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The Development and Validation of a Model of the Intention to Adopt and Integrate ICT into Science Teaching

Pongprapan Pongsophon[1]

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Abstract

This study aims to develop and test a causal model of teachers' intention to adopt and integrate ICT into teaching science, guided by Ajzen's Theory of Planned Behavior. The data were retrieved from the International Association for the Evaluation of Educational Achievement (IEA)'s database on the Second Information Technology in Education Study (SITES) 2006. The sample comprised 679 science teachers from 465 schools in 13 educational service areas in Thailand. To empirically test the model, LISREL 9.1 was employed. The results indicate that the model for ordinal variables provided an acceptable fit to the data ($\chi 2 = 449.08$, df = 239; $\chi 2/df = 1.87$, $p < .01$, RMSEA = 0.05, CFI = .99). Attitude ($\beta = .54$, $p < .01$) and perceived behavioral control ($\beta = .27$, $p < .01$) were significantly related to intention. However, the relationship between subjective norm and intention was not significant ($\beta = .12$, $p > .05$). These three determinants collectively explained 52% of the variance in intention.

Keywords: Structural Equation Modeling, Adoption and Integration of ICT into Science Teaching, Science Teachers

[1] *Corresponding Author,*
Department of Education, Faculty of Education, Kasetsart University, Bangkok, 10900, Thailand.
pongprapan.p@ku.th

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การพัฒนาและตรวจสอบความตรงโมเดลเจตจำนงในการใช้และบูรณการไอซีทีในการจัดการเรียนรู้วิทยาศาสตร์

พงศ์ประพันธ์ พงษ์โสภณ[1]

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บทคัดย่อ

งานวิจัยนี้มีวัตถุประสงค์เพื่อพัฒนาและทดสอบความตรงโมเดลเชิงสาเหตุเจตจำนงในการใช้และบูรณาการไอซีทีในการจัดการเรียนรู้วิทยาศาสตร์โดยใช้ทฤษฎีพฤติกรรมตามแผนของ Ajzen เป็นกรอบแนวคิด ใช้ข้อมูลจากฐานข้อมูลโครงการ Second Information Technology in Education Study (SITES 2006) ของสมาคมนานาชาติเพื่อการประเมินสัมฤทธิ์ผลทางการศึกษา ตัวอย่างวิจัยประกอบด้วยครูวิทยาศาสตร์จำนวน 679 คน จาก 456 โรงเรียน จาก 13 เขตพื้นที่การศึกษา ในการทดสอบความสอดคล้องระหว่างโมเดลกับข้อมูลเชิงประจักษ์ใช้โปรแกรม LISREL 9.1 ผลการวิจัยระบุว่า โมเดลซึ่งในข้อมูลมาตรอันดับให้ดัชนีความสอดคล้องกลมกลืนในระดับที่ยอมรับได้ ($\chi 2 = 449.08$, $df = 239$; $\chi 2/df = 1.87$, $p < .01$; RMSEA = 0.05; CFI = .99) โดยเจตคติ ($\beta = .54$, $p < .01$) และการรับรู้ถึงการควบคุมพฤติกรรมของตนเอง ($\beta = .27$, $p < .01$) มีความสัมพันธ์กับเจตจำนงอย่างมีนัยสำคัญทางสถิติ อย่างไรก็ดี บรรทัดฐานเชิงอัตวิสัยพบว่า ไม่มีความสัมพันธ์กับเจตจำนงอย่างมีนัยสำคัญทางสถิติ ($\beta = .12$, $p > .05$) ตัวแปรทำนายทั้งสามสามารถอธิบายความแปรปรวนของเจตจำนงได้ร้อยละ 52

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[1] *ผู้รับผิดชอบบทความหลัก,*
ภาควิชาการศึกษา คณะศึกษาศาสตร์ มหาวิทยาลัยเกษตรศาสตร์ กรุงเทพฯ 10900
feduppp@ku.ac.th

Introduction

ICTs offer a range of tools for use in school science activities to enhance both practical and theoretical aspects of science teaching and learning. These tools include but not limited to tools for data capture, processing, and interpretation; publishing and presentation tools; information systems; and educational software. With the assistance of these technologies, students' motivation and engagement are improved; self-regulated and collaborative learning facilitated; school and contemporary science linked; and work production expedited living more room for thinking, discussion, and interpretation (Demirci, 2009; Osborne & Hennessy, 2003). Unfortunately, Thai teachers have rarely adopted and integrated ICT in the classroom. This is evidenced in Second Information Technology in Education Study (SITES) 2006, an international comparative study conducted by the International Association for Evaluation of Educational Achievement (IEA). SITES aimed to study information and communication technology (ICT) usage and practices in teaching science and mathematics and its impact on teaching and learning process. The findings show that among the total number of 23 participating education systems, Thailand was reported having comparatively low computer and internet access for pedagogical use (Becker, 2001; Law, Pelgrum, & Plomp, 2008; Plomp, Anderson, Law, & Quale, 2009). In respond to this worrisome reality, Thailand government has launched the Master Plan on ASEAN Connectivity (ASEAN 2011) and national ICT for Education policies, widely known as, Thailand ICT 2020 (Ministry of Information and Communication Technology, 2011). These documents state that Thailand is committed to establishing information infrastructure to enable ICT to improve their competitiveness in the world economy.

