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RESEARCH ARTICLE

The impact of multilevel factors on technology integration: the case of Taiwanese grade 1–9 teachers and schools

Shihkuan Hsu · Ping-Yin Kuan

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Abstract Technology integration is influenced by many factors related to the teacher and the school environment. While many studies have examined factors that influence teachers' use of Information and Communication Technology (ICT) at the teacher level, a growing number of studies have suggested that it is beneficial to examine those factors using multilevel modeling. Multilevel analysis can separate the impact of teachers from the school environment and provide insight into the influence of those factors at each level. This study uses multilevel modeling to analyze data from 3,652 grade 1–9 teachers in 289 schools in Taiwan. The results of this multilevel analysis found both teacher-level and school-level factors contributing to the integration of ICT in the teaching process. Among teacher level factors, teachers' beliefs and hours of training in the previous year predicted ICT integration proficiency well. Among school level factors, training hours and teachers' perceived school support are the most important factors that impact ICT integration. School support is not only a significant factor at the school level but also a strong predictor at the teacher level. In addition, important school level variables included access to Internet connectivity, availability of projectors, and stability of computers. These results highlight the importance of individual teachers and the role schools play in ICT integration.

Keywords Educational technology · ICT integration · Large scale survey · Multilevel analysis · Elementary and secondary education

S. Hsu (✉)
Center for Teacher Education, National Taiwan University, No. 1 Roosevelt Road, Sec. 4, Taipei 106, Taiwan, ROC
e-mail: skhsu@ntu.edu.tw

P.-Y. Kuan
Department of Sociology, National Chengchi University, No. 64 Zhinan Road, Sec. 2, Taipei 116, Taiwan, ROC
e-mail: soci1005@nccu.edu.tw

Introduction

Progress in teachers' technology integration

Technology has become part of the school environment and teachers use it every day. Nowadays, computers, printers, scanners, digital cameras and the Internet are considered parts of basic school infrastructure. Software for word processing, calculations, multimedia and communication are accessible to most teachers. Instructional materials and tools created for school children are becoming increasingly available to students and teachers alike. More than ever before, teachers are expected to integrate Information and Communication Technology (ICT) equipment and resources into their lessons (Becker 2001; ISTE 2008). ICT is often referred to as information technology (IT) and instructional technology, and the term generally represents technology and computers. Despite numerous studies of teachers' ICT integration (Becker 2001; Hsu 2010; Russell et al. 2003), questions concerning its effects and conditions persist.

In order to understand ICT integration in school, researchers have explored the factors that influence usage by teachers (Cuban et al. 2001; Mueller et al. 2008; Zhao and Frank 2003). The school factors investigated by researchers include access to technology (Pelgrum 2001), school policy (Baek et al. 2008; Hew and Brush 2007) and school support (Phelps and Graham 2008), while individual factors include teachers' backgrounds (Shiue 2007), training (Galanouli et al. 2004; Lawless and Pellegrino 2007), beliefs (Hermans et al. 2008) and peer support (Burns 2002; Davidson 2005).

Multilevel analyses of influencing factors

In the past, factors influencing teacher ICT usage were examined mainly by using linear models at the individual level. Multiple linear regression models, such as stepwise regression and path analysis, have been used to examine the impact of these variables on teachers' use of ICT (Baylor and Ritchie 2002; Inan and Lowther 2010; Shiue 2007). Some researchers, however, have begun to use multilevel analysis to explore the influence of the group or organizational level variables on ICT integration (O'Dwyer et al. 2004; Tondeur et al. 2008). Since teachers at the same school have similar resources and share the same policy constraints, ICT support and usage directions, there is a school-level environment that impacts teachers' ICT integration efforts (O'Dwyer et al. 2004; Tondeur et al. 2008). Furthermore, factors related to school vary across districts and regions. Therefore, in order to understand the impact at different levels on teachers' ICT integration, it is useful to examine the influencing factors using a multilevel method of analysis.

Several researchers have explored the impact of factors influencing teachers' technology integration at different levels. For example, O'Dwyer et al. (2004) conducted a study of 3,600 teachers and analyzed the factors influencing ICT integration with Hierarchical Linear Model (HLM), a form of multilevel analysis. In their two-level HLM, one level was the school, and the other was the teacher. They found that about 84–94 % of total variance of teachers' ICT integration came from the teachers' level and about 6–16 % came from the school level. The variance from the school level was statistically significant for all four types of teachers' use of technology for teaching. As the results showed, several school-level factors, such as ICT integration training, pressure to use technology, availability of technology and restrictiveness of technology policy, were found to contribute significantly to one or more aspects of individual teachers' ICT integration.

In a similar study, Tondeur et al. (2008) used a two-level model to analyze factors influencing teacher ICT integration at school and teacher levels. They surveyed 527 teachers from 68 primary schools in Flanders, Belgium, using an instrument measuring three types of teachers' ICT integration practices: basic computer skills, the use of computers as information tools and as learning tools. Using multilevel modeling techniques, the study separated the influencing factors into two levels, teacher and school, to investigate how they contributed to the three types of ICT integration. Results of Tondeur, Valcke and van Braak were similar to O'Dwyer et al. (2004). They found that teachers' variables accounted for about 90 % of the variance and school level variables for the remaining 10 %. These results indicate that the variance among teachers is the main source of the differences in the use of ICT tools in schools, but school-level factors have a small but significant contribution. In their study, some of the factors at the school level were collected from school coordinators, such as availability of computers, but most of the school-level factors were also collected from teachers, such as teachers' perceptions of schools' ICT policy, availability of computers in the classroom with Internet connection and ICT training. Several school level factors included in the final model had significant effects on teacher use of ICT in teaching.

Studying aggregated factors at two levels

Using a multilevel model, it is possible to separate the impact of school-level factors from teacher-level factors. There are at least two ways to obtain the data for school level factors. The first choice, used in most previous studies, is to collect school level factors separately from teacher level factors. For instance, school size is a school level factor which can be collected from school administration data. In this case, the school level estimation is totally unrelated to the teacher level estimation. At times, school-level questions are separated from the questions asked at the teacher level, even though the issues are similar. For example, in the study by Tondeur et al. (2008), one of the teacher level factors addresses teachers' openness, and is termed "teachers' willingness to change." One of the school level factors is about teachers' perceptions of school openness, which is termed "teachers' perception of school innovativeness or openness to change." Although these are two separate items, they seem to measure a similar phenomenon, openness to change. In this case, the teacher level factors contain different items than the school level factors and items at each level are interpreted only at its own level.

The second choice is to measure the factors at the individual level and use their aggregated results at the school level. This method is particularly useful when some factors have an impact at both teacher and school level. For example, if a teacher were asked "How often do you feel your ICT integration effort was encouraged by school administrators?" the answer reflects the combined effects of individual factors such as personality and group effects such as school support. According to researchers in educational statistics and measurement, it is possible to calculate the impact of a factor such as this at two levels in a multilevel model using a technique called centering (Raudenbush and Bryk 2002, pp. 134–142; see also Kreft and deLeeuw 1998).

