Wu, T.-F., Chen, C.-M., Lo H.-S., Yeh, Y.-M., & Chen, M.-C. (2018). Factors Related to ICT Competencies for Students with Learning Disabilities. *Educational Technology & Society, 21* (4), 76–88.

Factors Related to ICT Competencies for Students with Learning Disabilities

Ting-Fang Wu[1], Cheng-Ming Chen[2], Hui-Shan Lo[3], Yao-Ming Yeh[4] and Ming-Chung Chen[5*]

[1]Graduate Institute of Rehabilitation Counseling, National Taiwan Normal University, Taiwan // [2]Department of Special Education, National Kaohsiung Normal University, Taiwan // [3]Department of Special Education, National Taiwan Normal University, Taiwan // [4]Department of Information Management, Kainan University, Taiwan // [5] Department of Special Education, National Chiayi University, Taiwan // tfwu@ntnu.edu.tw // tomson2@ms18.hinet.net // 80209003e@ntnu.edu.tw // ymyeh@mail.knu.edu.tw // mtchen@mail.ncyu.edu.tw
[*]Corresponding author

(Submitted November 16, 2016; Revised January 17, 2017; Accepted April 15, 2017)

ABSTRACT

The purpose of this study was to develop an explanatory model for the information and communication technology (ICT) competencies of students with and without learning disabilities (LD). A conceptual model was proposed, and included five major constructs: (1) attitude towards using ICT, (2) ICT competency, (3) demographic characteristics, (4) ICT access, and (5) purpose for using ICT. A self-reported questionnaire, Scale of Digital Participation (SDP), was designed by the authors and used to collect data. Data from 117 elementary school students with LD and 117 without LD were used to test the initial model. Meanwhile, data from 102 junior high school students with LD and 102 students without LD were used to evaluate the cross-validation of the revised model. The results of structural equation modelling (SEM) demonstrate acceptable goodness of fit for the initial ICT competency model but poor parsimony. Therefore, a revised ICT competency model with both parsimony and goodness of fit was generated using data from elementary school age students. Moreover, this new model was also able to further explain the complex phenomena of ICT competency for junior high school age students. Nevertheless, no differences were found between the elementary school and junior high school models, thereby confirming the cross-validation of the revised model.

Keywords

Information and communication technology, Students with learning disabilities, Structural equation modelling

Introduction

Information and communications technology (ICT) has been regarded as an equalizer for students with disabilities participating in learning activities (de Jong, Specht, & Koper, 2010; Huang et al., 2010; Tosun & Baris, 2011). Students with disabilities are enabled to participate in learning and communication with the support of ICT (Fichten et al., 2009; Ko, Chiang, Lin, & Chen, 2011). However, with the popularity of ICT use in our daily life, many barriers continue to exist, prohibiting some students from participating in learning. Thus, the digital divide has become yet another barrier facing students with disabilities.

The digital divide has been defined as the lack of opportunity to access ICT and the competencies to effectively use ICT (Mäkinen, 2006). Access and ability are two major issues when exploring the digital divide (DiMaggio, Hargittai, Celeste, & Shafer, 2004; Hargittai, 2003; Latimer, 2001; Mossberger, Tolbert, & Stansbury, 2003; Stanley, 2003; van Dijk, 1999; van Dijk & Hacker, 2003; Warschauer, 2003). Access is defined as the actual availability of and access to ICT devices. Ability is a term that covers both an individuals' ability to cope with ICT devices and the amount of help and support individuals receive from their social network (Lebens, Graff, & Mayer, 2009).

In addition to ICT access and ability, Martin (2003) adds motivation as another important factor necessary for using ICT to learn. Motivation refers to the individual's attitude towards learning through the use of ICT and the willingness to dedicate one's effort to acquire ICT competencies.

Disability has been emphasized as one factor that can impact individuals' access to ICT (Department for Education and Skills, 2001; Russell & Stafford, 2002). Results from the literature have shown that persons with disabilities have fewer opportunities to access ICT (Department for Education and Skills, 2001; Russell & Stafford, 2002; U.S. National Telecommunications and Information Administration, 2011). However, previous surveys on the digital divide have overlooked students with learning disabilities (LD) (U.S. National Telecommunications and Information Administration, 2011; Research, Development and Evaluation Commission, 2012), even though the students with LD represent approximately 5% of school-aged students

(Hallahan, Lloyd, Kauffman, Weiss, & Martinez, 2004). Only a few studies have focused on this population (Chen et al., 2014; Wu, Chen, Yeh, Wang, & Chang, 2014). Wu and her colleagues (2014) investigated 117 students with LD and their non-LD peers from 4th to 6th grade. The results indicated no significant difference in opportunities to access computers and the Internet, either at home or at school, between children with and without LD. However, the ICT competencies of children with LD were significant poorer than their non-LD peers. Chen and his colleagues' (2014) investigation also supported the existence of a difference in ICT competencies between students with and without LD.

While it seems to be a fact that a significant difference in ICT competencies exists between students with and without LD, the factors contributing to this phenomenon remain under-researched. Previous research does indicate that age, gender, demography, social economic status (SES), and disabilities are regarded as major factors related to the digital divide (Enoch & Soker, 2006; Lebens et al., 2009; Martin, 2003; Mckenzie, 2007; Stoilescu & McDougall, 2011; van Deursen, van Diik, & Peters, 2011; Vicente & López, 2010). Other recent studies have tended to focus on fluid variables, such opportunities for using ICT, or level of education, particularly when focusing on school-age children (Wu et al., 2014).

