Factors affecting technology integration in K-12 classrooms: a path model

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Abstract The purpose of this study was to examine the direct and indirect effects of teachers' individual characteristics and perceptions of environmental factors that influence their technology integration in the classroom. A research-based path model was developed to explain causal relationships between these factors and was tested based on data gathered from 1,382 Tennessee public school teachers. The results provided significant evidence that the developed model is useful in explaining factors affecting technology integration and the relationships between the factors.

Keywords Technology integration · Computer use · Technology use · Computer use in education · Path model

Today, in an effort to improve student learning and better prepare them for the future workforce, almost every school has Internet access and about one computer per every four students (Bausell 2008; National Center for Education Statistics [NCES] 2004). Unfortunately, increased availability of technology in the schools does not necessarily lead to improvement in classroom teaching practices (Lim and Chai 2008; Lowther et al. 2008; Ross et al. 2004; Rutherford 2004; Smeets 2005). Likewise, there is insufficient empirical support to claim that access to technology has either increased test scores or improved the quality of instruction to enhance student learning. These findings are evident when examining student achievement at the national level, as only 34% of 8th grade students performed at or above Proficiency in reading and mathematics (NCES 2008), as well as at

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the state and local levels (Lowther et al. 2008; Cox and Marshall 2007; Cuban 2001; Muir-Herzig 2004; Robertson 2002).

Research suggests that these disappointing outcomes are frequently associated with teachers lacking the necessary skills to integrate technology into the classroom (Baylor and Ritchie 2002; Ertmer and Hruskocy 1999; Eteokleous 2008; Russell et al. 2003; Van Braak 2001). A study conducted in 2000 by the National Center for Education Statistics revealed that only 23% of 1,674 surveyed teachers felt well prepared to integrate technology in their instruction. Yet, a 2009 report on U.S. trends reveals that only 20% of states require technology training or testing for recertification or participation in technology-related professional development (Hightower 2009). Recent studies indicate that contextual factors also play crucial roles in technology integration decisions and practices (Davis et al. 2009; Hernandez-Ramos 2005; O'Dwyer et al. 2004; Lim and Chai 2008; Zhao and Frank 2003), as discussed below.

Multiple previous studies have concluded that achieving technology integration into classroom instruction is a slow and complex process that is influenced by many factors (Ertmer et al. 2001; Levin and Wadmany 2008; Valcke et al. 2007). For example, research has traced a long list of factors originating from the teacher or school setting that significantly affected technology integration, such as teachers' beliefs and attitudes (Chen 2008; Jimoyiannisa and Komisb 2007; Lim and Chai 2008; Lumpe and Chambers 2001; Van Braak et al. 2004; Vannatta and Fordham 2004; Wozney et al. 2006), demographic characteristics of teachers (Bebell et al. 2004; Van Braak 2001), availability and access to computers and resources (Hohlfeld et al. 2008; NCES 2000; Norris et al. 2003), and school support structure (Davis et al. 2009; Ringstaff and Kelly 2002; Van Melle et al. 2003).

Technology integration in the classrooms

Although the use of technology in schools varies, it can be grouped primarily into three broad categories; technology for instructional preparation, technology for instructional delivery, and technology as a learning tool. Teacher's professional use of technology involves preparation for various classroom activities; such as, preparing instructional material, communicating or collaborating with peers, students and their parents, locating digital resources, and creating lesson plans (Bebell et al. 2004). When technology is used for instructional delivery, the teacher or students can use it. Teachers can present instruction by means of a projector or students may use computer-assisted learning applications such as drill and practice, tutorials, and simulations (Barron et al. 2006; Bitter and Legacy 2008; O'Dwyer et al. 2004). The third category, technology as a tool, involves student use of basic software applications to extend their abilities to solve problems, create products, or communicate and share their perspectives with each other (Jonassen et al. 2008; Morrison and Lowther 2010). Example applications include word processing, presentations, databases, spreadsheets, Web 2.0 tools, and concept mapping (Brown and Adler 2008; Niederhauser and Stoddart 2001). In this study, technology integration, sometimes cited as technology use, is considered to be comprised of any of these three types of computer uses as long as it is used for or supports classroom instruction (Smaldino et al. 2008).

As mentioned, technology integration research has identified several critical variables thought to be important in regard to achieving effective technology integration, such as teacher characteristics, access to technology, support, and so on. However, these variables have been examined in isolation from other variables, or from the school setting in which technology integration occurred (O'Dwyer et al. 2004; Zhao and Frank 2003). In order to

provide a framework and a holistic view of the technology integration process, it is critical to explore factors in an interrelated or hierarchically organized fashion, such as that provided by the path analysis approach (Tomarken and Waller 2005; Tondeur et al. 2008; Wolfle 2003; Zhao and Frank 2003).

