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IDENTIFYING TEACHER, SCHOOL, AND DISTRICT CHARACTERISTICS ASSOCIATED WITH MIDDLE AND HIGH SCHOOL TEACHERS' USE OF TECHNOLOGY: A MULTILEVEL PERSPECTIVE

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ABSTRACT

Investment in educational technology has increased rapidly in recent years and many observers have begun to question whether, and how technology is being used as a teaching and learning tool. In order to address this issue, this research used survey data collected from 1,404 *middle and high school teachers* in 52 schools across 22 Massachusetts school districts to examine how technology is being used by upper grade teachers, and examines the school and district organizational characteristics that are associated with increased use of technology as a teaching and learning tool. Specifically, this research used hierarchical linear regression (HLM) techniques to model the teacher, school and district characteristics associated with five specific teacher uses of educational technology. This research found that both teacher and organizational characteristics were each found to be associated with the five technology uses, and characteristics varied in their ability to predict the five different uses.

Over the past decade, federal spending for educational technologies such as personal computers, LCD projectors, and Palm Pilots, and related educational software applications, has increased dramatically from a previously unprecedented $21 million in 1995, to a peak of $729 million in 2001, and $700.5 million in 2004 (U.S. Department of Education, 2004). With increased spending for technology came increased access to technology, and so the student-to-computer

ratio in our schools decreased from 9:1 to around 4:1 during the same time period (Glennan & Melmed, 1996; Market Data Retrieval, 2001, 2003). This proliferation of educational technology has begun to change the permanent landscape of our schools as teachers and students acquire greater access to technology both in school and at home (Quality Education Data, 2003; U.S. Department of Commerce, Economics and Statistics Administration, & National Telecommunications and Information Administration, 2002). For example, data from the National Assessment of Educational Progress (NAEP) showed that 85% and 78% of teachers report using a computer to create instructional materials at home and at school, respectively (U.S. Department of Education, 2000). The National Center for Educational Statistics (NCES) also reported that by 2000 half of all U.S. teachers were using e-mail to "communicate with colleagues" and about one quarter of all teachers were communicating with parents via e-mail (2000). Additionally, data from the U.S. Census Bureau indicated that American children between the ages 9-17 reported using technology more than any other subgroup of the population (U.S. Department of Education, 2000).

Despite a substantial body of research focusing on the use of technology in our schools, definitions of "technology-use" vary widely and many discussions centering on technology-use in schools employ a generic definition of teachers' technology-use. As highlighted in the Office of Technology Assessment (OTA) 1995 report *Teachers and Technology: Making the Connection* (OTA, 1995), previous efforts to examine teachers' use of technology used different categorizations and definitions of what constituted technology-use in the classroom. As an example, a 1992 survey conducted by the International Association for the Evaluation of Educational Achievement (IEA) defined a "computer-using teacher" as someone who "sometimes" used computers with students. In 1994, Becker constructed a more sophisticated classification to identify computer-using teachers. Comparing the two measures, the OTA found that while the IEA study classified 75% of teachers as "computer-using teachers," Becker's measure classified only 25% of teachers this way. In recent years, the expansion of the Internet and e-mail access, the universal availability of software programs that are easier to use, and the growth of an entire industry dedicated to the production of educational software has further confounded the definition of "technology-use" (OTA, 1995).

Despite the challenges associated with defining technology use, the increasingly large expenditures on and growing access to technology raise important questions about the extent to which technology is being used for educational practices and what factors are influencing these uses. Seminal work by Becker, Anderson, Ravitz, and Wong (1998, 1999) and work by Mathews (1996) and Mathews and Guarino (2000) began to explore these two questions. Research by Becker and his colleagues found that teachers' and students' use of technology was both varied and widespread (Ravitz, Wong, & Becker, 1998, 1999, 2000). For example, in their nationally representative sample, 71% of teachers in

Grades 4 through 12 reported requiring their students to use a computer at least once during the 1997-1998 school year. Their work also found that nearly 75% of the teachers who reported not using technology *with* their students, reported using technology themselves for non-instructional purposes. In fact, the most frequent use of technology across all subject areas was not instructional use, but "professional uses of technology related to their day-to-day needs" (Becker, 1999, p. 31) such as preparing handouts for class (66% of all teachers reported doing so at least once a week). Other frequent non-instructional uses of technology included use for record keeping and student grading, with almost half of all teachers reporting this type of use on a weekly basis. In their study, Becker and his colleagues (2000) found that teachers who held constructivist beliefs were more likely to use computers in a variety of ways, to have greater technical expertise, and to use computers more frequently with their students. Not surprisingly, they also found that teachers who reported feeling comfortable with technology and had a positive philosophy toward computers made more frequent use of computers both in their own work and with their students.

