Exploring the Elements of a Classroom Technology Applications Implementation Framework

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Abstract

Technology use in the classroom has great potential to transform student learning, but in general, teachers still implement technology in limited ways and do not take full advantage of its potential. A careful review of the literature on technology implementation in the classroom showed that definitions of technology are fluid and that education researchers have defined the types of technologies used in classrooms in different ways. In addition to the technologies themselves, there is a diverse literature on the ways in which technology can be successfully implemented in the classroom; should the focus be on the content that is taught? On the way that it is taught? On which kinds of technology are used? This paper proposes a preliminary Framework of Classroom Technology Applications Implementation, drawing from in-depth classroom data collected from 59 teachers from September 2011 to February 2012. The preliminary framework provides a tool to describe and categorize teacher implementation of technology applications in four areas: a taxonomy of technology applications, alignment with STEM inquiry methods, relevance to real-world contexts, and pedagogical practices that encourage students to engage in active learning and critical thinking. The paper concludes with a description of three teacher groups based on the framework and an analysis of differences between teachers who have participated in technology-intensive professional development and those who have not.

Introduction

Real-world applications of technology, such as robotics, computer modeling and simulations, digital animation, multimedia production, biotechnology, and geospatial technologies, offer many benefits for K-12 classrooms including engaging students in real-world investigations and promoting interest in science, technology, engineering and mathematic (STEM) careers. Technology use in the classroom has great potential to transform student learning, but most literature shows that in general, teachers still implement technology in limited ways and do not take full advantage of its potential. For example, in a national survey, 1600 K-12 teachers and administrators were asked to rate their technology usage on 20 different benchmarks, ranging from administrative use of technology to classroom uses ("SIIA," 2012). They found that only 24% reported integrating technology of any type at a high level. Ongoing research of how teachers integrate technology in the classroom finds that while teachers use technology frequently as a tool in existing instructional practices, there is far less evidence of teachers using technology to teach in new ways (Bebell, Russell, & O'Dwyer, 2004; Dawson, 2012; Wright & Wilson, 2011). Real-world applications of technology in particular present significant challenges for teachers, including steep learning curves and the daunting task of gaining confidence and skill at guiding students through complex activities within the constraints of the K-12 classroom.

Intensive professional development (PD) focused on increasing teachers' skills and comfort with using technology in innovative ways offers one possible way to increase the use of complex technology in the classroom. The Innovative Technology Experiences for Students and Teachers (ITEST) program, funded by the National Science Foundation, is one program that supports such professional development. It provides teachers with access to STEM workplace technologies and ways to implement technology in classrooms that differ from other technology professional development because of the focus on STEM workplace technology applications. More than 50 teacher professional development projects were funded in the first five years of the ITEST program (2003-2008), working with thousands of teachers across the United States. The study described here, based on a comparative study of ITEST and non-ITEST teachers, is part of a larger study of those projects examining the impact of technology-intensive professional development on classroom teaching practices.

Literature Review

Our study sought to better understand the differences in technology implementation practices between teachers who had received technology-intensive professional development and those who had not, and to answer the question: *How do ITEST teachers differ in their classroom technology implementation compared to teachers who have not participated in an intensive technology professional development?* To address this effectively, we needed to first have clear definitions of both technology itself and of the kinds of implementation practices we are describing; this paper describes the Framework of Classroom Technology Applications Implementation that we developed to guide our work. A careful review of the literature on technology implementation in the classroom showed that definitions of technology are fluid and that education researchers have defined the types of technologies used in classrooms in different ways. In addition to the technologies themselves, there is a diverse literature on the ways in which technology can be successfully implemented in the classroom; should the focus be on the content that is taught? On the way that it is taught? On which kinds of technology are used? We present in this paper the literature and classroom implementation data that contributed to the final framework that emerged from this work.

Technology uses in the classroom

We need to first consider the types of technology applications used in the classroom. Some researchers limit technology definitions to the use of particular hardware (e.g. Britten and Cassady (2005) defined technology use as the use of computers). Many researchers focus on one specific aspect of technology integration, and use that specific definition to determine teacher implementation levels (e.g. Krikscey, 2012; Miranda & Russell, 2011; Ritzhaupt, Dawson, & Cavanaugh, 2012). Others have categorized technology uses in different ways. Inan and Lowther (2010) noted that teachers tend to use technology in one of three ways: for instructional preparation, for instructional delivery, and as a learning tool. Cox and Graham (2009) described two categories of classroom technologies: emerging technologies that are not yet part of a teacher's repertoire, and ubiquitous technologies, which are in common use in education. Lei (2010) defined technology quality by its uses (e.g. subject-specific technology use, social-communication technology use, entertain technology use), while Schofield and Davidson (2002) described incrementalist uses of technology vs. transformational uses of technology. Similarly, Maddux and Johnson (2005) described Type I technologies, in which technology makes traditional teaching strategies "faster, more efficient, or otherwise more convenient" (p. 3), in contrast to Type II technologies, which "make it possible to teach or learn in new and better ways" (p. 3) and lead to individualized instruction.

Alignment of technology implementation with STEM inquiry methods

In addition to identifying the types of technology applications used, we need to clarify the ways in which those applications are used in teaching practices, particularly the ways in which technology use can lead to changes in teaching practices that allow students to engage more actively with content and learn through doing and through inquiry (Hickey, Moore, & Pellegrino, 2001; Inan & Lowther, 2010). According to the National Science Education Standards, inquiry-based teaching consists of "developing and practicing both scientific inquiry skills as well as knowledge of content" ("National Research Council," 1995), and includes five essential features: 1) learners are engaged by scientifically oriented questions, 2) learners prioritize evidence that allows them to formulate and evaluate explanations about scientifically oriented questions, 3) learners develop explanations from evidence help answer scientifically oriented questions, 4) learners evaluate their explanations in relation to possible alternative explanations, and 5) learners communicate and provide a rationale for their proposed explanations (Crippen & Archambault, 2012).