The centering technique helps consider the impact of teacher attitudes towards school support on the outcome variable, teachers' ICT integration, at both individual and school levels. Assuming the teacher level is Level 1 and the school level is Level 2, at Level 1 individual teachers' scores are calculated using group-mean centered values so that each teacher's score is centered around school mean values. At Level 2, the aggregated school mean values are calculated to estimate the impact of the same variable at the school level

on the outcome variable (Kreft and deLeeuw 1998; Raudenbush and Bryk 2002). In short, with a group-mean centered independent variable at Level 1 and with the group mean aggregated from the same independent variable as a predictor at Level 2, it is possible to decompose the relationship between the independent variable and the outcome variable into its within- and between-school components (Raudenbush and Bryk 2002, p. 141). With the group mean centering, the variable at Level 1 effectively removes the group mean from the individual scores and the group mean variable at Level 2 becomes orthogonal to Level-1 values. The centering technique, although using only one item, provides an opportunity to separate the effects of one factor at two levels and can be a more efficient way of using test items. Therefore, the second choice was employed in the current study for measuring school support and training effects on ICT integration at both individual and group levels.

Research questions

The purpose of this study is to explore the factors that influence teacher ICT integration. Specifically, this study addresses the following research questions:

1. Do schools have a significant impact on teachers' ICT integration?

To answer this question, two-level HLM was used to examine the impact of school and teacher level factors on teachers' ICT integration. The multilevel analysis allows us to see, in addition to teacher level, if school level analysis is required to account for variance of teachers' ICT integration. If it is not, then a linear regression model that considers only teacher level factors would be sufficient.

2. What are the teacher level and school level factors that have significant impact on teachers' ICT integration?

If a multilevel analysis is justified, then the impacts of teacher level variables, such as teachers' backgrounds and attitudes, and factors related to the school level, including school structures and cultural variables, on teachers' ICT integration would be examined.

Variables included in the study

This study uses a multilevel model to explore the impact of different factors on teacher ICT integration at teacher and school levels. The main dependent variable is a teacher ICT integration proficiency scale (Hsu 2010) and independent variables are divided into teacher and school level factors. Most of the variables were collected using a survey of teacher ICT integration. Only two of the school structure variables, school type and school size, are taken from a Ministry of Education report (Ministry of Education 2006).

These independent variables were chosen because of their potential impact on teacher ICT integration, based on previous studies. Although many of them share similarities and are grouped into different categories, such as teachers' attitudes and school culture, they have not yet become established and verified scales and, therefore, they work as single-item independent variables. In this study, the impact of these variables on teachers' ICT integration is explored at different levels.

Dependent variables: teacher ICT integration proficiency

Several instruments have been developed to measure teacher ICT integration. However, there is no standardized system for measuring educational usage of technology (Russell et al. 2003). Some focus on different aspects of teachers' technology usage but others have concentrated on types of students' usage. Recent research has shown that teachers' usage and students' usage of ICT are different and should be measured separately (Hsu 2011; Russell et al. 2003). Given new perspectives on ICT integration, an instrument that measures teacher usage of ICT and includes more emerging issues of professional development and ethics seems more suitable for measuring teacher ICT integration proficiency (Hsu 2010).

The scale for teacher ICT integration levels used in this study was developed by interpreting and localizing the National Educational Technology Standards for Teachers (NETS-T) (ISTE 2000). A panel of local elementary and junior high school teachers in Taiwan was recruited as the design team for the questionnaire. These teachers developed a cross-reference table by matching ISTE standards with local teaching experience, including lesson preparation, teaching processes, monitoring of students and class evaluation. In the end, 40 items were used to evaluate teachers' ICT integration proficiency (see Hsu 2010 for a detailed description of the questionnaire). Respondents had to rank their use of each item during the past semester with one of four choices: "very often," "sometimes," "once in a while," and "never," with scores coded as 4, 3, 2 and 1, respectively. The results of factor analysis suggested six subscales for teachers' ICT integration:

(1) Preparation, including the use of word processor and Internet search tools (example: Used a computer to create lecture notes, class material and exam questions);
(2) Production, including creating multimedia material (example: Used the computer to record, edit sound or music in my course material);
(3) Communication, including using email and web to share and communicate with students and parents (example: Used e-mail or MSN to communicate with students);
(4) Instruction, including planning, teaching and evaluating lessons with ICT (example: Designed different evaluation criteria for students' ICT related activities);
(5) Development, including taking courses or attending workshops to learn about ICT integration (example: Attended conferences or read journals to learn about ICT integration methods); and
(6) Ethics, including teaching and considering ethics, health and safety issues during the course of implementing ICT lessons (example: Taught students the issues of Internet ethics and rules before they used the Internet).

The subscales in the instrument varied between 2 and 18 items. The scale was verified by exploratory factor analysis and confirmatory analysis on a split data set. For the entire sample, reliability coefficients of the six subscales were between .71 and .96, and factor loadings for the items included ranged from .58 to .91 (For a complete list of subscales, items and values, see Table 2 in Hsu 2010). This scale is the outcome to be explained by structural and cultural variables at the school level and the teacher level.

Independent variables of teachers' level (Level 1)

In keeping with recent research, independent variables include school and teacher level variables (O'Dwyer et al. 2004). Following the framework used by Tondeur et al. (2008), school level factors are categorized into structural and cultural variables, and teacher level

factors are categorized into background and attitudinal variables. The four types of independent variables, teacher background variables, teacher attitudinal variables, school structural variables and school cultural variables are discussed in turn.

Teacher background variables

Teacher background variables include gender, years of teaching and level of education. Teachers' gender and years of teaching are factors which potentially influence use of computers. Previous studies have found that males are more positive about the usefulness of computers (Gilliland 1990) and have higher frequency of usage of ICT tools for lesson preparation and grading (Chiero 1997). Years of teaching, on the other hand, often has a negative impact on teachers' use of computers (Chiero 1997; Inan and Lowther 2010). Inan and Lowther also suggest that years of teaching has a negative impact on teachers' ICT integration.

Education levels seem to make a difference in teacher ICT integration. Mathews and Guarino (2000) found that teachers' level of education predicts use of computers for educational purposes. Hsu (2010) also found that teachers with graduate degrees have significantly higher ICT integration proficiency than teachers with only a bachelor's degree.

Teacher attitudinal variables

Teachers' attitudes, beliefs and perceptions are regarded as important factors that influence adoption of technology in teaching. In the past, teachers' fear of educational computing, resistance to changing the existing pedagogy and lack of openness to innovation has been identified as barriers to ICT integration (Becker 2001). More recently, researchers have come to recognize that using ICT is a complicated process with teachers constantly trying to balance the use of technology, disciplinary constraints and students' learning and achievement (Davis et al. 2009; Hennessy et al. 2005). Teachers' morale, commitment and concern for students have become important issues (Baylor and Ritchie 2002; Davis et al. 2009; Ottenbreit-Leftwich et al. 2010). In addition, teachers' professional development has long been regarded as an important factor for ICT integration (Burns 2002; Crystal 2001; Culp et al. 2005). In past studies using multilevel methods, teachers' training has been placed at the school level and shown to have a significant impact on teachers' use of ICT (O'Dwyer et al. 2004; Tondeur et al. 2008). Attending training workshops offered by school, however, has to be a combined effort of teachers and schools. Schools have to offer appropriate training courses at a convenient time (Cuban et al. 2001) and teachers have to be willing to commit the necessary time and effort (Burns 2002; Crystal 2001).

In this study, therefore, three areas of teachers' perceptions and commitments are analyzed. The first set of variables encapsulates teachers' perceived support from the administrators, peers and technical staff or coordinators. The second set of variables emphasizes the importance of teachers' perception of technology's effectiveness in terms of work efficiency, as well as the value of technology in terms of improving students' learning. The third set of variables focuses on teachers' commitment to receiving training in ICT integration, measured by the hours spent on ICT integration related training during the previous year.

