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Guidance for Technology Decisions from Classroom Observation

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Abstract

Correlational analysis of two years of classroom observation indicates relationships between technology use and various classroom characteristics, including teacher roles and instructional strategies. Three observers used the ISTE Classroom Observation Tool (ICOT) to record 144 observations of classrooms participating in a variety of educational technology grant programs in the United States. The findings suggest that decision makers consider the instructional implications and possible unintended consequences of implementing different information and communication technologies. (Keywords: ISTE Classroom Observation Tool, ICOT, observation, planning, classroom, evaluation)

Classroom observation plays a crucial role in program evaluation (Worthen, Sanders, & Fitzpatrick, 1997). Schools can count up technology units installed and hours of professional development as inputs to a program. Surveys and interviews can record student and teacher attitudes about an innovation. Tests and school transcripts can quantify outcomes. But only observation of students and teachers at work can document the learning experience itself. In particular, observation helps determine whether an intervention has actually been implemented before a program tries to evaluate outcomes (Frechtling, 2002). Observation thus fills in the information required by the middle stages of intervention logic models (see Figure 1, p. 206). Without visible evidence that new practices are in effect (stage 3 of the model), studies of student outcomes (stage 4) that are supposed to be engendered by those practices may be moot.

Since 1999, the International Society for Technology in Education (ISTE) has conducted classroom observations as part of its evaluations of numerous initiatives funded by federal, state, and private grants (Bielefeldt, 2000, 2003; Kelly & Haber, 2003). In these projects, the point of the observations was to determine whether information and communications technologies (ICT) were being integrated into instruction. This is more complicated than noting that technologies are present and that students are attending to them. Numerous attributes determine what constitutes

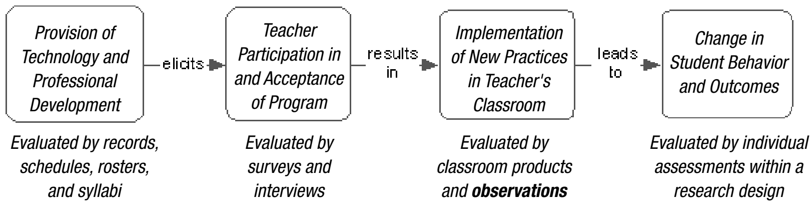

Figure 1. Classroom observations within an educational technology logic model.

true integration as defined by the National Educational Technology Standards (NETS), including alignment with curriculum and instruction, active interaction with technology tools, and the use of technology to promote a range of important cognitive skills (ISTE, 2000, 2002, 2007, 2008). Making this determination is important for two reasons. First, ICT integration can be a goal in itself to make school learning environments more like postsecondary education, workplaces, and homes in terms of technology access and use. Second, assessing outcomes related to ICT integration (e.g., student achievement or attitudes) is moot unless a project can show that classrooms actually changed.

In 2008, the Hewlett Packard Company funded ISTE to develop a computer-based note-taking application that would take advantage of tablet (pen-based) technology. The program, the ISTE Classroom Observation Tool (ICOT), can be used on any Windows or Macintosh computer and is optimized for tablets, which allow the user to hold the computer in one arm and write on the screen with a stylus. ICOT was based on protocols employed in previous ISTE program evaluations, particularly those presented in Kelly (2003); Kelly & Haber (2006).

Over the years that led up to ICOT, it became clear that the NETS are necessary but not sufficient for the purpose of program evaluation and improvement. The standards themselves do not describe how they are to be achieved, but that is the point of most project evaluations. Although program evaluations may not have the theory-building imperative of pure research, they are generally charged with estimating whether and how a successful initiative could be replicated or scaled. ISTE makes clear that achieving the standards is contingent on a number of essential conditions (ISTE, 2000, 2008). The ICOT looks at seven attributes of the learning environment that (a) are related by theory or experience to ICT integration and that (b) can be noted by classroom observation:

- Student groupings (individual, pairs/small groups, whole class)
- Teacher roles (lecture, model, interactive direction, moderation, facilitation)
- Learning activities (a lengthy list, with space for additions)
- Technologies used by teachers and by students (a lengthy list, with space for additions)

- Technology use time (recorded as presence during 3-minute segments of the class period)
- Percent of students engaged (estimated by noting students distracted during any two 3-minute segments)

Some important attributes, such as levels of teacher preparation or technology support, are essential conditions that are not explicitly included in the ICOT because they are not directly observable. Observers can comment on the extent to which these conditions are implied, but the circumstances under which they might become manifest are too diverse to code in a protocol that is already attending to numerous other aspects of the environment.