Technology applications can provide opportunities for inquiry learning through hands-on learning opportunities (e.g., using digital probes to collect scientific data or using computer-assisted design tools for creating blueprints) that mirror how professionals in the workplace use digital tools (Moeller & Reitzes, 2011). Online web resources provide almost limitless sources of data that can be used in designing inquiry-based lessons; Crippen and Archambault (2012) provide examples of teachers developing inquiry-supportive learning environments for their students using "cyberlearning materials that enable them to extend learning beyond the confines of the brick and mortar classroom" (p. 170). De Jong (2006)noted that computer simulations can help scaffold students' understanding and learning during inquiry-based activities. Computer environments can integrate scaffolding with simulations, providing guided inquiry opportunities, which may be more effective for STEM learning (Hmelo-Silver, Duncan, & Chinn, 2007; Kuhlthau, Maniotes, & Caspari, 2007; Mayer, 2004).

In addition to STEM content knowledge, the scaffolding provided by different technology tools allows students to learn methods of STEM inquiry including data collection and interpretation of findings (Chen, 2010; Lu, 2007), and strategies for solving complex problems and develop critical thinking skills (Hmelo-Silver et al., 2007; Hsu, 2008; Miller, McNeal, & Herbert, 2010). They learn to engage with real-world, ill-defined problems and make informed decisions about scientific issues that affect their lives (Crippen & Archambault, 2012).

Technological pedagogical content knowledge (TPACK) provides another framework that supports the successful integration of technology in teaching (Mishra & Koehler, 2006). In particular, the TPACK framework considers how teachers use the unique affordances of technology to transform content and pedagogy for learners. This framework integrates the dimension of *technological knowledge* with Shulman's original construct of pedagogical content knowledge (PCK) (Shulman, 1987). The TPACK framework separates technological content knowledge from technological pedagogical knowledge (Cox & Graham, 2009). Technological content knowledge refers to understanding how a given technology application can enhance the understanding of specific content, such as using *Mathematica*, a computational tool, to help students visualize geometric properties in three-dimensional structures. Technological pedagogical knowledge refers to understanding how to use a given technology application to support pedagogical strategies, such as engaging students in motivating, collaborative, or inquiry-based activities like using Google Earth to "fly" to locations and collectively study geographic features. Here is a further TPACK example: After considering the misconceptions that arise when students try to understand how phases of the moon occur, a teacher uses a computer simulation with guided instructions to help students investigate and discover the phases of the moon, rather than having the students simply memorize the names of the phases from a textbook diagram. Thus, teachers exhibiting high levels of TPACK understand how to effectively select appropriate technology applications that will help their students understand specific content using an appropriate pedagogical approach.

Relevance to real-world and STEM professional contexts

Using real world technology in the classroom provides teachers with opportunities to make learning more relevant both to students' own lives, as well as to make connections to the world of STEM careers that students may not be familiar with. This aligns well with the current development of the Next Generation Science Standards, which include applying science to real-world problems (Thomasian, 2011), as well as with the Common Core State Standards. Relevance can also mean being engaged in activities that produce concrete artifacts (Stearns, Morgan, Capraro, & Capraro, 2012). Problem-based learning includes a focus on real-world issues and practices (Stearns et al., 2012). Integrating technology in the classroom can also provide opportunities to introduce students to careers across STEM fields

(Ejiwale, 2012). In STEM-themed specialty schools and early college programs students often receive help from practicing engineers, inventors, and scientists (Thomasian, 2011).

Teaching pedagogies using technology

Literature on integrating technology into teaching looks both at what is taught, how the technology is used, and also what kinds of pedagogies are employed. The practices most often identified promote student-centered, in contrast to teacher-centered learning. For example, students explore their creativity (Lea, Stephenson, & Troy, 2003; Lu, 2007) and engage in deep thinking (Ravitz, Wong, & Becker, 2000). Student learning is interest-driven (Lu, 2007; Moeller & Reitzes, 2011; Ravitz et al., 2000; Russell, O'Dwyer, Bebell, & Miranda, 2004); students are self-directed (Hsu, 2008; Lea et al., 2003; Lu, 2007; Ravitz et al., 2000); students have increased responsibility and accountability for their own learning (Lea et al., 2003; Lu, 2007; Moeller & Reitzes, 2011; Ravitz et al., 2000); and students engage in active learning(Lea et al., 2003; Lu, 2007; Moeller & Reitzes, 2011; Ravitz et al., 2000). In student-centered learning the teacher acts as facilitator (Lea et al., 2003; Moeller & Reitzes, 2011; Ravitz et al., 2000; Russell et al., 2004); the learning environment is resource and activity rich (Jansen, 2011; Lu, 2007; Moeller & Reitzes, 2011; Ravitz et al., 2000; Russell et al., 2004); students collaborate with each other (Jansen, 2011; Lea et al., 2003; Lu, 2007; Moeller & Reitzes, 2011; Park & Ertmer, 2008; Ravitz et al., 2000); and students present to others (Chen, 2010; Hsu, 2008; Jansen, 2011; Lea et al., 2003; Lu, 2007; Moeller & Reitzes, 2011; Ravitz et al., 2000). While all of these pedagogical practices can be used with or without technology, using real world technology in the classroom can promotes the student-centered learning practices described here (Moeller & Reitzes, 2011). Maddux and Johnson (2005) note that the most successful implementation of what they term Type 2 technologies (see above) leads to individualized instruction and moves away from teacher-centered classrooms.

Methods

Our research explored teacher PD focused on real-world technology applications by examining design and subsequent classroom implementation for projects funded through the National Science Foundation's Innovative Technology Experiences for Students and Teachers (ITEST) program. ITEST specifically funded PD experiences that focus on the connections between science, technology, engineering and math (STEM) experiences in the classroom and STEM applications in the workplace. In the first phase of our research, we found that project leaders incorporated commonly-cited best practices in their PD, as well as several unique elements. These included a strong focus on authenticity, which occurred by aligning PD activities and materials with the process and nature of STEM inquiry, providing interaction with STEM professionals, emphasizing STEM careers, and placing PD activities and material within actual geographic locations (Stylinski, Parker, & McAuliffe, 2011). In our second phase, we examined teacher participants' technology use in the classroom through an online survey. The third phase, the subject of this paper, included a subset of the ITEST teacher participants and a comparative group of teachers who use technology in the classroom.

