Hayden, K., Ouyang, Y, Scinski, L., Olszewski, B., & Bielefeldt, T. (2011). Increasing student interest and attitudes in STEM: Professional development and activities to engage and inspire learners. *Contemporary Issues in Technology and Teacher Education*, *11*(1), 47-69.

Increasing Student Interest and Attitudes in STEM: Professional Development and Activities to Engage and Inspire Learners

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Abstract

The iQUEST (investigation for Quality Understanding and Engagement for Students and Teachers) project is designed to promote student interest and attitudes toward careers in science, technology, engineering, and mathematics (STEM). The project targets seventh- and eighth-grade science classrooms that serve high percentages of Hispanic students. The project design, student summer camp program, and professional development model have led to successful increases in student performance. The iQUEST student summer camp findings show that underserved populations of both female and male students experienced increased interest and attitudes toward science and technology. The iQUEST professional development model seeks to transform middle school science teachers from digital immigrants to advocates for technology being a critical part of student learning through integration of innovative technology experiences in formal science settings. Classroom observations illustrate how teachers have successfully implemented lessons that engage students in hands-on investigations, leading to deeper understanding of science and, therefore improving the potential of underrepresented students competing in STEM fields.

The U.S. Bureau of Labor Statistics predicts a 22% growth in jobs for fields related to science, technology, engineering, and mathematics (STEM) between 2004 and 2014 (U. S. Department of Labor, 2005). This change requires that the nation’s youth obtain specific skills and be provided opportunities to understand how they can best be prepared for the changes in workforce skill requirements. Lack of STEM-related skills will negatively impact women and minorities’ chances to compete for employment, wages, and leadership in all professional fields (Oakes, 1990).

Groups such as the National Science Board (2006) and the National Action Council for Minorities in Engineering (Frehill, DiFabio, & Hill, 2008) have called the current underrepresentation of minorities and women in STEM fields "America's pressing challenge" and "the new American dilemma." Leading businesses and education groups are teaming up and aiming new initiatives at increasing the number of minorities and women entering the pipeline for entry into STEM fields. Women make up 51% of the U.S. population, and Hispanics are the fastest growing minority in the U.S., expected to make up 30% of the nation's population by the year 2050. According to a report released by the National Science Board (2006), Hispanic representation in science and engineering occupations increased from 2 to 3.2% from 2000 to 2007, which is a small increase proportionally considering their overall percentage of the population. Additionally, the Tomas Rivera Policy Institute recently released a publication stating that Latinos are not only poorly represented in STEM fields, but that a severe gender gap exists between male and female representation for Latinos compared with that of other underrepresented populations (Taningco, Mathew, & Pachon, 2008).

Based on the current crisis, it is important for educational agencies to help develop the underrepresented population's potential to become professionals in areas that are essential to our nation's competetiveness in the global marketplace. Changes in today's workforce, along with the U.S. Bureau of Labor Statistics' expectations for job growth in STEM fields, require that our youth obtain sophisticated skills and support in these areas. In 2005, the National Assessment of Educational Progress found that student interest in science and mathematics was about equal for boys and girls at the fourth-grade level, but starting in middle school, girls' interest declined, and greater numbers of boys were found to complete courses in physics (Grigg, Lauko, & Brockway, 2006; National Center for Education Statistics, 2007).

According to the Doing What Works website sponsored by the U.S. Department of Education (2010a) for research-based practices, one of the five recommended practices to encourage girls toward math and science is called "Sparking Curiosity." Teachers are asked to provide students with engaging and meaningful activities as part of regular instruction in order to increase their interest and career aspirations in math and science.

> The more interested students are in a subject, the more involved they become in their assignments, putting effort into their studies and engaging in deeper levels of thinking. Experts believe that increased student engagement in math, and science at school will eventually lead to involvement in math- and science-related after-school activities and career aspirations. (U.S. Department of Education, 2010a, Sparking Curiosity Practice Summary, p. 1)

Literature Review

The underachievement and underparticipation of women and minorities in STEM has been explored for many years (Asher, 1985; Berryman, 1983; Gandara, 1995; Oakes, 1990; Rendon, 1985). Minority students' schooling experiences have a significant impact on their pathways into STEM careers. Of particular interest is teacher quality and experiences provided to students in the classroom in the area of science and the use of interventions to strengthen underrepresented youths' retention of learning over the long summer break. According to Oakes (1990), students who are able to attain careers in STEM fields first have to conquer an extensive educational pipeline (p. vi).

Oakes (1990) described three critical factors necessary to surpass successfully the educational pipeline: opportunities to learn science and math, achievement in these subjects, and students' decisions to pursue them. Similar to Oakes' findings on early schooling effects, Berryman (1983) found that the quantitative (math, science, technology) pool begins to form as early as elementary school. In her study, Berryman found trends in minority and female representation in advanced degree attainment in math and science, and their causes. Additional key findings in her study asserted that the quantitative pool reaches its maximum size prior to high school.

Minorities often diverge from the scientific pipeline during middle and high school years due to their placement in noncollege preparatory tracks characterized by low teacher expectations, lacking rigor and cultivation of problem solving and critical thinking skills (Oakes, 1990; Rendon, 1985). By the time students reach high school, the science pipeline flow is flowing mainly outward, as more students choose to, or are forced to, leave due to poor academic achievement. Consequently, lower achieving students enroll in vocational or general education courses that do not demand higher level mathematics and science knowledge (Berryman, 1983; Oakes, 1990).

Research identifying summer setback learning loss in students of lower socioeconomic status has attracted many educators to take a closer look at the current purpose, structure, and effectiveness of summer intervention programs. Studies have shown that schools do matter and that the achievement gap between lower and higher socioeconomic groups increases during the unschooled periods.

