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Laptops in the K-12 classrooms: Exploring factors impacting instructional use

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ABSTRACT

The purpose of this study was to examine factors affecting teachers' integration of laptops into classroom instruction. A research-based path model was tested based on data gathered from 379 K-12 school teachers to examine direct and indirect contributions of relevant institutional factors (overall support for school technology, technical support, and professional development) and teacher level factors (teacher readiness and teacher beliefs). The major premise of this study was that the hypothesized path model was powerful enough to explain a substantial amount of variance in teacher readiness (43%), beliefs (51%), and laptop integration (55%). The results suggest that teacher level factors (teacher readiness and teacher beliefs) strongly predict laptop integration, and that overall support for school technology and professional development have strong effects on teacher beliefs and readiness, respectively. All school-level factors also had a significant indirect impact on laptop integration, which is mediated by teacher readiness and beliefs.

1. Introduction

There has been a strong drive for one-to-one initiatives that provide one computer per student and teacher (Hayes & Greaves, 2008; Penuel, 2006; The Abell Foundation, 2008; Zucker, 2004). As a global trend, several laptop initiatives have been started in many countries such as Australia (Newhouse & Rennie, 2001), Canada (Sclater, Sicoly, Abrami, & Wade, 2006), France (Jaillet, 2004), and New Zealand (Cowie et al., 2008). In the last decade, many schools in the United States have attempted to provide one-to-one access to laptop computers, which enable all students and teachers to have anytime-anywhere computer access (Dawson, Cavanaugh, & Ritzhaupt, 2008; Grimes & Warschauer, 2008; Lei & Zhao, 2008; Rutledge, Duran, & Carroll-Miranda, 2007). In addition to comprehensive state-wide initiatives (e.g., Maine, Michigan), some schools are running different programs so teachers and students can have access to their own laptop at a reasonable price and also provide students with opportunities to check out computers if they cannot afford to buy one (e.g., Roanoke County Public Schools, 2003). A report from the National Center for Education Statistics (NCES) indicated that 10% of the public schools lent laptop computers to students in 2005 and another 3% of the schools plan to have laptop computers available to loan students (Wells & Lewis, 2006).

These increasing efforts for one-to-one projects have been mainly focused on three major goals: prepare students for the future workforce, improve students' skill and achievement, and increase the quality of instruction (Lei & Zhao, 2008; Lowther, Ross, & Morrison, 2003; Penuel, 2006; Zucker, 2004). Although research in this area is fairly new, there are limited but promising results indicating that students' achievement scores increased when the laptops are effectively integrated into instruction (Gulek & Demirtas, 2005; Lowther et al., 2003; Zucker & Hug, 2008). The most consistent finding is that students' and teachers' technology skills substantially improved with increased access to technology (Dawson et al., 2008; Lei & Zhao, 2008; Murphy, King, & Brown, 2007). Another commonly cited impact of laptop initiatives is the change in the classroom structure and activities. Several studies reported that one-to-one access increased computer use in the classroom, resulting in the higher student engagement in the instructional activities (Dawson et al., 2008; Dunleavy, Dexter, & Heinecke, 2007; Grant, Ross, Wang, & Potter, 2005; Grimes & Warschauer, 2008; Russell, Bebell, & Higgins, 2004).

2. Factors affecting laptop integration

Laptops computers are used in K-12 classrooms for various purposes, such as management, instructional preparation and delivery, and as a learning tool (Dunleavy et al., 2007; Falba, Grove, Anderson, & Putney, 2001; Jaillet, 2004; Lei & Zhao, 2008). In this study, laptop

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integration, sometimes cited as technology integration, is considered to be comprised of any type of laptop use that supports classroom instruction (Inan & Lowther, 2010; Smaldino, Lowther, & Russell, 2008). Regarding the factors affecting laptop integration, previous research offers extensive lists of school- and teacher-level factors including professional development, availability of resources and technical support, teacher readiness to integrate technology, and/or teacher beliefs and attitudes (Lowther, Inan, Strahl, & Ross, 2008; Murphy et al., 2007; Penuel, 2006).