Sample

The sample was drawn from former ITEST teachers who completed a survey of teaching practices administered in 2011, and included 24 teachers from nine ITEST projects. A comparison sample of 35 teachers was drawn from STEM teachers who responded to an open call for participation and who said they use technology in their teaching.

Data collection

Technology implementation during the Fall 2011 semester was monitored via biweekly surveys of classroom practice (see Appendix A for biweekly survey). In lieu of classroom observations, we used a "Scoop portfolio" (Borko, Stecher, & Kuffner, 2007), which has been demonstrated to provide reliable documentation of classroom practices. The Scoop process included having teachers submit five days' worth of classroom artifacts and instructional materials; teacher reflections before, during, and after the five days; and a post-scoop interview (see Appendix B for Scoop Portfolio overview and instructions). During the post-Scoop interview, the researchers could either follow up on materials submitted in the Scoop, or clarify teachers' reflections and artifact descriptions. We purposefully did not define "technology use" to teachers during the recruitment phase of our study. As such, we did not limit the range of technology implementation levels teachers might consider appropriate for our study.

Data analysis

We analyzed the data from the 59 study subjects using grounded theory; an inductive, discovery-oriented approach to qualitative research, in which theory is derived through "an iterative, concurrent process of data collection, coding, conceptualizing, and theorizing" (Fassinger, 2005, p.157). Grounded theory allows theory development to emerge from the data, obtained from comparing individuals experiencing basic social processes. We followed the basic steps of grounded theory; open coding, examining each scoop portfolio, and identifying categories of information (Strauss & Corbin, 1990); followed by axial coding, arranging the data based on the open coding categories, and finally selective coding, integrating the categories from the axial coding model to develop the framework described here. The iterative process of looking at the data, comparing the results with published literature, and reflecting on the two, led us to develop a framework that includes four categories to consider when looking at innovative implementation of technology applications in the classroom.

As noted earlier, one of the biggest challenges we faced in the coding and subsequent analysis was identifying indicators that could distinguish the characteristics of technology implementation; the Classroom Technology Applications Implementation Framework presented here provides a useful tool to both identify critical aspects of technology implementation, and to differentiate different teacher practices. We present the framework in this paper; in other papers we use the framework to analyze our data and answer our original research question.

Findings: Developing a Classroom Technology Applications Implementation Framework

While the literature review looked at technology applications, alignment with STEM inquiry methods, relevance, and pedagogical practices as four distinct categories, in practice they overlap and complement each other, and both researchers and practitioners have noted this. In order to account for the importance of each of the categories, we adopted all of them in our scoop analyses and in the indicators described here, and looked at all four categories in our data analysis.

Technology applications categories

Based on our study of classroom implementation combined with our literature review, we identify three technology categories in our taxonomy of classroom applications: 1) STEM workplace, 2) ubiquitous, and 3) instructional. STEM workplace technology applications are commonly used in STEM fields, but are not widely implemented in classrooms. Cox and Graham (2009) consider these to be emerging technologies in classrooms. We define ubiquitous technology applications as those that are ubiquitous in the

classroom as well as in STEM and other workplaces. Lastly, instructional technology applications are those designed specifically for use in instructional settings. Table 1 includes all the applications described by intervention and comparison teachers in our study classified into one of the three technology categories. When applicable, we also provide examples of specific software used by teachers.

Table 1. Technology application categories and definitions

	Technology application	Software examples
STEM workplace technology applications: common in STEM fields but not common in classroom	Robotics	Lego Mindstorm*
	Engineering design	CAD / 3-D modeling
	Computer modeling and simulations	Stella Ecobeaker*
	Digital animation and multimedia production	Adobe Suite Final Cut
	Biotechnology	NCBI database; Bioinformatics
	Geospatial technologies	ARCGIS / MyWorld*
	Probeware for field data collection	Vernier probes*/LoggerPro*
	Image data analysis	ImageJ
	Numerical data analysis	Bioinformatics; Wolfram Mathematica; SketchPad*
	Computer programming	Html / C++
	Gaming design	
	Virtual reality	3-D models
Ubiquitous technology applications: commonly used in STEM and other workplaces and other contexts, including the classroom	Word processing	Word
	Social networking	Wikis, Blogs, Facebook, Twitter, Discussion boards
	Presenting information	Prezi / Powerpoint
	Numerical data analysis	Spreadsheets / Excel
	Web-based information retrieval	
Instructional technology applications: designed specifically for use in instruction	Instructing	Webquests / Mathxl
	Assessing	Gradebook software; Online course management; Blackboard; ActiveVotes
	Role playing	Sim City / Quest Atlantis

*When teachers used technology applications designed for the classroom that mimic STEM workplace technology applications, we placed them in the STEM workplace technology application category.

Our original study design focused almost exclusively on an articulation of the STEM workplace technology applications, as these were the focus of the ITEST projects in our study. We found, however, that the comparison teachers were more likely to list ubiquitous or instructional technologies as part of their teaching practices, and so we added those two technology categories. Thus, our taxonomy of technology applications has three categories in contrast to other taxonomies that have identified two; Maddux & Johnson's (2005) Type I and Type II categories which focus on how technologies are used, or Cox & Graham's (2009) categories focused on teacher familiarity with the technology.

Technology implementation practices

Just as we built our taxonomy of technology applications by iteratively moving from the data to the literature and back again, we developed our preliminary framework of Classroom Technology Applications Implementation by identifying the characteristics of technology implementation that we found in the scoop portfolio data and comparing those with the literature on technology implementation. We found that teachers described using technology applications in alignment with STEM inquiry practices (Moeller & Reitzes, 2011; Ritzhaupt et al., 2012), and that these also aligned with the Next Generation Science Standards and the National Science Education Standards ("NGSS," 2011; "NCES," 2000), and the Common Core State Standards Mathematical Practices ("Common Core State Standards for Mathematics," 2011). Teachers also described pedagogical practices that encouraged student-centered learning (Hsu, 2008; Lu, 2007; Ravitz et al., 2000). A smaller proportion of teachers also used technology applications to promote students' understanding of real-world problems (Stearns et al., 2012). Among those teachers who did not engage in these types of practices, they tended to use technology as a substitute for other tools, within teacher-centered rather than student-centered instruction, and without coherently integrating the technology into the broader lesson plan. In Table 2 we present our Preliminary Framework of Classroom Technology Applications Implementation.