Heyns (1987) affirmed this idea, noting, “The answer from summer learning is straight forward. Schools promote learning relative to fixed periods of time without schooling; schools also equalize outcomes—not absolutely, but relative to the inequality produced when schools are closed” (p. 1153).

Alexander, Entwissle, and Olson (2001) presented a “faucet theory” as an explanation for this gap. In short, the faucet theory refers to the faucet being on when students are in session, with *all* students benefitting from school resources and making equal academic growth during this time, and the faucet being off for all students when school is not in session. Parents of middle-class students are able to make up for schools’ resources to a certain extent, but low socioeconomic families cannot afford to provide this option.

The National Education Technology Plan, released in 2010, recommended that “all learners...have engaging and empowering learning experiences both in and outside of school that prepares them to be active, creative, knowledgeable, and ethical participants in our globally networked society” (U.S. Department of Education, 2010b). For professional development in the area of technology, the plan recommended that educators “be supported individually and in teams by technology that connects them to data, content, resources, expertise, and learning.” The iQUEST project sought to address each of these recommendations through project activities.

Overview of the iQUEST Project

The iQUEST (investigations for Quality Understanding and Engagement for Students and Teachers) project is funded by the National Science Foundation under the category of Innovative Technology Experiences for Students and Teachers (ITEST award No. 0833753). The project brings technology-enhanced learning experiences as early intervention for middle school students in classrooms having high percentages of traditionally underserved populations in STEM fields, specifically focusing on Hispanic populations and girls. The five guiding principles of the iQUEST project are as follows:

1. Students' best chance to experience information and communication technology (ICT) enhanced learning comes from ICT-savvy teachers.
2. Students and teachers increase 21st-century workforce skills through ICT-enhanced learning experiences.
3. Students' and teachers' individual needs are addressed in learning communities.
4. Students who are engaged in hands-on investigations have deeper understanding of science concepts.
5. Students who see themselves as scientists pursue STEM careers.

Project teachers are provided professional development and mentoring to support them in becoming cyber-ready workforce members who feel comfortable incorporating innovative technology resources in classroom lessons to enhance students' understanding of scientific concepts and investigations. ICT resources such as visualization tools, interactive games, online collaboration, videoconferencing, and open source applications promote student interest in technology and science and prepare students as cyber-ready, 21st century workers who are prepared to pursue STEM careers.

The iQUEST Project includes six design elements, shown in Figure 1. Development of classroom resources and curriculum that align science and technology resources is completed through professional development activities, including yearly summer academies and lesson study rotations in classrooms. iQUEST classroom lessons integrate ICT within the learning of science concepts and are supported through online collaboration and mentoring. Outreach training brings school counselors together at workshops to increase their understanding of STEM-related career resources and materials important for their support of students, families, and teachers. Career videos are developed for use in workshops and for project participants and are posted on the iQUEST project website (***Editor's note:*** Website URLs can be found in the Resources section at the end of this paper).

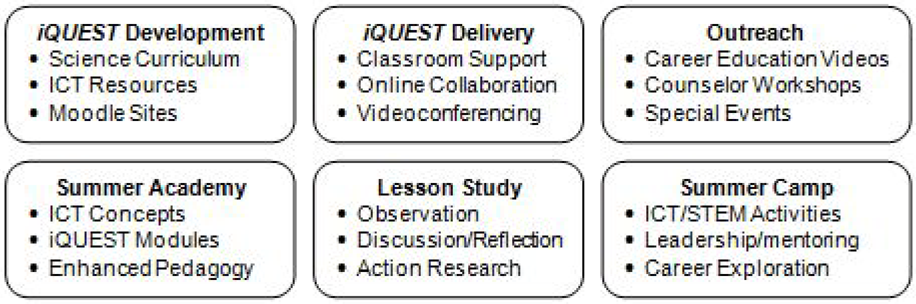

Figure 1. iQUEST Project design elements.

In addition, the project provides summer camp experiences for selected students to prepare them as leaders in project classrooms and provides valuable experiences to underserved populations of students targeted by the project. The project measures content knowledge in science and student levels of interest and attitudes toward STEM to determine whether project activities have a positive impact on students.

Research Questions

Through the design of the iQUEST project, project leadership seeks to improve the potential of underrepresented students competing in STEM fields. The primary research question is, does iQUEST improve the potential of underrepresented students to professionally compete in STEM fields? The project addresses the issues facing underrepresented youth in entering STEM fields through teacher professional development and intensive student summer camps.

This article describes answers to the research questions through two subquestions:

1. How does teacher professional development change the way teachers teach? Does the project improve teacher and student use of technology in science classrooms?
2. Do the student summer camps boost student interest in science and self-perceptions about ICT competences?

iQUEST Summer Camp

The iQUEST Summer Camp offers selected underserved populations of middle school students from project classrooms an opportunity to participate in a 1-week camp experience on the university campus. The first pilot camp was held during the summer of 2009, serving 24 Hispanic students. In 2010, iQUEST sponsored two coed 1-week camps, one serving 26 incoming seventh-grade students and the other serving 22 incoming eighth-grade students (demographics provided in Table 1). As a result of the summer camp experience, these students receive valuable learning experiences during the summer break period and are energized to become leaders during the next school year, due to their exploration of ICT tools and resources used in the project.

Table 1
Student Summer Camp Ethnicity

Ethnicity	8th Grade 2009	7th Grade 2010	8th Grade 2010
African American		2	
Native American		1	
Asian			2
Filipino			1
Hispanic	24	22	17
Pacific Islander		1	
Totals	24	26	22

Based on the iQUEST guiding principles, students are engaged in hands-on investigations to deepen their understanding of science concepts through integration of ICT-enhanced learning experiences within daily themes of the summer camp activities. The curriculum includes a variety of science activities from Earth science, physical science, and life science, with daily themes overlapping these three content areas. The iQUEST project leadership identified the theme of “Scientific Observations and Processes” for the summer camp curriculum based on these strands being included in both the California state standards (Bruton & Ong, 1998) and *National Science Education Standards* (National Research Council, 1996). Students learn about being skilled observers in a variety of venues through activities requiring them to record scientific data accurately and to reflect on the usefulness of well-organized data, as they work both individually and collaboratively.