Path analysis approach

Path analysis is an advanced statistical technique for examination of dependent and independent variables to reveal the relative effects of each variable on the other variables in the model (Allen 1997; Schumacker and Lomax 2004). Path analysis starts with a theory bound approach revealed with the construction of an explicitly formulated structural model (path diagram) that provides a pictorial representation of relationships among variables (Schreiber et al. 2006; Stage et al. 2004). In path models, arrows indicate the hypothesized paths and the direction of influences (Keith 1988b) between two types of variables: endogenous and exogenous (Kline 2005). Exogenous variables have no arrows toward them from other variables in the model and the value of the exogenous variable is not explained by the other variables. In contrast, an endogenous variable has several arrows coming toward it and its value is explained by one or more of the other variables (Klem 1995; Schumacker and Lomax 2004). Moreover, endogenous variables can be both dependent and independent variables (Klem 1995).

Calculation of path estimates provides the degree and direction of effects that is postulated to exist among a set of variables (Keith 1988a; Schumacker and Lomax 2004). The procedures yield three types of effects: direct, indirect, and total. A direct effect indicates the relationship between two variables with no mediating (intervening) variables. The direct causal effects are represented by standardized regression coefficients (beta). On the other hand, an indirect effect indicates the effect of an independent variable on a dependent variable through one or more mediating variables (Foster et al. 2005). The indirect effects are calculated by the sums of the products of direct effects through intervening variables in the model (Wolfle and Ethington 1985; Klem 1995). Total effect is simply the summation of the direct and indirect effects.

Previous path models examining technology integration

Considering the complexity of factors that affect technology integration in K-12 schools, the path analytic method provides a useful statistical approach to determine relationship among possible predictors of technology integration (Schreiber et al. 2006; Weston and Gore 2006; Zhao and Frank 2003). Unfortunately, only three studies have attempted to examine factors for technology integration by utilizing path analysis (Mathews and Guarino 2000; Robinson 2003; Van Braak et al. 2004).

Mathews and Guarino (2000) created a path model in an attempt to explain computer use as a function of the teacher's background and demographic characteristics. Teacher factors included academic degree, gender, computer proficiency, number of computers in the classroom, school level, and years of experience. Using data collected from approximately 3,000 teachers from Southeastern Idaho, they found that gender, years of experience, number of computers, and computer proficiency had a direct effect on computer usage; while years of experience had a direct effect on computer proficiency. Mathews and Guarino (2000) also indicated that years of teaching experience had an indirect effect on teachers' computer use. In other words, the more experienced teachers tended to use computers less frequently.

The model provided by Mathews and Guarino (2000) has several limitations. Although it attempted to include variables from both the school setting and teacher characteristics, the majority of the variables were teacher-level factors. Most critically, the proposed Mathews and Guarino's model lacked sufficient theoretical or research support to explain and define the relationships among the variables, which is considered as one of the fundamental components of a path analytic approach (Schumacker and Lomax 2004). Furthermore, an additional limitation of this model was that there was no measure of significance of the indirect effect.

Van Braak et al. (2004) created a path model explaining the different types of computer use through examining teacher demographic characteristics, computer experience, and attitudes. Upon testing the model on the data gathered from 486 primary school teachers, they found that some teacher-level factors such as attitudes toward computers in education and computer training had the strongest direct effect on computer use in the classroom. They also found that teacher age and prior computer experience had indirect effects on classroom computer use.

The Van Braak et al. (2004) model was the first attempt to explain how factors affected different types of technology use: in class and out of class. However, the variables in the path model, which explained only 21% of computer use in the classroom, were limited in illustrating the effect of factors on technology use. The authors attribute this limitation to the inclusion of only teacher-level factors in the model. Therefore, in order to more fully explain the technology integration, they suggest expansion of future models to include school-level variables (Van Braak et al. 2004).

Robinson (2003) used path analysis to determine the relationships between teacher demographic characteristics, computer proficiency, external support variables, teachers' perceptions toward using computers and self-report usage of computers in five Michigan charter schools. The teacher-level variables collected from 116 teachers included gender, age, teachers' education level, years of teaching, subjects taught, computer experience, and previous technology training. The school-level variables included teachers having the necessary software on their computer at school and having adequate technical and administrative support. The study revealed that teachers' use of computers for enhancement activities and teachers' computer proficiency were significant factors within the path model. Robinson's model indicated that computer proficiency mediates the indirect effect on computer use of teacher demographic characteristics and external support variables such as administrative support and the availability of software.