Table 2. Preliminary Framework of Classroom Technology Applications Implementation

Categories	Indicators	
	Science and Engineering*	**Mathematics**
Alignment with STEM inquiry Science, engineering, mathematics indicators	1. Students exhibit curiosity, define questions from current knowledge (NCES) 2. Students ask questions (for science) (NGSS) 3. Students define problems (for engineering) (NGSS) 4. Students propose preliminary explanations/hypotheses (NCES) 5. Students develop and use models (NGSS) 6. Students plan and carry out investigations (NGSS, NCES) 7. Students gather evidence from observations (NCES) 8. Students analyze and interpret data (NGSS) 9. Students explain based on evidence (NCES) 10. Students use mathematics and computational thinking (NGSS) 11. Students construct explanations (for science) (NGSS) 12. Students design solutions (for engineering) (NGSS) 13. Students consider other explanations (NCES) 14. Students test explanation (NCES) 15. Students engage in arguments from evidence 16. Students obtain, evaluate, and communicate information (NGSS, NCES)	**CC Mathematical Practices** 1. Students make sense of problems and persevere in solving them 2. Students reason abstractly and quantitatively 3. Students construct viable arguments and critique the reasoning of others 4. Students model with mathematics 5. Students use appropriate tools strategically 6. Students attend to precision 7. Students look for and make use of structure 8. Students look for and express regularity in repeated reasoning
Pedagogical practices encouraging student-centered learning	1. Students present to others 2. Students explore their creativity 3. Students engage in deep thinking (no right answer) 4. Student learning is interest-driven 5. Students work with independence/autonomy/self-direction 6. Students have increased responsibility and accountability for their own learning 7. Student engage in active learning 8. Teacher is facilitator 9. The learning environment is resource and activity rich 10. Students collaborate with each other	
Relevance to students	1. Student learning is focused on authentic problems 2. Student learning has real-world application 3. Student learning links to STEM career 4. Student learning links to STEM professionals	

*The science and engineering indicators were drawn from two sources, as noted; when the final Next Generation Science Standards are published, we will adapt the indicators to reflect those changes.

Applying the framework

The preliminary framework has thus far provided a useful way to describe and categorize teacher implementation of technology applications. We found that most teachers fell into one of three groups. Table 3 provides a description of each of the groups and a teacher example from our study sample.

Table 3. Classroom Technology Applications Implementation: Teacher Groups

Teacher Group	Example from Data
Intense: Teachers with indicators from all three categories of practices, often more than one indicator from each category, and usually using more than one technology application in more than one category	Teacher used GIS/GPS lessons and activities to teach students about land use and water pollution. Students used two different types of mapping software (FieldScope, MyWorld) to identify point sources of pollution in their neighborhood; strong place-based component. Student learning was aligned to STEM inquiry practices, encouraged active student learning, and focused on community issues. Used STEM workplace technologies, ubiquitous technologies (excel for data analysis), and instructional technologies (ppt as teacher presentation tool).
Medium: Teachers with indicators from two categories of practices (usually alignment with STEM inquiry methods and pedagogical practices encouraging student-centered learning), often using more than one technology application in more than one category	Teacher used unit from ITEST project curriculum to learn statistical methods. Students used online database to obtain data, completed teacher-designed worksheet of statistical calculations, produced ppt presentation of findings. Used multiple technology applications, students engaged in inquiry, all students used the same data rather than develop individual hypotheses.
Minimal: Teachers with indicators from none or only one of the categories of practices, and usually using technology applications from the Instructional category and sometimes from the Ubiquitous category. In addition, teachers in this group commonly used technology in one or more of the following ways: - Using technology as a substitute for other tools; - Using technology within teacher-centered instruction; - Using technology without coherently integrating it into the broader lesson plan.	Teacher taught unit on Geologic Time, Continental Drift, and Plate Tectonics. Students started with a pre test (using clickers) and a webquest to get familiar with the content, then had a discussion about the structure of the earth and reviewed what they learned through a game. Teacher used a variety of instructional technologies; displaying material with the document camera or smartboard, assessing with clickers. Technology was used as a substitute for other tools, and within teacher-centered instruction.

We used the Classroom Technology Applications Implementation Framework to classify each of the teachers in our study into one of the three groups (Table 4). While a similar percentage of ITEST and comparison teachers fell into group 1 (those teachers who used all three categories of practices and multiple technology applications), a higher percentage of ITEST teachers were in groups 1 and 2 (58.3%) than comparison teachers (45.7%).

Table 4. ITEST and Comparison Teachers by Group

	ITEST		Comparison	
	Frequency	Percentage	Frequency	Percentage
Intense	5	20.8	6	17.1
Medium	9	37.5	10	28.6
Minimal	10	41.7	19	54.3
Total	24	100.0	35	100.0

Discussion

Typical, often low-end, classroom technology applications tend to support existing teacher-centered pedagogical practices rather than transforming practice (Barron, Kemker, Harmes, & Kalaydjian, 2003; Zhao & Frank, 2003). Some researchers and practitioners align high-quality technology integration with student-centered learning (Hickey et al., 2001; Inan & Lowther, 2010). Maddux and Johnson (2005) argue that what they term Type II technologies, or those which enable improvements and innovations in instruction or learning, can be successfully integrated into teaching only when there is a pedagogical shift towards individualized instruction. The importance of making content relevant to students and making connections to STEM careers is often cited by those who are advocating pedagogical practices that lead to student-centered learning (Lea et al., 2003; Moeller & Reitzes, 2011; Ravitz et al., 2000; Stearns et al., 2012). Implementation of STEM inquiry methods also leads toward pedagogical practices fostering student-centered learning (Chen, 2010; Hsu, 2008; Lu, 2007; Park & Ertmer, 2008). The preliminary framework successfully delineates the specific differences between those teachers who use technologies who "make it possible to teach or learn in new and better ways" (Maddux & Johnson, 2005, p.3), who foster student practices in STEM inquiry (Crippen & Archambault, 2012), apply science to real-world problems (Stearns et al., 2012), and promote student-centered learning (Moeller & Reitzes, 2011), from those who use technology in ways that do not transform their teaching or student learning.