Explaining Variation within Projects

The present study arose out of questions related to the ISTE evaluation of several educational technology grant programs from 2008–2010. Although the projects varied in specific focus, grade level, and technologies used, certain common emphases appear in the projects' grant announcements and proposals. One emphasis was 21st century skills, generally articulated as abilities to not only use technology, but to use it in ways analogous to modern work environments for information acquisition, analysis, and sharing. Grant announcements tended to cast this concern as a workforce-development issue (National Science Foundation 2007, 2008). Proposals also stressed the cognitive benefits of ICT for engaging students in learning and invoking higher-order cognitive skills. In doing so, they cited a mix of research (e.g., Barak, 2004; Bransford, Brown, & Cocking, 1999), policy documents (e.g., Commission on Educational Technology, 2005) and vendor claims (e.g., Creative Learning Systems, 2011). The NETS fit in with this approach, contrasting traditional "teacher-directed, memory-focused instruction" and "knowledge from limited, authoritative sources" with newer "student-centered, performance-focused learning" and "learner-constructed knowledge from multiple information sources and experiences" (ISTE, 2008, p. 4).

In the dominant paradigm, new knowledge is not simply transmitted by a teacher. Rather, the projects deemed it important that students express and use their skills with hands-on activities in group settings that would make their knowledge manifest, shared, and open to revision and extension. This constructivist, Vygotskian notion that learning is social and takes place at the frontiers of an individual's prior and new knowledge (Vygotsky, 1978) was assumed as often as it was articulated, but the selection of references and activities makes clear that it was present in all of the projects discussed here.

Inevitably, there were differences across classrooms in the extent to which students were able to participate in hands-on, student-centered learning. These differences showed up on the ICOT observations as different proportions of time spent with technology by students and teachers, a preponderance of one or another teacher role, and observer ratings of more or less essential uses of technology. In the original contexts of the observations, the presumptive reasons for these classroom differences had to do with variations within the grant-funded professional development projects themselves. The numbers of teachers involved in most projects was small (less than 30). The identities and unique professional development histories of individuals were well known. No attempt was made to generalize from each of these small samples beyond their respective projects because the local factors (e.g., being in a particular training cohort) were so obvious and because the numbers were so small.

However, over a period of 2 years and numerous observations, a more general research question emerged. Given the common technology standards and pedagogical values, why the differences in technology integration? One of the obvious possibilities—differences in resources—was not sufficient. Evaluators noted that classrooms in wealthy districts with lots of technology and a history of professional development did not necessarily provide more hands-on ICT activities for students. For this study, the question was distilled as: What are the observed relationships between students' technology use and the technologies and classroom environments that teachers arrange for them?

Method

Sample and Data Characteristics

ISTE observed 109 teachers from seven technology projects under U.S. Department of Education and National Science Foundations grants in two states during 2008–2010. After 2 years, the ICOT database included 189 records from six observers. I removed observations conducted by trainee observers that were missing key data or that had contradictory records, leaving 144 observations from three researchers who had undergone common training (16 observations from one observer on two programs, 26 from one observer on three programs, and 104 from one observer on seven programs). I retained observations for 85 teachers, with one to seven observations per teacher (mean = 1.69, median=1). Half of the observations were in science classrooms, 16% were in language arts, 19% were in math, 8% were in social studies, and the remaining 6% were in various electives or technology. About 3% of observations were in primary grades (K–2), 27% were in elementary (grades 3–5), 55% in middle school (grades 6–8), and about 14% were in high school (9–12).

For this cross-project analysis, I removed individual identifying information, except for arbitrary dummy codes to identify multiple instances of the same teacher or the same observer.

Observation Process

ICOT version 1.0 was used for all of these observations. Version 1.0, which included the original NETS for Teachers (ISTE 2002), was a free-standing application written for the Adobe AIR platform. (In 2010, the ICOT was revised to emphasize the second edition of the NETS for Students [ISTE, 2007], and the application was moved to a macro-enabled Microsoft Excel spreadsheet.) Table 1 (p. 210) shows the full list of variables included in ICOT v1.0.

ICOT observations typically last for the major part of a class period. ICOT observers try to be in classrooms at or near the start of a class period. Along with initial observations about the setting (number of students, presence of technology, room arrangement, special characteristics of the environment), the observer records a start time. Every 3 minutes after that, the observer checks boxes to indicate if students and/or teachers are using technology and whether they are using it for learning (a computer that is powered up but unattended does not count as "in use," and looking for lost passwords or playing recreational games does not count as "in use for learning"). At the end of an observation, the ICOT calculates the total minutes observed, the proportions of that time that teachers and students used technology, and the proportions of technology-use time devoted to learning.

A typical structure for a classroom with multiple computing devices was for a teacher to introduce a topic in one of the teacher-directed roles (lecturing, modeling, or interactive direction). This could be the reading of a poem, a review of the periodic table, or a demonstration of a science probe. Then the students would be "turned loose" as individuals or groups to study or create, with the teacher in a facilitating role. This might include conducting research on the web or in a lab, analyzing data, or producing a presentation.