Meanwhile, the digital divide remains a complex concept, which is comprised of a variety of factors, including attitude, ability, and access. Which one should be the focus? While ability or competence might be the core of this complex concept, studies have also shown that access is one of the key factors influencing ICT competence (e.g., van Deursen et al., 2011). In addition, due to the diffusion of ICT in developed and developing countries, the importance of access has tended to be replaced by that of competency (van Dijk, 2006; Warschauer, 2003).

Since the digital divide is a complex phenomenon, it is impossible to explore it simply through bivariate analysis, as this basic approach not only increases the type I error rate, but is unable to deal with latent variables. Therefore, structural equation modeling (SEM) is deemed a proper solution for testing conceptual or theoretical models which are comprised of many variables. In addition, SEM is able to analyze latent variables and observed variables simultaneously. Therefore, SEM has been widely adopted to analyze complex phenomenon (Bowen & Guo, 2012), including recent digital divide research (e.g., Constantin, Taylor, Park, & Cho, 2006; van Deursen et al., 2011).

Some studies which have adopted available theoretical frameworks, such as the Technology Acceptance Model (TAM) (e.g., Tarhini, Hone, & Liu, 2014) for their research. However, this study, as with van Deursen et al. (2011), proposed an initial model which first included possible factors found in the literature, and then excluded insignificant factors and paths to create a revised SEM model based on best analytical results. However, could the model generated from SEM testing be useful and explanatory when applied to a different data set? Previous studies seem to stop testing the revised model (e.g., Tarhini et al., 2014) or to use half of the original sample to test the revised model (e.g., Igbaria, Guimaraes, & Davis, 1995). However, cross-validation should be further tested to demonstrate the effect of the revised model across different groups (MacCallum, Roznowski, Mar, & Reith, 1994).

Based on the abovementioned considerations, the purpose of the current study was to develop an explanatory SEM model to represent the relationships among key ICT competency factors. The authors first designed an initial conceptual model which included all the proposed factors generated from previous studies. The theoretical framework is shown in Figure 1, and includes five major constructs, (1) attitude towards using ICT (confidence and motivation), (2) ICT competency (basic computer skills, Office software use, and Internet use), (3) demographic characteristics (disabilities, grade), (4) ICT access (family ownership of a computer, frequency of Office software use) and (5) purpose for using ICT (learning, social interaction, leisure, and daily life needs), proposed as a theoretical conceptual model. The significance of paths between factors were tested, and only significant paths were included in creating an increasingly parsimonious revised model. Additionally, in order to explore cross-validation, a sample from another group of participants was used to examine the goodness of fit of the revised SEM model. Furthermore, tests of measurement invariance were conducted to compare the two models. As such, the specific research questions of this study are:

- Could the five proposed factors related to ICT competency be used to develop an SEM model which could explain these complex phenomena and the relationships among factors for elementary students with and without learning disabilities?
- Would the final revised SEM model also explain the complex phenomena of ICT competency factors for junior high school students with and without learning disabilities?
- Would differences between SEM models for elementary school and junior high school students be found?

