Emerging technology as a vehicle for teacher change: Frameworks and assessment strategies

The National Science Foundation Information Technology Experiences for Students and Teachers (ITEST) program seeks to increase opportunities for middle and high school teachers and students to learn about, experience and use information technologies within the context of science, technology, engineering and math (STEM) and in ways that parallel professional applications and promote interest in information technology (IT) careers. ITEST provides access to cutting-edge technology to students traditionally underrepresented in STEM fields through its youth-based projects, and to the teachers who work with these students through comprehensive projects. The comprehensive projects work with teachers in intensive summer workshops and full-year ongoing follow-up to aid them in their implementation of varied and intensive technology experiences. Thirty-eight ITEST comprehensive projects across the country have involved more than 3800 teachers in integrating emerging technologies into existing curriculum.

This panel presentation provides an in-depth study of the ways that ITEST comprehensive projects conceptualize the changes in teacher attitudes and practices that result from participation in ITEST, addressing questions such as:

- How do science and technology teacher professional development programs define and describe changes in teaching beliefs and practices?
- How do these changes lead to the effective implementation of sophisticated science and technology into formal classroom teaching?
- How do ITEST comprehensive projects describe their professional development models and the technology that is part of their models?
- How can researchers effectively measure and describe changes in teacher practices and beliefs, and outcomes for teaching and student learning?

The panel is divided into five presentations: the first reviews existing research on IT and STEM professional development; the second presents findings from a study of 38 ITEST projects investigating how projects have designed their work to promote teacher change; and the last three present case studies of ITEST projects that highlight the findings from the overall research. The literature review, study, and accompanying case studies demonstrate i) how ITEST projects provide a unique professional development context for teacher change through the use of emerging, cutting-edge technologies in the context of real scientific investigation; ii) how ITEST projects share common outcomes within a variety of models; and iii) the need for a more rigorous research approach to measure outcomes across projects and show the potential for ITEST-type projects to promote lasting and profound teacher change through incorporating emerging technologies into teaching.

<u>Measuring teacher change in science and technology professional development</u>

The literature review addressed the following questions: *How do science and technology teacher professional development programs define and describe changes in teaching beliefs and practices? How do these changes lead to the effective implementation of sophisticated science and technology into formal classroom teaching?*

The review first considered the ways that teacher change has been conceptualized and studied in science and technology, then looked more carefully at the methods used for the research, and concluded with a proposed research agenda for ITEST projects. We began with the goals of teacher change, addressing areas of complexity in teacher change such as the symbiotic relationship between changes in belief and changes in practice (Baumfield, 2006; Ertmer, 2005; Guskey, 1986; Loucks-Horsley, Hewson, Love, & Stiles, 1998), and described studies focusing on teacher change in four areas: i) knowledge/beliefs (Gordon, Gerber, & Price, 2002; Jeanpierre, Oberhauser, & Freeman, 2005; Watts, 2005); ii) technology integration (Astor-Jack, Balcerzak, & McCallie, 2006; Irving, 2006; Krajcik, Blumenfeld, Marx, & Soloway, 2000; Linn, 2003; Watts, 2005); iii) inquiry practices (Davis, Petish, & Smithey, 2006; Jeanpierre et al., 2005; Watts, 2005); and iv) understanding diverse learners (Lee, Hart, Cuevas, & Enders, 2004; Peck, Barton, & Klump, 2007). We then looked at methodological challenges of measuring teacher change, including: the tension of measuring change processes that can take years to manifest themselves within a time-constrained research study; the difficulties of relying on teacher self-assessments for measuring changes in practices and beliefs; and the difficulty of arriving at a common, measurable, definition of inquiry learning (Brinkerhoff, 2006; Ertmer, Addison, Lane, Ross, & Woods, 1999; Tal, Dori, & Keiny, 2001). We concluded the review by identifying three ways in which ITEST projects are uniquely situated to address gaps in the current research:

- ITEST projects use emerging technologies as tools to engage in real science, moving beyond the 'first generation' of technology education research that focused on incorporating computers into the classroom. Using emerging technologies in a middle and high school context allows teachers, and students, to expand their concept of formal learning;
- ITEST projects work directly with students traditionally underrepresented in the STEM field. There is a need for research to look at the impact of ITEST-type programs on diverse sectors of youth;
- The ITEST program is a unique combination of formal and informal education, with universities, science museums, and schools joining together to improve both classroom teaching and student out-of-school experiences. The impact on teachers of spending concentrated time outside of the classroom engaging in real science with emerging technologies deserves further research.