The task of defining implementation practices led us to an extensive iterative process that resulted in the framework presented here. The four aspects of technology implementation provide a comprehensive description of the myriad ways that teachers are using multiple technology applications in the classroom. Those teachers who are using STEM workplace technologies to engage their students in STEM inquiry tend to use pedagogical practices that are more student-centered, and are more likely to make connections to the real world, either placing the learning in a local context, or connecting to the workplace. The inter-relatedness of technology use, pedagogical practices, and alignment with STEM inquiry practices, also resembles TPACK (Mishra & Koehler, 2006). By identifying the specific indicators for each of the four categories, the Framework provides a tool with many potential uses, from teacher professional development to classroom observations.

We hypothesized that those teachers with intensive professional development in ITEST-like projects, with the emphasis on STEM workplace technologies, would tend to be those who use more STEM workplace technologies, and who use them in ways that combine with other technology applications, align with STEM inquiry, are based in real-world contexts, and promote student-centered learning. As noted above, a greater percentage of ITEST teachers were in Groups 1 and 2, indicating a greater use of technology applications in ways that align with STEM inquiry, that promote student-centered learning, and that incorporate real-world contexts. However, many comparison teachers also were in Groups 1

and 2, and merit further analysis. The depth and quality of the Scoop portfolio data allows this, and our ongoing analysis includes the following:

- Exploration of teacher backgrounds, including the professional development experiences of comparison teachers, to identify those who, though not participating in ITEST, had ITEST-like professional development;
- Inclusion of the role of the local context in teaching practices, including student backgrounds and access to technology for students and teachers;
- Examination of teacher understandings of the role of technology applications in their teaching.

The Classroom Technology Applications Implementation Framework will facilitate a deeper examination of how teacher experiences, local context, and teacher world views contribute to technology implementation practices, and ultimately to student classroom experiences.

Appendix A
Biweekly Survey

Teacher Information

1. What is your username/study ID number?
2. For validation purposes, please enter your initials.
3. The two-week period this feedback form refers to is:

    NOTE: Please conform to these dates as closely as possible when reporting your classroom activities. If your school year/instruction begins in the middle of one of these windows (e.g., September 1), simply begin reporting for the next full two-week period (e.g., September 12-23).

    - August 1-12
    - August 15-26
    - August 29-September 9
    - September 12-23
    - September 26-October 7
    - October 10-21
    - October 24-November 4
    - November 7-18
    - November 21-December 2
    - December 5-16
    - December 19-30
    - January 2-13

Instructional Technology Software

4. How often in the past two weeks have <u>you or your students</u> used the following technology SOFTWARE for instruction or learning?

    NOTE: This question asks only about software being used. You will have an opportunity later to indicate what hardware/tools you or your students use in your instruction/learning.

    1 (Never)   2   3   4   5 (Every Lesson)

    - <u>Communication Software</u>: used to share ideas and receive information from others remotely through email, blogs, listservs, web-conferences and other digital communication (Gmail, Skype, etc.) [Note. This category excludes social networking software, which has its own category below.]
    - <u>Course Organization Software</u>: used to design or maintain a course website or other tool to organize course-related activities such as homework and grading (Blackboard, Moodle, etc.)
    - <u>Digital Design Software</u>: used to produce mass media products such as web pages, videos, animation, and podcasts (InDesign, Dreamweaver, Final Cut, etc.)
    - <u>Engineering Design Software</u>: used to create materials such as robotic devices (LEGO robotic software, etc.)
    - <u>Field Data Collection Software</u>: used to digitally record data in a remote or outdoor setting (PASCO or Vernier software used with probes, Sky Scouts, etc.)
    - <u>Gaming Software</u>: used to role-play or solve problems in a rule-based Internet or video environment (Quest Atlantis, SimCity, etc.)
    - <u>Geovisualization Software</u>: used to model geographic features, such as topography (Google Earth, GeoMapApp, etc.)

- <u>Image Data Analysis Software</u>: used to analyze imagery and reveal information not apparent from visual inspection (ImageJ, etc.)
- <u>Modeling and Simulation Software</u>: used to represent and manipulate objects, concepts, or systems (Stella, Inspiration, etc.)
- <u>Numerical Data Analysis Software</u>: used to analyze mathematical patterns and relationships (spreadsheets, graphing, bioinformatics, etc.)
- <u>Presentation Software</u>: used to display information to an audience for instructional purposes (Microsoft PowerPoint, Apple Keynote, Activ Inspire, etc.)
- <u>Programming Software</u>: used to create and edit numeric, graphic, and/or command-driven code underlying computer programs to create a game, webpage, simulation or other product (C++, html, etc.).
- <u>Social Networking Software</u>: used to exchange ideas and work or collaborate with others remotely (Facebook, Twitter, wikis software, online toolkits like Wiggio/LiveBinder or Google Docs, etc.) [Note. This category excludes other communication software, which has its own category above.]
- <u>Spatial Data Analysis Software</u>: used to analyze data with reference to position (ArcGIS, My World, FieldScope, etc.)
- <u>Student Assessment Software</u>: used to administer or track student assessments (SOL, BART, etc.)
- <u>Virtual Reality Software</u>: used to interact with simulated environment (QuickTime Virtual Reality, Wii software, etc.)
- <u>Web Search Software</u>: used to conduct research on the internet, whether in preparation for instruction or as part of instruction (Google, Yahoo!, etc.)
- <u>Word Processing Software</u>: used to prepare documents or other printed material for instructional purposes (Microsoft Word, WordPerfect, etc.)
- Other (if you selected 'Other' please describe here what was used: _____)

Instructional Technology Hardware
5. How often in the past two weeks have <u>you or your students</u> used the following technology HARDWARE for instruction or learning? (select all that apply):

1 (Never)   2   3   4   5 (Every Lesson)
- Desktop computer
- Laptop computer
- Global positioning system (GPS) unit
- Tablet or smartphone (iPad, iTouch, iPhone, Android, etc.)
- Digital probe for measuring physical, chemical or biological variables (PASCO or Vernier probeware, etc.)
- Student response system (clickers, etc.)
- Graphing calculator
- Digital still or video camera
- Digital audio recorder
- Digital projector (Smartboard, ELMO, Mimio, microscope projector, LC projector, etc.)
- Other (if you selected 'Other' please describe here what was used: _____)

Purposes of Technology Use
6. How often in the past two weeks have <u>you or your students</u> used TECHNOLOGY for the following purposes in your classroom?