Overall support for school technology coming from key stakeholders, including teachers, staff, administrators, students, parents, and the community, has often been considered to be a critical component of a successful laptop integration effort (Inan & Lowther, 2010; ISTE, 2007; Murphy et al., 2007; Nachmias, Mioduser, Cohen, Tubin, & Forkosh-Baruch, 2004; Rutledge et al., 2007). O'Dwyer, Russell, and Bebel (2004) indicated that administrative encouragement to use technology was one of the strongest predictors of teachers' computer use. Another study revealed that principal understanding and support was an essential component in classroom use of technology (Dawson & Rakes, 2003). Similarly, Cooley (2001) identified peer support as one of many important factors that affect teacher use of computers in the classroom.

Availability and quality of *technical support* have also been considered as very important factors in laptop integration efforts (Grimes & Warschauer, 2008; Penuel, 2006). Dexter, Anderson, and Ronnkvist (2002) found that the availability and quality of technical support significantly predicted the frequency of teacher computer use in classroom activities. The fast and constantly changing nature of computer technology makes it difficult for teachers to keep up with the pace set by emerging software and technologies. Furthermore, the tendency for laptop computers to be unreliable and prone to technical problems often causes teachers to resist using them unless on-site support is available (Sandholtz & Reilly, 2004; Zucker & Hug, 2008).

Insufficient *professional development* of teachers has been an escalating concern for all technology integration initiatives and projects (Lawless & Pellegrino, 2007). Presently, K-12 schools have invested heavily to acquire computer-based technologies. However, potential educational benefits of these investments cannot take place unless teachers are prepared to use these computers effectively in their instruction (Dawson et al., 2008; Rutledge et al., 2007). For example, Sivin-Kachala and Bialo (2000) examined over 300 studies of computer use and found that teacher training was the most significant factor influencing the effective use of classroom computers. Silvernail and Lane (2004) reported that teachers' laptop use is higher for teachers who have participated in more professional development activities.

Teacher readiness to integrate laptops into instruction is one of the key components of successful laptop initiatives (Inan & Lowther, 2010; Kanaya, Light, & Culp, 2005; Penuel, 2006). In order to achieve effective use of laptops, teachers should be prepared to have knowledge, skill, and confidence to effectively design and implement lessons that support student learning and achievement of standards-based objectives (Dawson et al., 2008; Donovan, Hartley, & Strudler, 2007). Teachers who reported feeling well prepared to use technology were more likely to use laptop computers in their teaching practices as compared to teachers who felt unprepared (Inan & Lowther, 2010; Murphy et al., 2007; NCES, 2000).

Research commonly suggests *teacher beliefs* to be one of the critical factors of successful laptop integration (Lei & Zhao, 2008; Penuel, 2006; Windschitl & Sahl, 2002; Wozney, Venkatesh, & Abrami, 2006). Similarly, many researchers indicated that teacher beliefs appeared to influence the amount of computer use in the classroom (Ertmer, 2005; Sclater et al., 2006; Van Braak, Tondeur, & Valcke, 2004; Windschitl & Sahl, 2002). For example, Wozney et al. (2006) found that the perceived value of technology use was the most important factor in understanding computer use among teachers. Similarly, Inan and Lowther (2010) found that teachers' perception of technology's influence on student learning and classroom activities was a critical factor impacting technology integration.