Student engagement (anecdotally cited as a benefit of technology by many of the observed teachers) is assessed by observing student behaviors in relation to the 3-minute chart. A student distracted from the lesson for any reason over more than a single 3-minute period is counted as not engaged. The proportion of students left after subtracting disengaged students is the percent engaged. In most classrooms, engagement as measured by this criterion was quite high ($M = .93$, $SD = .09$, or 1–2 students disengaged out of an average-sized classroom of 24 in this sample).

All ICOT variables except one involve only "present/absent" decisions by the observer. The exception is a prompt for evaluators to rate the unique contribution of technology in comparison to alternatives. Essential indicates that the lesson could not have been conducted without the technology. A simulation that analyzes real-time data might be an example. Useful indicates that the integrated technology provided distinct advantages over conducting the lesson without the tools. Completing a research and writing project online in two periods that otherwise take a week would probably have this rating. Somewhat useful indicates that the technological approach was comparable but not superior to an alternative. Presenting similar content in a slideshow that on a chalkboard or overhead projector

Table 1. ICOT Observation Variables

Teacher Roles
Lecturing
Interactive Direction
Facilitate/Coaching
Modeling
Moderate Discussion

Learning Activities
Give Presentation
Create Presentation
Run Simulations
Research
Information Analysis
Write
Take Tests
Drill & Practice
Hands-On Skills

Technologies Used by Teachers (t) and by Students (s)
Digital camera
Wiki (s*)
Presentation
Tablet computer
Document camera
Graphics (t*)
Handheld
Desktop
Word processing (t*s*)
Spreadsheets
Database (t*s*)
Video production
Concept map
Interactive board
Library database
Laptop computer
Clickers
Web browser
Videoconferencing
Email
Blog
Calculator
Simulation (s*)
Science probe
Podcast
Web authoring
Video camera
Drill & practice

Number of Students

Student Groupings
Individual
Pairs or Small Groups
Whole Class

Engaged %

Technology Use Time
Total minutes observed
% of total minutes during which teachers used technology
% of teacher technology use devoted to teaching and learning
% of total minutes during which students used technology
% of student technology use devoted to teaching and learning

Need for Technology
Not useful
Somewhat useful
Useful
Essential

NETS for Teachers (1st edition)
1A.1. operating system procedures*
1A.2. routine hardware and software problems
1A.3. content-specific tools
1A.4. productivity tools*
1A.5. multimedia tools*
1A.6. interactive communication tools
1A.7. curriculum-based presentations/publications
1A.8. curriculum-based collaborations*
1A.9. appropriate technology selected
2A.1. developmentally appropriate learning activities
2A.2. technology-enhanced instructional strategies
3A.1. learning experiences address content standards
3A.2. learning experiences address student technology standards
3B.1. technology supports learner-centered strategies
3C.1. technology applied to develop students' higher order skills
3C.2. teacher applies technology to develop students' creativity
3D.1. class management facilitates engagement with technology
3D.2. technology integrated as a teacher tool
3D.3. technology integrated as a student tool
3D.4. student grouping varied as needed to facilitate learning
4A.1. student learning of subject matter assessed with technology*
4A.2. teacher assesses student technology skills
4A.3. teacher employs a variety of assessment strategies
6A.1. teacher models legal and ethical technology practices
6A.2. teacher explicitly teaches legal and ethical technology practices
6B.1. diverse learners enabled and empowered.*
6D.1. safe and healthy use of technology promoted*
6E.1. equitable access to technology for all students.

** Indicates significant differences in frequencies reporting by different observers of the same teachers.*

Table 2. Observer Identifications of Technologies and Standards

Observer	# Teacher Technologies	# Student Technologies	# NETS Addressed
1 (*N* = 16)	4.1	3.8	16.1
2 (*N* = 10)	3.6	3.3	21.1
3 (*N* = 29)	1.6	2.0	10.6

would be an example. Not useful indicates that the lesson would have benefitted from different media altogether. One example would be projecting a complex relationship (e.g., a complicated chemical reaction or a multistep math problem) piece by piece, one computer screen at a time, when the entire system could only be illustrated in a larger physical format such as a wall-sized chalk or dry-erase board.

Observer Reliability

The three observers had trained together on an earlier version of the protocol using the iterative procedure described by Kelly and Haber (2006). I computed chi-square frequencies on ratings for 12 teachers, whom were observed by each of the three observers on a total of 36 occasions. I found no significant differences ($p < .05$) in the frequencies of most variables (i.e., in most cases, no observer appeared to be systematically stricter or more lax in coding an attribute as present). A comparison of mean estimates of student engagement also showed no significant differences across observers. I observed significant variation in coding for five technologies: databases, graphics, simulations, wikis, and word processing (flagged with asterisks in Table 1). Difficulties in coding were related to the converging nature of the technologies. For instance, "word processing," once synonymous with a dedicated computer program, is now a common function within many other applications. Some observers recorded its presence only when a dedicated program was running; others checked the technology whenever any text editing function was in use.

