

Beyond Computers In The Classroom: Factors Related To Technology Adoption To Enhance Teaching And Learning

Janet A. Buckenmeyer, Purdue University Calumet, USA

ABSTRACT

How is technology being integrated to the extent possible toward the goals of improving teaching and learning? Research suggests that teachers will be more likely to try new methods of teaching if certain conditions exist. It is not known which conditions are more likely to influence a teacher's decision to integrate technology into the curriculum. Accordingly, the purpose of this study was to investigate the relationships between technology adoption and conditions such as available resources to support the use of technology, teachers' attitudes toward technology, and adequacy of professional development. Data to address the specific research questions were obtained from secondary-level teachers (n = 144) from a suburban school district who participated in professional development and responded to a survey designed for this study. Among other findings, analyses revealed that professional development and available resources were significantly related to technology adoption. Recommendations based on the findings, including implications for professional development, are discussed.

Keywords: Technology Integration, Technology Adoption in Schools, Conditions of Adoption

MORE THAN COMPUTERS IN CLASSROOMS: FACTORS RELATED TO TECHNOLOGY ADOPTION TO ENHANCE TEACHING AND LEARNING

 One of the most pervasive and far-reaching of the technological influences on teaching and learning has been the introduction of the computer into the classroom (Office of Technology Assessment, 1995). While not providing a total solution to the challenges that schools face (OTA, 1995), computer technology does provide teachers and students with a variety of opportunities that were not available previously, including the capability of providing simulations of otherwise costly, time consuming, or dangerous situations, instant global communications, and immediate access to limitless information.

Furthermore, the phenomenon known as the “Digital Divide” illustrates the very real issue that schools do exist that have limited access to technology. While making the technology available is critical, it is only the beginning of the solution. Recent studies have recognized that it is not only the lack of computers that teachers in these poor inner-city and rural schools face. Further barriers include having significantly less training to use technology than teachers in more affluent schools, having technical support systems are not as well funded, and using the available technology in the classroom quite differently (Kleiman, 2000). When considering issues of equity, therefore, all essential conditions for appropriate technology integration need to be examined, not just the number of computers available. Thus, the challenge is *not* getting appropriate technology into classrooms, but getting those in classrooms prepared to use those technologies, and facilitating greater willingness to incorporate changing technologies as they emerge.

In spite of this potential, school administrators and teachers in the United States still in 2005 remain reluctant to rapidly embrace technological innovation, or to adapt computer technologies that are well-suited to instructional purposes. Access to technology within schools has expanded dramatically; however, a less-dramatic change has been apparent in policies designed to improve the ability of teachers and administrators to use technology effectively (Swanson, 2006).

As early as 1999, a national survey by Becker (1999) revealed that a majority of teachers—as many as 70 percent—are not using the technologies available to them. The reasons for this are varied and complex. Earlier studies suggest that teachers' educational beliefs play an important role in how they choose to appropriate and make use of technologies in their classrooms (Honey & Moeller, 1990). For teachers whose beliefs are more traditional, there exist different and more complicated barriers to adoption (Honey & Moeller, 1990).

The results of a more recent study by Firek (2003) remain disappointingly consistent with Becker's 1999 study: beginning teachers still do not have the skills needed to successfully integrate technology into the curriculum. A teacher's pre-service training may contribute to his or her reluctance to adopt technological solutions. In-service teachers also apparently lack adequate support for technology use. In 1993, Hadley and Sheingold concluded that the access to technology was necessary but not sufficient for making appropriate integration possible. Marcinkiewicz (1994) concluded that simply having more technology does not in itself persuade teachers to begin to use them. Almost a decade later, the report entitled "*Teachers' Tools for the 21st Century: A Report on Teachers' Use of Technology*," revealed that even now, though the majority of schools had access to some form of technology, a mere one-third of teachers reported feeling well prepared or very well prepared to use computers and the Internet for classroom instruction (National Center for Education Statistics, 2000).

This problem has not abated over time. In fact, the opposite is happening. Consider this statistic: Market Data Retrieval (MDR) data show that the percentage of schools where most teachers are considered "beginner" users of technology has substantially declined, from 35 percent in 1999 to 15 percent in 2005 (Swanson, 2006). We're actually in worse shape when it comes to teacher technology use than we were in 1999.