Throughout the camp, students experience the fun and excitement of science in a shared community of peer learners. Activities involve students in collaborative investigations, including observation, guided inquiry, socialization, and interaction with experts, peers, and instructors. For example, students work in pairs to observe and classify live crabs through organized notes used later to identify specific crabs seen in displayed photographs.

In another activity student groups use digital probes to measure the electromagnetic spectrum. The probes are part of a lab that will be available to classrooms during the year to explore a variety of scientific investigations. A favorite activity during the summer camp involves a videoconference with an imaging scientist from Rochester Institute of Technology, who guides students through the process of taking apart a consumable camera to investigate the variety of technology within a low-cost tool (see Video 1).

Video 1 may be found online at
http://projects.cs.csusm.edu/sanch132/videos/video1.mov

Students participate in both virtual and physical dissection activities of cow or sheep eyes to investigate and observe the geometric shapes and angles associated with the anatomy and physiology of the eye. Geocaching takes student groups through an Earth science adventure with the help of Global Positioning System receivers, and during a career panel, experts present via videoconferencing to share the use of technology in their daily work.

Each day ends with students writing reflections as blog entries, hosted online in a camp web album, incorporating digital images taken throughout the day. At home, students share their photos and reflections with family members through the online iQUEST summer camp environment hosted on the university server. The summer camp week culminates with a showcase where students and instructors celebrate the successes and excitement of the summer camp with parents and community guests.

Summer Camp Impact on Student Attitudes and Interest

To assess the impact of the summer camp activities on student attitudes toward science and technology, two surveys were administered at the beginning and end of each iQUEST summer camp week. The Test of Science Related Attitudes (TOSRA) survey (Fraser, 1981) was piloted by the iQUEST Project prior to the first summer camp and narrowed from 70 items to 28 items that related to student attitudes and interest toward science careers. The 31-item Information and Communication Technology Attitude (ICTA) survey developed by the project was used to assess student self-perceptions for ICT skills. Both instruments use 5-point Likert scales, on which respondents indicate their levels of agreement with various statements about science or ICT skills.

In the case of the ICTA, all statements are positive. The short form of the TOSRA included 13 of Fraser’s original negative statements. These items were reverse-coded prior to analysis. In the results that follow, higher levels of agreement always indicate more positive attitudes toward the topic. Both assessments were administered in the morning of the first day of the camp, and in the afternoon of the last day. Results presented here are based on these data.

The data approximated normality, but were somewhat platykurtic. Due to the nonnormality of the distribution, we compared results from both parametric and nonparametric tests. Results about statistical significance presented here are conservative estimates, accounting for risks associated with nonnormality (D'Agostino, Belanger, & D'Agostino, Jr., 1990) and family-wise error (Benjamini & Hochberg, 1995).

Significance tests showed that TOSRA scores increased for students collectively, and Figure 2 presents changes in scores over time by gender. While both boys and girls showed increases in TOSRA scores over time, only the increases for boys were significant: average increase over time was slightly greater than one half standard deviation.

Differences between boys and girls were not significant at either Time 1 or Time 2, although the increases for boys’ scores over time surpassed the change for girls (see Table 2). At Time 2, a smaller standard deviation suggests that girls were more certain about their feelings regarding interest in science compared to Time 1. Therefore, the lack of a significant increase was not likely due to chance.

According to an ANOVA test, grade level was the only characteristic by which students differed on the TOSRA (Figure 3 displays these trends). Differences between grade levels were not significant at either Time 1 or Time 2, and over time, gains were significant only for eighth graders (see Table 3). Unlike the eighth-grade girls and all boys, seventh-grade girls did not show a significant gain in the TOSRA.

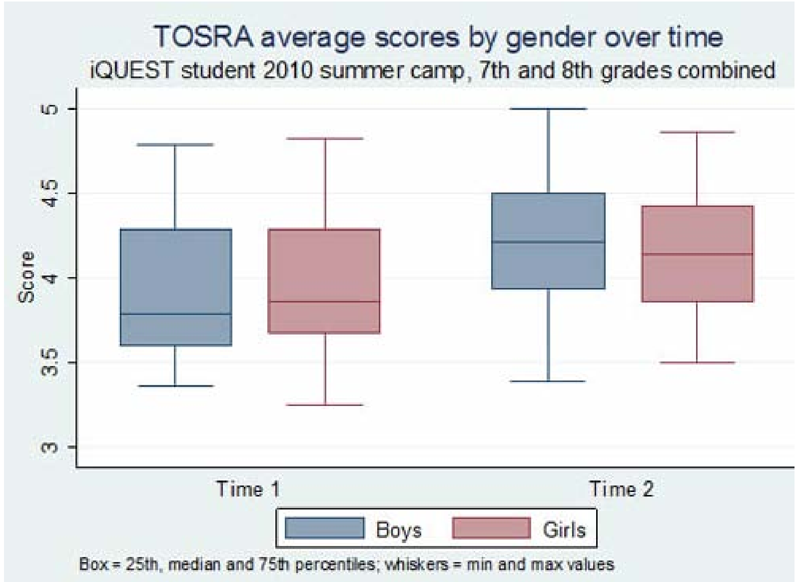

Figure 2. Student Summer Camp TOSRA scores by gender over time.