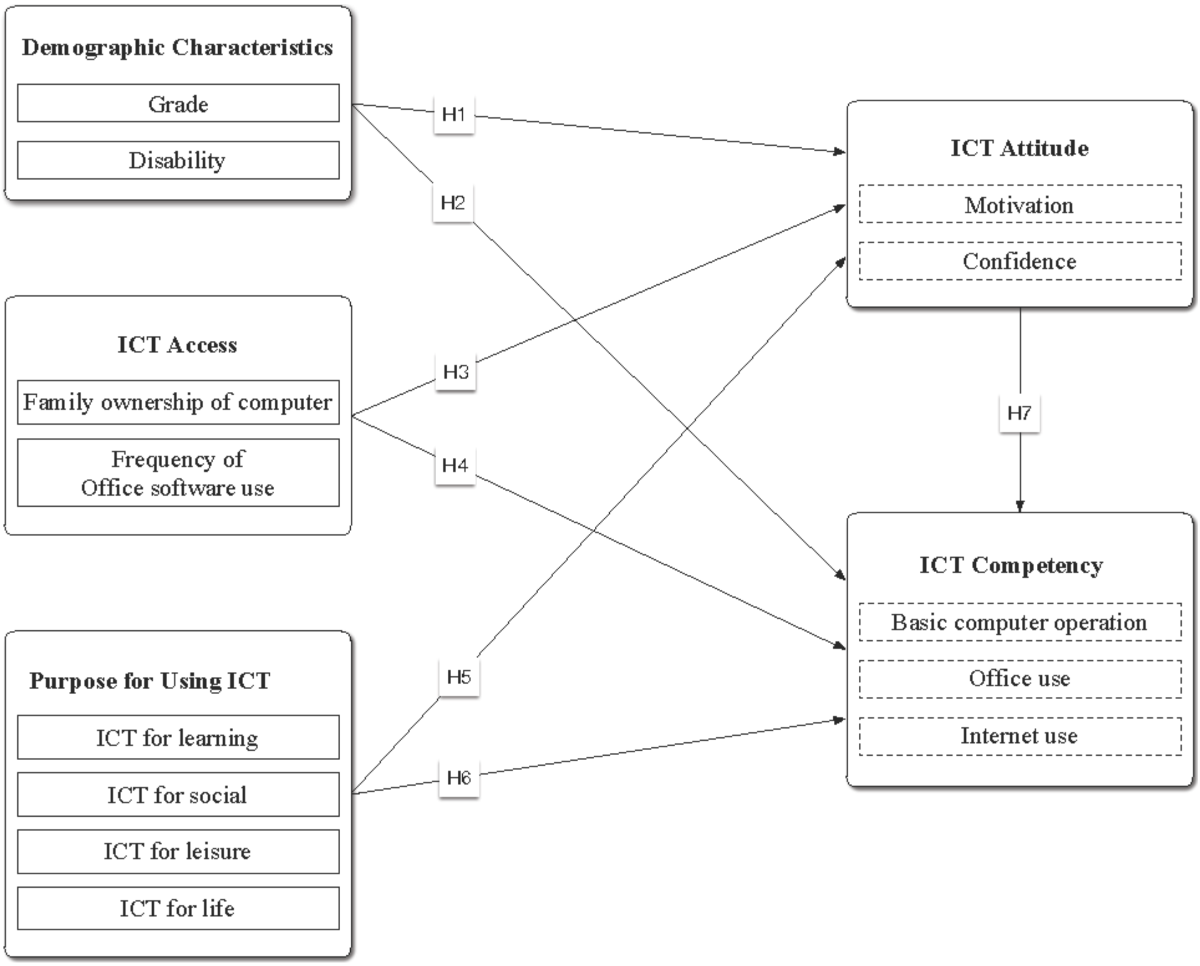

Figure 1. Theoretical Conceptual Model and Hypotheses of ICT competencies

The specific hypotheses in this study are the following:
Hypothesis1a: Students without LD will have a better attitude towards using ICT than students with LD.
Hypothesis 1b: Higher grades will be associated with more positive ICT attitude.
Hypothesis 2a: Students without LD will have higher levels of ICT competency than students with LD.
Hypothesis 2b: Higher grades will be associated with higher levels of ICT competency.
Hypothesis 3a: Students who have a computer at home will have more positive ICT attitudes than students without a computer at home.
Hypothesis 3b: The frequency of using Office software will be associated with more positive ICT attitude.
Hypothesis 4a: Students who have a computer at home will have higher levels of ICT competency.
Hypothesis 4b: The frequency of using Office software will be associated with higher levels of ICT competency.
Hypothesis 5a: Higher levels of using ICT for learning activities will be associated with more positive ICT attitudes.
Hypothesis 5b: Higher levels of using ICT for social interaction will be associated with more positive ICT attitudes.
Hypothesis 5c: Higher levels of using ICT for leisure activities will be associated with more positive ICT attitudes.
Hypothesis 5d: Higher levels of using ICT for life activities will be associated with more positive ICT attitude.
Hypothesis 6a: Higher levels of using ICT for learning activities will be associated with higher ICT competency.
Hypothesis 6b: Higher levels of using ICT for social interaction will be associated with higher ICT competency.
Hypothesis 6c: Higher levels of using ICT for leisure activities will be associated with higher ICT competency.
Hypothesis 6d: Higher levels of using ICT for daily life activities will be associated with higher ICT competency.
Hypothesis 7: Students' with more positive ICT attitude will demonstrate higher levels of ICT competency.

Methods

Research design

The purpose of this study was to develop a model which could explain the relationships among ICT competency and other proposed factors. The authors first developed a theoretical conceptual model (see Figure 1). Then, data from a previous study (Wu et al., 2014) was used to test the initial model and to generate a revised model. Finally, data from another sample was used to test the revised model. Therefore, two studies were conducted. The first study investigated the relationships among the abovementioned five constructs. The resulting analyses were then used to revise the theoretical model to create a revised model. In the second study, data generated from another sample was used to examine the goodness of fit of the revised model. Then tests for measurement invariance were conducted to compare the relative fit of the two models.

Participants

In the first study, data were reanalyzed from a previous study (Wu et al., 2014), adopting paired sampling based on gender and grade. 234 students from elementary schools in Taiwan were recruited, including 117 students with LD and 117 non-LD peers (NLD). To test the cross-validity of the revised model, 204 students from junior high schools in Taiwan (LD = 102, NLD = 102), participated in the second study. The number of participants is listed on Table 1.

Participants with LD were recruited through telephone calls to special education teachers of elementary and junior high schools in Taiwan. They were asked to invite their students with LD to participate in this investigation. Students with LD were diagnosed and identified by the local education authorities based on the specific criteria: (a) normal intelligence quotients; (b) significant intra-individual differences among skills; and (c) significant difficulties in academic performance, such as listening comprehension, oral expression, word recognition, reading comprehension, writing, and calculation, were not improved after interventions provided through regular instruction. Furthermore, no neurological deficits, intellectual delay, physical impairments, or cultural disadvantage were reported. All participants with LD were placed in regular classes with their non-disabilities peers. The non-LD peers were also recruited from the same schools. Parental consent was obtained before the investigation.

Table 1. The number of students with and without LD

	LD			NLD		
Grade	Male	Female	Subtotal	Male	Female	Subtotal
4th	23	19	42	23	19	42
5th	28	12	40	28	12	40
6th	26	9	35	26	9	35
7th	15	9	24	15	9	24
8th	31	6	37	31	6	37
9th	30	11	41	30	11	41

Instruments

A self-developed questionnaire, *Scale of Digital Participation,* was adopted. For elementary school students, the questionnaire was titled as *Scale of Digital Participation for Elementary School Students*, while for junior high school students, the title of the instrument was *Scale of Digital Participation for Junior High School Students.* The questionnaires contained identical items in five major sections: personal demographic information, current status of ICT access, purpose for using ICT, ICT competency, and ICT attitude.