Similarly, Mathews' study (1996, 2000) which examined 3,500 K-12 survey responses from teachers found that "technology-use" is not a unitary concept. Mathews' research examined teachers' use of technology for the preparation of class materials, for reporting attendance, for word processing, for tutorials that explain concepts/methods, and for drill and practice. Using ordinary least squares regression to examine technology-use, Mathews found that context variables varied in their ability to predict the many different technology-uses that were observed among teachers, confirming the hypothesis that there is no useful single measure of generic technology-use that can capture the myriad of ways that technology can be used as a teaching and learning tool. For example, Mathews found teachers' level of education to be a powerful predictor of teachers' use of technology to prepare instructional materials, record attendance, and perform word processing, while the number of students in the class was a strong predictor of technology use to record and calculate grades, and for drill and practice. Mathews' work was the first to use regression models to predict deconstructed measures of how teachers use technology as a professional tool.

Although the work by Becker et al. (1998, 1999, 2000, 2001) and Mathews (1996) demonstrated the refinement of measurement that is possible in assessing teachers' use of technology, and their statistical models show that context variables differ in terms of their relationship to each of the defined technology-uses, a commonality across the work of Becker et al. (1998, 1999, 2000, 2001) and Mathews (1996) is the absence of contextual or organizational measures taken at the school or district[1] level. Instead, their research focused on the teacher

[1] In the United States, a school district is a local educational agency that is directed by an elected board of education whose purpose is to operate the local public schools. All public schools within a school district are administered together.

characteristics that potentially influenced technology-use. Although Becker and his colleagues' work included some measures of school culture, these were measures taken at the teacher level and were not aggregated to create school or district averages that could be included in the prediction models for understanding school-to-school differences in technology-use. Thus, neither study included potentially alterable variables measured at the school or district level that may be affecting the adoption of technology in the classroom by teachers. Given that a teacher's decisions to use technology in the classroom is likely to be influenced by decisions made and actions taken at the school or district level, it is important to examine the relationship between school and district characteristics and teachers' use of technology.

More recently, research by O'Dwyer, Russell, and Bebell (2004) and Bebell, Russell, and O'Dwyer (2004) examined how teachers are using technology in schools and how the organizational characteristics of schools impact the adoption and use of technology as a teaching and learning tool within elementary schools. Using survey data from 1,490 elementary school teachers, 96 principals, and 22 district leaders, and adopting a multilevel regression modeling approach, O'Dwyer et al. (2004) examined the relationship between teacher, school and district characteristics, and the frequency with which *elementary school teachers* used technology for a variety of purposes. Specifically, their research formulated hierarchical linear regression models to predict elementary school teachers' use of technology for delivering instruction, teacher-directed student use of technology during classtime, teacher-directed student use of technology for creating products, and teachers' use of technology for class preparation. Similar to the findings from the research by Becker et al. (1998, 1999, 2000, 2001) and Mathews (1996), O'Dwyer et al.'s (2004) work confirmed the utility of examining deconstructed measures of technology use; they found that predictor measures varied in their ability to predict the many ways that technology is used by teachers, thus providing more accurate models of technology-related behaviors in the classroom. In addition, and perhaps more importantly, O'Dwyer et al.'s (2004) work identified several characteristics that reside above the classroom level over which schools and districts have control that were associated with increased use of technology among elementary school teachers. These characteristics included: the extent to which professional development focused on technology integration, the variety of technology-related professional development that was available to teachers, emphasis (e.g., pressure) placed on technology use by school leaders, the availability of technology within schools, and the types of policies and restrictions that exist regarding student use of technology in schools. Through these complex, hierarchical linear regression models, practitioners and policy makers have the potential to develop a greater understanding of the policies and practices at both the teacher, school and district levels that facilitate the adoption of technology in the classroom to support teaching.

The research presented here follows O'Dwyer et al. (2004) research on elementary teachers' use of technology by examining the relationship between school and district organizational characteristics and *middle and high school teachers'* use of technology. Using survey data collected from 1,404 *middle and high school* teachers in 52 schools in 22 Massachusetts school districts, this research examines how technology is being used by teachers in the middle and upper grades, and examines the school and district organizational characteristics that are associated with increased use of educational technology. Based on these findings, implications for middle and high school technology-related policies and practices are explored.

USEIT STUDY DATA

This research analyzed data collected as part of the Use, Support and Effect of Instructional Technology (USEIT) study to examine the teacher, school and district characteristics associated with teachers' technology-use in middle and high school grades. The USEIT study, which was conducted in 22 school districts in Massachusetts, was conducted to better understand how educational technologies are used by teachers and students, and what factors influence these uses. The three-year study began during the Spring of 2001 and was divided into two phases. During the first phase (2001-2002 school year), information about district technology programs, teacher and student use of technology in and out of the classroom, and factors that influence these uses were collected through site visits and surveys. In total, data were obtained from 120 district level administrators, 122 principals, 4400 teachers, and 14200 students in elementary, middle, and high school.[2] In addition, over 300 interviews with district and school leaders, technology support specialists, and library/media specialists were conducted. During the second phase (2002-2003 school year), case studies that focused on specific issues related to technology support and use were conducted. The USEIT sample design allowed students, teachers, principals and district-level administrators to be linked to each other.