Table 2
Student Summer Camp Mean TOSRA Scores by Gender Over Time

Group	Time 1	Time 2	Freq	Difference/Time
Boys	3.907 (0.418)	4.182 (0.440)	21	**0.275*** (0.022)
Girls	3.964 (0.459)	4.145 (0.412)	23	0.182 (-0.047)
Total	3.936 (0.436)	4.163 (0.421)	44	**0.226*** (0.015)
Difference by gender	0.057	-0.036		-0.093

Note: Mean scores appear in cells for Time 1 and Time 2; standard deviations are in parentheses. "Freq" refer to the frequency count of students who completed the assessment at both times.
*$p < 0.05$

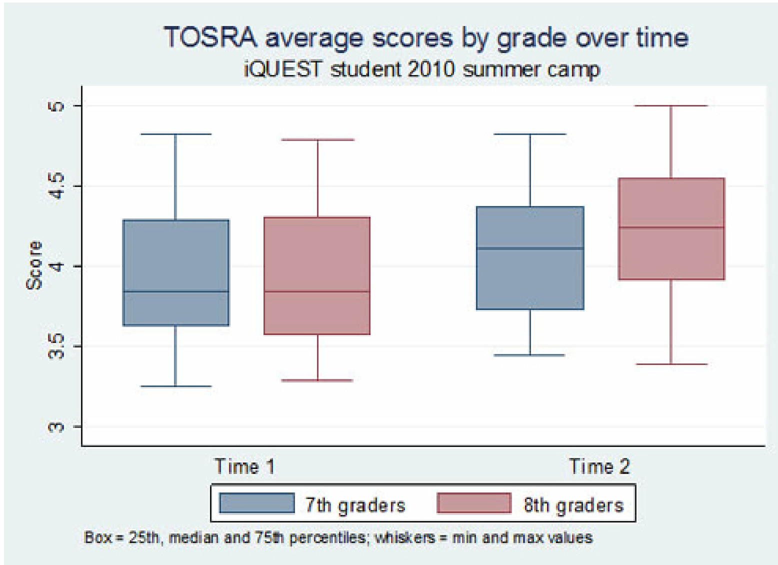

Figure 3. Student Summer Camp TOSRA scores by grade level over time.

Table 3
Student Summer Camp Mean TOSRA Scores by Grade Level Over Time

Group	Time 1	Time 2	Freq	Difference
7	3.930 (0.423)	4.102 (0.419)	24	0.173 (-0.004)
8	3.945 (0.461)	4.235 (0.423)	20	**0.290*** (-0.038)
Diff	0.015	0.133		0.118

Note: Mean scores appear in cells for Time 1 and Time 2; standard deviations are in parentheses. “Freq” refer to the frequency count of students who completed the assessment at both times.
*p < 0.05

Whereas the TOSRA measured student interest in science and science-related careers, the ICTA assessed student self-perceptions about ICT competence. An ANOVA including all variables did not suggest significant differences by gender, grade, or ethnicity. However, aggregate scores (scores for all students combined) increased significantly. Figure 4 shows changes in ICTA scores over time by gender.

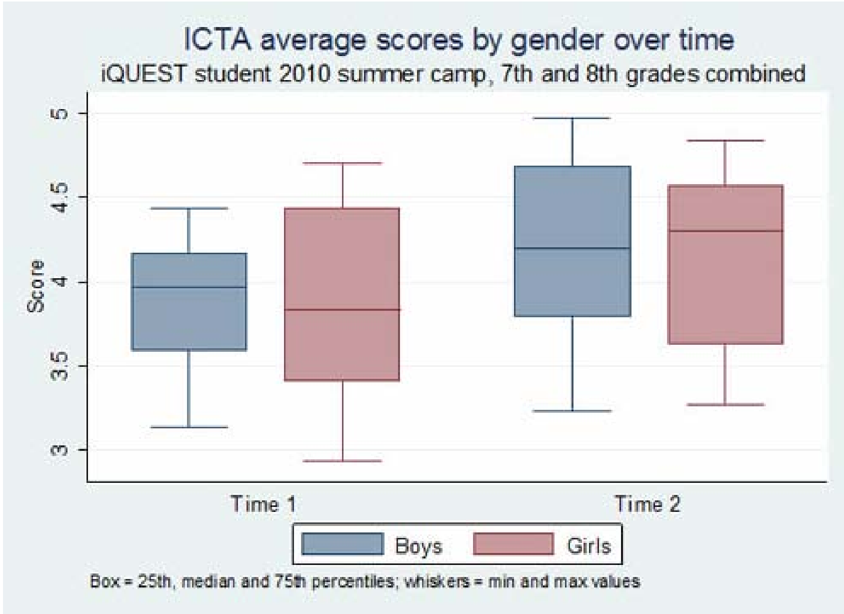

Figure 4. Student Summer Camp ICTA average scores by gender over time.

Scores for girls and boys increased significantly over time with an effect size of over one half of a standard deviation, suggesting that students reported higher feelings of self-competence with ICT skills by the end of the week (see Table 4). Differences between boys and girls at times 1 and 2 were small and statistically insignificant.

Table 4
Student Summer Camp ICTA Scores by Gender Over Time

Group	Time 1	Time 2	Freq	Difference/ Time
Boys	3.874 (0.372)	4.194 (0.524)	21	**0.320*** (0.153)
Girls	3.852 (0.530)	4.157 (0.525)	23	**0.305*** (-0.005)
Total	3.863 (0.456)	4.175 (0.519)	44	**0.312*** (0.063)
Difference/gender	0.021	0.037		-0.015

Note: Mean scores appear in cells for Time 1 and Time 2; standard deviations are in parentheses. "Freq" refer to the frequency count of students who completed the assessment at both times.
*p < 0.05

Compared to the TOSRA, rates of gain by gender were more consistent: girls' scores increased at the same rate as boys' for the ICTA. This result suggests that, although boys from the summer camps reported a greater increase in interest in science, the rate of growth in ICT skills self-assessment was equal by gender. Finally, results for the ICTA by grade level almost identically mirror those for the TOSRA: While both groups made gains over time, the rate of gain for eighth graders superseded that for seventh graders.