Independent variables of school level (Level 2)

School structural variables

ICT equipment and access provided by school is a key factor in teacher ICT integration (Pelgrum 2001). Access to technology is not limited to computers but also includes projectors, Internet connections and other equipment. The location of the equipment is also important for integration of ICT. For example, Tondeur et al. (2008) found that three types of computer access are not of equal value: (1) availability of computers only contributes to the use of ICT in terms of basic skills; (2) computers with an Internet connection contribute to teachers' use of ICT as information tools; and (3) computers in the classroom with Internet connections contribute significantly to teachers' use of ICT as learning tools for students. Along the same lines, Norris et al. (2003) argued that availability of computers in classrooms is essential for use during class hours. Furthermore, school size plays a role in teachers' usage of ICT as well. Small schools usually have more collegiality. However, small schools are often short of staff and teachers might lack time for creating ICT lessons (Hennessy et al. 2005).

School cultural variables

School culture has been cited by many researchers as an influencing factor for ICT integration. School policy establishes exterior constraints, demand and support for teachers to use ICT in classes. Baek et al. (2008), for example, found that one of the most important reasons for teachers' ICT integration was fulfillment of external requirements by school or district administrators.

In addition to explicit policy requirements, there are subtle arrangements that can encourage or discourage teachers' ICT integration. Cuban et al. (2001) found that even in a school where technology is plentiful, training workshops were often scheduled at inconvenient times which prevented or discouraged teachers from attending. The constraints on ICT usage (from school administrators) may not be personal, as they generally represent the bigger and more complicated culture of curricular and instructional systems (Cuban et al. 2001).

On the other hand, administrative encouragement is usually invaluable for teachers' ICT integration. Administrators with a vision or a solid plan have been observed as an important precursor of successful ICT integration (Gulbahar 2007; Lim 2007). In a three-year qualitative study, Phelps and Graham (2008) found schools can develop a supportive culture for teachers' ICT integration by implementing a process consistent with teachers' metacognitive development. This kind of culture of welcoming and encouraging new and creative thinking and practices, including willingness to take up challenges or openness to change, whether at school or at teacher level, has been identified as an important aspect of teachers' ICT integration (Baylor and Ritchie 2002; Tondeur et al. 2008).

Besides school administrators, peer support and technical support are also important factors that affect teachers' learning and professional development for ICT integration. In order for teachers to develop new knowledge and skills for ICT integration, it is necessary to have a community within a school (Burns 2002; Crystal 2001). Teachers need the support of their peers (Crystal 2001), as well as technical assistance (Davidson 2005) in order to solve problems and develop ICT integration proficiency.

Using this framework, factors at both teacher level and school level are analyzed in a multilevel model to investigate their respective contributions to ICT integration. Table 1 summarizes Level 1 and Level 2 independent variables, and reports the scale and subscales for teachers' ICT integration.

Table 1 Description of independent variables

Variable name	Mean	SD	Description and coding
School structural variables (Level 2)			
Availability of projectors	.63	.24	1 = yes, 0 = no
Stability of computers	.77	.18	1 = yes, 0 = no
Internet connectivity	.88	.15	%
School size	.60	.69	2 = big, 1 = medium, 0 = small
School type	.34	.48	0 = elementary school, 1 = secondary school
School cultural variables (Level 2)			
Plan for ICT at school	.47	.22	0 = no, 1 = yes
Training hours (ICT related in the past year) (group mean)	1.99	1.16	0 = 0 h, 1 = 1–4 h, 2 = 5–10 h, 3 = 11–20 h, 4 = greater than 20 h
ICT efforts being encouraged (group mean)	2.55	.65	4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree
ICT as school priority (group mean)	2.85	.63	
Peer support (group mean)	2.50	.64	
Technical support (group mean)	2.52	.67	
Teacher background variables (Level 1)			
Sex	.65	.48	0 = male, 1 = female
Years of teaching (per 5 years)	10.06	6.88	Years of teaching (per 5 years)
Education-Normal college	.03	.16	0 = Bachelor's degree, 1 = Normal college
Education-40 Credit courses	.09	.28	0 = Bachelor's degree, 1 = 40 Credit courses
Education-Master's degree	.22	.41	0 = Bachelor's degree, 1 = Master's degree
Teacher attitudinal variables (Level 1)			
Training hours (ICT related in the past year) (group mean centered)	1.99	1.16	0 = 0 h, 1 = 1–4 h, 2 = 5–10 h, 3 = 11–20 h, 4 = greater than 20 h
ICT efforts being encouraged (group mean centered)	2.55	.65	My effort in integration is appreciated and encouraged by the administrators
ICT as school priority (group mean centered)	2.85	.63	ICT integration is the area that my school wants to promote
Peer support (group mean centered)	2.50	.64	I often discuss technology integration in teacher planning meetings
Technical support (group mean centered)	2.52	.67	I work with computer teachers to create lessons together
Perceived effectiveness of ICT in improving work efficiency[a]	3.11	.52	I believe that ICT integration could help me improve my work efficiency
Perceived effectiveness of ICT in improving students' learning[a]	3.04	.53	I believe that ICT integration could help my students to improve academic achievement

[a] These items are coded as: 4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree

Methods

The survey

In total, a sample comprising 3,729 teachers from 315 elementary and junior high schools in Taiwan was collected. The sampling method used probability proportional to size (PPS) in a multistage cluster sampling design. Elementary schools and junior high schools were

divided into two sample strata. All schools in a stratum were arranged from the largest to the smallest in terms of number of teachers and the total number of teachers was calculated. Both paper and web versions of the questionnaire were available to teachers. Fifteen teachers were asked to participate, at each school. For schools with fewer than 15 teachers, all teachers were asked to participate (see Hsu 2010). For multilevel analysis purposes, schools with less than 5 participants were deleted from the data set. The data included in this study was 3,652 teachers from 289 schools, with 5–15 teachers per school (12.64 teachers in average).

The main body of the questionnaire measures teachers' ICT integration. Most of the questions regarding variables influencing ICT integration were in different parts of the same questionnaire. In addition to attitude and perception related questions, several items addressed computers, equipment and Internet access. These questions were written such that they were comprehensible to teachers. For example, when asking about Internet connectivity at school, the question was not "What percent of your school computers are on the Internet?" Instead, the item was written as "In the classroom where you usually teach, how many computers are there, and how many of them are connected to the Internet?" In other words, instead of asking general questions regarding accessibility, the survey phrased the questions in terms of specific teaching conditions.

Analytical method

This study uses HLM to examine the impact of variables at two levels on teachers' ICT integration. Level 1 includes teacher background and teacher attitudinal variables. Level 2 includes school structural and cultural variables. To determine whether teachers' perceptions of school support have both individual effects and collective school effects on ICT integration, four variables measuring teachers' perceptions of school support were operationalized into variables at both school and teacher level. The four school variables are perceptions of encouragement of ICT efforts by the school, perceptions of ICT as school priority, perception of support from peer teachers and perception of support from technical staff. The group-mean aggregated variables were used at Level 2 to compare the impact of average support perceived by teachers across schools, while the same variables were calculated using group mean centered values, entered at Level 1, to estimate the effects of these variables at individual teacher's level on the outcome variables at the same school (Kreft and deLeeuw 1998; Raudenbush and Bryk 2002). In addition to the four items regarding teachers' perceptions of school support, teachers' training hours in the previous semester was separated into teacher level and school level using the same method.