The reasons for not using technology are numerous, and have been chronicled elsewhere. If student achievement is the ultimate goal, and if technology can be an effective aid in the fulfillment of that goal, then it is logical to assume that teacher implementation of technology will help achieve that goal. Helping teachers to use technology effectively may be the most important step to assuring that current and future investments in technology are realized (OTA, 1995). Anyone who has worked with schools and teachers recognize that the teacher adoption of technology is as much of an issue today as it was ten years ago. The question remains: what factors *are* related to appropriate incorporation of technology, and what conditions will foster adoption?

RESEARCH QUESTIONS

Two primary research questions were addressed in this study. First, what are the relationships between the resources available to teachers in support of technology adoption, teachers' attitudes toward technology, teachers' professional development, and teacher use of technology and stage of adoption? Second, what conditions are more likely to promote technology integration into classroom instruction by teachers? That is, what is most important?

These questions are not trivial, but are key to accruing the benefits that technology can offer for teachers and students. The first question attempts to discover if attitude, support for actual use, or professional development opportunities impact the level of use in the classroom? If so, to what extent? The second question, then, follows up on the first: if we know the factors that predict technology integration, what conditions can be put into place by administrators in order to facilitate adoption by a greater number of teachers? If it can be determined what is most needed for teachers to use embrace adoption of available technologies, then perhaps the figure can be transformed from the current 70% (or 85%) of teachers who do not use technologies in their classrooms to 70% (or 85%) who do. Because much computer technology already in classrooms is not being used to realize the potential benefits for teaching and learning that they have to offer, it makes sense to pursue a national policy of "No Computer Left Behind." This policy begins with studying the diffusion of this innovation, so that the conditions can be replicated

METHODS

The present research was conducted with educators (n=144) who participated in a professional development program related to the use of educational technology. All of the participants were certified teachers or other school personnel working in two large suburban high schools in a Midwestern state. The sample could be considered homogeneous because the characteristics of the teachers and the school population are typical of a

suburban population; the majority of both populations is white and middle or upper-middle class, and a large percentage of the families is considered “white-collar” workers. Further, more than 80 percent of the surveyed teachers have taken post-baccalaureate classes, with about 60 percent earning a Master’s degree. Each school averages about 1500 students per year and average class size is 20 students. At least 89 percent of the respondents reported that they owned a computer and used it in some capacity. However, only 38 percent of the teachers reported that they had received any formal training or had been certified at a novice level of use, according to Ohio SchoolNet guidelines. Table 1 summarizes the demographic characteristics of the participants.

Table 1: Demographic Characteristics Of Participants

Sex			
	Male	Female	No Response
N =	58	81	5
Age (in years)			
Mean =	43.2	SD =	11.1
Years of Experience in Education			
Mean =	16.4	SD =	10.4
Computer Experience			
Area	N	Percent	
Own	128	89	
Certified	38	26	
Primary Teaching Assignment/Content Area			
Area	N	Percent	
Science	19	13.2	
Mathematics	19	13.2	
English	17	11.8	
Career/Tech	14	9.7	
Social Studies	12	8.3	
Foreign Language	8	5.6	
Art	5	3.5	
Music	4	2.8	
Physical Education/Health	4	2.8	
Business	3	2.1	
School Medial Specialist	3	2.1	
Guidance/Counseling	1	0.7	
Administrative Assignment	1	0.7	
Other	22	15.3	
No Response	12	8.3	
Highest Educational Level Attained			
Level	N	Percent	
BA/BS	23	16.0	
Bachelor’s + 15	32	22.2	
MA/MS	34	23.6	
Master’s + 15	22	15.3	
Master’s + 30	25	17.4	
PhD/EdD	2	1.4	
Missing	6	4.2	

A survey was developed and administered to all participants. Excluding demographic items, the survey consisted of 75 items formatted as Likert-type statements to which participants responded with a rating of 1 – 5. Seventy-four of the items comprised four subscales, three of which were considered to be predictors of technology adoption. The predictor subscales are identified as: *Professional Development, Available Resources and Support, and Attitude toward Technology*. These subscales were conceptualized as measuring the impact of professional

development, the extent of available resources and support for technology use, and attitude and self-efficacy with respect to the use of technology for teaching and learning. The fourth subscale, *Technology Adoption/Use*, served as the criterion variable and was a direct measure of participants’ adoption and use of technology for educational purposes. One additional item asked participants to classify themselves according to one of six specific adoption stages. The *Stage of Adoption* variable included the following levels, sequentially from lowest to highest: Awareness, Learning the Process, Understanding and Application, Familiarity and Confidence, Adaptation to Other Contexts, and Creative Application to New Contexts.