Proportions were also significantly different across observers for seven of the NETS*T indicators (flagged with asterisks in Table 1). To some extent, ambiguity in the NETS reflects the previous convergence of technologies (e.g., "productivity tools" [NETS•T 1A4] and "multimedia tools" [NETS•T 1A5] may now reside within the same computer application. In other cases, the variability in recorded NETS and technologies may accurately portray what happened in the classroom of the same teacher on different occasions. However, the three observers recorded significant differences in the mean overall numbers of technologies and standards on the two programs they all observed. The differences across observers presented in Table 2 are significant ($F[1,2] = 9.30$, $p <. 0001$).

In any case, conclusions based on the standards and technologies flagged in Table 1 need to be treated with caution.

Table 3. Teacher Roles and Learning Activities by Type

Variable	Levels of Variable	Student–Teacher Locus
	Facilitation	Student-Centered
	Moderated Discussion	
Teacher roles	Lecture	
	Interactive Direction	Teacher-Centered
	Modeling	
	Creating Presentations	
	Presenting	
	Writing	Student-Directed (study, creation, and communication)
	Information Analysis	
Student learning activities	Research	
	Simulations	
	Drill And Practice	
	Hands-On Training	Teacher-Directed (instruction and assessment)
	Taking Tests	

Analysis

The analysis looked at seven types of variables within the ICOT: (a) teacher roles, (b) student groupings, (c) student learning activities, (d) the amount of time the technology was used, (e) the types of technology used, (f) student engagement, and (g) the need for technology use. The projects for which these observations were conducted were intended to influence these variables in particular ways. They were designed to promote:

- Teachers in roles as facilitators, modelers, and moderators
- Student collaborative work
- Student creativity and communication within the curriculum
- Student interaction with technology
- Student engagement in class

A first step was to see if there were patterns of teacher roles, student groupings, and learning activities that were related to different levels of student engagement with technology. The initial finding was that, at this level of detail, almost every observation was unique. The ICOT has a total of 17 levels across these three variable types. In 144 observations, there were 127 unique patterns of these 17 attributes. Clearly some collapsing of categories would be necessary to find meaningful patterns across observations.

The constructivist theory behind the programs for which the observers collected these data emphasized increasing hands-on, creative, student-directed activities versus teacher-directed, knowledge-transfer pedagogy. In terms of locus on this student–teacher axis, the ICOT includes two student-centered teacher roles (facilitation and moderation) and three teacher-centered roles (lecture, interactive direction, and modeling). Within student activities, the ICOT includes six that are primarily student-centered creation and study (creating/delivering presentations, writing, research, information analysis, and running interactive simulations), and three that are primarily teacher directed (tests, drill and practice, and hands-on skill training), as can be seen in Table 3.

When collapsing classroom characteristics in terms of student/teacher centeredness and direction, the data set had 28 unique patterns for 116 observations for which all these data points were filled in, as shown in Table 4 (p. 214).

With the levels collapsed, 10 patterns of teacher roles, student groupings, and learning activities can describe three-quarters of the observations. Most patterns show a mix of teacher-centered and student-centered teacher roles. Student-directed activities appeared twice as often as did teacher-directed activities. Whole-class instruction was observed in most periods, but in 83% of cases, it was mixed with individual and small-group work. Teacher roles also tended to be mixed in a period, with 70% of observations noting both teacher-centered and student-centered roles. Activity types tended to be more homogenous within a period, with 78% of observations noting either student-directed or teacher-directed activities.

It is important to note that all these attributes of the classroom are not necessarily recorded at the same time. For example, when we look at the correlations of roles, groupings, and activities, we find that there is no correlation between teacher-directed activities and whole-class organization (Table 5, p. 215). That does not mean that teachers generally conduct class as a whole group without directing learning activities (although that can occur). Rather, it means that the fact that teachers convene the class as a whole during some part of a period has no relation to whether they include student-directed learning activities in some part of the same period. On the other hand, there are only so many minutes in an hour, and teachers make decisions about how to spend that time. As noted above, types of learning activities tend to be mutually exclusive.

A certain mix of differing roles and groupings appears to be common and possibly essential at certain points in a lesson or unit. An approach that many teachers in these technology initiatives followed was to begin a lesson with lecture and modeling of the technology procedures to be used, after which students were “turned loose” as individuals or in groups to study a topic, take assessments, or create products. These scenarios would be reflected in patterns such as 1, 2, 3, and 5. Simpler patterns were generally “steady-state” periods in which a particular activity dominated. An observer coming into class that had begun a project in a previous period might see students enter a room and independently return to their ongoing work. The observer would describe that environment in a manner similar to pattern 15 and would describe a period in which students take notes on a lecture or undergo an assessment in a manner similar to pattern 13.