Information Technology Experiences for Students and Teachers: Professional Development Models, Evaluation, and Teacher Change

Our study examined professional development models of ITEST comprehensive projects and the ways in which projects conceptualized and measured the impact of professional development on teacher participants. Our final goal is to measure the impact of ITEST projects on teacher practices, but we had to first identify the specific outcomes the projects seek, and develop instruments capable of being used across a broad range of projects to measure those outcomes. We began with the question, *How do ITEST comprehensive projects describe their professional development models and the technology that is part of their models?* We reviewed project proposals, annual reports and evaluations; we conducted an online survey of project leaders; and we conducted in-depth phone interviews with a subset of study participants.

ITEST projects target a wide range of disciplines (computer science, environmental science, bioscience, and engineering) and information technologies (geographic information systems, biotechnology, 3-D modeling, robotics, digital video production, and gaming), but they share many common strategies and challenges. All provide IT classroom resources developed by the project team and/or teacher participants along with extensive in-person and remote training and support. All provide opportunities for teachers to 'practice' in the context of summer programs with youth, before transferring their newfound skills to the classroom setting. All focus on communities and youth that have been traditionally under-represented in IT careers.

While the projects focus on different aspects of emerging technologies, work with teachers from many different types of communities, and have different models of professional development, this study found that they share common targeted outcomes for teacher change. The outcomes fall into three broad categories: teacher practices, teacher attitudes/beliefs/confidence, and teacher IT knowledge and skills. While this study did not measure the extent to which projects met these outcomes, project leaders described specific changes they have observed. Most projects cite improvements in teacher knowledge, skills and practices. Teacher participants led more IT activities with students; were more confident using these activities; and incorporated more student-driven instruction. Most importantly, teachers used the targeted IT as a tool rather than a topic, and some applied their new technology skills throughout their teaching, beyond the specific ITEST project.

Project leaders affirmed, in both surveys and interviews, that their projects have had a positive impact on participating teachers. In many cases, their project-specific evaluation instruments detect those positive changes. However, while leaders overwhelmingly describe positive changes in teacher practices and attitudes, their strongest evidence is often anecdotal. Individual projects develop their own evaluation instruments, and while this in turn helps each project to describe the unique characteristics of change in their project, it has not permitted cross-project analysis to measure common outcomes. This study has allowed us to identify those common outcomes and to have the necessary information to develop common instruments with which to measure critical elements of teacher change across projects.

Eyes in the Sky: Facilitating Teacher Change through Geospatial Information Technology

The *Eyes in the Sky* program engages middle and high school teachers in an eighteen-month professional development experience that provides expertise in geospatial information technology tools (GIS, ImageJ, and GPS) and research inquiry pedagogy. Through a twelve-week distance learning program and a two-week face-to-face workshop, *Eyes in the Sky* prepares teachers to incorporate, within their curricula, geospatial information technologies (GIT), satellite imagery, and authentic science data to investigate local or regional issues such as water use, urban growth, or resource management.

The *Eyes in the Sky* summer workshop experience employs the standard ITEST format for comprehensive projects, with students and teachers participating in a face-to-face workshop. In addition, during the summer workshop, representatives from local businesses, industry, and governmental agencies make presentations about the role of GIT in their careers and lead activities that demonstrate how they use GIT in their jobs. These activities give students a view of how an "eyes in the sky" perspective addresses many community and environmental problems. During the school year, teachers implement GIT-based community research projects with their students. Projects include analyses of light pollution, studies involving saguaro cacti, and mapping and re-vegetation of a local pond habitat.

The *Eyes in the Sky* professional development model utilizes GIT professionals in a unique way, differently from what typically occurs in other programs. Rather than simply asking career professionals to speak about their work, they are invited to engage students in the summer workshop with inquiry-based activities that help to build GIT skills. These problem-based scenarios focus on real-world issues that arise as GIT professionals carry out their jobs. With one career speaker, students plotted the spread of invasive plant species in a local national park to predict future environmental impacts. In another, students worked with a hydrologist to investigate well water levels. Other activities ranged from predicting where a burglar might strike by analyzing the spatial distribution of recent burglaries to considering fifty years of changes in land use in the Phoenix metropolitan area. These activities had a tri-fold benefit to teachers: 1) they provided concrete examples of real-world uses of GIT; 2) they provided ideas that teachers could implement with their own students; and 3) as teachers worked through the activities, they reinforced their GIT skills.