3. Conceptual framework

3.1. Path analysis approach

Path analysis is an advanced statistical technique for analyzing relationships among a set of variables to reveal the relative effects of each variable on the other variables (Allen, 1997; Schumacker & Lomax, 2004). Path analysis starts with postulation of the relationships that exist among a set of variables based on theory, research, and logic (Keith, 1988b; Klem, 1995; Raykov & Marcoulides, 2000). Along with a path analysis, a path model is usually developed to provide a pictorial representation of hypothesized relationships among the variables (Schreiber, Nora, Stage, Barlow, & King, 2006; Stage, Carter, & Nora, 2004). In path models, there are two types of variables: endogenous and exogenous (Klem, 1995). An endogenous variable has several arrows coming toward it (Klem, 1995; Schumacker & Lomax, 2004). Sometimes, an endogenous variable can be both a dependent and independent variable, which is represented as the variable having both incoming and outgoing arrows in the path model (Klem, 1995). Exogenous variables have no arrow links toward them from other variables in the model (Klem, 1995; Schumacker & Lomax, 2004).

Calculation of path coefficients, represented by standardized regression coefficients, provides the degree and direction of effects that are postulated to exist among a set of variables (Keith, 1988a; Schumacker & Lomax, 2004). The calculation procedures yield three types of effects: direct, indirect, and total. A direct effect indicates the effect of one variable on another after controlling for the other variables in the model. The direct effect of a variable indicates whether that particular variable uniquely impacts the dependent variable after taking account of the overlap with the variance that is shared between the other variables and the dependent variable. On the other hand, indirect effect represents the effect of one variable on another variable through mediating variables (Foster, Barkus, & Yavorsky, 2005). Indirect effect is estimated by summing the direct effect coefficients of all possible routes of that variable through mediating variables (Klem, 1995; Wolfle & Ethington, 1985). The sum of the direct and indirect effects produces the total effect.

3.2. Hypothesized path model

In order to explore factors affecting teacher laptop use in the classroom, the technology integration model developed by Inan and Lowther (2010) is adapted (Fig. 1). The proposed model explains relationships between factors (overall support for school technology, technical support, professional development, teacher readiness, and teacher beliefs) that previous research reported to be important in

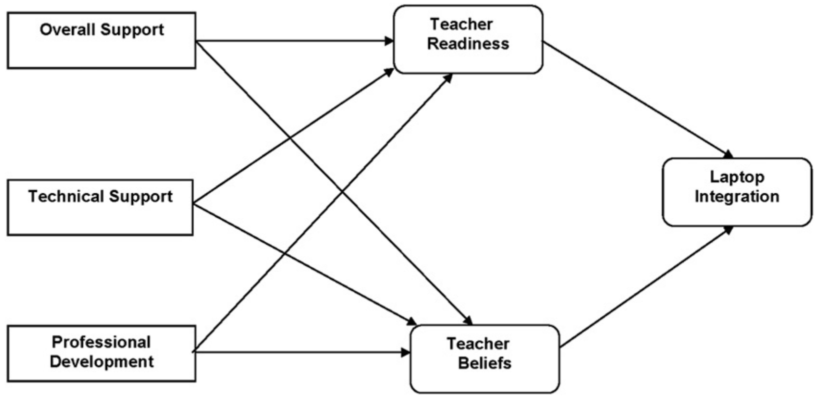

Fig. 1. Hypothesized path model.

teacher laptop integration into classroom instruction. The major variables and associated descriptions used in the path model are presented in Table 1.

The path diagram directing this study consists of three blocks of variables. The first block is exogenous variables and includes school-level factors: overall support for school technology, technical support, and professional development. The second block has two teacher level factors: teacher readiness and teacher beliefs. Laptop integration forms the final block. According to the model, laptop integration was hypothesized to be directly influenced by teacher beliefs and teacher readiness (Inan & Lowther, 2010; Shiue, 2007; Van Braak et al., 2004). As seen in Fig. 1, overall support for school technology, technical support, and professional development were hypothesized to influence teacher readiness and teacher beliefs (Hermans, Tondeur, Van Braak, & Valcke, 2008; Inan & Lowther, 2010; Ross, Hogaboam-Gray, & Hannay, 1999; Shiue, 2007; Van Braak et al., 2004; Zhao, Lei, & Frank, 2006). Three exogenous variables (overall support for school technology, technical support, and professional development) were also hypothesized to influence laptop integration indirectly (Inan & Lowther, 2010; Robinson, 2003; Teo & Wei, 2001; Tondeur, Valcke, & Van Braak, 2008). These influences were mediated by the teacher readiness and teacher beliefs (Inan & Lowther, 2010).