To evaluate the necessity of using multilevel analysis, a null model having neither Level 1 nor Level 2 independent variables was first established. The null model assesses the extent to which variance of the outcome variable is attributed to either the individual level or the group level before introducing the influencing variables. For the purpose of model comparison, two additional models that went beyond the null model were investigated (see the Appendix) before we decided on the final model.

In the final model, variables for teacher level and school level were included to show the impact of these factors on variability of teacher ICT integration across schools. The final model used in this study was an intercepts-as-outcome model with only intercepts at Level 1 modeled to vary across Level 2 units, i.e., schools. In other words, prediction of the mean of teacher ICT integration at each school was improved upon by the information of school structural and cultural variables. The impact of teachers' variables at Level 1 on teacher ICT integration was treated as constant across schools. The parameters of the multilevel

regression models were estimated using the Full Information Maximum Likelihood (FIML) estimation procedure available in the HLM6.06 software (Raudenbush et al. 2004). The FIML method does not have to adjust for the degrees of freedom for small samples, as in the case of the Restricted Maximum Likelihood method. These two methods produce similar results in the case of large samples, as in this study (Luke 2004; Raudenbush and Bryk 2002). Moreover, FIML estimation offers more information for model comparison, such as Chi-square difference test.

Results

In the null model, of the overall variance of ICT integration, 10.3 % was attributed to variability between schools and 89.7 % to individual teachers (see Table 2). After including the influencing factors in the final model, the variance explained by those factors amounted to 55.5 % of the variance at the school level. At the teacher level, inclusion of the factors explained 26.9 % of the variance. In other words, introducing these factors explained about 26.9 % of 90 % of the total variance.

Teacher background variables

Several of teachers' demographic backgrounds variables had an impact on ICT integration (see Table 3). In general, male teachers seemed to have higher ICT integration than female teachers, based on three of the six subscales and on the average ICT integration score. Years of teaching seemed to correlate negatively with the level of ICT integration while graduate degrees correlated positively.

Teacher attitudinal variables

Almost all attitudinal variables had significant impact on ICT integration. Training hours, defined as teachers' participation in training sessions related to ICT during the previous year, had a strong impact on all subscales.

Among the four teacher perceived school support variables calculated by school-mean centered scores, three were significant and positive. There are moderate bivariate correlations among the four school support variables (Pearson's r ranges from .40 to .61). Teachers' perceptions of administrators' encouragement of ICT integration efforts had the strongest impact. Teachers' perceived support from colleagues and support from technical staff in creating ICT lessons were also important factors. However, whether ICT integration was a policy priority did not have a positive impact on teachers' ICT integration. In fact, it had a negative impact on Subscale 2, production.

The last two variables were about teachers' beliefs: teachers' perceived effectiveness of ICT in improving work efficiency and in students' learning. These two items are also moderately correlated (Pearson $r = .60$). Teachers' perceived effectiveness of ICT in improving work efficiency had a strong impact on almost all subscales and overall ICT integration. The regression coefficients were high on Subscales 1 (preparation), 2 (production) and 3 (instruction). Teachers' perceived effectiveness of ICT in improving students' learning also had a positive impact on ICT integration. The effects were significant for five of six subscales and for the overall score.

Table 2 The percentage of variance of ICT integration explained by the null model and the final model

Model	% of variance explained	(1) Preparation (%)	(2) Production (%)	(3) Communication (%)	(4) Instruction (%)	(5) Development (%)	(6) Ethics (%)	ICT integration (%)
Null	School level	6.1	9.6	10.3	14.5	4.9	8.4	10.3
	Teacher level	93.9	90.4	89.7	85.5	95.1	91.6	89.7
Final	School level	37.7	59.1	33.0	48.5	55.2	47.9	55.5
	Teacher level	9.9	27.8	8.3	24.5	19.1	12.7	26.9

Table 3 The impact of first and second level variables on teacher ICT integration (final model)

	(1) Preparation	(2) Production	(3) Communication	(4) Instruction	(5) Development	(6) Ethics	ICT integration
	β (SD)	β (SD)	β (SD)	β (SD)	β (SD)	β (SD)	β (SD)
Intercept	2.56 (.17)***	.35 (.19)	.64 (.25)*	.10 (.22)	.94 (.18)***	.95 (.23)***	.92 (.15)***
School structural variables (Level 2)							
Internet connectivity	−.06 (.10)	.23 (.10)*	.34 (.14)*	.31 (.12)*	.22 (.10)*	.32 (.13)*	.23 (.08)**
Availability of projectors	.02 (.06)	.24 (.06)***	.06 (.08)	.01 (.07)	.01 (.06)	−.07 (.08)	.05 (.05)
Stability of computers	.16 (.09)	.22 (.10)*	.26 (.13)*	.28 (.11)*	.01 (.09)	.18 (.12)	.19 (.07)*
School size	−.02 (.02)	−.03 (.02)	−.02 (.03)	.04 (.02)	−.03 (.02)	.04 (.02)	.00 (.01)
School type (elementary vs. secondary)	.10 (.03)**	.02 (.03)	−.09 (.04)*	.01 (.04)	.05 (.03)	.01 (.04)	.02 (.02)
School cultural variables (Level 2)							
Plan for ICT at school	−.16 (.07)*	−.06 (.08)	−.16 (.11)	.04 (.09)	−.08 (.07)	.01 (.10)	−.07 (.06)
Training hours (group mean)	.11 (.03)***	.06 (.03)*	.03 (.04)	.07 (.03)*	.17 (.03)***	.11 (.04)**	.09 (.02)***
Perception of ICT efforts being encouraged (group mean)	−.09 (.07)	.21 (.07)**	.29 (.10)**	.19 (.08)*	.07 (.07)	.11 (.09)	.13 (.05)*
Perception of ICT as priority (group mean)	.12 (.06)	−.06 (.07)	−.01 (.09)	.03 (.08)	.09 (.06)	.11 (.08)	.05 (.05)
Peer support (group mean)	−.05 (.07)	.24 (.08)**	.01 (.11)	.07 (.09)	−.03 (.07)	.01 (.10)	.04 (.06)
Technical support (group mean)	−.10 (.07)	−.02 (.08)	.04 (.10)	.17 (.09)	.02 (.07)	.10 (.10)	.04 (.06)
Teacher background variables (Level 1)							
Sex[a]	.10 (.02)***	−.10 (.02)***	−.04 (.02)	−.11 (.02)***	−.04 (.02)	−.12 (.02)***	−.05 (.01)**
Years of teaching (per 5 years)	−.05 (.01)***	−.05 (.01)***	−.04 (.01)***	−.02 (.01)**	−.01 (.01)	−.02 (.01)	−.03 (.01)***
Education-Normal college	−.05 (.06)	.06 (.06)	.03 (.07)	.12 (.06)*	.07 (.06)	−.01 (.07)	.04 (.04)
Education-40 Credit courses	.02 (.03)	.02 (.03)	.04 (.04)	.01 (.04)	.01 (.04)	.00 (.04)	.02 (.03)
Education-Master's degree[c]	.01 (.02)	.11 (.02)***	.07 (.03)*	.08 (.02)**	.07 (.02)**	.01 (.03)	.06 (.02)**
Teacher attitudinal variables (Level 1)							