Personal demographic information included grade and LD or non-LD status. ICT access focused on opportunities to use ICT and ownership of ICT equipment (e.g., frequency of Office software use, and family ownership of a computer). Since ICT access for students with LD did not differ from their non-LD peers (Wu et al., 2014), this paper used family ownership of a computer and frequency of using Office software alone to represent ICT access.

This study considered four major purposes for using ICT: learning, social interaction, leisure, and daily life needs. Using ICT for learning includes using ICT to learn foreign languages and to complete assignments. Using

ICT for social interaction includes using social media to interact with friends, such as through Facebook. Using ICT for leisure includes playing games and listening to music. Finally, using ICT for daily life needs consists of searching for information for train schedules, or online shopping.

The subscale for ICT competency used in the previous study consisted of six types of computer skills, which included basic computer operation (10 items), word processing (10 items), spreadsheet software use (10 items), presentation software use (7 items), graphic software use (4 items), and Internet use (10 items) (Wu et al., 2014). In this study, there were too many types of ICT skills for inclusion in the SEM model. Therefore, we combined word processing (10 items), spreadsheet software use (10 items), and presentation software use (7 items) into a new category named Office software use (27 items). Then, Office software use, basic computer operation (10 items), and Internet use (10 items) were included in the model. Each item comprised a simple ICT task. For example, the item “Can you download a file from a website?” is one of the items used for assessing Internet use skills. It is a yes/no question. If the student indicates the ability to perform this task, one point was scored for this item. The average points, which ranged from 0.00 to 1.00, were used to represent ICT competency for each category, collectively named as the Competency Index (CI). Higher CI represented greater competency (Wu et al., 2014).

The subscale of ICT attitude includes two concepts, motivation (4 items) and confidence (2 items) in using ICT. Motivation towards using ICT included four items. For example, “I am interested in learning knowledge related to computer and internet use” was one of the motivation items for attitude towards ICT.

Wu and her colleagues (2014) established content validity and internal consistency for the questionnaire adopted in this study. The internal consistency of each category of ICT competency and attitude, represented by Cronbach’s α, were reliable (basic computer operation = .80, Office use = .95, Internet use = .89, motivation = .42; confidence = .39). Test-retest reliability was established through the use of a Pearson product-moment correlation coefficient, by completing the questionnaire a second time after a two week interval, with the test-retest reliability results as follows: basic computer operation $r = .75$, $p < .01$; Office use $r = .80$, $p < .01$; Internet use $r = .83$, $p < .01$; motivation $r = .46$, $p < .01$; and confidence $r = .62$, $p < .01$. Thus, the statistical results demonstrate the sufficient reliability of the instrument.

Procedure

Printed questionnaires were delivered to the sampled schools. A letter of explanation was also attached. The procedure for completing the questionnaires was explained during contact with the schools. Although the instrument is a self-reported questionnaire, students with LD could not complete it by themselves due to their reading deficiencies. To ensure their understanding, each questionnaire item was read aloud to the students with LD before they completed the questionnaires by themselves. Student without LD were invited to fill in the questionnaire during computer class or in the morning before classes began. They were allowed to ask questions as they filled in the questionnaire, including the meaning of items.

Data analysis

The initial ICT competency measurement model, in which all the coefficients among factors were open for estimation, was tested and analyzed by structural equation modeling (SEM) using the software AMOS (version 22). The commonly recommended fit indices when reporting SEM analyses were conducted, including preliminary fit criteria, overall model fit, and the fit of the internal structure of the model. The preliminary fit criteria include: positive error variances, significant error variances, correlations not exceeding 1, and factor loadings ranging from .05 to .95 (Bagozzi & Yi, 1988).

For this study, several indices were used to test the overall model’s fit, including the goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), root mean square error of approximation (RMSEA), standardized root mean residuals (SRMR), normed-fit index (NFI), and parsimonious normed-fit index (PNFI). For goodness of fit to be demonstrated, the recommended values for these indices should be as follows: GFI > .90, AGFI > .90, RMSEA < .08, SRMR < .05, NFI > .90, and PNFI > .50.

In addition to the indices regarding the overall model’s fit, reliability and convergent validity of the factors within the proposed model were estimated, using composite reliability (CR) and average variance extracted (AVE) were used. The criteria for CR is > .60 and AVE is > .5.

First, the authors tested the fitness of the initial model using the above indices. Meanwhile, the PNFI was used to determine if the initial model was parsimonious. Factors with non-significant direct effects on predicted variables were excluded if they negatively impacted the fitness of the initial model. The revised model that resulted from the initial model was used to answer the abovementioned hypotheses.

Meanwhile, multiple-group analysis was used to test the measurement invariance between the elementary school junior high school models to explore cross-validation. $\triangle\chi^2$, △NFI, △IFI, △RFI and △TLI between the two models were included as indicators to represent invariance of measurement weights, structural weights, structural covariance, structural residuals, and measurement residuals. Measurement invariance would be accepted if $\triangle\chi^2$ was insignificant ($p \geq .05$) and the absolute value of △NFI, △IFI, △RFI and △TLI were lower than .05 (Little, 1997). The two models would be regarded as having no significant differences based on acceptance of the measurement invariance criteria.

Results

An SEM model for ICT competencies

Pearson product-moment correlation was adopted to test the relationship among the explored variables. As the correlation coefficients (shown on Table 2) suggest, each variable has a significant relationship with at least one of the others variables. As such, all variables were included in the full model.