3.3. Purpose of the study

Considering the path model as a research framework, the study mainly examined the following research questions:

(1) Do teacher readiness and beliefs directly influence teachers' laptop integration?
(2) Do school level factors (overall support for school technology, technical support, and professional development) indirectly influence teachers' laptop integration?
(3) Do teacher readiness and beliefs mediate the indirect effects of school-level factors on teachers' laptop integration?

4. Method

4.1. Participants

A total of 195 Michigan schools received 2005–2006 Freedom to Learn (FTL) grants. The schools represented both private and public districts from across the entire state. In addition, the participant schools included those from rural Michigan as well as all major metropolitan areas. Although the participating schools included elementary, middle and high schools, initial implementation primarily occurred at the 6th grade level. Specifically, teachers from 76 FTL schools completed the online survey. The sample size for the analyses was 379, representing all teachers who had complete data on all of the variables used in the analyses.

4.2. Data collection instrument

The FTL-TTQ is an adaptation of the 20-item five-part validated Teacher Technology Questionnaire (TTQ) (Lowther & Ross, 2000). The adaptation from TTQ to FTL-TTQ involved addition of four new items related to professional development and replacing the terms

Table 1
Description of variables used in the path model.

Variables	Description
Overall support for school technology	Teachers' perception of support from administration, peers, students, parents, and community for laptops integration
Technical support	Teachers' perception on adequacy of technical support, availability of resources, and assistance with laptops
Professional development	Teachers' perception on adequacy and amount of professional development and training opportunities provided in the school regarding laptop integration into classroom instruction
Teacher readiness	Teachers' perception of their capabilities and skills required to integrate laptops into classroom instruction
Teacher beliefs	Teachers' perception of laptops' influence on student learning and achievement and impact on classroom instruction and learning activities
Laptop integration	Teachers' self-rating of frequency of laptop integration in their instruction

"computers" or "technology" with "FTL laptop computers." The TTQ (Lowther & Ross, 2000; Sterbinsky & Burke, 2004) and FTL-TTQ (Lowther, Strahl, Inan, & Bates, 2007; Lowther, Strahl, Inan, & Ross, 2009) have been validated and are commonly used in research and evaluation studies (Grant et al., 2005; Lowther et al., 2008). The reliability of the TTQ was determined to be high for each subscale of the instrument, ranging from .75 to .89 (Inan & Lowther, 2010). Similarly, for this study, the reliability coefficients of FTL-TTQ subscales were high ranging from .73 to .92.

Using a five-point Likert-type scale that ranges from (1) strongly disagree to (5) strongly agree, teachers rated their level of agreement with statements regarding six main technology integration-related areas: teacher beliefs, teacher readiness, overall support for school technology, technical support, professional development, and laptop integration. The *overall support for school technology* scale attempted to assess teachers' perception of administrative, peer and community support for laptop integration in their schools with four items such as "Parents/Caregivers and community members support our school's FTL program" and "Teachers receive adequate administrative support to integrate laptops into their instruction." Teachers' perception on the adequacy of *technical support*, availability of resources, and assistance with software and troubleshooting in their schools was measured by four items such as, "Most of our FTL laptops are kept in good working condition" and "I can readily obtain answers to technology-related questions." The *Professional development* scale encompasses four items to measure teachers' perception on amount and adequacy of training opportunities regarding laptop use in their schools, such as "I have frequently participated in professional development." The *teacher readiness* scale includes four items such as "I know how to meaningfully integrate laptops into lessons" to measure the teachers' feeling and perception of their capabilities and skills required for laptop integration. *Teacher beliefs* scale measure teachers' perception of laptops' influence on student learning and achievement and impact on classroom instruction and learning activities. The scale includes six items such as "The use of the laptops has improved the quality of student work" and "The use of computers has increased the level of student interaction and/or collaboration." The item, "I routinely integrate the use of laptops into my instruction" was used to assess *laptop integration*, or teachers' perception on the frequency of laptop use in their classroom instruction.