1 (Never)   2   3   4   5 (Every Lesson)

- To drill factual material
- To create a mass media product (website, digital video, animation, podcast, etc.)
- To communicate with other students for academic purposes (email, texting, Skype, blogs, Twitter, Facebook or other social networking websites, etc.)
- To communicate with STEM professionals (email, texting, Skype, blogs, Twitter, Facebook or other social networking websites, etc.)
- To collect, analyze, or graph data
- To run models or simulations
- To acquire basic computer skills (saving a file, printing a document, etc.)
- To map data
- For role-playing or problem-solving games
- To browse the Internet for ideas or information
- To prepare and present information (PowerPoint, etc.)
- To create materials or write a computer program (create a game, drive a robotic device, etc.)
- To write a document, such as a report or research paper
- For note-taking
- To engage in open-ended lab investigations
- To take a test, or take a quiz
- To complete a performance task
- To write responses that require students to explain their thinking
- To work on short exercises related to the topic
- To develop technical or scientific writing skills, including creating equations, graphs and tables
- To work on interdisciplinary lessons
- To acquire knowledge or skills (listening to podcasts, using online tutoring programs, etc.)
- Other (if you selected 'Other' please describe here what was used: _____)

Reflections on Technology Use in Your Classroom
For the following set of questions, please think about a lesson or activity in the past two weeks, in which you tried to implement an innovative, new, or interesting use of technology in your classroom.
7. Please provide a brief description of how you used technology in this lesson or activity.
8. Please describe if and how technology made this lesson or activity <u>effective and successful</u>.
9. Please describe if and how technology made this lesson or activity <u>challenging or problematic</u>.

This is the end of the survey. Thank you for your participation!

Appendix B
Scoop Portfolio Overview and Instructions

Capturing What Takes Place in Your Instruction
Our study examines the integration of technology in STEM instruction in the classroom. Probably the most accurate way to do this would be to observe every lesson, catalog every assignment, and examine every test. However, this method is too time-consuming for both teachers and researchers. As a result, we are utilizing an alternative method of collecting information about each STEM class, known as a "Scoop" in which we are investigating **your best use of technology in your instruction over a five-day period.**

A Scoop of Classroom Material
One way scientists study unfamiliar territory (e.g., freshwater wetlands, Earth's crust) is to scoop up all the material they find in one place and take it to the laboratory for careful examination. Analysis of a typical Scoop of material can tell a great deal about the area from which it was taken.

We would like to do something similar in classrooms, i.e., scoop up a week's worth of material and conduct an in-depth analysis to learn how technology is being used in the classroom. Although the five-day period which the Scoop entails may not completely capture an entire teaching unit in your classroom, your descriptions and reflections about the material you submit will help to frame what you do submit within the larger context from which it was pulled.

Items you should include as part of your Scoop are:
- *Instructional materials you prepared for the class*: e.g., written plans, copies of Teacher's Edition suggestions to teachers, handouts, assignments, descriptions of technology tools that will be used, assessments, and descriptions of the instructional setting
- *Instructional materials generated during class* by you or your students: e.g., notes or problems and questions displayed to students, notes written to yourself about the lesson, notes written to yourself about the students, student-created instructional materials such as rubrics or review questions
- *Evidence of students' technology use*: e.g., screenshots, URLs of websites visited, computer-generated output
- *Photographs of the instructional context*: e.g., seating arrangement, information displayed to students, instructional and technology tools used during the lesson by you or your students, and materials created during the lesson that cannot otherwise be scooped.

If you think of other things that could help us to understand your classroom and your students' use of technology in instruction, please include these as part of your Scoop.

Reflections on the Scoop
In addition, we want to know about your plans for the Scoop period, your reactions to each day's lesson, and your overall thoughts about the set of lessons. We will ask you to respond to reflection questions:

- Once, before the Scoop period begins
- After each day's lesson, and
- Once, at the end of the series of lessons in the Scoop timeframe.

We recognize that the process of assembling the Scoop Portfolio will require a moderate amount of extra work for the five-day period it entails. However, the Scoop Portfolio can also be a valuable learning tool for your own professional development, such that it can be helpful for describing and reflecting on your own instructional practices, and for collaborating with colleagues and researchers to better understand the nature of STEM learning and technology integration in your classrooms. In addition, the stipend that you will earn as a participant in this study is meant to alleviate some of the burden of the extra work involved.

Scoop Checklist
Please read through these task lists before beginning the Scoop. Once you have started the Scoop, refer back to the lists as necessary to make sure you have completed the daily activities. At the end of the Scoop period, review the tasks again, as well as the Final Checklist, to be sure your portfolio is complete.

- Tasks to Complete BEFORE the Scoop
  - Familiarize yourself with the Scoop Portfolio instructions and materials. We encourage you to ask questions (pd2practice@edc.org) about anything that is unclear.
  - Select a 5-day timeframe to use for the Scoop that represents your best use of technology in your instruction. For more information on how to select a Scoop timeframe, see the "Selecting a Scoop timeframe" section below (p. 4).
  - Write or upload an audiorecording of your responses to the Pre-Scoop Reflection Questions, to be completed once before the Scoop period begins.
- Tasks to complete DURING the Scoop
  - Record your scooped class plans daily in the calendar provided. For more information on how to complete the calendar, see the "Calendar" section below (p. 5-6).
  - Collect and upload instructional materials you *prepared for the class*, including (but not limited to) written plans, copies of Teacher's Edition suggestions to teachers, handouts, assignments, descriptions of technology tools that will be used, assessments, and descriptions of the instructional setting. We are intentionally not defining "technology" for the purposes of this Scoop, so as to not limit what you may include in your portfolio. Please feel free to include anything and everything you consider to be technology. For more information on how to collect instructional materials, see the "Collecting Artifacts," "Collecting Instructional Materials," and "Describing Instructional Materials" sections below (pp. 6-7).
  - Collect and upload instructional materials *generated during class* by you or your students, including (but not limited to) notes or problems and questions displayed to students, notes written to yourself about the lesson, notes written to yourself about the students, student-created instructional materials such as rubrics or review questions. For more information on how to collect instructional materials, "Collecting Artifacts," "Collecting Instructional Materials," and "Describing Instructional Materials" sections below (pp. 6-7).
  - Collect and upload evidence of students' technology use, including (but not limited to) copies of student assignments or assessments, screenshots, URLs of websites visited, and computer-generated output. For more information on what types of student work to select, see the "Selecting Evidence of Student Technology Use" and "Describing and Reflecting on Evidence of Student Technology Use" sections below (pp. 7-8).
  - Upload photographs of the instructional context, including (but not limited to) seating arrangements, information displayed to students, instructional and technology tools used during the lesson by you or your students, and materials created during the lesson

that cannot otherwise be scooped. For more information on what to photograph, see the "Taking Photographs" section below (pp. 8-9).