Table 4. Observed Group/Role/Activity Patterns by Frequency

	Pattern									
	Student Groupings			Teacher Roles		Learning Activities				
Pattern #	Individual Work	Pairs/ Small Groups	Whole Class	Student-Centered	Teacher-Centered	Student-Directed	Teacher-Directed	Frequency	% (N =16)	Cumulative %
1		X	X	X	X	X		15	0.13	0.13
2	X		X	X	X	X		14	0.12	0.25
3	X		X	X	X	X	X	12	0.10	0.35
4			X	X	X	X		9	0.08	0.43
5	X		X	X	X	X	X	8	0.07	0.50
6	X			X		X		7	0.06	0.56
7		X	X	X	X		X	7	0.06	0.62
8	X			X	X	X		5	0.04	0.66
9			X		X	X		5	0.04	0.71
10	X	X	X		X	X		5	0.04	0.75
11		X		X	X	X		3	0.03	0.78
12			X		X		X	3	0.03	0.80
13	X		X		X		X	3	0.03	0.83
14	X			X	X		X	2	0.02	0.84
15		X		X		X		2	0.02	0.86
16		X		X		X	X	2	0.02	0.88
17		X			X		X	2	0.02	0.90
18			X	X	X		X	2	0.02	0.91
19	X			X			X	1	0.01	0.92
20		X		X	X	X	X	1	0.01	0.93
21			X	X		X	X	1	0.01	0.94
22	X	X		X	X	X		1	0.01	0.95
23	X	X		X	X		X	1	0.01	0.96
24	X		X		X	X		1	0.01	0.97
25		X	X	X		X		1	0.01	0.97
26		X	X	X			X	1	0.01	0.98
27	X	X	X		X		X	1	0.01	0.99
28	X	X	X	X	X	X	X	1	0.01	1.00
Relative Frequency by Level	0.53	0.37	0.77	0.83	0.87	0.80	0.41			

Patterns of Technology Use

The amounts of time that technology is used by students and teachers are related to individual and whole class groupings, student-centered teacher roles, and student study activities (see Table 6). In the case of groupings and roles, the relation between teacher and student technology use is reciprocal.

Table 5. Correlations between Groupings, Roles, Technology Use and Need, and Student Engagement

	Grouping			Teacher Roles		Learning Activities	
	Individual	Groups	Whole Class	Student-Centered	Teacher-Centered	Student-Directed	Teacher-Directed
Individual	1.000						
Groups	-0.443‡	1.000					
Whole Class	-0.669‡	0.460‡	1.000				
Student-Centered	0.106	0.237†	-0.161	1.000			
Teacher-Centered	0.090	0.099	0.112	-0.257†	1.000		
Student-Directed	0.196*	0.090	-0.083	0.211*	0.038	1.000	
Teacher-Directed	-0.112	0.117	0.001	0.069	0.047	-0.454‡	1.000

**Correlation significant*, $p < .05$.

† Correlation significant, $p < .01$.

‡Correlation significant, $p < .001$.

Table 6. Correlations between Groupings, Roles, Technology Use and Need, and Student Engagement

	Grouping			Teacher Roles		Learning Activities		Technology Use			
	Individual	Small Groups	Whole Class	Student-Centered	Teacher-Centered	Student-Directed	Teacher-Directed	Student	Teacher	% Students Engaged	Need for Tech in Lesson
Student Tech Use	0.266†	0.125	0.345‡	0.350‡	0.013	0.167	0.161	1.000			
Teacher Tech Use	-0.348‡	0.143	0.293‡	0.442‡	0.053	0.314‡	0.111	-0.441‡	1.000		
% Students Engaged	0.119	0.089	0.119	0.148	0.044	0.027	0.010	0.216*	-0.199*	1.000	
Need for Tech in Lesson	0.300‡	0.059	0.300‡	0.280†	0.020	0.340‡	0.013	0.514‡	0.339‡	0.154	1.000

**Correlation significant*, $p < .05$.

† Correlation significant, $p < .01$.

‡Correlation significant, $p < .001$.

Observers saw relatively more student technology use and less teacher technology use in classrooms with an emphasis on individual student work and student-centered teacher roles. This same pattern was observed for small-group classroom organization, but the difference was not significant. A lower proportion of time with student technology use and a higher proportion of teacher use were observed in classrooms with whole-class organization.

Student and teacher technology use are negatively correlated. Student study activities were associated with more time spent in teacher and student technology use.