Unlike the previous models, the path model created by Robinson (2003) incorporated contextual variables to explain how teachers' personal and contextual variables affect technology integration. Another strength was that the model originated from the Technology Acceptance Model (Davis 1989), a widely accepted conceptual framework that explains how users perceive and use a new technology (Ma et al. 2005). However, the study was limited in sampling with regard to testing only 116 teachers, all from private charter schools. Thus, the generalizability of the study to other school settings may be questioned (Klem 1995). Similar to the two previous models, Robinson also did not provide any measure of the significance of indirect effects.

Hypothesized path model

In order to examine direct and indirect effects of teacher characteristics and school-level factors on teachers' technology integration, a research-based path model was developed in

the present study. This path model, an extended version of Robinson (2003), explains hypothesized causal relationships between factors that previous research reported to be important in technology integration. The major variables and associated descriptions used in the path model are presented in Table 1.

As shown in Fig. 1, the model consists of four blocks of variables. The first block is exogenous variables and includes teacher demographic characteristics and school characteristics related to supporting technology integration. The second block has only teachers' computer proficiency, and the third block has two teacher-level factors: teachers' beliefs and

Table 1 Description of variables

| Variables	Description
Age	Self-reported age of participants
Years of teaching	Self-reported number of years as a teacher
Computer proficiency	Teachers' perception of their own computer ability level
Computer availability	The number of computers available in the classroom for student use
Teachers' beliefs	Teachers' perception of technology's influence on student learning and achievement and impact on classroom instruction and learning activities
Teachers' readiness	Teacher perception of their capabilities and skills required to integrate technology into their classroom instruction
Overall support	Teachers' perception of support from administration, peers, parents, and community for technology integration in the school
Technical support	Teachers' perception on adequacy of technical support, availability of resources, and assistance with computer software and troubleshooting
Technology integration	Teachers' self-rating of frequency of technology integration in their instruction
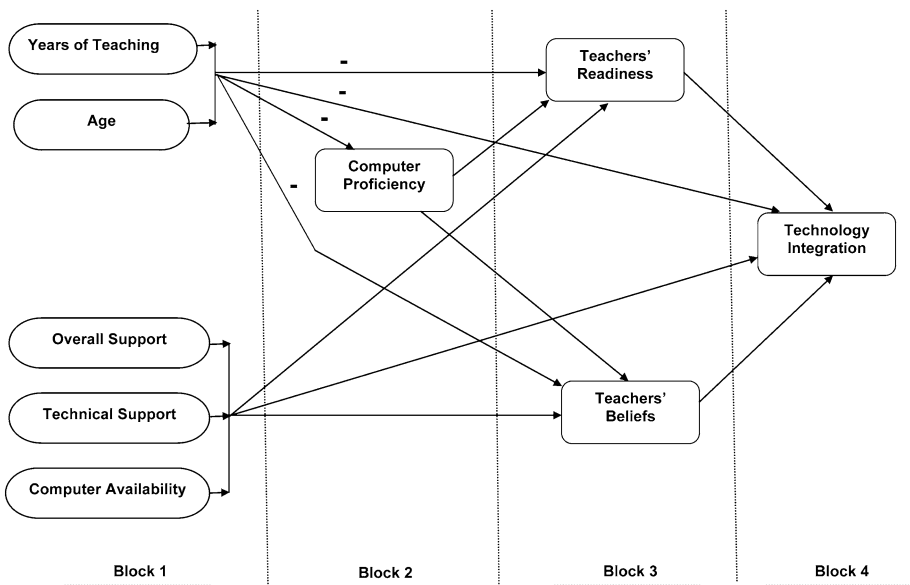
Fig. 1 Hypothesized path model