In order to examine the teacher, school and district characteristics associated with teachers' technology-use in middle and high school grades, the current article presents analyses based on survey responses from 1,404 middle and high school teachers in 52 schools across 22 Massachusetts school districts. Special education teachers were excluded from the analyses as these teachers were unlikely to have their own intact classrooms and so their survey responses could not be linked to a specific group of students, making their data unsuitable for the types of multilevel modeling conducted here. In

[2] For a complete description of the study design, response rates, sample demographics, and survey instruments see Russell, O'Dwyer, Bebell, and Miranda (2004).

Table 1. Middle and High School Sample Characteristics

Subject areas		Grades taught	
English/Language Arts	31.4%	Sixth grade	13.8%
Mathematics	28.0%	Seventh grade	16.3%
Social Studies/Geography/History	26.8%	Eighth grade	17.0%
Science	25.3%	Ninth grade	33.7%
Foreign Language	0.6%	Tenth grade	38.8%
Technology Education	1.1%	Eleventh grade	41.6%
Music/Arts	0.8%	Twelfth grade	38.2%
Other	2.6%		

addition, given that the purpose of this article was to formulate hierarchical linear models to predict teachers' use of technology, the analyses were restricted to the survey data.

Table 1 provides information about the subject areas and grades that these teachers reported teaching. Note that teachers were asked to identify all grades and subject areas taught and so it was possible for teachers to report teaching more than one subject area and grade level.

The data in Table 1 show that the majority of teachers in the sample reported teaching the main subject areas of English/language arts, mathematics, social studies/geography/history, and science. The table also shows that all middle and upper grades were represented in the sample, with teachers reporting that they taught eleventh grade most frequently (41.6%). Fifty-nine percent of the sample was female, and the majority of teachers in the sample (53%) reported that they had been teaching for more than 10 years at the time the survey was administered. Fewer than 6% of the middle and high school teachers reported teaching for less than one year. Approximately 69% of the teachers surveyed reported having Internet access in their classrooms, and roughly 15% reported having access to three or more desktop computers in their classrooms. Thirty-five percent of the teachers reported that they do not have access to desktop computers in their classrooms, and of this percentage 88% have access to computers in either a lab/media center or in the library. Only about 2% of the sample reported not having access to either desktop computers or laptop computers in their classrooms, lab/media centers, or libraries.

The USEIT study was designed to focus on a broad range of issues related to teacher and student use of technology, and included several survey items that focused specifically on the ways in which technology is used and the factors that influence use. In the analyses presented here, a subset of survey items from the

teacher, school principal, and district technology director[3] survey were used to provide insight into the policies and practices that influence the adoption of technology as a teaching and learning tool in middle and high school classrooms. It is important to note that throughout this work, the term technology refers specifically to computer-based technologies including personal computers, LCD projectors, and Palm Pilots.

OUTCOME MEASURES: DEFINING TEACHER TECHNOLOGY USE

Previous research has found that "technology-use" is a complex construct that is best represented by nuanced and specific measures of how technology is being used (Bebell et al., 2004; O'Dwyer et al., 2004). Understandably, the way in which technology-use is defined has important implications for identifying the characteristics that influence use. In order to tap into the multidimensional construct that is technology-use and using many of the survey items developed by Becker et al. (1998, 1999), Russell et al. (2003) developed the USEIT surveys to measure a large number of variables related to technology use. Building upon the theory-driven design of the surveys, middle and high school teacher responses were analyzed using principal component analysis, and a number of measurement scales representing specific categories of technology-use were identified and created by combining subsets of survey items that were closely related to each other (Bebell et al., 2004).

The use of measurement scales to examine behavioral attributes has advantages over the use of single survey items. First, measurement relying on a single survey item will likely contain more error than measurement made with a scale containing multiple survey items. Second, the use of more than one item to measure an attribute has important consequences for the validity of the measure. A measurement scale, through its individual items, can often represent the multiple aspects of a concept in a single measure. For example, a measure of student use of technology may be made up of items about students' use of technology at home, in the classroom, for leisure, or for school work. Measurement of the attribute using just a single item could result in the loss of information about other aspects of the attribute. By measuring many facets of an attribute and combining them into a single scale, the validity of the measure may be increased. Principal components analysis was used to provide evidence that the theoretical scales were indeed measuring a single, unidimensional attribute.

In this article, five specific teacher uses of technology were examined. These were as follows:

[3] In the United States, district technology directors are typically responsible for directing technology programs within school districts.

1. Teacher-use of technology for delivering instruction;
2. Teacher-directed student use of technology during classtime;
3. Teacher-directed student use of technology to create products;
4. Teacher-use of technology for class preparation; and
5. Teacher-use of e-mail for professional purposes.

Table 2 presents the five technology-use scales, the individual items used to create the scales, and the reliability of the scales for the middle and high school teacher sub-sample. Use of technology for delivering instruction was measured using a single item and each of the other outcomes was composed of a linear combination of at least three items. To facilitate comparisons across technology-use prediction models, each technology-use scale was created using a weighted linear combination of the item responses and was standardized to have a mean of zero and a standard deviation of 1. In the multilevel regression models, these five outcome measures were modeled as a function of teacher, school, and district characteristics.