Table 2. Correlation matrix

	2	3	4	5	6	7	8	9	10
1.Disability	000	.017	-.318**	-.146*	-.225**	-.061	-.236**	-.166*	-.397**
2.Grade	-	.001	.171**	-.003	.080	-.026	-.113	.039	.193**
3.Family ownership of a computer	-	-	.090	.143*	.260**	.195**	.194**	.147*	.162*
4.Office software use	-	-	-	.363**	.467**	.284**	.410**	.282**	.530**
5.ICT for learning	-	-	-	-	.238**	.160*	.359**	.152*	.201**
6.ICT for social	-	-	-	-	-	.520**	.462**	.313**	.572**
7.ICT for leisure	-	-	-	-	-	-	.453**	.274**	.329**
8.ICT for life needs	-	-	-	-	-	-	-	.210**	.370**
9.ICT attitude	-	-	-	-	-	-	-	-	.498**
10.ICT competency	-	-	-	-	-	-	-	-	-

Note. $^{*}p < .05$; $^{**}p < .01$.

Table 3. Standardized path coefficients of the initial and revised ICT competence models

Model	Independent variable	Outcome variable	Direct effect	*p*	% of variance
Initial model	Family ownership of a computer	ICT Attitude	.11	.12	
	Office software use	ICT Attitude	.19*	.03	
	Grade	ICT Attitude	-.03	.68	
	Disability	ICT Attitude	-.07	.33	
	ICT for social	ICT Attitude	.13	.17	23%
	ICT for life needs	ICT Attitude	-.09	.35	
	ICT for leisure	ICT Attitude	.25**	.01	
	ICT for learning	ICT Attitude	.06	.44	
	ICT Attitude	ICT Competencies	.37***	.00	
	Family ownership of a computer	ICT Competencies	.01	.85	
	Office software use	ICT Competencies	.15*	.02	
	Grade	ICT Competencies	.15**	.01	
	Disability	ICT Competencies	-.26***	.00	67%
	ICT for social	ICT Competencies	.33***	.00	
	ICT for learning	ICT Competencies	-.04	.47	
	ICT for leisure	ICT Competencies	-.03	.63	
	ICT for life needs	ICT Competencies	.08	.22	
Revised model	ICT for leisure	ICT Attitude	.30***	.00	
	Office software use	ICT Attitude	.25***	.00	20%

ICT Attitude	ICT Competencies	.38***	.00	
ICT for social	ICT Competencies	.37***	.00	
Office software usage	ICT Competencies	.15*	.02	65%
Grade	ICT Competencies	.15**	.00	
Disability	ICT Competencies	-.28***	.00	

Note. $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

SEM was adopted to test the proposed initial measurement model. The results obtained from the analysis indicated a good overall fit of the initial model ($\chi^2 = 65.951$, $p < .001$; GFI = .959; AGFI = .866; CFI = .960, RMSEA = .076; SRMR = .0280; NFI = .936) and the internal structure of the model was also consistent (ICT attitude CR = .6874, AVE = .5284; ICT competencies CR = .8670, AVE = .6855). This theoretical model explained 67% of the total variance for ICT competency.

In this model, the purpose of using ICT for leisure activities and frequency of Office software use had positive direct effects on attitude towards ICT (.30, p =.00; .25, p < =.00). These two model explained 20% of the total variance for attitude towards ICT (shown in Table 3).

The most powerful direct positive effect on ICT competency was ICT attitude (.37, p =.00). The results also indicate that grade, the purpose of using ICT for social interaction, and frequency of Office software use had direct positive predictive effects (.15, p = .01; .33, p =.00; .15, p = .02) while disability had a direct negative effect (-.26, p =.00) on ICT competency (shown in Table 3).

This initial model also explained 23% of the total variance for attitude towards ICT. The results indicate that frequency of Office software use and the purposes of using ICT for leisure activities were positively and significantly associated with attitude towards ICT (.19, p = .03; .25, p = .01) (shown in Table 3).