teachers' readiness to integrate technology. Technology integration forms the final block. Of the exogenous variables, only the teachers' demographic characteristics were hypothesized to influence the first endogenous variable—the teachers' computer proficiency (Drent 2006; Mathews and Guarino 2000; Robinson 2003). The effects associated with teachers' age and years of teaching experience on all of the endogenous variables were hypothesized to be negative (Mathews and Guarino 2000; Van Braak et al. 2004; Bebell et al. 2004). As seen in Fig. 1, teachers' age, years of teaching experience, computer proficiency, and school characteristics (overall support, technical support, and computer availability) were hypothesized to influence teachers' beliefs and teachers' readiness to integrate technology (Bebell et al. 2004; Ertmer 2005; Ross et al. 1999; Shiue 2007). According to the model, technology integration was hypothesized to be directly influenced by all variables used in the model (Baylor and Ritchie 2002; Becker and Ravitz 2001; Hernandez-Ramos 2005; Mumtaz 2005; Nachmias et al. 2004; O'Dwyer et al. 2004; Wozney et al. 2006). Teachers' demographic characteristics, computer proficiency, and school characteristics were also hypothesized to influence technology integration indirectly (Hew and Brush 2007; Robinson 2003; Van Braak et al. 2004; Zhao et al. 2006). These influences were mediated by the teachers' computer proficiency, beliefs, and readiness to integrate technology (Drent 2006; Hew and Brush 2007; Shiue 2007; Van Braak 2001).

Purpose of the study

The purpose of this study was to examine the effects of teachers' individual characteristics and environmental factors on teachers' technology integration. Furthermore, this study was designed to explain relationships between these factors by developing a path model grounded on previous research and tested with data gathered through teacher surveys. Considering the path model as a research framework, we examined the following research questions:

(1) Do teachers' demographic characteristics influence their technology integration?
(2) Do teachers' beliefs, readiness, and computer proficiency influence their technology integration?
(3) Do school characteristics influence teachers' technology integration?
(4) Do teachers' computer proficiency, beliefs, and readiness mediate the indirect effects of teachers' characteristics and school-level factors on teachers' technology integration?

Method

Data collection instrument

The Teacher Technology Questionnaire (TTQ), a two-part instrument, was used to collect teachers' perceptions of computers and technology integration (Lowther and Ross 2000). In the first section, teachers rate their level of agreement with 20 statements regarding five main technology-related areas: (1) teachers' perception of technology's influence on student learning and achievement and impact on classroom instruction and learning activities (Teachers' Beliefs), (2) teachers' feeling and perception of their capabilities and skills required for technology integration (Teacher Readiness), (3) teachers' perception of administrative, peer and community support for their technology integration in their

classroom instruction (Overall Support), (4) teachers' perception on adequacy of technical support, availability of resources, and assistance with computer software and trouble-shooting (Technical Support) and (5) teachers' perception on the frequency of technology integration in their instruction (Technology Integration). Items are rated with a five-point Likert-type scale that ranges from (1) Strongly Disagree to (5) Strongly Agree. The second section of the TTQ collects the respondent demographic information and qualifications (e.g., teachers' age and years of teaching experience). Furthermore, teachers rate their level of computer ability as very good, good, moderate, poor, or no ability and report whether or not they have a home computer and how many computers are available for student use in their classrooms.

The TTQ has been validated (Lowther and Ross 2000; Sterbinsky and Burke 2004) and is commonly used in research and evaluation studies (Lowther et al. 2008; Corbeil and Valdes-Corbeil 2007; Grant et al. 2005). The reliability of the TTQ was tested on 4,863 teacher participants, who had completed the instrument previously as a part of research projects for Center for Research in Educational Policy. Reliability coefficients were determined to be high for each subscale of the instrument, ranging from .75 to .89.

Participants

The data were collected from teachers employed at 54 schools participating in the first year of Tennessee EdTech Launch One (ETL1) and Two (ETL2), which were funded through Title II Part D (EdTech) of the No Child Left Behind act. The survey data from all ETL1 and ETL2 program and control schools was collected in spring semester in 2004 and 2005, respectively. The sample size for the analyses was 1,382, representing all teachers who had complete data on all of the variables used in the analyses. The largest proportion of the participants had been teaching more than 15 years (40.7%). Almost every teacher had a home computer (93.7%) and most teachers rated their computer ability as "moderate" (38.5%) or "good" (41.8%) (Table 2).