- o Write or audiorecord your responses to the Daily Reflection Questions at the end of each day
- Tasks to Complete AFTER the Scoop
    - o Write or upload an audiorecording of your responses to the Post-Scoop Reflection Questions
    - o Select a date and time for your Post-scoop phone interview using the "Post-scoop interview calendar" tab on the PD2Practice website.
- Final Checklist (Please be sure you have completed all of the items listed below)
    - o Pre-Scoop reflection (once)
    - o Uploaded and described instructional materials and photographs
        - ▪ Day 1
        - ▪ Day 2
        - ▪ Day 3
        - ▪ Day 4
        - ▪ Day 5
    - o Uploaded and described evidence of students' technology use
    - o Calendar of scooped class plans
    - o Daily reflections
        - ▪ Day 1
        - ▪ Day 2
        - ▪ Day 3
        - ▪ Day 4
        - ▪ Day 5
    - o Post-Scoop reflection (once)

TASKS TO COMPLETE BEFORE THE SCOOP

Selecting a Timeframe
Please collect the Scoop for the equivalent of five consecutive days of instruction in your selected class. It is ideal for the Scoop to begin at the start of a new instructional unit or topic, but we are first and foremost interested in seeing a time period of what you consider your best incorporation of technology in your instruction. You may start on any day of the week (i.e., the scooped days do not have to be Monday through Friday). You should start scooping at a logical point in your lesson plans. For example: if you are starting a new unit of instruction that incorporates technology on Wednesday, then your Scoop should start on Wednesday.

The five days of instruction might not coincide with five consecutive school days. If you teach on a block schedule, you should collect your Scoop for the equivalent of five days of instruction on a regular (non-block) schedule, assuming 50-minute periods. This will most likely be 3 days of instruction on the block schedule.

Even if you typically teach your class every day, your class schedule may be disrupted by assemblies, disaster drills, etc. Please do not include these days or other non-instruction days in your Scoop; instead, add replacement instructional days at the end.

Pre-Scoop Reflection Questions (to be answered once, before the Scoop period begins)
1. What about the context of your teaching situation is important for us to know in order to understand the lessons you will include in the Scoop?

This may include:
- characteristics of students
- features of the school and/or community
- how you access technology in your classroom
- anything else you may find pertinent to our understanding of your teaching environment

2. What does a typical lesson that incorporates technology look like in your classroom? If it varies day to day, then please describe the various possibilities.

This may include:
- daily "routine" activities, such as checking out equipment at the start of class
- the format of the lesson (lecture, discussion, group work, etc.)
- description of any technology software or hardware you are using and the students' past experience with it
- description of a typical week if you have different lesson formats for each day (For example: introduction lesson on Monday, group work on Tuesday, review questions on Wednesday, etc.)

3. What are your overall plans for the set of lessons that will be included in the Scoop?

This may include:
- a description of what the students have been learning until the point when the Scoop begins

- an overview of the lessons you will be teaching during the Scoop (e.g., description of subject area content, lesson goals/objectives, instructional strategies, student activities)
- how your plans to incorporate technology are anticipated to enhance the set of lessons

4. Why do you feel this week reflects your best use of technology in your instruction?

TASKS TO COMPLETE DURING THE SCOOP

Calendar

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
Date					
Length of session					
Topic of session					
Curriculum materials used					

DATE
LENGTH OF SESSION: For most teachers, this will be the number of minutes in the class period and it will not vary from day to day.
TOPIC OF SESSION: In this section, please add a descriptive title for the day's activities. For example (for a mathematics class):
- Use Excel to compare tables, graphs and equations as ways to represent the relationship between two variables
- Review converting ratios and fractions to percents
- In-class work on review problems from Middle School Mathematics, Chapter 3, pages 114-116
- Problem solving activity— describe geometric patterns using pictures, tables, and formulas
- Investigation— use a computer assisted design (CAD) program to begin project to build a scale model of a dream house, considering costs, area, etc

CURRICULUM MATERIALS USED: List any materials used in the lesson, which were not specified above. For example (again, using a mathematics class):
- Instructions for technology used with students (e.g., Excel, CAD)
- Examples of graphs and tables
- Directions for pattern and function activity
- Guiding questions for problem-solving activity on building dream house
- Vocabulary list from unit on coordinate geometry

NOTE: For all of the materials, please try to submit a scanned copy or an uploaded picture.

Collecting Artifacts
There are two kinds of artifacts that we are interested in collecting: instructional materials and student work. We would like you to **scoop** *all* **of your instructional materials**. As the teacher, you will have generated most of these materials; however, there are instances in which students may contribute to

instructional materials by creating an instructional document. Please include these instructional materials as well.

The second type of artifact to collect is student work. We would like you to **scoop only** *samples* **of student work** that illustrate their use of technology. Detailed instructions on selecting student work are given in a later section.