4.3. Data analysis

Path analysis, a type of ordinary least-squares procedure, was used to analyze the study data within the parameters of the model shown in Fig. 1. The path analysis was carried out in two phases: assumption checking and path model estimates. Prior to estimating the path coefficients, descriptive statistics of the mean and standard deviation were calculated for each variable in the model. After that, an explanatory analysis was completed on each one of the endogenous variables to check the assumptions of multiple regressions. Tests on linearity, normality, and homoscedasticity were found to satisfy the assumptions for each equation. Similarly, the analyses indicated that there were no multicollinearity problems in the data. Additionally, there were no outliers or influential data points, which significantly influenced the regression results. Subsequent to assumption checking, the path model was estimated by using GEMINI (Wolfle & Ethington, 1985) and Mplus 5 statistical programs (Muthén & Muthén, 2008).

To assess the model fit, the following indices were considered: chi-square test of model fit, comparative fit index (CFI), Tucker Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR). A non significant chi square value indicates a good fit (Weston & Gore, 2006). A TLI value that approaches 1 is considered a good fit (Dion, 2008). For other indicators, the accepted value is above .95 for CFI and is below .05 for RMSEA (Dion, 2008; McDonald, 2002). All indices showed a good fitness of the laptop integration model considering the correlation between teacher beliefs and readiness (Dion, 2008; McDonald, 2002; Weston & Gore, 2006). Fit indices for this model were as follows: *chi-square* = 3.90, df = 3, $p = .27$; TLI = .99; CFI = .99; RMSEA = .03.

5. Results

Teacher beliefs, teacher readiness, and laptop integration are endogenous variables and overall support for school technology, technical support, and professional development are the exogenous variables of the model (see Table 1 and Fig. 1). Except for laptop integration, the two other 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 presented in Table 2. The impact on each endogenous variable will be discussed in detail below.

The five variables hypothesized to impact laptop integration in the model explained 55% of the variance of teachers' laptop integration. Consistent with the conceptual model, only teacher readiness and teacher beliefs indicated a significant positive direct effect on laptop integration. The direct effects of teacher beliefs (Beta = .44) and teacher readiness (Beta = .40) can be considered as strong. All hypothesized paths toward teacher readiness were found to be significant. Three exogenous variables explained 43% of variance in teacher readiness. Professional development had the strongest effect on teacher readiness to integrate laptops (Beta = .32), followed by overall support for

Table 2
Direct effects in factors influencing teacher laptop integration model.

Variables	Endogenous (dependent) variables		
	Teacher beliefs	Teacher readiness	Laptop integration
1. Overall support for school technology	.49*	.26*	-.10^{NS}
2. Technical support	.14*	.20*	.06^{NS}
3. Professional development	.19*	.32*	.02^{NS}
4. Teacher readiness	–	–	.40*
5. Teacher beliefs	–	–	.44*
R^2	.51	.43	.55

*$p < .001$, NS = Non-significant.

Table 3
Direct, indirect, and total effects on laptop integration.

Variables	Direct	Indirect	Total
1. Overall support for school technology	−10	.32*	.21*
2. Technical support	.06	.14*	.20*
3 Professional development	.02	.21*	.22*
4. Teacher readiness	.40*	–	.40*
5. Teacher beliefs	.44*	–	.44*

*$p < .001$.

school technology (Beta = .26). Variables in the model explained 51% of the variance in teacher beliefs. Across the significant factors, overall school technology support had the strongest effect on teacher beliefs (Beta = .49).

In regard to indirect effects, as hypothesized in the conceptual model, all three hypothesized variables had a significant indirect effect on laptop integration (see Table 3). Overall support for school technology had the strongest indirect effect, followed by professional development and technical support. Teacher beliefs had the highest total effect on laptop integration, which is a result of its significant direct influence on laptop integration. Similarly, the factor of teacher beliefs is very important in the model because it also carries most of the indirect effects on laptop integration. All hypothesized variables were also found to be having significant total effects on laptop integration.