	N	%
Age		
29 and younger	226	16.4
30–39 yeas	350	25.3
40–49 years	358	25.9
50–59 years	400	28.9
60 and older	48	3.5
Years of teaching		
5 or less	344	24.9
6–10 years	242	17.5
11–15 years	234	16.9
16 or more	562	40.7
Computer proficiency		
No ability	5	0.4
Poor	114	8.2
Moderate	496	35.9
Good	521	37.7
Very good	246	17.8

Table 2 Participants by demographic characteristics (N = 1,382)

Data analysis

The analysis of this study was carried out in three phases: assumption checking, interaction analysis, and path model estimates. As a type of ordinary least-squares procedure, the model estimation should meet the assumptions of multiple regression. Therefore, prior to estimating the path coefficients, an explanatory analysis was completed on each one of the endogenous variables. The analyses indicated that there were no multicollinearity problems in the data. All regression equations were also tested on linearity of the independent-dependent variable relationship, normality, and homoscedasticity and found to satisfy those assumptions. Additionally, examination of the possibility of outliers of influential data points indicated that there were no participants who individually influenced the regression results. Subsequent to the exploratory analyses, in order to decide whether it was necessary to calculate the path model separately, the interaction between teachers from program and control schools was analyzed. Subsequent to the interaction analysis, the path model was estimated for a combined sample based upon the result of the interaction test. The path model was estimated by using GEMINI software, developed by Wolfle and Ethington (1985).

Results

Computer proficiency, teachers' beliefs, teachers' readiness, and technology integration are endogenous variables of the model (see Table 1 and Fig. 1). Except for technology integration, all the endogenous variables serve as both dependent and independent variables. For each exogenous variable, the magnitude, direction, and significance of direct and indirect effects were calculated. The standardized regression coefficient (Beta) and coefficient of determination (R^2) for equations of endogenous variables are given in Table 3. Below, impact on each endogenous variable will be discussed in detail.

The eight variables hypothesized to impact technology integration in the model explained 56.4% of the variance of teachers' technology integration. According to a conceptual model, all variables are hypothesized to have a direct effect on technology

Table 3 Direct effects in factors influencing technology integration model

Independent variables	Endogenous (dependent) variables			
	Computer proficiency	Teacher beliefs	Teacher readiness	Technology integration
1. Computer Availability	.093*	.097*	.052*	.126*
2. Technical support	.119*	.160*	.207*	−.060
3. Overall support	.101*	.485*	.361*	.040
4. Years of teaching	−.119*	−.019	−.064*	−.011
5. Age	−.247*	−.045	.014	.056
6. Computer proficiency	–	.185*	.452*	.025
7. Teachers' readiness	–	–	–	.493*
8. Teachers' beliefs	–	–	–	.289*
R^2	.175	.500	.624	.564

* $p < .01$

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integration. However, only teachers' readiness, teachers' beliefs, and computer availability indicated a significant positive direct effect on technology integration after controlling for the other variables in the model. This finding suggests that the higher the value of these variables, the higher the teachers' technology integration. The teachers' readiness (Beta = .493) had the strongest effect among the variables having a significant direct effect. The direct effects of teachers' beliefs (Beta = .289) and computer availability (Beta = .126) can also be considered as strong and medium, respectively.

Teachers' demographic characteristics, computer proficiency, and school characteristics explained 62.4% of variance in teachers' readiness. Except for age, all hypothesized paths toward readiness were found to be significant. Computer proficiency had the strongest effect on teachers' readiness to integrate technology (Beta = .452), followed by overall support (Beta = .361), technical support (Beta = .207), years of teaching (Beta = −.064), and computer availability (Beta = .052). As hypothesized, the direction of effect from years of teaching to readiness was negative; i.e., when teachers' years of experience increase, their feelings of readiness to integrate technology decreases. Teachers' age, however, was found to have no significant direct effect on teachers' readiness.

Variables in the model explained 50% of the variance in teacher beliefs. Teachers' computer proficiency (Beta = .185) and all of the school-level variables (overall support, Beta = .485; technical support, Beta = .160; and computer availability, Beta = .097) had positive significant influences on teachers' beliefs. Across the significant factors, overall support had the strongest effect on teachers' beliefs. Contrary to the conceptualized path model, none of the teachers' demographic characteristics had a significant direct effect on teachers' beliefs.

Variables in the model explained a limited amount of variance (17.5%) in teachers' computer proficiency. As hypothesized, both teacher demographic characteristics, age (Beta = −.247) and years of teaching (Beta = −.119), had significant negative influences on computer proficiency. This finding suggests that computer proficiency decreases with age and years of teaching experience. It was hypothesized in the model that teachers' perceptions of school characteristics would have no impact on their computer proficiency. However, in contrast, it was found that all of the school-level variables—overall support, technical support, and computer availability—positively impacted teachers' computer proficiency.

In regard to indirect effects, as hypothesized in the conceptual model, all variables except teachers' beliefs and readiness had a significant indirect effect on technology integration (see Table 4). Overall support had the strongest indirect effect, followed by computer proficiency, technical support, and computer availability. As predicted, indirect effects of age and years of teaching on technology integration demonstrated a negative impact.