As can be seen in Table 2, the reliabilities for the scales were each greater than 0.70, with the teacher-directed student use of technology to create products having the lowest reliability (0.74), and the teacher-use of e-mail for professional purposes having the highest reliability (0.87).

To provide a sense of the degree to which teachers used technology for each of these five purposes, Figure 1 contains the average score across each of the items that comprised the use scales.

The average scores are displayed on a scale which ranges from low to high use. The figure shows that middle and high school teachers reported using technology for class preparation most frequently, while they directed their students to use technology during classtime least frequently. It is interesting to note that this pattern is the same as that observed for the elementary school teacher sub-sample from the USEIT study; elementary teachers also reported using technology most frequently for preparation purposes and least frequently for directing their students to create products using technology (O'Dwyer et al., 2004). A full discussion of the teacher use technology patterns observed across the USEIT study data may be found in Bebell et al., (2004).

METHODOLOGY

Given that decisions to make technology available in the classroom are typically made at the school or district level, it is important to examine the school system as a hierarchical organization within which technology use occurs. This approach potentially allows alterable characteristics at the school or district levels to be identified that could positively affect the use of technology as a teaching and learning tool in the classroom. A hierarchical approach to analyzing the factors that are associated with increased technology-use requires the analysis of

Table 2. Outcome Scales, Constituent Items, and Reliability for Middle and High School Teachers

Outcome measure	Constituent items
Teacher-use of technology for delivering instruction	How often do you use a computer to deliver instruction to your class?
Teacher-directed student use of technology during classtime Cronbach's alpha = 0.85	During classtime how often did students work individually using computers this year?
	During classtime how often did students work in groups using computers this year?
	During classtime how often did students do research using the Internet or CD-ROM this year?
	During classtime how often did students use computers to solve problems this year?
	During classtime how often did students present information to the class/using a computer this year?
	During classtime, how often did students use a computer or portable writing device for writing this year?
Teacher-directed student use of technology to create products Cronbach's alpha = 0.74	How often did you ask students to produce multimedia projects using technology?
	How often did you ask students to produce Web pages, Web sites, or other Web-based publications using technology?
	How often did you ask students to produce pictures or artwork using technology?
	How often did you ask students to produce graphs or charts using technology?
	How often did you ask students to produce videos or movies using technology?
Teacher-use of technology for class preparation Cronbach's alpha = 0.82	How often did you make handouts for students using a computer?
	How often did you create a test, quiz, or assignment using a computer?
	How often did you perform research and lesson planning using the Internet?
Teacher-use of e-mail for professional purposes Cronbach's alpha = 0.87	How often did you e-mail teachers in your school?
	How often did you e-mail communication with school and district administration?
	How often did you e-mail students' parents?

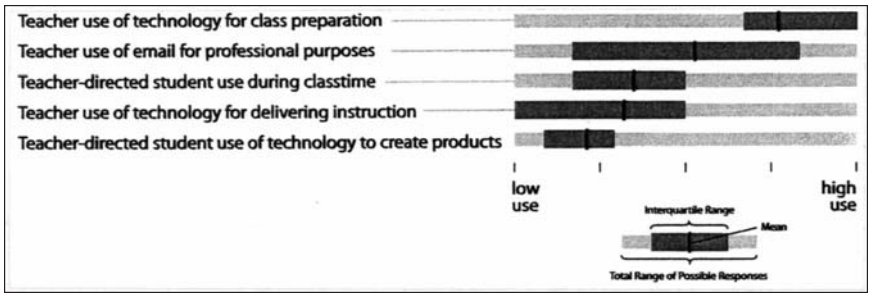

Figure 1. Frequency of middle and high school teacher technology uses.

individuals within groups, and (1) permits the examination of technology-use as a function of classroom, teacher, school and district characteristics simultaneously; (2) permits the relationship between characteristics such as school socioeconomic status or the availability of technology-related professional development, and technology-use to vary across schools; and, (3) explores differences among teachers within schools and differences between schools at the same time therefore producing a more accurate representation of how organizational characteristics impact technology-use in the classroom.

Recognizing this importance, the purpose of this study was to examine middle and high school teachers' use of technology from a multilevel perspective. Specifically, using data collected as part of the USEIT study, this research applied hierarchical linear regression modeling (HLM) techniques to examine the ways in which middle and high school teachers' use of technology was associated with the characteristics of their schools and districts. Using a two-level model, this research examined each of the five technology-use measures as a function of teacher characteristics at level-1, and as a function of school and district leadership characteristics, and technology-related policies at level-2. Based on these two-level models, implications for school and district technology-related policies and practices were explored.

Although it might be considered more appropriate to model technology-use as varying within-schools, between-schools within-districts, and between-districts using a three-level hierarchical model, it was not possible to reliably do so with these data given the limited sample of participating school districts (n = 22). For this reason, the between-school variability will be confounded with the between-district variability in the models presented in this research.