5.1. Synopsis of findings

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

- Teacher beliefs and readiness directly influence teachers' laptop integration
- School-level factors (overall support for school technology, technical support, and professional development) indirectly influence teachers' laptop integration.
- School-level factors (overall support for school technology, technical support, and professional development) positively influence teacher beliefs and teacher readiness.
- Teacher beliefs and readiness mediated the indirect effects of school-level factors on teachers' laptop integration.

6. Discussion

This study used a path analytic approach to examine the direct and indirect effects of teacher beliefs, teacher readiness, professional development, overall support for school technology, and technical support on laptop integration in K-12 classrooms. Overall, the framework provided by the model is supported by the findings. The major premise of this study was that the hypothesized model paths were powerful enough to explain a substantial amount of variance in teacher readiness, beliefs, and laptop integration. Within all variables, teacher readiness and teacher beliefs were the most important factors with the highest direct effect. Furthermore, professional development and overall support for school technology proved to be influential factors that impacted laptop integration through indirect effects. All of the school-level variables in the model had an indirect impact on laptop integration, which is mediated by teacher beliefs, and readiness.

Of all factors examined in the model, the most important influence on laptop integration was the unique impact of teacher beliefs over and above the other independent variables. The finding is supported by previous research, which suggests that teacher beliefs impact computer use in the classroom (Hermans et al., 2008; Lowther et al., 2009; Sclater et al., 2006; Vannatta & Fordham, 2004; Windschitl & Sahl, 2002). In regard to factors affecting teacher beliefs, all school level factors (overall support for school technology, technical support, and professional development) have been found to substantially influence teacher beliefs. Similarly, previous research supports the findings that the overall support for technology in the school and professional development significantly influence teacher beliefs (Inan & Lowther, 2010; Lumpe & Chambers, 2001; Murphy et al., 2007).

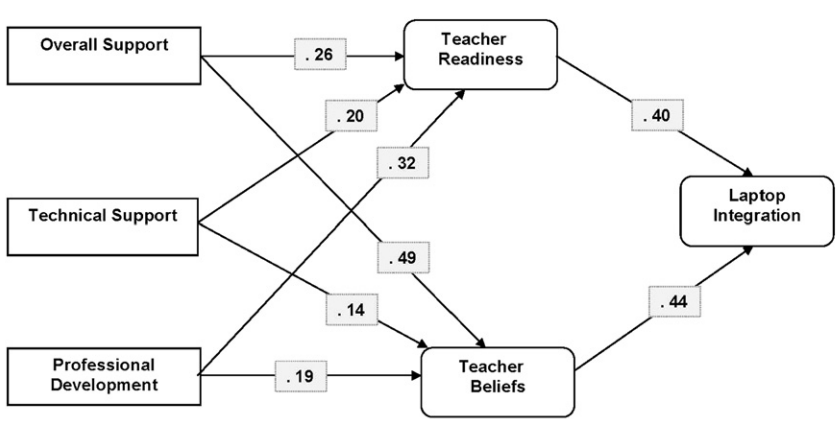

Fig. 2. Estimated path model.

Like teacher beliefs, the current study indicated that teacher readiness is another critical factor that explains teachers' laptop integration. The findings were consistent with previous studies indicating that teachers who feel ready to integrate technology, used computers more frequently in the classroom (Inan & Lowther, 2010; Kanaya et al., 2005; NCES, 2000). When examining factors contributing to teacher readiness, all school level factors were influential, but professional development took priority. Basically, if teachers receive professional development, their readiness to integrate laptops into instruction also increases (Donovan et al., 2007; Hernandez-Ramos, 2005; Ross et al., 1999). Previous studies also indicated that teachers feel more ready to integrate laptops in school settings with administrative support, peer collaboration, and technical support (Davis, Preston, & Sahin, 2009; Murphy et al., 2007; Sandholtz & Reilly, 2004).