RESULTS

Findings from this study can be grouped into three areas. First, analyses were performed to evaluate the instrument itself. Second, relationships between the predictor and criterion variables were examined, as were relationships between specific items included on various subscales and the criterion variables. Finally, regression analyses were conducted to evaluate the relative contributions of the three subscales and to assess the overall predictive power of a model in which the three subscales were used to predict adoption and use of technology. Results of each of these groupings of analyses are presented in the following subsections.

Instrument Evaluation

For each of the three predictor subscales, summary data were obtained and reliability analyses were conducted, and subscale intercorrelations were computed. Additionally, data on the *Stage of Adoption* variable were summarized. Results of these analyses are presented in Table 2. As the results shown in the table demonstrate, the survey yielded highly dependable data, with all subscale and total scale reliabilities above .80. Also, with the exception of the correlation between *Available Resources and Support* and *Technology Adoption/Use* which was not statistically significant, all of the subscales were moderately and statistically significantly correlated, suggesting that the subscales measured related, though relatively unique aspects. Further, the correlation between these subscales may actually be underestimated; the modest strength of the correlations obtained in this study may be the result of the fairly homogeneous sample used. Further research may be warranted to discover the extent to which such homogeneity is typical in other settings.

Table 2: Subscale And Criterion Variable Summary Statistics, Reliabilities, And Intercorrelations

Subscale Analyses				
<i>Subscale</i>	<i>Number of Items</i>	<i>Reliability (Alpha)</i>	<i>N</i>	
Professional Development	14	.84	139	
Available Resources & Support	20	.93	138	
Attitude toward Technology	24	.90	138	
Technology Adoption/Use	16	.93	135	
Subscale Intercorrelations				
<i>Subscale</i>	Professional Development	Available Resources	Attitude toward Technology	Technology Adoption/Use
Professional Development		.391**	.566**	.329*
Available Resources & Support	---		.275**	-.157
Attitude toward Technology	---	---		.504**
Note: ** = p<.01, two-tailed				
Stage of Adoption				
<i>Stage</i>	<i>N</i>	<i>Percent</i>		
Awareness	1	0.7		
Learning the Process	11	7.6		
Understanding and Application	19	13.2		
Familiarity and Confidence	37	25.7		
Adaptation to Other Contexts	32	22.2		
Creative Application to New Contexts	33	22.9		
Missing	11	7.6		

Beyond the findings related to instrument quality lies the first substantive finding of this research: each of the variables (i.e., the subscales *Professional Development*, *Resources*, and *Attitude toward Technology*) was correlated with the primary outcome variable (*Technology Adoption/Use*) as hypothesized. That is, *Professional Development* and *Attitude toward Technology* were both moderately positively related to *Technology Adoption/Use*, while the extent of *Available Resources and Support* was not significantly related to *Adoption/Use*. This finding confirms previous research suggesting that the availability of computing technology in classrooms is not a barrier. The significant correlation between *Professional Development* and the criterion of *Adoption/Use* ($r = .329$) indicates that technology tends to be more readily adopted in the presence of relevant professional development activities or experiences.

Relationships Between Individual Items And Technology Adoption/Use

Correlation coefficients were also calculated to describe the relationship between all individual items in the subscales and the criterion, *Technology Adoption/Use*. Because it is not feasible to provide all correlations here, a sample of item-to-total correlations is provided in Table 3, along with a key to interpretation of the Likert scale points. Table 3 also shows the wordings of three representative items from each subscale.

Table 3: Scale Point Descriptions And Sample Item Information

Scale Point Descriptions				
Scale Values	Range	Interpretation		
4.6 – 5.0		Strongly Agree or Highly Proficient		
3.6 – 4.5		Agree or Above Average Proficiency		
2.6 – 3.5		Undecided or Moderate Proficiency		
1.6 – 2.5		Disagree or Slightly Proficient		
1.0 – 1.5		Strongly Disagree or Not Proficient		
Sample Subscale Items, Means, Standard Deviations, and Item-Total Correlations				
<i>Professional Development Subscale</i>				
Item Wording	Mean	SD	r	n
1) “Using a trial and error approach has increased my knowledge of computer use.”	3.94	.97	.37**	143
2) “Periodicals/professional literature related to computer use has increased my knowledge on use of computers.”	2.40	1.24	.34**	143
3) “Websites on the Internet for guidance on constructing lessons are helpful to me for integrating computer use into my classroom practice.”	3.33	1.18	.21*	139
<i>Available Resources/Support Subscale</i>				
1) I need more training with technology.	4.03	.95	-.30**	143
2) I need more examples in the use of technology in my content area”	3.95	1.02	-.19*	141
3) I need more time to learn to use computers.	3.84	1.15	-.31**	142
<i>Attitude toward Technology Subscale</i>				
1) “My role as the teacher will be dramatically changed because of the Internet within the near future.”	3.31	1.05	.290**	143
2) “Using educational technology is a strategy employed by effective teachers.”	3.75	.94	.402**	143
3) “Using educational technology increases student learning.”	3.56	.79	.357**	140