Table 4 Direct, indirect, and total effects on technology integration

Variables	Direct	Indirect	Total	Importance
1. Computer availability	.126*	.082*	.208*	5
2. Technical support	−.060	.184*	.124*	6
3. Overall support	.040	.349*	.389*	2
4. Years of teaching	−.011	−.073*	−.084*	7
5. Age	.056	−.081*	−.024	8
6. Computer proficiency	.025	.277*	.302*	3
7. Teachers' readiness	.493*	–	.493*	1
8. Teachers' beliefs	.289*	–	.289*	4

* $p < .01$; 1 = highest importance; 8 = lowest importance
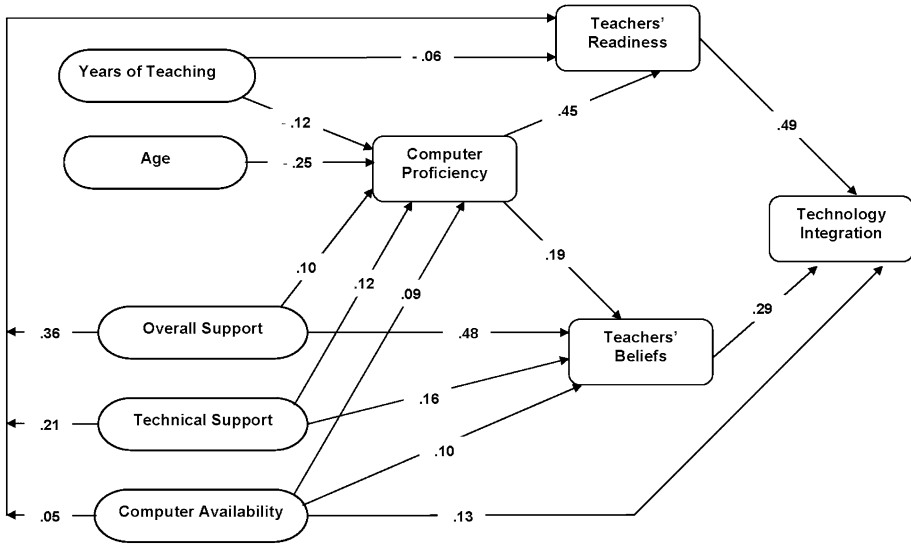
Fig. 2 Estimated path model

Teachers' readiness had the highest total effect on technology integration, which is a result of its significant direct influence on technology integration. Furthermore, teachers' readiness is a very important factor in the model because it carries most of the indirect effects on technology integration. Overall support and computer proficiency had the second and third strongest effects on technology integration, which is mainly the result of their strong indirect effects. Teachers' beliefs, computer availability, technical support, and years of teaching were also found to be significant total effects on technology integration.

Synopsis of findings

A summary of key findings and a revised path model are presented below (see Fig. 2):

- Teachers' demographic characteristics (years of teaching and age) negatively affect their computer proficiency.
- Teachers' demographic characteristics (years of teaching and age) negatively and teachers' computer proficiency positively affect their technology integration.
- Teachers' beliefs and readiness positively influence their technology integration.
- School-level factors (availability of computers, technical support, and overall support) positively influence teachers' beliefs and teachers' readiness.
- Teachers' beliefs and readiness mediated the indirect effects of school- and teacher-level factors on teachers' technology integration.

Discussion

The current study used a path analytic approach to examine the direct and indirect effects of teachers' demographic characteristics and perceptions of school setting on technology

integration in K-12 classrooms. Overall, the framework provided by the model is partially supported by the findings. The model clearly illustrates that teacher technology integration is a complex process that is influenced by both teacher characteristics and their perception of school environments. Below, discussions of direct and indirect effects of each variable are presented.