Summer Camp Successes

The iQUEST leadership identified what it takes to implement informal science experiences successfully for middle school students that increase interest and attitudes toward science and technology for targeted populations. The summer camp successes provided insight into the professional development needed to increase student interest and attitudes in science. The remaining sections will present the iQUEST Professional Development Model and insights into the types of classroom activities that have engaged students in formal settings.

Professional Development Model

The iQUEST professional development model for teachers targets formal science learning experiences in classrooms to support students' increase of knowledge, interest, and attitudes in science and technology. Middle school science teachers are supported by iQUEST for 2 years, including a 3-day summer academy and two technology infused collaborative lesson study rotations each school year, and ongoing support through the iQUEST project design elements shown in Figure 1.

Summer Academy

The iQUEST summer academy for professional learning is grounded on decades of research in cognitive science that has built a significant knowledge base on how people learn (Bransford, Brown, & Cocking, 1999; Donovan & Bransford, 2005). Summer academy activities are designed to expand teachers' appreciation of both science and the role of ICT in science discoveries. Teachers take field trips to science labs at the university and in local companies and organizations. In addition, teachers interact with science faculty from Rochester Institute of Technology through videoconferencing via Skype. The interaction with scientists helps teachers recognize the connection between science concepts covered in middle school curriculum and cutting edge research. For example, in a field trip to General Atomics Fusion Lab, eighth-grade teachers experienced an ah-ha moment when Rick Lee, D III-D Tokamak operations scientist and fusion education manager, presented a model of the periodic table (shown in Figure 5) from the perspective of fusion. Teachers felt they had a deeper understanding of the structure of elements through referencing this model and plan to use the image with their students.

When science teachers talk about engaging learning activities for students, they often refer to traditional, hands-on experiments such as dissecting a cow's eye or building a rocket. The use of ICT in science learning is often limited to using the Internet as a research tool in some classrooms. As teachers interact with scientists, the iQUEST project leadership continuously brings teachers' attention to how ICT is an integral component of modern scientific research. For instance, Rick Lee demonstrated use of the control room at General Atomics, where researchers use computers to monitor experiments and make adjustments during their trial iterations (Figure 6).

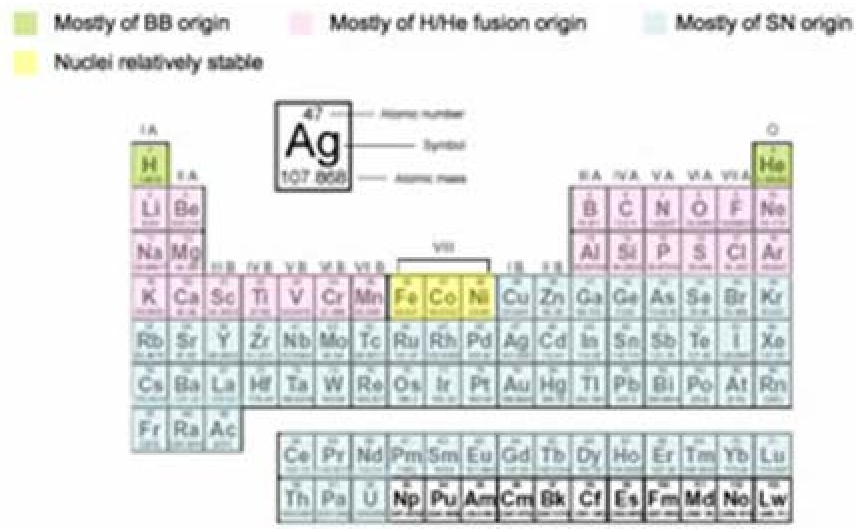

Figure 5. Periodic table presented by Rick Lee from General Atomic Fusion Lab.

Figure 6. General Atomic control center room showing technology resources.

As teachers become inspired by their interaction with scientists, the iQUEST summer academy curriculum provides an opportunity for teachers to identify appropriate instructional strategies to integrate ICT activities in their classroom. The project uses a learning management tool to host professional development materials for teachers.

Through social networking elements such as chat, wikis, blogs, forums, journals, and other tools, the project creates a collaborative online environment where teaching strategies can be discussed, supported, and actualized by participants. These experiences support professional dialog during the school year and beyond, as well as to assist digital immigrants (teachers) in adapting teaching strategies to use technologies that are most attractive and familiar to students, who are digital natives (Goldsmith, Haviland, & Smith, 2002; Prensky, 2001).

Collaborative Lesson Study

The iQUEST Collaborative Lesson Study (Bransford et al., 1999) protocol builds a community of practice in which teachers routinely share collaboratively developed lessons and share their learning, working in teams facilitated by a project leader. The iQUEST Lesson Study Design has adapted the traditional Lesson Study model (Fernandez & Yoshida, 2004) to focus specifically on technology tools as an intervention to increase student understanding.

Participating teacher teams focus on a learning gap identified from one of their classrooms, then identify a technology resource or tool to support students in overcoming the learning gap (Figure 7). By clarifying and incorporating teachers' individual beliefs, values, and priorities during the planning phase, Collaborative Lesson Study circumvents a common roadblock toward improvement (Lewis, Perry, & Murata, 2006).

Figure 7. iQUEST teachers designing a lesson to focus on technology.

After teachers have planned the lesson, they team-teach at one of their school sites, debrief and refine, and then teach it again with a different group of students. A key component in CLS is the observation and recording of events during the teaching and analysis of student work through the lens of student outcomes during debrief sessions. Thus, lesson study promotes understanding of how students respond to and understand content, and it documents the process leading to the development of effective lesson design and teaching pedagogy (Boyd, 2008).

In a standards-based school culture, information about what students are actually learning is essential to instructional improvement (Lewis, 2002; Stigler & Hiebert, 1999). Thus, CLS promotes understanding of how students respond to and understand content and leads to the development of effective science teaching (Perry, Lewis, & Akiba, 2002).