Note: * = $p < .05$; ** = $p < .01$

Among the individual relationships between *Professional Development* items and *Technology Adoption/Use*, it is interesting to note that several training activities were significantly correlated to technology adoption. Included among those activities were using a trial and error approach, the use of professional literature, and the use of Internet websites for constructing lessons and designing strategies. Although the overall correlation

between the subscales of *Available Resources and Support* and *Adoption/Use* was nonsignificant, several individual items are noteworthy. For example, as shown in Table 3, items tapping the extent to which participants believe that have enough training in technology—and desire additional support in that area—showed significant relationships to their current level of adoption and use of technology. Finally, as would be predicted based on previous research, participants’ attitudes toward technology showed demonstrable relationships to their adoption and use; the sample items from this subscale are illustrative of the strong and uniform relationships in this area.

Regression Analyses

The final analyses performed were a pair of regression analyses to determine the relative contributions of the three components and to assess the overall predictive power of a model in which the three components were used to predict adoption and use of technology. In the first analysis, the three subscale total scores were used as independent variables and the total score on *Technology Adoption and Use* served as the dependent variable. In the second analysis, the same independent variables were used, but in this case, the dependent variable was the participant’s current *Stage of Adoption*. Results of these analyses are presented in Table 4.

Table 4: Results Of Regression Analyses

Analysis 1: Dependent Variable = Technology Adoption/ Use Model Coefficients and Significance of Predictors					
	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	22.676	7.172		3.162	.002
Professional Development Total	.318	.129	.223	2.471	.015
Available Resources Total	-.300	.069	-.334	-4.348	.000
Attitude toward Technology Total	.471	.086	.481	5.477	.000

Model Summary					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	7352.385	3	2450.795	24.421	.000
Residual	12042.736	120	100.356		
Total	19395.121	123			

R	R Square	Adjusted R Square	Std. Error of the Estimate
.616	.379	.364	10.01779

RESULTS OF REGRESSION ANALYSES

**Analysis 2: Dependent Variable = Stage of Adoption
Model Coefficients and Significance of Predictors**

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	1.884	.810		2.327	.022
Available Resources Total	-.027	.008	-.306	-3.559	.001
Attitude toward Technology Total	.031	.010	.310	3.140	.002
Professional Development Total	.039	.015	.266	2.627	.010

Model Summary					
	Sum of Squares	df	Mean Square	F	Sig.
Regression	46.683	3	15.561	12.748	.000
Residual	142.821	117	1.221		
Total	189.504	120			

R	R Square	Adjusted R Square	Std. Error of the Estimate
.496	.246	.227	1.105

As the results in Table 4 demonstrate, the combinations of subscales are significant predictors for both *Technology Adoption and Use* and *Stage of Adoption*. Not only are the combinations of predictors significant in both cases ($p < .001$) but the models as a whole are fairly powerful, with these three variables predicting approximately 38% and 25%, respectively, of the variance in outcomes. Further, the independent variables in each model are each singly significant predictors. Interestingly, the relative contribution of predictor varies, depending on the dependent variable. For example, the variable *Attitude toward Technology* is the strongest predictor of the criterion *Technology Adoption/Use*, while *Available Resources and Support* is the most powerful predictor for *Stage of Adoption*.

DISCUSSION

As has been noted elsewhere, integration of the computer into the curriculum often lags primarily due to soft factors (Ertmer, 1999). Teachers use computers; however, that use has not extended to effective integration. Several implications for technology adoption and the change process in the K-12 environment are suggested by the results of this study. It would seem that certain factors must be present in order to facilitate the embrace of emerging technologies by those in classrooms.

This study addressed two issues. The first line of investigation involved an exploration of the relationships between attitude toward technology, available resources and support, and professional development together and technology use by teachers, including the current stage of adoption. Clearly, the data supports that such relationships exist. Twenty-five to almost forty percent of the change in teachers' stage of adoption and use of technology can be explained by the presence of these three factors. That is, it is the convergence of the teacher attitude, the professional development they receive, as well as the access to available resources and support that makes appropriate integration possible (NCES, 2000; Hadley and Sheingold, 1999). The first implication from this study supports previous research confirming that it is the unique combination of factors that facilitates appropriate integration.