Direct and indirect effects of factors on technology integration

The total effects that originated from teacher demographic factors were somehow limited. Of the two variables that represented teacher demographic characteristics, only the years of teaching, but not age, had a significant total impact on technology integration. Although the direct effects of these variables were not significant, their indirect effects were. These effects are mediated by other endogenous variables: teachers' computer proficiency, beliefs, and readiness. Previous research (Robinson 2003) provides similar findings, and indicates that age directly affects teachers' computer proficiency and indirectly effects teachers' technology use. Furthermore, Van Braak et al. (2004) indicated that age can indirectly affect teacher computer use which is mediated by teacher attitudes toward computers. In regard to years of teaching experience, this study partially supported Mathews and Guarino (2000) path model, which indicated that the years of teaching can influence technology use both directly and indirectly. As expected, the direction of the path was negative; indicating that veteran teachers' readiness and technology integration were lower in comparison to novices. This pattern is an indication that new graduates have more knowledge on technology integration and feel better prepared compared to more experienced peers. This finding is not surprising because teachers who recently graduated from a teacher preparation program would be more technology competent (Jones and Madden 2002; O'Dwyer et al. 2004) and more prepared to integrate technology into classroom instruction (Mims et al. 2006). Studies agreeably suggested that veteran teachers may have less computer proficiency and confidence to integrate technology; thus limiting opportunities for changing their daily teaching practices or trying new technologies in their classrooms (Robinson 2003; Snoeyink and Ertmer 2002).

The current study indicated that computer availability directly and indirectly increases teacher technology use. As most previous studies found, there is a strong relationship between the frequency of computer use and the number of computers available in the classroom (Becker and Ravitz 2001; Norris et al. 2003). Fortunately, access to technological resources and equipment has consistently increased. Today, almost every school has Internet access and about one computer per every four students (Bausell 2008). However, studies continuously indicate that computer access is necessary but not sufficient for establishing technology integration in the classrooms (Ross and Lowther 2003; Smeets 2005). It is not surprising to see limited technology integration even when computers and necessary software are available in the classroom (Lowther et al. 2008; Cuban et al. 2001).

Variables from the school environment had a strong influence on all endogenous variables: teachers' computer proficiency, belief, and readiness. Overall support took the second highest importance within the variables affecting technology integration. The literature supports this finding in that technology integration is influenced by the support that comes from peers, administration, and the community (Hernandez-Ramos 2005; Lumpe and Chambers 2001; Mumtaz 2005). The other school-level variable, technical support was also important in explaining technology integration. Despite the lack of direct influence on technology integration, technical support has considerably high influence on all mediating variables, so its effect was indirect in nature. As previous studies have indicated, teachers

usually need assistance while integrating technology, should problems arise when installing and using software or handling technical issues (Sandholtz and Reilly 2004). With sufficient technical support, teachers feel more competent and ready to integrate technology (Hernandez-Ramos 2005; Sandholtz and Reilly 2004).

Teachers' computer proficiency is found to be one of the most important factors affecting their technology integration. An interesting aspect of this finding was that almost all of its impact on technology integration resulted from indirect effects. Teachers' computer proficiency positively influenced teacher readiness and beliefs, which in turn influenced technology integration. Two previous path models (Mathews and Guarino 2000; Robinson 2003), in contrast, found that the effect of computer proficiency was significant and direct. However, neither of these models accounted for potential mediating variables such as teacher belief or readiness. This study confirms that the effect of computer proficiency is strong, but it is indirect in nature.

Consistent with the hypothesized model, teacher demographics had a negative impact on teacher computer proficiency; when teachers' age and years of experience increase, their computer proficiency decrease. In contrast to the hypothesized model, all school setting variables had a significant influence on teacher computer proficiency. It is likely that those schools with higher overall and technical support provide better professional development and training opportunities for teachers to increase their computer proficiency (Baylor and Ritchie 2002).

The current study supported the hypothesis that teacher belief is one of the essential factors that explains technology use. The finding is in alignment with the abundance of previous research that suggests that the personal beliefs and dispositions of teachers may relate to technology integration in the classroom (Ertmer 2005; Jimoyiannisa and Komisb 2007; O'Dwyer et al. 2004; Vannatta and Fordham 2004). In regard to factors affecting teachers' belief, school level factors (overall support, technical support and computer availability) have been found to substantially influence teachers' belief as teachers receive support and positive expectations from the community and administration (Mumtaz 2005; Windschitl and Sahl 2002). An early study by Becker and Ravitz (1999) indicated that the climate under which teachers' practice may alter teacher beliefs as well as their classroom practices. Furthermore, Lumpe and Chambers (2001) provided a comprehensive list of contextual factors such as resources, administrative support, parental support, technical support, and professional development that impacted teachers' beliefs.

Teachers' computer proficiency was another variable found to influence teachers' beliefs. Teachers like to feel comfortable with technology before utilizing the technology (Snoeyink and Ertmer 2002). The teacher demographic characteristics, which impact teacher computer proficiency and readiness, were not found to influence the teachers' beliefs. This finding suggests that there might be other teacher-level variables that influence teacher beliefs such as subject area of teaching and previous technology training (Hew and Brush 2007; Lih-Juan et al. 2006).