Table 3 continued

	(1) Preparation	(2) Production	(3) Communication	(4) Instruction	(5) Development	(6) Ethics	ICT integration
	β (SD)	β (SD)	β (SD)	β (SD)	β (SD)	β (SD)	β (SD)
Perception of ICT efforts being encouraged (group centered)	.04 (.02)*	.19 (.02)***	.12 (.02)***	.14 (.02)***	.10 (.02)***	.10 (.02)***	.11 (.01)***
Perception of ICT as priority (group centered)	.02 (.02)	−.06 (.02)**	.00 (.02)	.00 (.02)	.03 (.02)	.04 (.02)	.00 (.01)
Peer support (group centered)	−.04 (.02)	.11 (.02)***	.08 (.03)**	.15 (.02)***	.02 (.02)	.09 (.03)**	.07 (.02)***
Technical support (group centered)	−.05 (.02)**	.08 (.02)***	.10 (.02)***	.10 (.02)***	.03 (.02)	.08 (.02)**	.06 (.01)***
Training hours (group centered)	.06 (.01)***	.12 (.01)***	.05 (.01)***	.12 (.01)***	.14 (.01)***	.11 (.01)***	.10 (.01)***
Perceived effectiveness of ICT in improving work efficiency	.24 (.02)***	.19 (.02)***	.04 (.03)	.09 (.02)***	.22 (.02)***	.13 (.03)***	.15 (.02)***
Perceived effectiveness of ICT in improving students' learning	.06 (.02)**	.10 (.02)***	.07 (.03)*	.06 (.02)**	.08 (.02)**	.05 (.03)	.07 (.02)***
Null model							
Level 2—school $\sigma^2_{\mu 0}$	.020 (.004)***	.042 (.006)***	.057 (.008)***	.065 (.008)***	.021 (.004)***	.049 (.008)***	.025 (.004)***
Level 1—teacher $\sigma^2_{\varepsilon 0}$	.307 (.007)***	.398 (.010)***	.499 (.012)***	.387 (.009)***	.408 (.010)***	.534 (.013)***	.222 (.005)***
Final model							
Level 2—school $\sigma^2_{\mu 0}$	.011 (.003)***	.015 (.003)***	.035 (.006)***	.031 (.005)***	.008 (.003)**	.023 (.005)***	.010 (.002)***
Level 1—teacher $\sigma^2_{\varepsilon 0}$	.276 (.007)***	.287 (.007)***	.456 (.011)***	.291 (.007)***	.329 (.008)***	.464 (.011)***	.162 (.004)***

* $p < .05$; ** $p < .01$; *** $p < .001$

[a] 0 = male, 1 = female, so a negative coefficient in the table indicates male teachers having a higher scale score

[b] Dummy coding is used for the degree of education with bachelor's degree as the comparison group

School structural variables

Among school structural variables, Internet connectivity and computer stability had the greatest impact on teacher ICT integration subscales and the overall ICT integration score. Availability of projectors and screens during instruction was particularly important to teachers in using presentation software and producing multimedia materials (production subscale). In this study, about 95.9 % of teachers indicated that computers in their classrooms were connected to the Internet. In addition, about 61.8 % of the teachers indicated that they had access to projectors and about 76.7 % said computers and equipment were stable during class. This finding suggests that access to the Internet and computer stability are essential and projectors and screens are important for teachers to produce instructional materials or to use ICT during instruction.

School size and school type did not seem to influence teacher ICT integration overall score. In terms of subscales, secondary teachers were more proficient in using word processing and Internet search for lesson preparation compared to elementary school teachers but the latter used Internet or ICT tools for communication with parents and students more often.

School cultural variables

Among the school cultural variables calculated by aggregated school mean values, training hours and teachers' perception of school administrators' encouragement both had a significant impact on teacher ICT integration. In addition, peer support was important in terms of Subscale 2, production.

Whether the school had an overall plan for ICT integration, however, was found to have a negative impact on Subscale 1, preparation. This was probably because most of the schools had official ICT improvement goals, but many did not follow through with these programs. Claiming ICT integration to be a school priority did not seem to impact teacher ICT integration. In addition, in the effort to assist teachers on the development of ICT lessons, at the school level perceived support from peer teachers had significant impact, but the technical support staff variable was not statistically significant.

The importance of school cultural variables in teacher ICT integration across schools can be revealed by calculating the contextual effect, which is defined as the difference between the coefficient of a school cultural variable and coefficient of its corresponding teacher attitudinal variable (Raudenbush and Bryk 2002, pp. 139–141). For instance, from Table 3, the coefficient of perception of ICT efforts being encouraged as a school cultural variable on the subscale of communication is .29 and the coefficient of the corresponding variable at the teacher level is .12. The difference is .17, which is the expected difference between two teachers who perceive the same level of encouragement but teach at different schools that differ by one unit in terms of average perceived encouragement. In such circumstances, teacher A and teacher B may be equally influenced by how their ICT integration effort has been encouraged by school administrators, but the actual difference will be much greater if teacher A is in a school which has a higher school mean in terms of school administrators' encouragement to teachers' ICT effort. Regarding the contextual effects, in addition to the perception of ICT efforts being encouraged, teachers' participation in training workshops during the previous semester and the perception of peer support as school cultural variables also has a fairly strong contextual effect on various subscales and the overall score of teacher ICT integration.

Discussion

Using a large representative dataset collected in Taiwan, the present study found that about 10 % of the variance of teacher ICT integration can be attributed to school level factors while teacher level variables can account for about 90 % of the total variance. These results are in line with O'Dwyer et al. (2004) and Tondeur et al. (2008). Moreover, the present study found that effects of some factors are limited to either school or teacher level while other factors work at both levels.

Access to computer and Internet is important

In school structural variables, school size was not an important factor. Although large schools seem to have contributed negatively to teacher ICT integration, the effect was not significant. Small schools have fewer teachers and thus greater communication and better collegiality which contribute to teacher ICT integration. Having fewer teachers in a school, however, may lead to less flexible schedules in terms of teaching and administrative responsibilities, making it harder for teachers to attend professional training programs (Cuban et al., 2001; Galanouli et al., 2004). Therefore, for small schools, the possible positive and negative effects might cancel each other out and fail to produce a significant effect. On the other hand, large schools with more people and resources may have less frequent interaction among teachers, resulting in absence of significant effects. School types, on the contrary, seem to have a mixed effect. Junior high school teachers scored higher on instructional preparation and Internet search, perhaps because they have to prepare for classes and need to find information on the Internet and to create worksheets and tests. Junior high school teachers, however, do not contact students or parents using ICT as often as teachers in elementary schools. This may be due to the fact that students are older and more mature (Hsu 2011) and require less parental contact.

The type of ICT access available at the school level has a significant impact on teacher ICT integration. Previous studies have indicated that access to technology is not limited to technology itself (Norris et al. 2003; Tondeur et al. 2008); it also includes functionality and usefulness to the teachers during ICT-based instruction. In this study, three types of access are included: connectivity to the Internet, availability of projectors and stability of computers and connectivity during the instruction. The results found that Internet connectivity is essential to teacher's ICT integration. Although only 5–10 % of the teachers across all 25 counties and municipal school districts in Taiwan indicated that they have computers but not Internet connections in their classrooms, those who do not have Internet connection were at a disadvantage in ICT integration.

The other important type of ICT access is the stability of computers and the Internet connection. This variable has a strong impact on several subscales and the overall score. Of course, the computer and network hardware need to be functional for enabling teachers to use it during ICT integration. Many schools do not have the requisite funding to maintain functionality of computers and other ICT equipment, especially during times of financial difficulty (Bichelmeyer and Molenda 2006). For teachers to integrate ICT, it is important for school districts to have continuous funding for ensuring the machines are functional.