Once it was established that the combination of the factors was considered predictive, the relative weight or importance of the individual factors and their contribution to technology use and adoption was examined. Singly, each individual factor was a predictor of technology use and stage of adoption. Even more interesting, attitude toward technology was found to be the strongest predictor of teacher technology adoption and use, while having available resources and support was the most powerful predictor for stage of adoption. This line of thought is developed more fully below.

This study also investigated the relationships between individual items, or factors, surveyed and teacher technology integration. The following recommendations are gleaned from the reported strength of the teacher responses as well as the results of the regression analysis.

First, increased professional development opportunities should be afforded to educators who are called on to increase the effective use of technology for instructional purposes. Technology integration can be promoted by integrating technological applications with traditional content-based professional development opportunities. Technology-specific training activities can also be less formal, in which teachers work together to learn new technologies, and trial and error approaches are encouraged. This finding is supported by the literature which states that technology integration does happen when teachers are prepared to use it (NCES, 2000; Becker, 1999).

Second, additional time (support) must be allocated to the technology needs of educators. Time is needed both to learn new technologies themselves and to learn to integrate those technologies in the classroom (Maney, 1999; Sandholtz, Ringstaff & Dwyer, 1997; OTA, 1995; Hadley & Sheingold, 1993). In a study by Franklin, Turner, Kariuki and Duran (2002), technology mentors indicated that the teachers took longer than expected to gain new computer knowledge and skills. This finding and recommendation is consistent with that offered by Vannatta and Fordham (2004) who found that the teacher attributes of time commitment to teaching, an openness to change, and professional development opportunities best predicted technology integration. Most important, time spent on learning and using technology has a positive relationship with technology achievement (Liu, Maddux, & Johnson, 2004). When not enough time is provided, teachers often resort to what is already known, and so fail to try new methods to teach students.

Third, adequate technical assistance (support) must be provided to support technology adoption and that support must be timely (Maney 1999; McKenzie, 1999). If equipment is not going to work, and if no one is available to help when the inevitable operational problems occur, then even the teachers who use technology may become frustrated and abandon beneficial tools.

Finally, a consistently strong predictor of adoption and use of technology is attitude toward technology. Attitudes are important to the process of technology adoption (Marcinkiewicz, 1994; Honey & Moeller, 1990). Teachers are the implementers of change. This notion underlies curriculum dissemination and program replication, and drives educational policy (Craig, 2006). Attitude toward technology plays a key role in shaping teacher use of technology in classroom practice (McGrail, 2005). Ertmer (2005) suggests that in order to change teacher beliefs, research needs to be done in the areas where teachers have first-hand experiences with technology, vicarious experiences where teachers observe successful implementation, and social-cultural influences through professional learning communities. In general, teachers need to see the effectiveness of technology on student learning outcomes. Effective technology integration will only occur through sustained training and professional development activities, which requires time allotted to that purpose.

In summary, this research adds to and reinforces what we know about adoption and use of technology by discovering more about the relationships between the resources available to teachers in support of technology adoption, teachers' attitudes toward technology, teachers' professional development, and both their adoption/use of technology and their stage of adoption. Second, this study has helped identify the conditions most likely to promote technology integration into classroom instruction by teachers.

Obviously, replication of this study would be warranted to the extent that the characteristics of the sample differ from those in other locations. In addition, it is noted that this study is using self-reported data for its analysis and conclusions. The limitations from using this type of data are inherent; the usefulness from the data are only as strong as the quality of the responses. However, to the extent that these teachers are similar in their needs and perspectives to others, this research suggests practical approaches that can be pursued to assist those interested in fostering the process of technology adoption.

If change is to occur in the classrooms, it must begin with the teacher, not the technology. In this article, additional light has been shed on the factors that will promote teachers' embrace of change. Of course, there is much additional to be learned. Ideally, replications and extensions to this research will help to refine what we know and, ultimately, a set of research-based guidelines might be established to promote effective technology integration toward the goal of instructional improvement and increased learning.

AUTHOR INFORMATION

Janet Buckenmeyer, Ph.D. is an Assistant Professor and Program Chair of the Instructional Technology Program for the Graduate School of Education at Purdue University Calumet. She teaches courses in appropriate technology integration, learning theories and technology, instructional design, and web-based instruction. Her research interests focus on technology integration and student learning, teacher preparation, and educational change. Dr. Buckenmeyer received her PhD in Curriculum and Instruction from the University of Toledo in 2001.

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