Table 7. Correlations of Classroom Characteristics with Technologies That Students (S) and Teachers (T) Use Frequently

		Grouping			Teacher Roles		Learning Activities		Technology Use			
Technology	User, % (*N* = 134)	Individual	Small Groups	Whole Class	Student-Centered	Teacher-Centered	Student-Directed	Teacher-Directed	Student	Teacher	% Students Engaged	Need for Tech in Lesson
Presentation Software	T 24%	-0.018	0.132	0.163	-0.037	0.052	0.131	-0.044	-0.040	0.040	-0.148	0.223*
	S 10%	0.041	-0.017	-0.050	0.068	0.056	0.249†	-0.225*	0.116	-0.103	0.112	0.150
Interactive Whiteboard	T 48%	-0.197*	-0.150	0.260†	-0.258†	0.063	-0.341‡	0.111	-0.350‡	0.684‡	-0.178*	-0.338‡
	S 25%	-0.237†	-0.107	0.151	-0.255†	0.019	-0.428‡	0.246†	-0.296†	0.569‡	-0.116	-0.251†
Response System	T 10%	-0.085	0.012	0.076	-0.209*	0.069	-0.366‡	0.325‡	0.147	0.306‡	-0.025	-0.119
	S 10%	-0.055	-0.010	0.044	-0.122	0.081	-0.396‡	0.400‡	0.174*	0.349‡	0.019	0.147
Web Browser	T 25%	0.214*	0.170	-0.054	0.156	0.201*	0.432‡	0.003	0.268†	-0.217*	-0.031	0.433‡
	S 34%	0.301‡	0.065	-0.227†	0.191*	0.148	0.556‡	-0.211*	0.369‡	-0.425‡	-0.048	0.422‡

**Correlation significant,* $p < .05$.
† Correlation significant, $p < .01$.
‡Correlation significant, $p < .001$.

Technology Need and Technology Use

Observers' ratings of the need for technology within a lesson approximated the size and direction of the various correlations with proportion of time in which students used technology. In classes where students were observed to use technology more, work as individuals, work with teachers who adopt student-centered roles, and engage in study activities, observers tended to rate the technology use as more essential to the lesson. In classrooms that emphasized whole-class instruction with the teacher using technology for a larger proportion of time, observers tended to rate technology use as less necessary to learning.

Student Engagement and Technology Use

There is an inverse relationship between the amount of time teachers and students use technology. Further, observers tended to rate engagement higher as student technology-use time increased and lower as teacher technology-use time increased. To make this more concrete, Table 7 lists the most common hardware and software—those that observers saw teachers and students using in at least 10% of classrooms—along with the correlations between each technology's use and other classroom characteristics (observers also noted frequent use of word processing and simulations, but because of previously mentioned concerns about coding, Table 7 does not include those applications).

The strongest positive relationships were between interactive whiteboards and teacher technology use (i.e., teachers with whiteboards use them a lot). The strongest negative relationships were between student Web browsing and teacher technology use (those tend not to occur together in the same period) and between student whiteboard use and student-directed learning (whiteboards tend to be used for teacher-directed learning). Other strong

Table 8. NETS•T (2000) Performance Indicators, % of Observations in Which Addressed (*N* = 144)

Standard	Performance Indicator	%
Technology Operations & Concepts	1A.1. operating system procedures*	0.30
	1A.2. routine hardware and software problems	0.47
	1A.3. content-specific tools	0.42
	1A.4. productivity tools*	0.35
	1A.5. multimedia tools*	0.23
	1A.6. interactive communication tools	0.10
	1A.7. curriculum-based presentations/publications	0.58
	1A.8. curriculum-based collaborations*	0.13
	1A.9. appropriate technology selected	0.83
Designing Learning Experiences	2A.1. developmentally appropriate learning activities	0.83
	2A.2. technology-enhanced instructional strategies	0.81
Teaching, Learning, & Curriculum	3A.1. learning experiences address content standards	0.84
	3A.2. learning experiences address student technology standards	0.58
	3B.1. technology supports learner-centered strategies	0.53
	3C.1. technology applied to develop students' higher-order skills	0.31
	3C.2. teacher applies technology to develop students' creativity	0.15
	3D.1. class management facilitates engagement with technology	0.63
	3D.2. technology integrated as a teacher tool	0.64
	3D.3. technology integrated as a student tool	0.58
	3D.4. student grouping varied as needed to facilitate learning	0.38
Assessment & Evaluation	4A.1. student learning of subject matter assessed with technology*	0.22
	4A.2. teacher assesses student technology skills	0.03
	4A.3. teacher employs a variety of assessment strategies	0.06
Social, Ethical, Legal, Human Issues	6A.1. teacher models legal and ethical technology practices	0.00
	6A.2. teacher explicitly teaches legal and ethical technology practices	0.03
	6B.1. diverse learners enabled and empowered*	0.00
	6D.1. safe and healthy use of technology promoted*	0.09
	6E.1. equitable access to technology for all students	0.54

associations are between Web browsing and lessons in which observers rated technology use as valuable, and between Web browsing and lessons that involved student-directed learning.