To develop a better understanding of the organizational factors that were associated with increased technology-use, extensive theory-driven, exploratory data analyses were conducted to identify variables observed to be associated with each of the five teacher technology-uses. These independent variables included:

grade level taught, number of years teaching, access to technology, type and availability of professional development, perceived need for technology-related professional development, pressure to use technology, the level of technology-support available, teachers' pedagogical beliefs, as well as teachers' comfort level with technology, and beliefs about the efficacy of technology. The variables and composite measurement scales included in the exploratory phase are listed along with their Cronbach's alpha measures in Table 3. A complete discussion of the psychometric properties of these predictor measures may also be found in Bebell et al. (2004).

For a number of predictors, teacher measures were aggregated to the school level in order to create a measure of average school characteristics. In addition, a proxy for school-mean socioeconomic status was created using data collected from students in the USEIT study. Specifically, data regarding the number of books in the home and the amount of technology available in the home collected from the students of the middle and high school teachers included in the sample were combined and aggregated to the school level. These measures have been used in previous research studies to estimate students' socioeconomic status (see for example, Beaton & O'Dwyer, 2002; Martin, Mullis, Gregory, Hoyle, & Shen, 2000; Mullis et al., 1996; O'Dwyer, 2002). Principal components analysis was used to create a standardized measure of school mean socioeconomic status for each of the 52 schools. The reliability of this measure was found to be 0.85. To facilitate interpretation, all predictor variables and composites were standardized to have a mean of zero and a standard deviation of 1.

In an effort to assess the validity of the survey responses for capturing technology-related behaviors, the relationship between the site visit data and the district level survey data was examined. As mentioned previously, site visits were conducted in each of the participating districts. These site visits included interviews with district and school leaders as well as personnel who worked specifically on technology-related issues. Through a process involving multiple blind readers of interview and site visit transcripts, recurring themes in the data were identified and site visit ratings were created. By comparing the site visit ratings and the survey responses it was possible to examine the extent to which the data collected through the site visit interviews provided information that was consistent with the data collected through the district level surveys. To this end, correlations among the site visit ratings and district level survey responses were calculated. Each of the correlations between the two measures of the same domain were positive and moderately high (for a complete discussion, see Russell et al., 2004). These results are reasonable and support the notion that within domains examined, both data sources appear to be measuring similar constructs. Thus, there appears to be reasonable evidence regarding the validity of the two data collection procedures.

Guided by past research and theory, exploratory multilevel models were formulated and predictors were identified that were significantly associated

Table 3. Variables and Composites Included in Exploratory Analysis Phase

	Cronbach's α
Measures taken at the teacher level	
Perceived importance of technology for the school/district	0.96
Chracteristics that shape technology use in your classroom	0.95
Leadership emphasis on technology	Single item
Teachers' need for professional development for basic skills	0.83
Teachers' need for professional development relating technology integration	0.65
Student characteristics obstruct technology use	0.74
Leadership and teacher input issues obstruct technology use	0.82
Lack of access obstructs technology use	0.79
Quality of computers obstructs use	0.75
Poor professional development obstructs technology use	0.65
Problems incorporating technology obstruct use	0.83
Problems getting technology to work obstructs technology use	0.88
District success implementing the technology program	0.87
Importance of computers for teaching	0.84
Teacher confidence using technology	0.86
Pressure to use technology	0.81
Community support for change	0.92
Support for growth	0.82
Relationship with principal	0.78
Computers harm student learning	0.73
Beliefs about teacher-directed instruction	0.68
Belief that computers help students	0.54
Constructivist beliefs	0.60
Measures taken at the school or district level	
Number of restrictive policies scale	0.79
Line item funding for technology	0.96
Leaders discuss technology	0.86
Evaluations consider technology	0.82
Principal's technology-related discretion	0.77
Variety of technology-related professional development	0.94
The extent to which professional development focuses on technology integration	0.73
School mean socioeconomic status	0.85

with technology-use. Since the emphasis during the analysis was on an exploratory approach, a significance level of 0.10 was adopted as the criterion for inclusion in the models in preference to the more stringent 0.05. Variables identified during the exploratory stage were combined into more parsimonious models to predict each of the five technology use measures. This allowed each of the five technology uses to be predicted by different sets of independent variables.

RESULTS

Table 4 presents the within- and between-school/district variance components for each of the five technology-use outcome measures modeled using an unconditional, two-level hierarchical linear model. Data from 1,404 middle and high school teacher in 52 schools across 22 Massachusetts school districts were used for these analyses. The results indicate that although the majority of variability in each use existed among-teachers within-schools, a statistically significant percentage of the total variability in each outcome lay between schools/districts. The largest between group differences occurred for the measure concerned with how often teachers use e-mail for professional purposes, where 62% of the variability in professional e-mail use occurred between schools/districts indicating that teachers within schools were more like each other than they were like teachers in other schools/districts in terms of their professional use of e-mail. The smallest between-school/district differences in technology-use occurred for the teachers' use of technology for preparation measure and the teacher-directed student use of technology to create products measure. The small percentage of variability between schools/districts for these measures has implications for the predictive power of the multilevel models; context variables measured at the school/district level will have very little power to explain these small differences among schools/districts for these technology-use measures.