Support, Mentoring and Workshops

Another critical component of the iQUEST professional development model is the ongoing support for teachers as they implement technology-enhanced lessons in their classrooms. The project coordinator begins his role as mentor during the summer academy, setting up monthly communications with teachers to individualize support for each teacher as they implement technology-rich science lessons. The coordinator uses Skype for virtual meetings in addition to site visits.

Computer science and education college students support classrooms in the implementation of multiple lessons each semester (Figure 8). Often the computer science students work with teachers in setting up and testing ahead of time and then assist as technical support during the lesson. For instance, two project teachers implemented the program Scratch into the study of the elements from the periodic table.

Figure 8. Computer science student interacts with middle school students in iQUEST classrooms during implementation of Scratch for study of the Periodic Table.

The iQUEST project hosts monthly workshops for teachers that provide a menu of topics to match their needs in order to offer continuous opportunities to expand their skills and resources. Presenters for the workshops are practicing middle school science teachers who share their resources, strategies, and insights providing additional connections that expand the project learning community.

Professional Development Impact on Teaching Practice

The iQUEST evaluation plan includes both formative and summative assessments on the impact of professional development activities and on the overall impact on participating teachers' ability to effectively integrate technology in science classrooms. For formative assessment, surveys provide feedback following each professional development event to guide planning and mentoring of teachers. Classroom observations in the fall provide insight into how technology skills learned during the summer academy are implemented in classrooms. The project coordinator reports monthly to the leadership team on how teachers are progressing on their action plan goals.

For summative assessment, classroom observations are used to gain insight into changes in teaching strategies, types of innovative technology used in classrooms, and overall effectiveness of lessons for engaging students during science inquiry. A year-end teacher survey provides insight into the elements of professional development that are most helpful and the challenges experienced. It also asks for suggestions for the leadership team to consider as they plan the next year of the program.

The iQUEST project has provided professional development and support for 16 eighth-grade teachers and 14 seventh-grade teachers from schools with significant numbers of targeted student populations (see Table 5). Although student populations represent diversity, only 12%of the teachers are from populations other than White. This ratio is representative of the overall teacher diversity in region middle school science classrooms.

Table 5
Demographics for Participating iQUEST School Districts

District	Enrollment	% Hispanic	% Native American	% Free Meals
San Marcos	16,844	47.5	0.6	37.3
Vista	26,207	50.4	0.6	39.1
Valley Center/Pauma	4,593	37.8	10.1	35.7
San Diego City	131,034	43.8	6.0	61.0
Fallbrook	5,617	49.4	.8	58.4
Oceanside	21,517	53.3	.7	52.7
Santee	6,278	13.2	.4	28.9
Escondido	19,319	64.5	.4	57.5
Dehesa	830	15.3	2.7	6.3
Poway	33,305	11.1	.4	11.1
Note: Mean scores appear in cells for Time 1 and Time 2; standard deviations are in parentheses. “Freq” refer to the frequency count of students who completed the assessment at both times. *p < 0.05				

The demographics in Table 6 show the diverse makeup of project classrooms during the 2009-2010 school year.

Professional Development Survey. At the end of each professional development event, an online survey is completed by teachers that includes questions such as (a) What worked? (b) What needs do you have? and (c) What will you take back to your classroom?

Table 6
iQUEST Student Demographics for Project Classrooms in 2009-2010 (N = 1,259)

Ethnicity	**%**
White	46.2
Hispanic	39.2
African American	3.9%
Asian	3.7%
Pacific Islander	1.9%
Filipino	1.9%
American Indian	1.8%
Gender	**%**
Male	45.2%
Female	54.8%

The responses from teachers are sent out immediately to the leadership team in order to inform decision-making for timely adjustments and support for teachers as they apply their learning in their classrooms. The ongoing and timely modifications made by project leaders are appreciated by teachers, and the adjustments provide stronger ongoing support, increasing opportunities for success. Over the year, the project conducts approximately 20 surveys related to professional development activities.

Overall, the survey responses include comments documenting the positive experiences teachers have during the training sessions, but constructive comments are also included providing insight into adjustments needed and offering opportunities to target teacher-specific needs. For instance, lesson study teaching rotations were scheduled during the week that followed a Saturday planning meeting for teachers where they designed their lessons in teams. Based on feedback from a teacher who commented, “Need more time in between the first initial lesson study meeting and the teaching date, to make sure that technology will cooperate,” the leadership changed the schedule to provide an entire week for these adjustments to be made prior to the teaching rotations in classrooms.

Surveys also provide feedback on what is working well for teachers. For instance, following the Lesson Study planning session in fall 2009, teachers were asked, “What parts of the Lesson Study workshop worked for you?” Nine of 15 teachers indicated that the most valued aspect of lesson study was the peer interaction, planning, and sharing. Other comments included statements saying that focusing on student outcomes was valuable and that devoted time to lesson planning was appreciated.

Teacher Action Plans. A culminating event to the summer academy is the development of an individualized action plan for each teacher to identify appropriate professional growth and support needed to actualize their implementation of project lessons and resources. During monthly meetings with the project coordinator, teachers provide updates on their progress, successes, and challenges. The project coordinator reviews teacher progress and supports their completion of the action plan throughout the year. Modifications are made in their plan if the teacher identifies a new direction based on successes, challenges, or student needs.

Participating teachers have commented on how valuable iQUEST support is as they transition to using more technology in their classroom. In addition, an online environment is set up for teachers to share challenges and lessons learned within an online community, providing peer support for their own professional growth.

Classroom Observations. The International Society for Technology in Education (ISTE) and the project leadership conducted observations in eighth-grade science classrooms on December 9-11, 2009, and March 15-18, 2010. Thirteen classrooms were observed in both fall and spring. An additional classroom was observed by two observers in the fall as a training exercise only. Seven public middle schools and one private school were involved. Class sizes averaged around 27, with the exception of a nine-student class in the charter school and one class of approximately 20 students.