Norris et al. (2003) suggested that for ICT to be useful more computers should be available to teachers and students during instruction. The availability of screens and projectors during classes is essential, but this is an elusive goal for many schools. Most traditional classrooms are not equipped with LCD projectors due to budget constraints. If teachers want to make a digital presentation, they are required to set up a TV monitor or a

portable projector. However, it is very difficult for teachers to set up the machines during the limited time available between classes. Likewise, access to a projector contributes significantly to teachers' production of multimedia materials.

The impact of teachers' attitudinal factors are important

Three elements of teacher background, sex, years of teaching and education level, were examined. Male teachers scored higher on teachers' ICT integration, whereas female teachers scored higher on word processing and Internet searches, as specified in the preparation subscale. No differences were found in terms of communication, as measured by Subscale 3, or professional development measured (Subscale 5). This finding supports the previous finding that male teachers are more proficient in using ICT for creating multimedia materials (Gilliland 1990) but also suggests that female teachers are more proficient in word processing and Internet searches.

Teachers with greater seniority (more years of teaching experience) seemed to be slower in learning communication tools or making multimedia lesson materials, which has a negative impact on overall ICT integration proficiency. Several studies have found that teachers with longer years of service do poorly on integrating ICT into classes (Chiero 1997; Inan and Lowther 2010). The results of this study also found that the longer the teacher's tenure, the less ICT they use.

The impact of teachers' education level was stable across all subscales. In this study, teachers with advanced degrees had greater ICT integration, which confirms the previous finding that teachers' level of education predicts their use of ICT in education (Mathews and Guarino 2000). It may be that teachers learn to use ICT software and hardware more proficiently during graduate school. Teachers who work on advanced degrees may also have a greater need to have their own computers and have more experience in creating digital documents and presentations.

Teacher attitudinal variables had a strong impact on teacher ICT integration. Hours of training were a strong predictor of teacher ICT integration. The results confirmed that policy and practice emphasis on professional development encourages teacher ICT integration (Bichelmeyer and Molenda 2006; Davis et al. 2009). What should be noted, however, is that the intensity of training matters. The training item asked teachers how many hours of ICT-related training they had completed during the previous year, and the five choices ranged from 0 to over 20 h. The results suggest that the duration or intensity of training affects ICT proficiency and this was evident in case of teachers who had undergone over 11 h or less than 3 h of training. This finding confirms previous researchers' findings about teachers' attitudes and commitment to learning about ICT and teaching with ICT (Hennessy et al. 2005; Mueller et al. 2008).

Teachers' perceptions of effectiveness of ICT in improving the efficiency of instructional activities have a strong effect on ICT integration, especially in the area of preparing course material, professional development and ethics issues. This finding highlights the practicality of ICT usage in teachers' everyday lives, such as searching for references, making handouts, producing presentations and grading. Previous researchers have mentioned that it seems to be an important factor (Baek et al. 2008) and this finding supports that claim.

Perceived effectiveness of ICT in improving students' learning was also an important factor for integrating ICT into lessons. This reason has been advocated by researchers in the past (Inan and Lowther 2010; Mueller et al. 2008). Teachers who develop ICT-integrated lessons undertake the extra work because they want their students to have a better

understanding of the material (Baylor and Ritchie 2002). Some researchers felt that teachers use ICT to encourage students to develop problem solving, inquiry or other constructivist learning skills (Becker 2001). Given the range of teachers' beliefs about ICT, the results of this study suggest that if teachers felt that ICT-integrated lessons and materials helped students to learn, they seemed to use more of ICT in class.

Variables can have impacts at both school and teacher levels

Five variables which have the potential to contribute to both teacher and school level variance were included at both levels. Among them, four items are about teachers' perceptions of school policy priorities and encouragement for ICT integration and collaboration with peers and technical staff in creating ICT-integrated lessons. One additional item focuses on teachers' training hours during the previous year. At the school level, mean values of groups of these items were used, and group-mean centered scores were used at the teacher level. Looking at both levels together, administrators' encouragement was an important factor. The coefficients for three of the six subscales at school level and all subscales at teacher level were significant. Therefore, it seems likely that school administrators' encouragement of teachers' ICT efforts is important both individually for teachers and contextually for schools. Similar effects can be observed for hours of training during the previous year. The results confirm and expand past studies in that school policy and emphasis on ICT and teachers' professional training are important school level variables (O'Dwyer et al. 2004; Tondeur et al. 2008). School level policy has been regarded an important factor for teacher ICT integration (Baek et al. 2008; Gulbahar 2007). However, the way it is implemented at both school and teacher level has not been sufficiently explored. This study suggests that it is important for a school to have a policy that encourages teachers' ICT efforts, and it is also essential for individual teachers to feel positive about it.

In terms of school cultural variables, three factors regarding teachers' perceptions of school policy, priority and action were included but they did not have a significant impact on teacher ICT integration proficiency. These factors without significant impact are retained because they are placed in two different levels and other researchers can compare their results with the findings of this study and understand how these variables interact and influence each other.

As the results showed, whether the school has overall plans for ICT integration or whether the administrators state that ICT integration was their school policy priority was not the most important factor. What matters the most is whether teachers receive encouragement from school administrators. This result provides a closer look at the school culture fostered by administrators. As Cuban et al. (2001) suggested, schools routinely offer training sessions on ICT integration at times when teachers are unable to attend. The results showed that when the administrators appreciate teachers' ICT integration effort, it has a strong positive effect on results at the school level. When teachers are working together to use ICT in their lessons, they often form a community, which is regarded as an important factor for teachers to learn new ICT integration skills. In this study, teachers' perceptions of peer collaboration was found significant at the teacher level, but not at the school level, except for one subscale. Similarly, teachers' perceptions about collaboration with technical staff was significant at teacher's level, but not at school level. This may be due to the fact that most schools in Taiwan are understaffed and technical support personnel are in short supply. When technical support is available, the staff tends to fix

computers and maintain networks, not coach teachers. As such, they have little time to work with teachers to develop ICT integrated lessons. Teachers who did get technical support felt that they benefited from it and were able to improve their ICT integration. Therefore, it is possible that when there is an active group of teachers at a school, the impact may not be felt at the school level. At this point of time, it seems likely that small groups or communities at schools are mostly individuals working together, and not teams purposely formed or promoted by schools.

Limitations and implications

Naturally, there are limitations of the current research, and these issues suggest directions for future research. One of the limitations is the over-generalization at the school level from aggregated individual data. In the current study, only 15 teachers were selected at each school, and not all of them participated in the survey. For big schools, over-generalization may be more of a problem. Future research along these lines should collect more data from each school to confirm the current findings. Moreover, to determine which variables have both individual and group effects is another challenge for multilevel analysis and the use of the centering technique. In this study, teachers' attitudinal variables are emphasized and, therefore, aggregated into school culture variables. Other researchers, however, may find that additional variables have collective effects, such as teachers' age or beliefs in technology's efficiency or contribution to student learning and, therefore, should be examined. As more studies are done using multilevel analysis methods, a clearer picture of the dynamics between teachers as individuals and schools as a whole will emerge.