At each level in the multilevel models, variables were included to explain some of the available variance in each of the five outcome measures. Table 5 presents the standardized regression coefficients and their associated standard errors for the variables that combined to produce the most parsimonious prediction models for each of the five types of teacher technology-use measures. All predictors were significant at $p \leq 0.1$, and bolded values were significant for at least $p \leq 0.05$. A discussion of each model follows.

Teacher-Use of Technology for Delivering Instruction

Not surprisingly, the teacher-level model indicated that teachers who reported higher levels of confidence using technology (0.144) were more likely to use technology for delivering instruction. In addition, teachers who reported having difficulty integrating technology into the curriculum were less likely to use

Table 4. Unconditional Variance Components for Five Technology Uses for Middle and High School Teachers

	Teacher use of technology for delivering instruction	Teacher-directed student technology use during class time	Teacher-directed student technology use to create products	Teacher use of technology for class preparation	Teacher use of e-mail for professional purposes
Percent of variance within schools	82%	67%	92%	97%	38%
Percent of variance between schools/districts	18%[a]	33%[a]	8%[a]	3%[b]	62%[a]

[a]The amount of variability between schools is significant for $p < .001$.
[b]The amount of variability between schools is significant for $p < .05$.

technology for delivery (–0.122). Teachers' constructivist beliefs were also positively, though not significantly, associated with use of technology for delivering instruction.

The teachers' reported "availability of technology composite" (0.356) and the "poor professional development obstructs use" composite (–0.364) were statistically significant predictors of the between school/district differences among teachers' use of technology for delivering instruction. These coefficients indicate that teachers who reported higher levels of technology availability tended to use technology more for this purpose, and teachers who reported that they were ill-prepared through their professional development tended to use technology less for this purpose.

Teacher-Directed Student Use of Technology during Classtime

At the teacher level, beliefs about student-centered instruction (0.141), and beliefs about the positive impacts of technology for students (0.090) were significantly positively related to teachers' reports of how often they direct students to use technology during classtime. Similar to the previous outcome measure, teachers who reported problems incorporating technology into the curriculum were less likely to have their students use technology during classtime.

Similar to the model for predicting teachers' use of technology for delivering instruction, at the school/district level, school-mean availability of technology was significantly positively related to the extent to which teachers directed their students to use technology during classtime (0.441). The model also showed that teachers in districts with line item funding for technology reported using technology more frequently for this purpose. Principals' discretion related to technology decisions was positively, though not significantly related to this particular use of technology.

Teachers Direct Students to Create Products Using Technology

At the school/district level, teachers' reported lack of access to computers was a significant, negative predictor of the extent to which teachers directed students to create products using technology (–0.278). Similarly, the amount of restrictive policies related to technology in place within a school or district was negatively associated with the frequency with which teachers' directed students to create products using technology (–0.051). The extent to which teacher evaluations considered technology was a significant and positive predictor of the frequency with which teachers directed their students to create products using technology (0.165).

At the teacher level, beliefs about student centered instruction (0.136), the positive impacts of technology for students (0.123), and teacher confidence using

Table 5. Multilevel Regression Models for Predicting Middle and High School Teachers' Use of Technology

	Teacher use of technology for delivering instruction	Teacher-directed student use of technology during class time	Teachers direct students to create products using technology	Teachers use technology for preparation	Teacher use of e-mail for professional purposes
	Coefficient (s.e.)	Coefficient (s.e.)	Coefficient (s.e.)	Coefficient (s.e.)	Coefficient (s.e.)
School/District Model					
Teachers report that poor professional development is an obstacle (school mean)	**–0.364 (.12)**				
Variety of available technology-related professional development (district mean)				**0.068 (.03)**	
Socioeconomic status index (school mean)			0.077 (.04)		
Principal's professional use of e-mail with teachers					**0.375 (.09)**
Teachers report that professional development focuses on technology integration (school mean)					
Teachers report that access is an obsolete (school mean)			**–0.278 (.10)**		
Line item funding for technology (district mean)		**0.633 (.20)**			
Principal's discretion related to technlogy decisions		0.236 (.12)			
Teacher perception of superintendent's emphasis on technology (school mean)				**–0.080 (.02)**	**–0.268 (.08)**

Teachers report pressure to use technology (school mean)			0.217 (.13)		
Teachers report on the availability of technology (school mean)	**0.356 (.06)**	**0.441 (.07)**		**0.261 (.06)**	**0.432 (.09)**
Amount of restrictive policies for using technology			**–0.051 (.02)**		**0.272 (.07)**
Evaluations consider technology (district mean)			**0.165 (.07)**		
Teachers report that technology quality is an obstacle (school mean)					
Teacher Model					
Problems incorporating technology into the curriculum obstruct use	**–0.122 (.03)**	**–0.055 (.03)**			
Issues with the quality of technology obstruct use					
Teachers report that access is an obstacle		–0.032 (.03)	**0.079 (.04)**	**0.114 (.05)**	
Issues with students obstruct technology use					
Teacher believes in student-centered instruction	0.058 (.03)	**0.141 (.02)**	**0.136 (.03)**	**0.142 (.02)**	**0.095 (.02)**
Teacher believes that computers help students		**0.090 (.02)**	**0.123 (.03)**		
Teacher confidence using technology	**0.144 (.03)**	0.041 (.03)	**0.091 (.03)**	**0.276 (.03)**	**0.127 (.02)**

Note: Bolded values represent statistical significance for p at least $< .05$.

technology (0.091) were each significant, positive predictors for this outcome measure. Access to technology was also a significant predictor of differences among teachers within schools (0.079) for this type of technology-use.