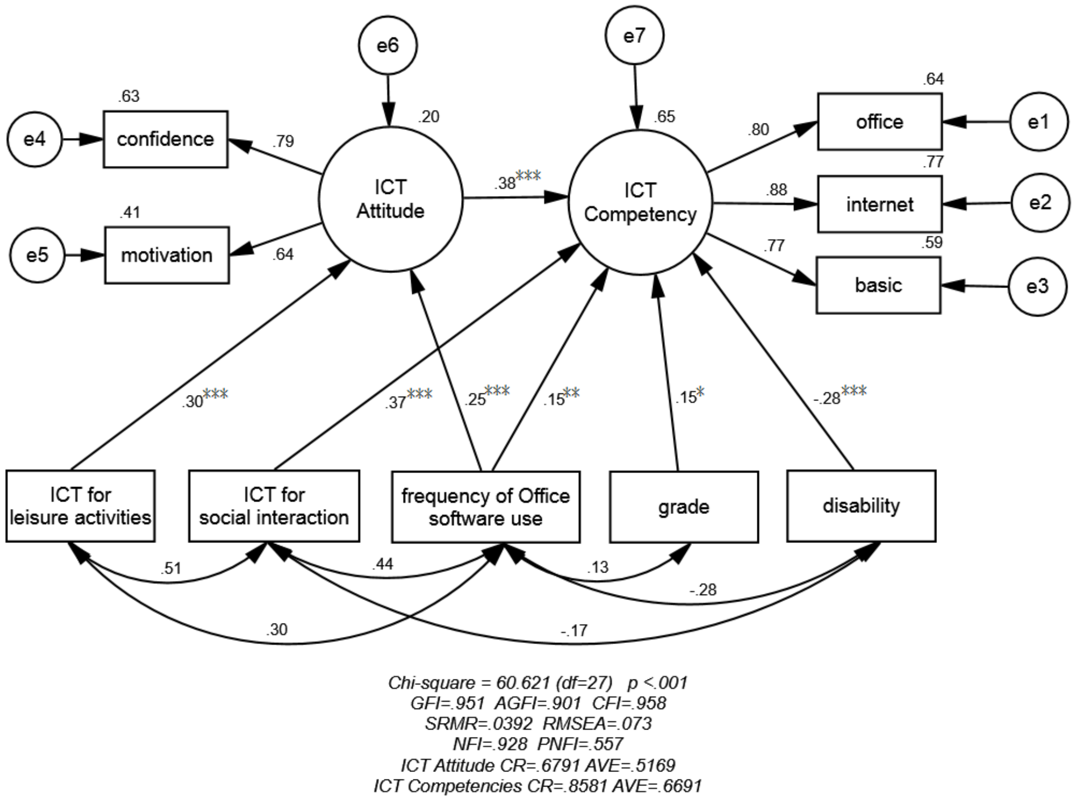

Figure 2. The standardized path coefficients of the revised ICT competency model: Elementary students sample

Although most of the indices of the proposed initial model met the goodness-of-fit criteria, the PNFI index, indicating the parsimony of the model, was poor (PNFI = .336), meaning the model should be simplified. Furthermore, the lack of significant path coefficients also illustrated the existence of many unrelated factors. Therefore, a new revised ICT competency model (Figure 2) was proposed by excluding insignificant paths.

The new revised model explained 65% of the total variance of ICT competency with better goodness of fit for the elementary student sample (χ^2 = 60.621, p < .001; GFI = .951; AGFI = .901; CFI = .958, RMSEA = .073; SRMR = .0392; NFI = .928; PNFI = .557; ICT attitude CR = .6791, AVE = .5169; ICT Competencies CR = .8581, AVE = .6691).

In this revised model, the factors which have direct and significant effects on ICT competency are disability, grade, using ICT for social interaction, frequency of Office software use, and attitude towards ICT. The attitude towards ICT latent variable also has a direct positive effect on ICT competency (.38, p =.00). Disability, grade, frequency of Office software use and using ICT for social purpose also have the direct predictive effects on ICT competencies (-.28, =.00; .15, p = .00; .15, p = .02; .37, p =.00) (shown in Table 3).

Overview of the hypotheses

Based on the significance of the standardized path coefficients shown in Table 2, the hypothesis testing results are summarized in Table 4. H1 (1a, 1b), H3 (3a, 3b), and H5 (5a, 5b, 5c, 5d) were proposed to test the effects of demographics, ICT access, and purposes for using ICT on attitude towards ICT. As Table 4 shows, only two hypotheses (H3b, H5c) were accepted, which suggests that the frequency of using Office software and the use of ICT for leisure activities do have positive effects on ICT attitude. Family ownership of a computer, grade, disability, and using ICT for learning, social interaction, and daily life needs had no effects on ICT attitude.

Table 4. The summary of the results of hypotheses testing

Hypotheses	Results
Hypothesis1a: Students without LD will have a better attitude towards using ICT than students with LD.	Rejected
Hypothesis 1b: Higher grades will be associated with more positive ICT attitudes.	Rejected
Hypothesis 2a: Students without LD will have higher levels of ICT competency than students with LD.	Accepted
Hypothesis 2b: Higher grades will be associated with higher levels of ICT competency.	Accepted
Hypothesis 3a: Students who have a computer at home will have more positive ICT attitudes than students without a computer at home.	Rejected
Hypothesis 3b: The frequency of using Office software will be associated with more positive ICT attitudes.	Accepted
Hypothesis 4a: Students who have a computer at home will have higher levels of ICT competency.	Rejected
Hypothesis 4b: The frequency of using Office software will be associated with higher levels of ICT competency.	Accepted
Hypothesis 5a: Higher levels of using ICT for learning activities will be associated with more positive ICT attitudes.	Rejected
Hypothesis 5b: Higher levels of using ICT for social interaction will be associated with more positive ICT attitudes.	Rejected
Hypothesis 5c: Higher levels of using ICT for leisure activities will be associated with more positive ICT attitudes.	Accepted
Hypothesis 5d: Higher levels of using ICT for life activities will be associated with more positive ICT attitudes.	Rejected
Hypothesis 6a: Higher levels of using ICT for learning activities will be associated with higher ICT competency.	Rejected
Hypothesis 6b: Higher levels of using ICT for social interaction will be associated with higher ICT competency.	Accepted
Hypothesis 6c: Higher levels of using ICT for leisure activities will be associated with higher ICT competency.	Rejected
Hypothesis 6d: Higher levels of using ICT for daily life activities will be associated with higher ICT competency.	Rejected
Hypothesis 7: Students' with more positive ICT attitudes will demonstrate higher levels of ICT competency.	Accepted

H2 (2a, 2b), H4 (4a, 4b), H6 (6a, 6b, 6c, 6d), and H7 were proposed to examine the effects of demographics, ICT access, purposes for using ICT, and attitude towards ICT on ICT competency. As the results shown in Table 4, five hypotheses were accepted (H2a, H2b, H4b, H6b, H7). Disability, grade, frequency of Office software use, using ICT for social activities, and ICT attitude had significant effects on ICT competency. However, family ownership of a computer and using ICT for learning, leisure, and daily life needs had no effects on ICT competency.