This study confirms previous findings that both teacher and school level factors have an impact on teacher ICT integration. Using a large data set from Taiwanese grade 1–9 teachers, this study found that if schools can provide teachers access to technology with stable computers and Internet connectivity, they are more likely to integrate ICT into their lessons. Teachers' personal backgrounds, such as being a male, receiving a graduate degree and being younger, tend to have greater impact on ICT integration. Besides teachers' personal backgrounds and school structural factors, this study further examined teachers' perceptions of school administrative, peer and technical support at individual level and group level using multilevel analysis and centering techniques. The results showed that teachers' feelings of being encouraged by administrators had an effect on ICT integration at both individual and school level. Teachers' engagement in ICT related professional training also had both individual and school effects. These results suggest that when school administrators provide teachers with opportunities for training, and actively encourage teachers in ICT integration efforts, the effects are mostly likely to be significant. Other factors such as peer support and technical support, however, were found to have effects only at the individual level. These results do not suggest that schools should pay less attention to teachers' need for peer support and technical support. It is possible that if schools make more concentrated efforts in fostering peer and technical support, which may in turn translate into perception of school support, more group effects are likely to be observed in the future. Additional analysis also found that there are moderate correlations among the four items regarding teachers' perceived support from school policy, administrators, peer teachers and technical staff. It is, therefore, suggested that in the future, teachers' perceptions of school support can be formulated into a rigorous and verified measure to highlight the importance of the

impact from school support on teacher ICT integration. ICT integration is a complicated issue that needs both teachers and schools to make orchestrated efforts to see the effects.

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Appendix

For the purpose of model comparison, two additional models were investigated. The first model was a partial model or the middle model in comparison to the full model, and the second model was a raw data model which was similar to the final model (see Tables 4, 5). The first model can be viewed as a middle model in between the null model and the final model. The middle model contained the same Level 1 variables as the full model with the five teacher attitudinal variables regarding school support centered on the school means, but the middle model does not contain the five school-level variables aggregated from the individual level at Level 2 (see Table 4). In other words, the middle model assumed that there was no difference between the schools means regarding these five variables. As the results of the deviance statistics and the Chi-squares showed, the middle model is better than the null model in its explaining power (see Tables 7, 8), but it explains a significantly smaller proportion of variance at the school level (43.30 %) compared to the final model (58.52 %) (see Table 6).

In the raw data model, the variables were neither centered nor aggregated. Each variable was used once either at Level 1 or Level 2 (see Table 5). In other words, in the raw data model, the variances for the five teacher perceived school support variables stayed within the teacher level. As the model comparison results (see Tables 6, 7 and 8) and several researchers suggested, the raw data model explains a similar proportion of variance as the final model (Kreft and deLeeuw 1998; Kreft et al. 1995) but it does not separate the impact of the variables nor offer easy interpretation. For the purpose of the present study, the final model was chosen because it explains the most variance and it partitions the impact of variables at different levels in a more meaningful way.

Table 4 The impact of Level 1 and Level 2 variables on teacher ICT integration (middle model)

	Preparation β (SD)	Production β (SD)	Communication β (SD)	Instruction β (SD)	Development β (SD)	Ethics β (SD)	ICT integration β (SD)
Intercept	2.48 (.10)***	1.16 (.11)***	1.34 (.15)***	1.12 (.13)***	1.50 (.11)***	1.76 (.14)***	1.56 (.09)***
School structural variables (Level 2)							
Availability of projectors	.01 (.06)	.31 (.06)***	.12 (.08)	.08 (.08)	.04 (.06)	−.01 (.08)	.09 (.05)
Stability	.12 (.09)	.20 (.10)*	.29 (.13)*	.32 (.12)**	−.02 (.10)	.19 (.12)	.18 (.08)*
Internet connectivity	−.02 (.10)	.26 (.11)*	.37 (.15)*	.37 (.13)**	.30 (.11)**	.39 (.14)**	.28 (.09)**
Size	−.03 (.02)	−.01 (.02)	.00 (.03)	.07 (.02)**	−.01 (.02)	.06 (.02)*	.01 (.02)
Type	.06 (.03)*	.03 (.03)	−.08 (.04)	.00 (.04)	.01 (.03)	−.01 (.04)	.00 (.03)
School cultural variables (Level 2)							
Planning	−.08 (.06)	.13 (.07)	−.01 (.09)	.30 (.08)**	.16 (.07)*	.27 (.08)**	.13 (.05)*
Teacher background variables (Level 1)							
Sex[a]	.10 (.02)***	−.10 (.02)***	−.04 (.02)	−.11 (.02)***	−.04 (.02)	−.12 (.02)***	−.05 (.01)**
Years (per 5 years)	−.05 (.01)***	−.05 (.01)***	−.04 (.01)***	−.02 (.01)**	−.01 (.01)	−.01 (.01)	−.03 (.01)***
Education-Normal college[b]	−.06 (.06)	.07 (.06)	.03 (.07)	.13 (.06)*	.07 (.06)	−.01 (.07)	.04 (.04)
Education-40 Credit courses[b]	.02 (.03)	.01 (.03)	.04 (.04)	.00 (.04)	.01 (.04)	.00 (.04)	.01 (.03)
Education-Master's degree[b]	.01 (.02)	.11 (.02)***	.07 (.03)*	.08 (.02)**	.07 (.02)**	.01 (.03)	.06 (.02)**
Teacher attitudinal variables (Level 1)							
Training hours (group centered)	.06 (.01)***	.12 (.01)***	.05 (.01)***	.12 (.01)***	.14 (.01)***	.10 (.01)***	.10 (.01)***
Perception of ICT efforts being encouraged (group centered)	.04 (.02)*	.19 (.02)***	.12 (.02)***	.14 (.02)***	.10 (.02)***	.10 (.02)***	.11 (.01)***
Perception of ICT as priority (group centered)	.02 (.02)	−.06 (.02)**	−.01 (.02)	−.01 (.02)	.02 (.02)	.04 (.02)	.00 (.01)
Peer support (group centered)	−.04 (.02)	.11 (.02)***	.08 (.03)**	.15 (.02)***	.02 (.02)	.09 (.03)**	.07 (.02)***
Technical support (group centered)	−.05 (.02)**	.07 (.02)***	.10 (.02)***	.10 (.02)***	.03 (.02)	.08 (.02)**	.06 (.01)***
Perceived effectiveness of ICT in improving work efficiency	.24 (.02)***	.20 (.02)***	.05 (.03)	.09 (.02)***	.23 (.02)***	.14 (.03)***	.16 (.02)***

Table 4 continued

	Preparation β (SD)	Production β (SD)	Communication β (SD)	Instruction β (SD)	Development β (SD)	Ethics β (SD)	ICT integration β (SD)
Perceived effectiveness of ICT in improving students' learning	.06 (.02)**	.11 (.02)***	.07 (.03)*	.07 (.02)**	.09 (.02)***	.06 (.03)*	.08 (.02)***
Null model							
Level 2—school σ^2_{t0}	.02 (.00)***	.04 (.01)***	.06 (.01)***	.07 (.01)***	.02 (.00)***	.05 (.01)***	.03 (.00)***
Level 1—teacher σ^2_{e0}	.31 (.01)***	.40 (.01)***	.50 (.01)***	.39 (.01)***	.41 (.01)***	.53 (.01)***	.22 (.01)***
Middle model							
Level 2—school σ^2_{t0}	.01 (.00)***	.02 (.00)***	.04 (.01)***	.04 (.01)***	.01 (.00)***	.03 (.01)***	.01 (.00)***
Level 1—teacher σ^2_{e0}	.28 (.01)***	.29 (.01)***	.46 (.01)***	.29 (.01)***	.33 (.01)***	.46 (.01)***	.16 (.00)***

* $p < .05$; ** $p < .01$; *** $p < .001$

[a] 0 = male, 1 = female, so a negative coefficient in the table indicates male teachers having a higher scale score

[b] Dummy coding is used for the degree of education with bachelor's degree as the comparison group

Table 5 The impact of first and second level variables on teacher ICT integration (Raw data model)