Observations averaged around 40 minutes in the fall and about 50 minutes in spring, with a range from 15 minutes to over an hour. Five of the 13 classes met in traditional science rooms with lab tables instead of or in addition to student desks. Four of the classes met in computer labs and six in standard classrooms.

Each observation was recorded by one observer. Sixteen were conducted by the external evaluator from ISTE, one by the iQUEST principal investigator, and nine by the iQUEST project coordinator. The instrument used was the ISTE Classroom Observation Tool (ICOT), which records details of classroom setting, technology use, teacher and student roles, and evidence of meeting the *National Educational Technology Standards* (NETS; ISTE, 2008). The three observers had previously trained together on an earlier version of the ICOT and used the joint observations to recalibrate their understanding of the rubric.

According to the iQUEST Observation report for 2009-2010 school year, completed by the project external evaluator from ISTE, "iQUEST students and teachers both spend more time in class using technology than did students and teachers in other ICOT-observed classrooms in 2008-2010." Looking only at middle school classrooms observed by the same individuals, iQUEST students spent 72% of classroom time engaged with technology, compared to 56% in other classrooms (N = 31).

ICOT rates the need for technology integration in terms of alternatives: Would there have been a way to conduct the lesson without the technology tools? Observers can give one of four responses regarding the technology:

1. Not needed; other approaches would be better.
2. Somewhat useful; other approaches would be as effective.
3. Useful; other approaches would not be as effective.
4. Essential; the lesson could not be done without it.

Ratings were given in 25 cases. Mean ratings were similar across fall and spring visits (mean/median ratings of 3, "useful"), and were slightly higher than those of non-iQUEST middle school sites observed by the same individuals. The non-iQUEST mean of 2.7 was not significantly different from the iQUEST mean, although iQUEST had higher proportions of high ratings, $\chi^2(2df) = 6.92$, $p = 0.031$. In more than half of the iQUEST observations, technology was useful or essential (Figure 9). Either the activity could not have been done (e.g., as when collecting real-time data with a probe) or it could not have been done in the available time (e.g., replicating experiments in a single class period).

Reasons for rating technology as “somewhat useful” (i.e., no better than alternatives) included uses of technology that simply replicated traditional presentations of material or situations where the potential benefits of technology were constrained by lack of access or other resources (i.e., battery drain terminating a lesson early). The one example where an observer rated a lesson’s technology as less useful than an alternative was a situation where a time-consuming art activity facilitated with technology likely detracted from the quality of scientific information that the students were being asked to research and present. Had the class been devoted to art, the rating might well have been “essential.”

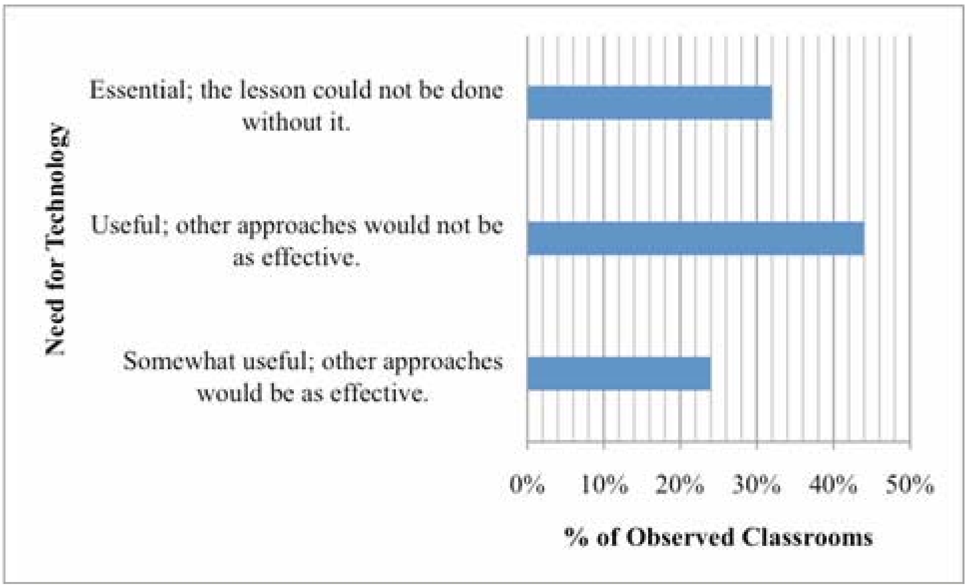

Figure 9. ICOT chart showing the identified Need for Technology, % of classrooms by level (N = 25).

The ICOT also asks observers to make summary estimates about each lesson:

- To what extent were students engaged?
- Did the technology integrated into the lesson provide an advantage?

The evaluation of engagement is subjective, but for the purposes of the iQUEST observations, the following criteria were used. “Non-engaged” behavior was any lack of attention or disruption that persisted over two ICOT timekeeping periods. That behavior might include dozing, playing, joking with friends, arguing, or anything that pulled a student away from participating in the class activities. The proportion of students identified as not engaged was subtracted from the total to obtain the percent engaged. (For example, one student out of 20 distracted for 3 or more minutes would be recorded as an engagement level of 95%.) The percent represents the lowest level of engagement observed during the period at any one time.

Looking across 21 observations in both winter and spring on which observers recorded engagement percentages, the norm was for classes to be 100% engaged in iQUEST lessons (Figure 10), with the lowest level being 80%, or about 6 students out of 30 disengaged. In some cases, less-than-full engagement seemed to be an individual matter. Some students may have had particular problems with attention or behavior, and these issues tended to emerge as they were faced with the responsibility to work independently or in lab teams. At the same time, whole-class instruction, where students were not actively engaged in any activity besides listening or watching, was another situation in which students could be seen withdrawing or engaging in distracting behaviors.