Teachers' Use of Technology for Preparation

The availability of technology was a strong positive predictor of the between school/district differences in the frequency with which teachers reported using technology for preparation (0.261). Similarly, the variety of technology-related professional development available to teachers was a significant predictor of teachers' use of technology for preparation (0.068). Also at the school/district level, teachers who reported feeling pressure to use technology were less likely to report using technology for preparation (–0.080).

Within schools, teachers' confidence using technology was the strongest predictor of whether teachers used technology for preparation (0.276). Similarly, constructivist beliefs and increased access to technology were associated with higher levels of technology use for preparation among teachers.

Teacher-Use of e-Mail for Professional Purposes

Teachers' professional use of e-mail was significantly related to a number of the predictors included in the exploratory data analysis. Not surprisingly, at the school/district level, principals' professional use of e-mail with teachers was a significant and positive predictor of teachers' professional use of e-mail (0.375). Similar to the model for predicting teachers' use of technology for preparation, teachers' perception of their superintendent's emphasis on technology was significantly negatively related to teachers' professional use of e-mail (–0.268). The strongest predictor of the between school/district differences in teachers' professional use of e-mail was the availability of technology in school (0.432). Unlike the model for predicting the frequency with which teachers directed their students to create products using technology, the number of technology-related restrictive policies that were in place the school was a significant positive predictor of e-mail use (0.272). It may be that schools with more highly evolved technology infrastructure, including e-mail access for teachers, were the schools that have the most restrictive policies relating to technology-use.

Variance Explained

When context variables were added at the teacher and school/district level, a portion of the available variance was explained. The percentages of variance explained by the models, shown in Table 6, indicate that the models were generally not very powerful for explaining differences in technology-use among teachers within schools. Specifically, four of the five models explained less than 10% of the available variability in technology use within schools.

Table 6. Variance Explained by the Five Models

	Teacher use of technology for delivering instruction	Teacher-directed student technology use during classtime	Teacher-directed student technology use to create products	Teacher use of technology for class preparation	Teacher use of e-mail for professional purposes
Percent of variance within schools					
Within schools	82%	67%	92%	97%	38%
Between schools	18%[a]	33%[a]	8%[a]	3%[b]	62%[a]
Percent of level-specific variance explained by each model					
Within schools	6%	6%	5%	12%	7%
Between schools	78%	75%	66%	73%	72%
Percent of total variance predicted by variables	19%	28%	10%	15%	48%

[a]The amount of variability between schools is significant for $p < .001$.
[b]The amount of variability between schools is significant for $p < .05$.

At the school/district-level, the models explained a larger percentage of the available variance. The model for predicting teachers' professional use of e-mail appeared to be the most powerful, explaining 72% of the available variability in use among schools/districts. Given that almost 62% of the total variability resided between schools/districts, this model explained a substantial percentage (48%) of the total variability in teachers' professional use of e-mail. The model for predicting teachers' use of technology for preparation predicted 73% of the variability among schools/districts, but given that only 3% of the total variability lay between schools/districts for this use, this was not a large percentage of the total variability in the use measure. Similarly, the model developed for teacher-directed student use of technology to create products explained 66% of the available variance (8%) between schools/districts. The between school/district models for the frequency with which teachers used technology to deliver instruction and the frequency with which teachers directed their students to use technology during classtime explained a substantial percentage of the between school/district variance (78% and 75%), and so in total, 19% and 28%, respectively of the total variability in the outcomes were explained.

When compared with the models predicting similar uses of technology among elementary school teachers (O'Dwyer et al., 2004), these models explained comparatively larger percentages of the variability due to the between school/district differences, and so overall, explained larger percentages of the total variability in the technology-use outcomes.

DISCUSSION

In recent years, school districts have begun to invest heavily in educational technology and, subsequently, the national average student-to-computer ratio has decreased to 4:1. At the same time, the variety of ways in which technology is used to support teaching and learning both in and out of the classroom has increased rapidly. The increased access and variety of technology tools available has complicated the way in which teacher technology use is defined. As educational technology and its use in the classroom continue to evolve, it is vital that we continue to remain informed about the variety of ways in which technology is actually used and the policies and practices that promote the use of technology as a teaching and learning tool.

Although an informative body of research has examined factors that influence the extent to which individual teachers use technology, primarily for instructional purposes, little empirical research has focused on the role of schools and districts in shaping teacher use of technology. Without question, researchers, policy makers, and technology advocates acknowledge the role that schools and districts play in shaping teacher technology use. For several years, the U.S. Department of Education has emphasized the importance of preparing teachers to use technology through pre-service and in-service training. Similarly, the

Milken-Exchange on Educational Technology has identified several conditions under which technology use is believed to increase. Among the conditions are: strong leadership, professional preparation, and the technological capacity of the system (Lemke & Coughlin, 1998). While it may seem intuitive that each of these factors may influence technology use, there is little empirical research that examines how school and district-level characteristics influence the adoption of technology by individual teachers. In order to address this issue, and adding to previous research examining elementary teachers' use of technology (O'Dwyer et al., 2004), this research examined middle and high school teachers' use of technology in light of teacher, school and district characteristics.