	Preparation β (SD)	Production β (SD)	Communication β (SD)	Instruction β (SD)	Development β (SD)	Ethics β (SD)	ICT integration β (SD)
Intercept	2.45 (.10)***	.36 (.11)**	.68 (.14)***	.17 (.12)	.96 (.11)***	1.00 (.14)***	.94 (.08)***
School structural variables (Level 2)							
Availability of projectors	.01 (.06)	.26 (.06)***	.07 (.08)	.01 (.07)	.01 (.06)	−.07 (.08)	.05 (.05)
Stability	.14 (.09)	.21 (.09)*	.27 (.13)*	.32 (.11)**	.00 (.09)	.19 (.12)	.19 (.07)*
Internet connectivity	−.04 (.10)	.21 (.10)*	.34 (.14)*	.31 (.12)*	.24 (.10)*	.33 (.13)*	.23 (.08)**
Size	−.03 (.02)	−.04 (.02)	−.02 (.02)	.04 (.02)*	−.03 (.02)	.04 (.02)	.00 (.01)
Type	.08 (.03)**	.04 (.03)	−.08 (.04)	.02 (.04)	.04 (.03)	.01 (.04)	.02 (.02)
School cultural variables (Level 2)							
Planning	−.13 (.06)*	−.08 (.07)	−.17 (.09)	.04 (.08)	−.04 (.06)	.04 (.08)	−.06 (.05)
Teacher background variables (Level 1)							
Sex[a]	.10 (.02)***	−.10 (.02)***	−.04 (.02)	−.11 (.02)***	−.04 (.02)	−.12 (.02)***	−.05 (.01)**
Years (per 5 years)	−.05 (.01)***	−.05 (.01)***	−.04 (.01)***	−.02 (.01)**	−.01 (.01)	−.02 (.01)	−.03 (.01)***
Education-Normal college[b]	−.05 (.06)	.07 (.06)	.03 (.07)	.12 (.06)*	.07 (.06)	−.01 (.07)	.04 (.04)
Education-40 Credit courses[b]	.02 (.03)	.02 (.03)	.04 (.04)	.01 (.04)	.01 (.04)	.00 (.04)	.02 (.03)
Education-Master's degree[b]	.01 (.02)	.11 (.02)***	.07 (.03)*	.08 (.02)**	.07 (.02)**	.01 (.03)	.06 (.02)**
Teacher attitudinal variables (Level 1)							
Training hours	.07 (.01)***	.11 (.01)***	.05 (.01)***	.12 (.01)***	.15 (.01)***	.11 (.01)***	.10 (.01)***
Perception of ICT efforts being encouraged	.03 (.02)	.20 (.02)***	.13 (.02)***	.14 (.02)***	.10 (.02)***	.10 (.02)***	.11 (.01)***
Perception of ICT as priority	.03 (.02)	−.06 (.02)**	−.01 (.02)	.00 (.02)	.03 (.02)	.05 (.02)*	.01 (.01)
Peer support	−.04 (.02)*	.12 (.02)***	.08 (.02)**	.15 (.02)***	.01 (.02)	.09 (.02)**	.07 (.01)***
Technical support	−.05 (.02)**	.07 (.02)***	.10 (.02)***	.11 (.02)***	.03 (.02)	.08 (.02)**	.05 (.01)***
Perceived effectiveness of ICT in improving work efficiency	.24 (.02)***	.19 (.02)***	.04 (.03)	.09 (.02)***	.22 (.02)***	.13 (.03)***	.15 (.02)***
Perceived effectiveness of ICT in improving student learning	.06 (.02)**	.10 (.02)***	.07 (.03)*	.06 (.02)**	.08 (.02)**	.05 (.03)	.07 (.02)***

Table 5 continued

	Preparation β (SD)	Production β (SD)	Communication β (SD)	Instruction β (SD)	Development β (SD)	Ethics β (SD)	ICT integration β (SD)
Null model							
Level 2—school $\sigma^2_{\mu 0}$	.02 (.00)***	.04 (.01)***	.06 (.01)***	.07 (.01)***	.02 (.00)***	.05 (.01)***	.03 (.00)***
Level 1—teacher $\sigma^2_{\varepsilon 0}$	.31 (.01)***	.40 (.01)***	.50 (.01)***	.39 (.01)***	.41 (.01)***	.53 (.01)***	.22 (.01)***
Raw data model							
Level 2—school $\sigma^2_{\mu 0}$	.01 (.00)***	.02 (.00)***	.04 (.01)***	.03 (.00)***	.01 (.00)***	.02 (.01)***	.01 (.00)***
Level 1—teacher $\sigma^2_{\varepsilon 0}$	.28 (.01)***	.29 (.01)***	.46 (.01)***	.29 (.01)***	.33 (.01)***	.46 (.01)***	.16 (.00)***

* $p < .05$; ** $p < .01$; *** $p < .001$

[a] 0 = male, 1 = female, so a negative coefficient in the table indicates male teachers having a higher scale score

[b] Dummy coding is used for the degree of education with bachelor's degree as the comparison group

Table 6 The percentage of variance of ICT integration explained by the null, middle, final and the Raw data model

Model	% of variance	Preparation (%)	Production (%)	Communication (%)	Instruction (%)	Development (%)	Ethics (%)	ICT integration
Null	School Level	6.05	9.56	10.20	14.45	4.81	8.37	10.20
	Teacher Level	93.95	90.44	89.80	85.55	95.19	91.63	89.80
Middle	School Level	28.04	48.52	28.95	39.47	29.54	41.11	43.30
	Teacher Level	10.24	27.99	8.64	24.80	19.34	12.97	27.12
Final	School Level	45.12	63.29	37.44	51.77	61.50	52.30	58.52
	Teacher Level	10.25	28.04	8.63	24.80	19.40	13.01	27.15
Raw data	School Level	39.31	61.37	36.26	51.01	59.90	51.95	58.25
	Teacher Level	10.22	28.02	8.61	24.80	19.39	13.00	27.14

Table 7 Deviance statistics of the four models

Model	DF	Preparation	Production	Communication	Instruction	Development	Ethics	ICT Integration
Null	300	6226.14	7245.77	8076.59	7222.29	7234.96	8292.06	5122.08
Middle	282	5805.04	5995.83	7706.66	6140.92	6435.81	7730.57	3926.87
Final	277	5776.73	5950.16	7688.43	6101.44	6382.34	7704.11	3881.82
Raw data	282	5787.48	5957.09	7691.66	6104.05	6385.41	7705.17	3882.84

Table 8 Model comparisons: Chi-square tests

Model comparison	Preparation	Production	Communication	Instruction	Development	Ethics	ICT Integration
Null vs. Final	449.41***	1295.61***	388.16***	1120.85***	852.62***	587.94***	1240.26***
Null vs. Middle	421.10***	1249.93***	369.93***	1081.37***	799.15***	561.49***	1195.21***
Null vs. Raw data	438.66***	1288.67***	384.94***	1118.23***	849.55***	586.88***	1239.24***
Middle vs. Final	28.31***	45.68***	18.23**	39.48***	53.47***	26.45***	45.05***
Raw data vs. Final	10.75	6.94	3.22	2.61	3.07	1.06	1.02

* $p < .05$; ** $p < .01$; *** $p < .001$

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Shihkuan Hsu is an associate professor in the Center for Teacher Education at National Taiwan University. Her research interests include educational technology and teacher education

Ping-Yin Kuan is an associate professor in the Department of Sociology at National Chengchi University, Taiwan. His research interests include sociology of education and survey research