particular context to problem-solve and engage in a cycle of self-directed learning (Eggen & Kauchak, 2001). By modeling the step-by-step process for participants when implementing projects back at their schools, teachers and students feel more confident in their own technological capabilities and how they can be applied to answer a variety of place-based questions. Through project-based learning, the technology training focuses on imparting larger geospatial concepts through in-depth analysis, and by having participants begin using GIS tools to ask questions about why, and not just where the problem occurs (Baker & White, 2003).

This focus on geospatial concepts is reinforced by working with participants on how to apply the technology skills using existing school infrastructure and working across many software platforms. The CREST program provides modest technology equipment (such as four recreational-grade GPS units) to increase the technological capacity within participating schools, but implementation primarily occurs through preexisting available technology infrastructure. The infrastructure at each participating school widely varies, reinforcing the need for technology trainers to teach across multiple geospatial-software platforms. To accomplish this, CREST provides beginner and intermediate classes in each technology area. The GIS training courses provide a variety of software package options including QGIS, Google Earth, ESRI's ArcExplorer Java Edition for Education (AEJEE), and ArcView. The software package CREST trainers use is determined by the participants' project needs and the technology infrastructure available at each school. While this complicates the delivery of technology training, it ensures that learning is targeted and directly applicable to the classroom.

Throughout the weeklong intensive training, participants learn software basics and then apply their new skills by completing an individual project, so that they each leave with a finished map product. This allows participants to experience the project from conception to completion, an important training aspect for modeling what will occur during the implementation of projects throughout the year. Individual project topics vary, but all are focused on practicing skills that will be necessary for successful project implementation throughout the school year.

Many projects focus on local data collection and analysis using GPS units, while others focus on searching for and centralizing data layers to plan for curricula to be implemented back at school.

Throughout the school year, project staff members regularly follow up with participants, assess their needs, and ensure that teams stay on target with the implementation timeline that is created during the Summer Institutes. CREST staff members visit each school quarterly and provide additional on-site technology trainings and place-based curriculum-development seminars as necessary to keep the momentum of implementation at each site going. Professional development reform strategies are incorporated by continuing the PD experience throughout the school year by providing additional training within the classroom creating greater chances for lasting change in teacher practice (Garet, Porter, Desimone, Birman, & Yoon, 2001).

Just as important as providing strong professional development training opportunities is the development of a strong partnership between the PD provider and participating schools. CREST schools were recruited through ongoing relationships with teachers and administrators in each of the communities. Creating long-term partnerships builds in a level of trust and accountability, for both sides to work together collaboratively, and this assists not just for recruitment but also for higher levels of retention throughout the project. The importance of building good relationships and providing adequate on-site support led the CREST project to hire one full-time staff member whose job is to support CREST schools through all stages of project implementation. This staff member provides technical support and assists with curriculum planning via remote communications (email, and phone calls), creates how-to guides for frequently asked technology questions, and is available as a resource for teachers to attend classes during project implementation to assist with technology questions, becoming a support mechanism for teachers as they begin to incorporate this new pedagogy. Employing these supportive implementation strategies has proven effective through exciting curricular and project outcomes within the schools.

## 9.4 Project Outcomes

The CREST program was originally designed and delivered with 11 middle and high schools over a 3-year period. Further funding extended the program an additional 2 years, allowing for the addition of a new cohort of middle- and high-school teachers into the project to test the educational model for professional development. This brought the total number of participating schools in years four and five to 16. Qualitative and quantitative program evaluation instruments, including pre-/post-surveys, school site visits, and phone-interview protocols, measured the success of the CREST professional development model. Throughout the program, these instruments collected stories of successful curriculum development, measured gains in teacher and student confidence using new technology skills, and tracked levels of teacher change in technology implementation in the classroom and increases in student motivation in STEM-related fields. Below is a discussion of these findings from 11 schools after 4 years of participation and five schools with 1 year of experience in the CREST program.

All 16 participating schools incorporated geospatial technology into the curriculum in some form. While the types of projects varied depending on the community questions that SLC teams identified, three general categories naturally emerged:

- Environmental management: teachers and students use their surroundings as backdrops to study ecology and environmental-science concepts. Examples include using GPS to gather information about local clam flats, lobster habitat, and heirloom apple orchards and combining this student-collected data with GIS analysis to make recommendations to the community about resource management.
- Community planning: classes partner with towns and local organizations to plan for future land uses within their surrounding communities. Examples include students serving as consultants for a local town using GPS to collect data on mooring locations and harbor characteristics for the town's harbor-management plan, students creating a land-use plan for a local park by mapping potential trail locations and other park features, and students researching the feasibility of different alternative-energy sources to provide "green" power for their school building.
- Historical preservation: teachers and students partner with local historical societies and local senior citizens to learn about the cultural heritage within their communities. Project examples include students mapping the gravesites of sailors from a victorious early twentieth-century America's Cup sailing team comprised entirely of local residents and studying changes in residential and commercial development by digitizing old city maps and comparing them with current development patterns.