Examining the revised model with a different sample

Data collected from junior high school-age students were used to examine the goodness of fit of the revised model generated from data from elementary school-age students. The revised model (assuming the unconstrained model is correct) had goodness of fit (χ^2 = 132.042, p < .001; GFI = .944; AGFI = .885; CFI = .944, RMSEA = .058; SRMR = .0390; NFI = .912; PNFI = .547; attitude towards ICT: CR = .6352, AVE = .4688; ICT Competency: CR = .8246, AVE = .6119). The model explained 64% of the total variance of ICT competency. Meanwhile, it also explained 27% of the total variance of attitude towards ICT.

In this revised model for junior high school students, the attitude towards using ICT was able to predict ICT competency, with a direct and significant effect (.49, p < .001). The factors which have direct effects on ICT competency are disability, the purpose for social interaction, and frequency of Office software use (-.31, p < .001; .27, p < .001; .15, p = .04). These results also indicate that the purposes of using a computer for leisure and frequency of Office software use have direct predictive effects on ICT attitude (.35, p < .001; .32, p = .04).
Furthermore, the results of the measurement invariance test also indicate that these two ICT competence models - elementary school and junior high school - was invariant ($\triangle\chi^2$ = 1.436, p = .488; $\triangle$NFI = .001; $\triangle$IFI = 0; $\triangle$RFI = -.003; $\triangle$TLI = -.003). The results also reveal that the measurement weights, structural weights, structural covariance, structural residuals, and measurement residuals between these two models were equal, which indicate that no significant difference between the models, thereby confirming the cross-validation of the revised model.

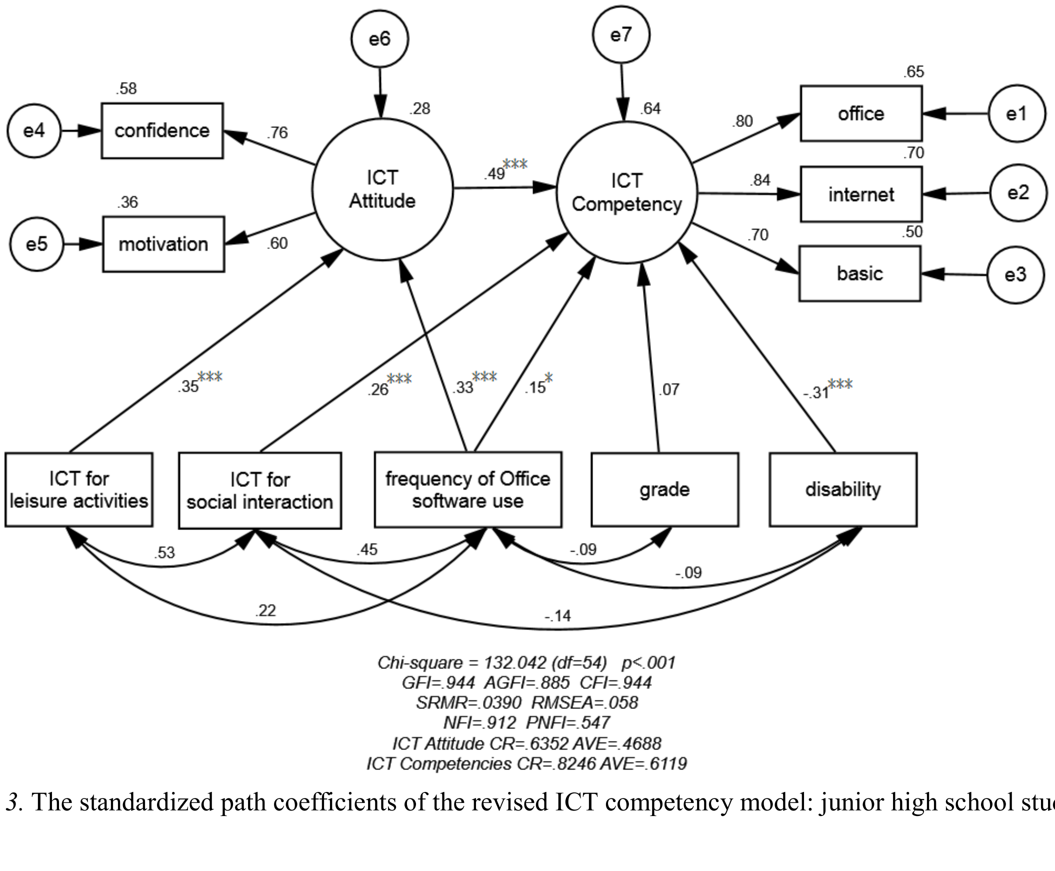

Figure 3. The standardized path coefficients of the revised ICT competency model: junior high school students

Discussion

The present study adopts SEM to explore the roles of proposed variables in explaining students' ICT competency. The revised measurement models shown in Figure 2 and 3 are able to address our research questions. The results of SEM show that the initial ICT competency model had goodness of fit but poor parsimony. Therefore, a revised ICT competency model with parsimony and goodness of fit was generated from data from elementary school age students. Furthermore, this new model was also able to help explain the complex phenomena of ICT competency for junior high school age students, as there was no difference between two models in terms of elementary school and junior high school students.

The explanatory variables, ICT attitude, disability, grade, frequency of Office software use, and using ICT for social and leisure purposes, could explain the 65% and 64% of total variance of ICT skills for elementary and junior high school age students. The percentage of variance explained was as high as the initial ICT competency model (67%). Meanwhile, using ICT for purposes of leisure and frequency of Office software use have direct effects on attitude towards ICT. The other three proposed variables, (1) family ownership of a computer, (2) using ICT for purpose of learning activities and (3) daily life activities, were excluded from the revised model because of their insignificant effect on ICT competence or attitude towards ICT.