Of all factors examined in the model, the one having the most important influence on technology integration was the teachers' readiness to integrate technology, after controlling for other model variables. These findings were consistent with previous studies indicating that teachers who feel ready and confident to integrate technology used technology more frequently in their classroom instruction (Kanaya et al. 2005; NCES 2000; Scheffler and Logan 1999). With regard to factors that contribute to the teachers' readiness, computer proficiency took priority. Basically, if teacher computer proficiency increases, the teachers' feeling to be more ready to integrate technology into instruction also increases (Hernandez-Ramos 2005). Most importantly, teachers' computer and software knowledge helps them

figure out the affordance of the technology and how particular software might be beneficial to student learning (Angeli and Valanides 2009; Newhouse and Rennie 2001; Snoeyink and Ertmer 2002).

Another teacher-level factor, years of teaching experience, demonstrates a direct and indirect negative influence on teachers' feeling of readiness. On the other hand, age indirectly affects teachers' feeling of readiness. As previously mentioned, this finding suggests that over the past few years, teacher education programs have increased the emphasis on better preparing teachers to integrate technology into their instruction. Previous studies also indicated that teachers feel more ready to integrate technology in settings that readily provide administrative support, peer collaboration, and technical support (Davis et al. 2009; Sandholtz et al. 1997). Sandholtz and Reilly (2004) emphasize the importance of availability of technical support in the school setting; indicating that when technical support is available to handle hardware and software troubleshooting, teachers are able to use technology more quickly and are more productive in their classrooms.

Limitations and implications

Path analysis, having distinct capabilities that are not available with other statistical procedures, is a useful technique for analyzing relationships among a set of variables. However, the path analytic approach cannot overcome limitations imposed by poorly developed models, highly correlated variables, and limited sample size (Petraitis 1996; Tomarken and Waller 2005). In this study, those limitations of path analysis are addressed by building a path model based on previous path models and research, conducting preliminary analyses to check assumptions, and having a large sample size (Allen 1997; Keith 1988b; Raykov and Marcoulides 2000; Wolfle 1985, 2003). The most critical limitation related to the path analysis is that it does not offer a test of causality; so it neither proves the causality nor confirms the direction of causality (Schneider et al. 2007). Therefore, the interpretation of findings should be considered cautiously, and the reported impact among variables should be considered as suggestive.

One of the feasible approaches for future studies is to extend this study with additional variables (Tomarken and Waller 2005). The addition of more school and demographic (or personal level) factors such school culture, teachers' workload, pedagogical beliefs, previous training, and experiences into the model can increase understanding of some of the variables for which the current path model provided a limited explanation (Hew and Brush 2007; Lih-Juan et al. 2006; Inan et al. 2009; Niederhauser and Stoddart 2001). Furthermore, some of the variables included in the model should be examined more closely. For example, future studies should consider sub-components of overall support, which can be separated into parts including administrative support, community support, and peer support (Clark 2006; Dawson and Rakes 2003; Mumtaz 2005; Nachmias et al. 2004).

Educational research is moving toward studying technology integration in the schools with more mixed-methods research that combines the strengths of qualitative and quantitative approaches (Creswell and Plano Clark 2007; Teddlie and Tashakkori 2009. Therefore, future studies should also include qualitative data such as classroom observations as well as data collected from principals, parents, and students. Such data would provide diverse perspectives and useful insights into understanding the complexity of technology integration in K-12 schools (Baylor and Ritchie 2002; Judson 2006).

Although there is still much to learn about teacher technology integration in schools (O'Dwyer et al. 2004), the current study's findings shed light on factors that affect

technology integration. To see the payoff of technology investments in the schools, the previously mentioned factors should be carefully considered and addressed in education policies and initiatives (Baylor and Ritchie 2002; Hernandez-Ramos 2005; Muir-Herzig 2004; Mumtaz 2005). In their efforts, schools should go beyond placing more computers into the classroom by building supportive structures with collaborative learning communities (Mouza 2003; Van Melle et al. 2003; Valcke et al. 2007). Professional development for teachers should help teachers acquire technology competencies and skills. Most importantly, professional development should show how technology can enhance student learning and how it can be used in a variety of core content areas (Dexter et al. 2006; Holland 2001; Newhouse 2001). Strategies that are considered to effectively change teacher beliefs such as personal and vicarious experiences should also be a major component of technology integration efforts (Albion 2001; Ertmer 2005; O'Dwyer et al. 2004).

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