7. Implications for practice

Ongoing professional development opportunities should be an integral part of the laptop programs and initiatives (Dawson et al., 2008; Grimes & Warschauer, 2008; Rutledge et al., 2007). Professional development opportunities should concentrate on both teacher beliefs and competencies (Inan, Lowther, Ross, & Strahl, 2010; Zucker & Hug, 2008). Schools can provide teachers with several opportunities to gain technical skill and experience with laptops, such as providing time for them to personally develop instructional materials. However, in order for teachers to develop effective integration lessons, it is critical that professional development focus on the pedagogical aspects of laptop integration to better ensure that use of laptops results in increased student learning (Dawson et al., 2008; Lowther et al., 2008; Murphy et al., 2007).

Improving teacher beliefs regarding the benefits of laptop integration should also be a major goal of professional development activities. For example, by observing an exemplary teacher using laptops, a teacher can increase his/her beliefs while gaining evidence that laptop use can make lessons more interesting (Ertmer, 2005; Mumtaz, 2005). Teacher beliefs may also be influenced by reviewing student products that are generated during a laptop-integrated lesson (Lowther et al., 2005; Snoeyink & Ertmer, 2002). Another suggestion to augment interactions and reflective conversations among teachers with similar experiences would be to build collaborative groups based on teachers' confidence and beliefs, or on teaching content areas (Ertmer, 2005; Windschitl & Sahl, 2002).

In order to achieve successful laptop programs, it is important for schools to create a technology supportive school environment (Clark, 2006; Hew & Brush, 2007; Inan & Lowther, 2010; Lumpe & Chambers, 2001; Nachmias et al., 2004). Important components of supportive school environments are high levels of school administrator interest, attention, and encouragement (Baylor & Ritchie, 2002; Peck & Sprenger, 2008). For example, Lawson and Comber (1999) indicated that technology integration is accomplished when senior management is committed to the idea of integration, aware of the problems experienced by the staff and willing to provide teachers with professional development and resources. Suggestions for addressing teachers' needs for technical support include building an organizational unit that conducts routine hardware checks and provides time for onsite technical support when problems occur (Bielefeldt, 2006; Dunleavy et al., 2007; Peck & Sprenger, 2008; Zucker & Hug, 2008). Sandholtz and Reilly (2004) reported that technology support systems reduced the need for teachers' technical skills and allowed them to move more quickly to integrate technology, rather than "being bogged down at the initial stage of trying to learn about the technology itself" (p. 506).

8. Conclusion

This research utilized path analysis to examine direct and indirect effects of the teachers' individual characteristics and institutional factors on teachers' laptop use. The estimated model provides a framework and picture of the laptop integration process in classrooms and explains relationships between factors affecting laptop integration. The model can provide practitioners and stakeholders guidance on how to resourcefully invest money for laptop integration by identifying and prioritizing critical factors (Inan & Lowther, 2010). Furthermore, the model can help to determine how to best utilize personal and technical resources to achieve gains in student learning and provide direction for future teacher training and support structures for schools (Dunleavy et al., 2007).

This study did not intend to evaluate the effectiveness or quality but, rather the amount of, laptop integration. However, the way and how well teachers integrate laptops affect students' learning (Lei & Zhao, 2008; Lowther et al., 2003). In order to provide deeper understanding about the integration of laptops, future studies should include qualitative data such as classroom observations, as well as data collected from principals, parents, and students on their perceptions and experiences. Combining qualitative and quantitative data would provide useful insights into understanding laptop integration in K-12 schools (Judson, 2006; Painter, 2001). Future studies may extend this study with additional variables such as school culture, teacher pedagogical beliefs, previous training, workload, and experiences (Hew & Brush, 2007; Lih-Juan, Jon-Chao, Jeou-Shyan, Shih-Hui, & Hui-Chuan, 2006).

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