NETS Teacher Standards

Table 8 shows the percentage of observations in which observers recorded each of the performance indicators from Table 1. Recall that seven indicators (1A.1, 1A.4, 1A.5, 1A.8, 4A.1, 6B.1, 6D.1) had inconsistent recording across reviewers; those percentages may not be accurate.

Leaving out the seven suspect items, the mean number of performance indicators observed per observation was 9.33 (range 0–19, standard deviation 4.62).

Table 9. Correlations of Numbers of Observed NETS•T Indicators with Classroom Attributes

	Grouping			Teacher Roles		Learning Activities		Technology Use		Need for Tech in Lesson
	Individual	Small Groups	Whole Class	Student-Centered	Teacher-Centered	Student-Directed	Teacher-Directed	Student	Teacher	
r	0.182*	0.134	-0.177*	0.306‡	0.134	0.361‡	-0.027	0.412‡	-0.233†	0.476‡
N	142	142	142	131	131	128	128	144	144	138

** Correlation significant,* $p < .05$.

† Correlation significant, $p < .01$.

‡Correlation significant, $p < .001$.

The NETS observations suggest that these technology-using classes displayed intentional design of instruction that integrated technology and content. Observed classroom management and student access were not somewhat lower than the observed evidence of preparation, suggesting that executing a lesson can be harder than planning it. Less-than-100% observations of "equitable access" do not mean that teachers treated students inequitably, but rather reflect the fact that some of the observed schools had technology infrastructure or support issues that constrained teachers' lessons. The frequency of observed "learner-centered strategies" is relatively high in terms of other NETS indicators, but lower than the recorded frequencies of student-centered activities (the correlation between the two variables was .36). Although some of these instances may be recording inconsistencies, they also reflect situations where learner-centered activities in a classroom did not make effective use of technology.

In terms of other classroom attributes, frequency of observing the NETS•T was positively correlated with individual student work, student-centered teacher roles, student-directed activities, a large proportion of student technology use, and observers' judgments about the need for technology. The frequency of observing the standards was negatively associated with whole-class grouping and higher levels of teacher technology use (see Table 9).

In terms of commonly used applications, the number of observed NETS•T indicators was positively associated with student use of presentation software and student or teacher browsing of the Web. The number of observed indicators was negatively associated with interactive whiteboard use (see Table 10).

Discussion

These results warrant three areas of discussion: interpretation of the correlations, the observation process, and the use of the NETS in evaluation.

Interpreting Results in Context

The question behind this investigation had to do with the relationships between classroom attributes, so interpretation of the correlation coefficients is the crux of the study. Perhaps the most important thing to keep in mind

Table 10. Correlations of Numbers of Observed NETS*T Indicators with Common Applications

Technology	User	r
Presentation Software	T*	0.118
	S*	0.286†
Interactive Whiteboard	T	-0.285†
	S	-0.237†
Response System	T	0.012
	S	0.001
Web Browser	T	0.434‡
	S	0.472‡

** T = Teachers, S = Students*

† Correlation significant, $p < .01$.

‡Correlation significant, $p < .001$.

is the context of the observations. The data on interactive whiteboards are illustrative. Teachers told observers they were very appreciative of interactive whiteboards. One of the programs the observers were evaluating was devoted to providing the boards and associated training throughout several school districts. As might be expected, given that the boards are a presentation medium, they are positively associated with whole-class instruction by the teacher. They are negatively associated with student-centered, individual, student-directed activities and with student use of technology in general. Typical use involved teacher lectures and demonstrations, although some classes used them frequently for student presentation of work. Some of the whiteboards' special features (hiding/showing images and integration with student response systems) made them effective as formative assessment tools. Teachers who used the boards invariably cited greater student engagement with material on the whiteboard compared to content presented with conventional lectures and visual aids.

Why then was there a negative correlation with engagement in Table 7? In classrooms with interactive boards, there may be no alternative. The board is often mounted on top of an older dry-erase or chalkboard. Once in place, it is used for everything from interactive simulations to the daily lunch menu. Observed engagement with effective lessons was sometimes offset by observed distraction during mundane activities that used the same technology. Thus observers often rated the board as only "somewhat useful: other approaches would work as well." That was true, although the obvious alternative (the chalkboard) was no longer accessible.

On the other hand, Table 7 does accurately represent the facts that teachers primarily used whiteboards and that high levels of teacher technology use were associated with lower levels of student engagement (see Table 6). Engagement was generally higher in dispersed-technology classrooms (labs or conventional classrooms with laptops), where students were more likely to use the technology than were teachers.