Collecting Daily Instructional Materials
It may help to think of scooping materials and taking photographs each day at three different points:

BEFORE THE LESSON:
Scoop all instructional materials you prepare for the class. For example:
   • written plans
   • copies of Teacher's Edition's suggestions to teachers, if you are using this to guide your instruction
   • handouts (e.g., notes, worksheets, problem descriptions)
   • assignments (e.g., directions for a project, pages to be read in a textbook)
   • information you intend to display to students (e.g. PowerPoint presentations, websites, overhead transparencies)
   • descriptions of technology tools that will be used
   • tests or other forms of assessment (including rubric, if applicable)
   • descriptions of the setting: (e.g. your classroom, a computer lab, the library, the school grounds)
Photograph the setting or instructional context. For example, include:
   • the seating arrangement
   • assignments, questions, problems, or instructions displayed to students
   • information on walls, specifically displayed for the lesson, such as posters or projections
   • instructional and technology tools to be used during the lesson
DURING THE LESSON:
Scoop all instructional materials you generate during the class. For example:
   • notes or problems and questions displayed to students
   • notes written to yourself about the lesson
   • notes written to yourself about the students
Photograph
   • or screencapture information displayed to students
   • student actions during the lesson (such as engaging in a discussion, writing information)
   • students using instructional tools and technology (without their faces)
AFTER THE LESSON:
Scoop any instructional materials that were not yet scooped before or during the lesson. For example:
   • information displayed to students
   • photocopies of revised lesson plans or notes to self on lesson plan or Teacher's Edition suggestions
   • copies of student‐created instructional materials such as rubrics or review questions
Photograph
   • any materials created during the lesson that cannot be scooped, such as a poster or project
   • any changes to instructional setting that could not be photographed with students in the room, such as the seating arrangement or set‐up of instructional tools or technology materials
NOTE: Include any additional materials that will help us understand technology use in the classroom.

Describing Daily Instructional Materials
When you upload electronic versions of daily instructional materials (or scanned copies or photographs), please indicate the following information for each item:
- the date
- a brief description of the artifact. For example:
    - o directions for group project
    - o rubric used for grading assessment

Selecting Evidence of Student Technology Use
We would like you to choose student work that is indicative of the kind of work your students do when using technology. This work can be from individual students or from a group assignment.
Select at least three activities or assignments during the course of the Scoop that reflect student use of technology. For each activity or assignment, pick three examples of student work that represent a range of technology implementation (high, medium, and low levels).

Scoop examples of high, medium, and low levels of technology use in student work for each of the three activities or assignments. These examples might come from:
- in-class assignments
- journal or blog entries
- portfolio pieces or other formal assessments
- homework assignments
- projects

Note: You do not have to provide sample technology work from the same students for each of the activities or assignments.

Scan a copy of any student-generated materials for which this is possible. Be sure to cover the student's name before scanning.

For student-generated materials that cannot be photocopied (e.g., a 3D model), please take a picture (or computer screen capture, if possible) of the student's work. Be sure to cover the student's name before taking the picture, and do not include the student's face in the picture.

Describing and Reflecting on Evidence of Student Technology Use
For each piece of evidence you submit, please indicate the following:
- whether the student work is of high, average, or low level of technology implementation
- why you rated it this way
- what this work tells you about the student's understanding of the content/material and what role technology might play in this understanding

Taking Photographs
Photographs are a good way to capture the learning environment in your classroom and to provide a sense of what your daily lessons look like and how technology is integrated in the lessons. So, throughout the Scoop timeframe, please take photographs regularly, if possible. If you will not be able to access a digital camera to use during your Scoop timeframe, please contact us (pd2practice@edc.org) and we will send you a disposable film camera to use.

We have not obtained permission for students' faces to be photographed, so please try to avoid taking pictures of students' faces.

We are interested in seeing photographs of:
- the classroom set-up (such as seating arrangement) every day
- bulletin boards
- contents of white/chalkboard at several points during the lesson
- student work on the board or on an overhead transparency (if it is not possible to upload a copy of the overhead transparency)
- technology software or hardware used during the lesson. If the technology is being used by students, please avoid taking pictures of their faces.

Please take pictures of any other things that you feel will help us to better "see" and understand your classroom and use of technology that you would not otherwise be able to include in your Scoop Portfolio.

You may want to consider asking a responsible student in the class to take some of the pictures for you while the lesson is taking place and make a note of what the photograph depicts. It would be best if you still prompted the student when to take the picture.

We would like 4 to 5 pictures per day during the Scoop timeframe.

Please remember:
- Try to avoid taking pictures of students' faces
- Use the flash when taking pictures. (Exception: When taking a picture of a white board or overhead, do not use a flash because it creates too much glare. If you do use a flash, take the picture at an angle to the board. It is better to scan overhead transparencies than to take pictures of them being projected on the screen.)
- Provide the date taken and a brief description of each photograph when you upload them to your Scoop Portfolio.

Daily Reflection Questions (to be answered every Scoop day, after the class is over)
Having access to your immediate thoughts and reactions following the lesson is crucial. Please make every effort to jot down your reflections right away after each Scoop class. Your daily reflections should focus on how technology was incorporated into the lesson, either by you, by the students, or both.

1. *What were your objectives/expectations for technology use (either by you or your students) during this lesson?*

2. *Describe the lesson in enough detail so we understand how the Scoop materials were used or generated.*

3. *Thinking back to your original plans for the lesson, were there any changes in how the lesson actually unfolded? Also, were there any surprising ways students used technology today that you weren't expecting?*

4. *How well were your objectives/expectations for technology use met in today's lesson? How do you know?*

5. *Will today's class session affect your plans for tomorrow (or later in the unit)? If so, how?*

6. *Is there anything else you would like us to know about this lesson that you feel was not captured by the Scoop?*

TASKS TO COMPLETE AFTER THE SCOOP

Post-Scoop Reflection Questions (to be answered at the end of the Scoop timeframe)
When answering these questions, please consider the entire set of lessons and all the materials you have gathered for the Scoop Portfolio. As with the Daily Reflection Questions, please focus your reflections on the incorporation of technology into your lessons this week.

1. *How does this series of lessons fit in with your long‐term goals of technology use for this group of students?*

2. *How representative of your typical instruction was this series of lessons (with respect to content, instructional strategies, student activities, and technology use)? What aspects were typical? What aspects were not typical?*

3. *How representative of your use of technology was this series of lessons? What aspects were typical? What aspects were not typical?*

4. *How well does this collection of artifacts, photographs, and reflections capture what it is like to learn [mathematics, for example] in your classroom? How "true‐to‐life" is the picture of your teaching portrayed by the Scoop?*

5. *If you were preparing this Scoop Portfolio to help someone understand your use of technology in teaching, what else would you want the portfolio to include? Why?*

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