One of the most important variables was that of attitude towards using ICT which demonstrated a positive and significant path coefficient with ICT competency, meaning that higher motivation and confidence towards using ICT may influence ICT competency. This study also supports Martin's (2003) perspective, that motivation should be regarded as an important factor for using ICT. It provides a new perspective on understanding the digital divide. Instead of looking at demographic factors, finding strategies for encouraging students to use ICT in their daily life and for learning activities could be a key to enhancing their ICT skills and competencies.

It is noteworthy that frequency of Office software use was the only a factor that influenced both ICT competency and attitude towards ICT. Students with greater frequency of Office software use (such as Word and Power Point) demonstrated better ICT competency and had a more positive attitude towards using ICT. One reason could be that the more one uses ICT, the better competency one develops. This relationship could also could be explained by the direct positive effect of using ICT for purpose of social interaction on ICT competency. In addition, the level of using ICT for social interaction reflects the frequency of using social media. Meanwhile, the competency of using social media might be related to ICT competency. For example, text entry is essential for using social media; uploading pictures or videos is also popular when using social media.

For both elementary to junior high school students, using ICT for learning is an important issue. However, the abovementioned revised model does not include the factor of using ICT for learning. One of the possible reasons might be the low reported use of ICT for leaning activities, with an average of 1.80 for elementary students and 1.75 for junior high students on a 4-point rating scale. Because of low participation, the importance of using ICT for the purpose of learning is not fully appreciated by students. The authors believe that using ICT for learning could provide students opportunities to practice their ICT competency which they also learn from ICT courses in school. This perspective might also be supported by the positive effect of using ICT for social interaction on ICT competency.

From the results of this study, it appears that providing formal ICT courses in school is insufficient. Alongside ICT courses, school should consider creating learning activities which require using ICT, for example for reports, presentations, and online discussions. Additionally, a variety of studies has demonstrated the effects of using ICT for learning, especially for students with disabilities (Starcic & Bagon, 2014). By integrating ICT with learning activities, students can practice and apply the competencies they have learned in the ICT courses, thereby benefitting their ICT competency. This perspective could also be supported by the significant positive effect of the frequency of using Office on ICT competency.

Disability is the single most important issue for us to explore. As the results indicate, disability has a negative effect on ICT competency. Students with LD reported lower ICT competency than their non-LD peers for both groups. The results confirm those of previous studies (Vicente & López, 2010; Wu et al., 2014), which regard disability as an important factor in the persistence of a digital divide. The results of this investigation also provide us an opportunity to reflect on the fact that students with LD perform poorer on ICT competency, even though they take ICT courses with their non-LD peers at school. It is possible that learning ICT skills using the same materials and methods may be inappropriate for students with LD (Wu et al., 2014).

However, disability did not have a significant direct effect on attitude towards using ICT. In other words, the reported attitudes towards using ICT were not significantly different for students with and without LD for both groups. Meanwhile students with a more positive attitudes perform better in terms of ICT competency. In the future, in order to promote attitudes towards ICT, we might offer students with LD specially designed ICT courses which can meet their individual learning characteristics, e.g., difficulties with reading, text entry, and working memory (Hallahan et al., 2004). For example, by providing more steps for the operating process based on the results of task analysis or offering alternative text entry methods, such as voice recognition. We can examine whether or not the influence of disability on ICT competency could be eliminated through offering appropriate ICT courses.

Age was regarded as one of the important factors concerning ICT competency and the digital divide in the previous studies (van Deursen et al., 2011; Enoch & Soker 2006). Grade might represent the effect of age in this study. Grade has a significant positive effect on ICT competency for the elementary school group but has no significant impact for the junior high school group. A ceiling effect might exist, since these ICT competencies which were investigated in this study included basic computer operations, Web use, and Office software use, all of which are essential but basic skills. Students have already started to learn these ICT skills from third grade in elementary school. The previous studies recruited participants ranging from teenagers to elders, but the participants of the current study were all digital natives (e.g., van Deursen et al., 2011). Therefore, the effect of grade on ICT competency was weak for the elementary school group and had no effect for the junior high school group. Meanwhile, we are unsure whether these differences will endure into the future.

The revised model also supports the notion that the digital divide has shifted from physical access to competency and usage (van Dijk, 2006). The "haves and have-nots" (Warschauer, 2003) is not a factor in the model, since more than 90% of students reported having one or more computers at home. Furthermore, the frequency of software usage, and attitude towards using ICT should be emphasized.

The present study illustrates that a revised model, derived through SEM, can illustrate structural relations among the proposed factors and ICT competency in a holistic and comprehensive framework. The model reflects the current situation only. As mentioned above, specially designed ICT courses for students with LD should be provided. And the effect of a new factor, ICT training programs, on ICT competency and attitude towards using ICT should be explored in the future.

In addition, the current study focused on recruiting students with learning disabilities. Although learning disabilities account for the highest percentage of school-age students with disabilities (Hallahan et al., 2004), different types of disabilities might have demonstrated different relationships among the same variables. Therefore, future studies could recruit students with other types of disabilities to exam whether or not the model still fits.

The ICT competency defined in this study focused on traditional laptops and desktops only. But the diffusion of handheld devices, e.g., smartphones and tablets, has reached high levels in developed and developing countries. Meanwhile, mobile learning or ubiquitous learning is also regarded as an essential trend for teaching and learning. Future studies could explore competencies relevant to the operation of handheld devices.

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