This is not to say that technology necessarily dictates practice. Observers encountered a few whiteboard-equipped classrooms where the teachers turned over operation of the technology to the students and then facilitated group use of these resources. This occurred in classrooms where teachers had at least one year of experience with the technology. Some of these instances involved interactive slates that allow the board to be operated from anywhere in the room. This tended to make the board more of a shared workspace than a forum for "stand-and-deliver" recitation at the board. These experiences suggest that flexibility in teaching with technology can be increased with experience and with more sophisticated tools.

However, there seems to be a path of least resistance with any technology. Whiteboards and presentation software are designed for an individual or small team to deliver information to a group. Laptops and Web browsers were designed for use by individuals. Alternative uses require additional technology and/or more energy in terms of classroom management and lesson planning. Educational planners need to be aware of these pedagogical pressures and relate them to their own priorities. A technology implemented in response to one need (e.g., formative assessment by the teacher) may have unintended consequences, such as reduced time or technology available for mastering "21st century skills" such as online research and collaboration.

Observations of Technology-Using Classrooms

The 2 years of observations provided several guidelines for observation practice. One is that the recording information electronically can greatly reduce total time for collecting and using observation data. The main savings is in transcription, which, in the case of paper forms, can take as long as the original collection. The first version of the ICOT (used in the observations presented here) had a cumbersome export function that did not take full advantage of this capability. Later versions corrected that problem. Any computer-based observation tool should have the ability to export files that can be opened in common statistics packages. The cost savings can make real-time observations a viable strategy in cases where they otherwise would be unfeasible.

Another guideline is that observation programs should be prepared for the wide diversity in classrooms. Even among projects that have gross similarities in purpose, professional development, and technology, there are numerous patterns of classroom attributes (see Table 4). The ICOT was designed so that its component sections can be used independently. This might apply when an administrator does a walk-through of a building to get an idea of how many teachers are using technology at all, or when assuming a particular instructional role. The ICOT observations suggest caution in this approach. Most classrooms display a wide range of attributes in a single period. Observing a particular attribute during a short slice of time may not be a reliable gauge of practice. Even full-period observations need to be informed by interviews or debriefs so that the context is clear. For example, slow transitions between activities that are picked up on the ICOT 3-minute chart as "technology used/not for learning" might be due to inadequate professional development or technical problems, or because an adventurous teacher is trying something new with full awareness that the lesson may encounter difficulties.

That in turn may affect how an observer codes other attributes, such as the need for technology or the attainment of standards. This level of interpretation is best attained by a project team agreeing on its criteria and conducting joint training with multiple observers (Fish, Hayden, & Bielefeldt, 2005). Even with this experience, the ICOT data presented in Table 2 suggest that observers need to periodically recalibrate their coding practices through joint observations and discussions.

Observing the NETS

As noted earlier, the NETS were the most difficult subsection of the ICOT to record consistently. Assessing the NETS has been a concern since the standards were first published in 1998 and continues to be a work in progress with the revised standards. Various products and services claim to be or are explicitly designated as "NETS-aligned" for purposes of assessment, instruction, or professional development (ISTE, 2011).

If anything, the challenge has increased with the revision of the standards that began in 2007. Whereas the original standards emphasized the use of the technology, the current standards emphasize the outcomes to be achieved with technology. "Teacher applies technology to develop students' creativity" (NETS•T, first edition, indicator 3C.2) has become "Teachers … promote, support, and model creative and innovative thinking and inventiveness" (ISTE, 2008). The revised NETS•S, which are used in the current version of the ICOT, elevate creativity and innovation to a standard in and of itself: "Students: (a) apply existing knowledge to generate new ideas, products, or processes; (b) create original works as a means of personal or group expression; (c) use models and simulations to explore complex systems; and (d) identify trends and forecast possibilities" (ISTE, 2007).

The student creativity standard involves the observer in multiple judgments, including whether the student really applies existing knowledge and whether that application actually results in the generation of new ideas. All these decisions come before even considering whether technology was used effectively in those pursuits. In any specific context, the NETS observer exploring this standard may be compelled to make the same type of decisions required in a study based on content frameworks such as the Common Core Standards for Mathematical Practice (Common Core State Standards Initiative, 2011).

Ultimately, NETS-based evaluations will have to make links with content. Even if one believes that the NETS embody skills that are valuable in their own right, we have to observe those skills in a specific context of teaching and learning. And the NETS are meaningful to the extent that they point to abilities beyond that context. One development that would contribute to improving observational studies of ICT in education would be a concordance of the revised NETS with emerging standards such as the Common Core, such that observations coded in one framework have meaning for the others.

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