Pre-/post-surveys following the CREST Summer Institutes technology training captured gains in participant confidence in using geospatial technology in the classroom. Participants answered a series of skill-based questions indicating confidence levels on a six-point Likert scale. Questions ranged from measuring confidence in completing specific tasks, such as collecting and downloading GPS data, to understanding broad geospatial concepts such as how GIS can be used to guide inquiry-based learning to answer local community questions. The 2008 Summer Institute survey showed statistically significant changes in comfort-level responses ranging from 1.0 to 4.0, with mean gains of 2.5 for the middle-school teachers and 2.6 for the high-school teachers (Nave, 2009).

The confidence levels of technology implementation reported during the Summer Institutes are reviewed during the school year as CREST evaluates the level of teacher change in technology integration. Among veteran CREST teachers, 90 % integrate the technologies fully, 3 % do so for special projects only, and 7 % do not use the technologies. Among the teachers from the new CREST schools (after less than 1 year in the program), 36 % fully integrate the technologies, 28 % do so for special projects, and 36 % do not yet use the technologies (Nave, 2009). Teachers reporting full integration do not view the technologies as strategies to be reserved for special occasions nor do they view the technologies as instructional "add-ons." As one middle-school teacher observed, "CREST has helped me teach the way I have always wanted to teach" (Nave, 2008). As has been observed in many other pedagogical research studies, these results reinforce findings that teacher engagement in long-term professional development experiences increases the impact that the PD experience has on teacher practice (Shields, Marsh, & Adelman, 1998; Weiss, Montgomery, Ridgway, & Bond, 1998).

The ultimate goal for the CREST project was to build in a level of sustainability that would continue past the 5-year grant period. The large percentage of teacher-change data showing technology integration is one measure that the CREST model is effective for creating lasting change. The pedagogical shift toward connecting schools and communities through place-based and project-based learning using technology is powerful once teachers experience the impact this type of learning has on their students. Another aspect of sustainability is continuing the relationships built before and over the 5-year grant period between project staff, teachers, school administrators, students, and community partners. These strong partnerships are one of the keys to successful program delivery, and continuing to communicate and to value each partner as a resource for the future keeps the lines of communication open and innovative ideas flowing. Similarly, the sustainable learning community structure of teachers and students encourages participants to foster and build a local network of educators who have experienced this professional development model and who are committed to supporting each other to continue this method of teaching and learning.

## 9.5 Successful Practice and Ongoing Research

CREST is unique in the design elements that define the PD model and that work toward changing pedagogy throughout an entire school site, not just in individual teachers' classrooms. Below is a description of this successful practice at work; it is useful as a guide when seeking to design similar professional development experiences.

CREST works with teachers across disciplines, including not only science teachers but also history, English, art, horticulture, technology, and math teachers. It provides a new context in which to think about how teachers interact and learn from one another. When pairing an art teacher and an economics/technology teacher together on a project, cross-pollination begins to occur and students benefit from that idea sharing in more than just one class. They begin to see connections and related applications of what they are learning in different classrooms, and their attitude about school begins to change into one of participatory learning instead of merely listening on the sidelines, asking "What does this have to do with me?" Geospatial technology works seamlessly with this cross-discipline learning strategy, enabling analysis at local, regional, and global scales to make real-world connections to learning in the classroom while meeting state and national standards in education (National Research Council, 2006).

Program evaluation has identified several key factors that lead to higher degrees of success in participating CREST schools implementing local projects including effective SLC teams and administrative support. Teachers begin to feel supported and comfortable in trying new ideas when there is a team of teachers in their building committed to the same goals of technology implementation. They also have more incentive to succeed in meeting their individual and team-project implementation goals because other team members are depending on their success. Critical to attaining these goals is the inclusion of school administration and leadership in developing the overarching SLC strategy for project implementation. When school leadership is vested in the SLC model, this style of teaching and learning becomes institutionalized, creating lasting, meaningful change (Nave, 2009).

While the CREST model provides one approach for delivering successful science professional development, there are several questions and complementary strategies that merit further research. CREST evaluation data has identified several successful means to affect teacher practice through professional development and has begun to measure baseline impacts on student motivation; this, however, is an area that requires further investigation. Additional research studies could identify factors and strategies that have positive outcomes for student motivation and correlate change in teacher practice with the effect on student motivation. The CREST model has been developed and tested in a rural environment; however, many of the program concepts could be applied in urban/suburban settings as well. Further research for transferring the model to urban/suburban schools would be a valuable way to test and refine ways in which this methodology may be used within a variety of professional development settings.

Integrating technology in the classroom often requires overcoming challenges, both technical and curricular. The growing accessibility of geospatial technology, coupled with effective professional development strategies, creates a powerful opportunity for integrating curricula and engaging students across disciplines and grade levels.

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