Overall, the hierarchical linear model results in Table 5 demonstrate that the predictor effects between schools/districts were larger than the effects within schools for all five uses of technology. Similar to findings from previous studies examining the relationship between school and district characteristics and teachers' technology-use (O'Dwyer et al., 2004), these results indicate that school and district characteristics differ in their ability to predict the five uses of technology defined here. This finding has implications for school leaders and policymakers as they continue to find ways to support the integration of technology into their schools; targeted policies and practices have the potential to encourage specific types of technology use in the classroom.

The models show that increased availability of technology was significant for predicting four of the five technology uses and was likely to result in increased use of technology for delivering instruction (0.356), increased teacher-directed use of technology by students during class time (0.441), increased teacher-directed use of technology by students to create products (0.432), and increased use by teachers for class preparation (0.261). Indeed, it is not surprising to find that access to technology plays a major role in a teachers' choice to use technology. This is particularly true for those uses of technology that directly involve students in a classroom environment where greater numbers of computers would facilitate technology use within a classroom, specifically teacher-directed use of technology by students during class time and teacher-directed use of technology by students to create products. It seems apparent that without reasonable access to technology, the majority of teachers do not go out of their way to systematically and frequently use technology with their students. To this end, there has been an upsurge of interest in 1:1 technology environments whereby every teacher and student has access to a computer. Early research and evaluation findings of 1:1 programs suggest that when technology access is ubiquitous, teachers' use of technology increases substantially (Maine Education Policy Research Institute (MEPRI), 2003; Russell, Bebell, & Higgins, 2004).

At the individual or teacher level, teachers who reported problems incorporating technology into the curriculum appeared less likely to use technology to deliver instruction (–0.122), and less likely to have their students use technology during classtime (–0.055). These findings confirm what many district level

curriculum directors and technology directors have anecdotally shared with the authors. Namely, that some teachers find it awkward, challenging, or without merit, to incorporate technology into their curriculum and lessons, and, in turn, do not use classroom applications of technology for instruction or with students. Indeed, the current data suggests that teachers' lack of technology use for instruction and with students seems to emanate from difficulties incorporating technology into their teaching rather than from problems with the available technology or student characteristics. In the current analyses, neither the quality of the available technology nor issues relating to student characteristics in the classroom were significantly associated with any of the five uses.

Confirming previous research findings (O'Dwyer et al., 2004; Ravitz et al., 2000), teachers' pedagogical beliefs and beliefs about the positive impacts of technology were positively related to each of the technology uses examined here. At the teacher level, the strongest positive predictor of whether a teacher used technology to deliver instruction (0.144), for class preparation (0.091), and for professional e-mail use (0.127) was a teacher's reported confidence using technology. In addition, teacher beliefs about the positive impacts of technology was one of the strongest predictors of whether teachers directed their students to create products using technology (0.123). Thus, in addition to technology access playing an important role in middle and high teachers' adoption of technology, the teachers' own background and comfort level with technology appeared to be of practical and statistical significance.

Consistent with Ravitz et al.'s (2000) findings, teachers who held constructivist beliefs were more likely to have their students use technology during classtime (0.141), to have their students create products using technology (0.136), were more likely to use technology themselves for class preparation (0.142), and were more likely to use e-mail for professional purposes (0.095). It is interesting to note that socioeconomic status was not a powerful predictor of the differences among schools/districts for any of the five uses and specifically, the relationship between teacher-directed student use of technology to create products and school socioeconomic status was small (0.077) and non-significant.

The findings at the school/district level demonstrate the importance of examining a variety of technology uses that may be influenced by characteristics at different levels in a school system's hierarchy. Importantly, the ability of a school or district to manipulate or alter all of the factors related to technology use in schools has implications for the school and district policies, practices, and leadership characteristics that may influence how, and the extent to which teachers use technology for a variety of purposes. Specifically, increasing availability of technology, providing line item funding for technology, altering restrictive policies related to technology, considering technology use as part of teacher evaluations, and providing easy access to a variety of professional development opportunities all have the potential to impact on one or more ways in which teachers use technology to support their teaching.

Despite the relatively small amount of total variability in technology use explained by the hierarchical linear models for some outcome measures, the findings at the school/district level illustrate the importance of examining technology use as a phenomenon that may be influenced by characteristics that reside outside of the classroom. Given that many of these characteristics may be revised or altered, school and district leaders have the potential to influence the ways in which, and extent to which teachers use technology for a variety of purposes. However, the small amount of variance explained in the technology use measures among teachers within schools and districts indicates that, although we are moving toward a greater understanding of the differences in use among schools, we have much to learn about the processes that influence technology use within schools.

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