Teachers participating in the *Eyes in the Sky* program changed in several ways. Teachers increased their own GIT skills, gained an awareness of how GIT is used in a variety of professions, and indicated that the summer institute format was beneficial by giving them the opportunity to immediately practice their GIT skills in the context of teaching students, and increasing their confidence about working with their own students during the school year. The most commonly cited challenges to classroom implementation included the difficulty of getting software installed on school computers and limited teacher access to those computers.

Comprehensive Information Technology in Rural Appalachia (CITERA)

The Comprehensive Information Technology in Rural Appalachia (CITERA) Project focuses on motivating 7th-9th grade students to consider careers in Information Technology (IT) to fill the increasing demand for technology workers in West Virginia and nationwide. The project targets middle and high school math, science, and technology teachers and provides IT career information and training in 3-D graphics. The project also engages guidance counselors to assist in conveying information about the abundance and variety of available IT careers. Over the past three years, over 55 teachers, 11 guidance counselors and 100 students from rural/socio-economically disadvantaged areas have participated.

Teachers participating in the CITERA Project learn to use 3-D graphics to enhance current curriculum. Teachers, counselors, and students visit technology companies and meet IT professionals who describe different careers and related educational pathways. Face-to-face training allows teachers to develop and field-test lessons in the summer, getting feedback from middle and high school students, before taking them to the classroom. The students play a valuable role as the evaluators of the lessons that the teachers will eventually make available through the CITERA website to other teachers.

The teachers enter the project at different technology skill levels, but all leave with a new technology skill (3-D graphics) and bolstered confidence to take back to "wow" their students. By taking lessons they currently teach, integrating 3-D graphics and a student-centered approach, the teachers can not only motivate students to learn, but also infuse real-world IT into the lesson. One chemistry teacher has students build virtual molecules using 3-D graphics. One math teacher uses a 3-D model she created to show how the formula for a cone is related to the formula for a cylinder and to explore hypotheses about other relationships. One technology teacher has her students work together as a software development team to build virtual models of various places.

For the CITERA Project, positive teacher change looks like teachers with more confidence using IT materials with students, teachers using more student-centered instruction, and teachers talking with students about IT careers. A teacher pre- and post-survey revealed significant positive change in several areas, including teachers' familiarity with IT careers and opportunities at the national and local levels, familiarity with courses and academic pathways important to prepare for an IT career, and their self-rating of learning how to incorporate IT into the design of math or science instructional lessons and units.

Crime Scene Information Technology (CSIT)

The New York Hall of Science, a hands-on science and technology center in Queens, NY, researched, prototyped and developed a forensic-science based information technology curriculum and portable laboratory for middle and high school teachers, known as Crime Scene Information Technology (CSIT). CSIT empowers educators to teach with information technology using forensic science, and increases confidence, competence and comfort among New York City teachers by supporting them with strong professional development and access to critical science resources. The curriculum has five mystery modules, each reflecting one of the key sciences: Living Environment, Ecology, Physics, Earth Science and Chemistry. The portable laboratory includes a class set of laptop computers, probes and sensors, microscopes, and expendable materials such as test tubes and rulers.

Teachers participate in a professional development institute where they engage in the mysteries as students themselves. They have the opportunity to reflect on teaching practice and pedagogy as they learn the curriculum. Additionally, they learn how to operate the technology and use the software for the forensic science mysteries that they will then borrow for their own classrooms once they complete the institute. Educators also co-teach the curriculum to students who attend weekend programs and camps at the Hall of Science in order to practice the curriculum before using it in their own classrooms.

A series of interviews, surveys and classroom observations were used to measure project impact on teacher development and growth. Teacher change was noted when teachers reported in three categories: science content, technology, and teaching practice. In general, all teachers reported increased competence with certain science concepts. Even those who generally felt comfortable with most of the content described how the curriculum allowed them to tackle their misconceptions about certain science concepts. Finally, teachers were hesitant about introducing such an open-ended mystery in their classroom and attempting to teach it over a series of forty-five minutes periods in a week. However, the excitement of the students, increased attendance rates and success at administering the mysteries encouraged teachers to continue the curriculum in the next year. Almost all of the teachers trained have requested the equipment to conduct the mysteries again next year.

The biggest challenge encountered by the project was that teachers needed the curriculum to align directly to mandated tests and to be modular so that lessons could happen in forty-five minute periods. They also requested a series of pre-labs so that students could learn about basic concepts, such as Punnet squares, before beginning a mystery.

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