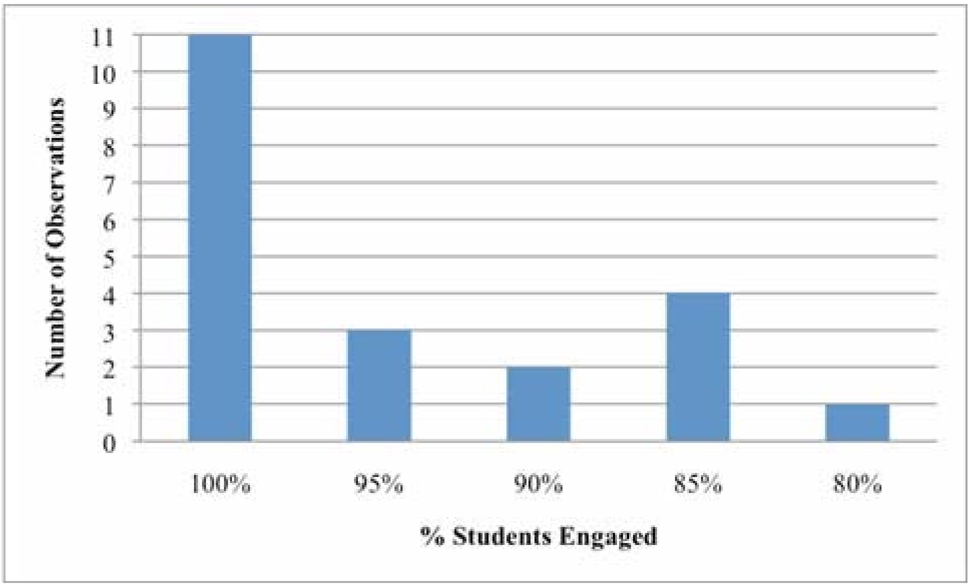

Figure 10. ICOT chart for percent of students engaged, showing frequencies by level (N = 21).

The iQUEST observations suggest that most participating teachers are integrating the grant professional development into engaging content-focused lessons. A distinctive iQUEST classroom management approach is a brief lecture followed by hands-on activities, usually done by groups of students, with the teacher modeling and facilitating learning behaviors. There were no control group observations, but compared to 31 middle school classrooms observed in other programs. IQUEST teachers and students

- use technology for more time (72% of period for students vs. 56% in other classrooms)
- are more likely to be in a facilitator role (65% of observations vs. 42% in other classrooms).
- are more likely to use small-group activities (65% of observations vs. 34% in other classrooms).
- are more likely to do hands-on training in technology and science techniques (27% of observations vs. 6% in other classrooms).

End-of-Year Survey. At the end of the first year, teachers were asked to complete a survey to indicate the parts of the professional development that were most helpful to them reaching the project goals and to comment on overall challenges. On a scale of 1 to 4 with 1 being *not very useful*, and 4 being *very useful*, the most useful elements from iQUEST are listed in order of rakings with the highest mean at 3.23 and the lowest mean being 2.61: (a) workshops, (b) collaboration with other project teachers, (c) equipment available for checkout by the project, (d) Lesson Study, (e) support from grant leadership, (f) support from computer science students, and (g) online resources. In the area of challenges and suggestions, frequency of comments was used for organizing the data.

Teachers indicated the top challenge was "finding time for activities," which appeared six times in responses. "Technology access and support at school sites" was mentioned five times, as were comments related to "unclear expectations" about the project. Challenges listed three times each included "learning new technologies" and" integrating technology." Suggestions offered from project teachers included, "clarifying expectations," mentioned four times, "providing more hands on workshops," "focus on integration with current resources," and "improve use of Web resources." All these suggestions are being reviewed and adjustments made wherever possible.

Conclusion

The iQUEST project has identified a model to deliver technology-enhanced activities that reinforce the learning of science concepts while supporting increased understanding of technology applications for target underserved populations of students. These activities, implemented during student summer camps, have shown increased interest and attitudes toward science and technology for project students. Therefore, iQUEST appears to have the potential of increasing student readiness for pursuing STEM career aspirations.

Based on the findings from the iQUEST student summer camp data showing increased interest and attitudes for the students who attend, the project leadership is working to identify ways to support implementation of similar experiences into classrooms to increase the positive impact for larger numbers of students. Using some of the summer activities and design features, teachers can provide their students with valuable skills and increased understanding needed for their future, in addition to increased career awareness related to STEM fields. The project will also track summer camp students through the year and into high school to identify whether the summer experiences impacted their course selection and career paths.

In responding to the question of how teacher professional development changes the way teachers teach, classroom observations indicate that teachers implement lessons that apply technology in useful ways that successfully engage students. Teachers indicate that barriers for access to using technology have been overcome through the support of the project. For instance, teachers now have access to digital probes, GPS devices, and online tools for supporting digital learners.

According to the year 2010 iQUEST Report by the project evaluator, "students of iQUEST teachers make significant learning gains during the year, and iQUEST professional development for teachers positively affects student performance." Though these gains are not generalizable at this time, there are clear trends in these data that support the claim that elements of iQUEST teacher professional development can boost students' achievement in many contexts. Teachers in the project will be involved in a second year of iQUEST professional development and are likely to increase their implementation of innovative technologies as they are provided additional opportunities to plan and collaborate with other project teachers.

Resources

ISTE Classroom Observation Tool (ICOT)
http://icot.iste.org

International Society for Technology in Education (ISTE)
http://www.iste.org

General Atomics Fusion Lab: Science Education Foundation
http://www.sci-ed-ga.org/index.html

iQUEST Project Web Site
http://www.csusm.edu/iquest

Scratch Web Site
http://scratch.mit.edu/

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