Regarding ICT for education, the Ministry of ICT in partnership with the Ministry of Education have promoted the use of ICT in classrooms to enhance quality of teaching and learning, expand access, and sustain life-long learning. The students are encouraged and facilitated to learn to use ICT and use ICT to learn so they gain knowledge and skills and become IT and internet-literate. In terms of teachers' empowerment, the Ministry of Education have initiated a great number of professional development programs aiming at improving teachers' capacity on effective ICT-Pedagogy integration and advocated the development of a whole-school support strategy on selecting, evaluating, and integrating ICT into teaching and learning process (Kijtorntham, Andhivarothai, Kaewkor, & Yamtim 2012).

This present study is carried out to examine the relationship between factors affecting the adoption and integration of ICT into science teaching by developing and testing hypothetical structural equation model. Previous research shows that some of the prevailing factors that determine teachers' use of computers and ICT in the

classroom are found to be associated with teacher personal characteristics such as skills and competency (Preston, Cox, & Cox, 2000), teachers' confidence and development of their self-esteem in using ICT and their pedagogical skills in incorporating ICT (Goldstein, 1997), motivation from significant others (Marcinkiewicz, 1996), and teachers' own technical expertise and professional experience in using computer applications, and their personal involvement in their profession. This study attempted to develop a theoretical structure that can explain teachers' use of ICT in teaching by focusing on psychological factors. A research model elaborated from Ajzen's (1985) Theory of Planned Behavior (TPB), a widely applied theory of social psychology, was proposed and examined. The findings from this study would suggest policy makers, educational administrators, and practitioners the conditions under which science teachers would be more likely to adopt and integrate ICT into his or her science lesson to enhance students' learning.

Research Objective

The present study aims to develop and test a casual model of teachers' intention to adopt and integrate ICT into science teaching guided by Ajzen's Theory of Planned Behavior.

Theoretical Framework

The present study aims to develop and test a casual model of teachers' intention to adopt and integrate ICT into science teaching guided by Ajzen's Theory of Planned Behavior.

The theory of planned behavior (TBP) was proposed by Ajzen (1985). This theory indicates the link between belief and behavior (Ajzen & Fishbein, 1980). It has been tested and confirmed by a number of studies in various fields such as marketing, education, public relation, and education on a number of issues such as condom use, pro-environmental behaviors, intention to prevent becoming overweight and GM food-consumption (Armitage & Conner 2001; Sutton, 1998). The theory states that the strongest or most proximal predictor of behavior is intention. Behavioral intention is an individual's readiness or perceived likelihood that he or she will perform or engage in a given behavior. The intention is thought to be the result of multiple factors including attitude toward performing the behavior, subjective norm, and perceived behavior control.

The attitude toward behavior (ATT) is the degree to which performance of the behavior is positive or negative valued. The attitude is determined by behavioral belief (BB), an individual's belief about the consequences of performing a behavior. The

subjective norm (SN) is the perceived social pressure to engage or not engage in performing a behavior. It is a person's belief about whether other people feel that he or she should perform the target behavior. The subjective norm is influenced by normative belief (NB), an individual's perception of social normative pressure. Perceived behavioral control (PBC, or self-efficacy) is an individual's perceived ease or difficulty of performing a behavior. It is determined by control beliefs (CB) — how that person thinks about the presence of factors that may facilitate or impede performance of the behavior. Perceived behavior control is also found to directly determine actual behavior. These factors have a direct relationship with the intention in that positive attitude toward behavior and more favorable subjective norm, and the greater the perceived behavioral control, the more likely the person would intend to perform the behavior of interest. In the same direction, the perceived behavioral control could be hindered by negative control beliefs, in the case of sustainable behaviors, for example, constraints such as a lack of accessible recycling infrastructure.

When TPB is applied to explain factors influencing teachers' adoption and integration of ICT into teaching in this study, the proposed model is described here (Veen, 1993; Williams, Coles, Wilson, Richardson, & Tuson, 2000). If teachers believe in the benefit of ICT in promoting students' learning (BB), it is likely that they will have positive attitude (ATT) and intend (IN) to adopt and integrate it into teaching and learning process. If adoption and integration of ICT in classroom is a national policy and highly valued by their principal and colleagues, they would intend to follow this social norm (SN) (Marcinkiewicz, 1996). If the teachers perceive a high likelihood of success on using ICT for educational purposes (PBC) and such success is under his or her control (CB), he or she will intend to use ICT in classroom. If teachers have no time committed, no technical and mental support, no understanding from their colleagues and superiors, no collaboration in schools, unsupported structure of educational systems, and restrictive curricula, they will think they could not make it; they would think that it was too difficult to accomplish. They start to lose confidence by these uncontrollable external barriers (Goldstein, 1997). Hence, the hypothetical model to be tested empirically in this study can be illustrated in Figure 1.

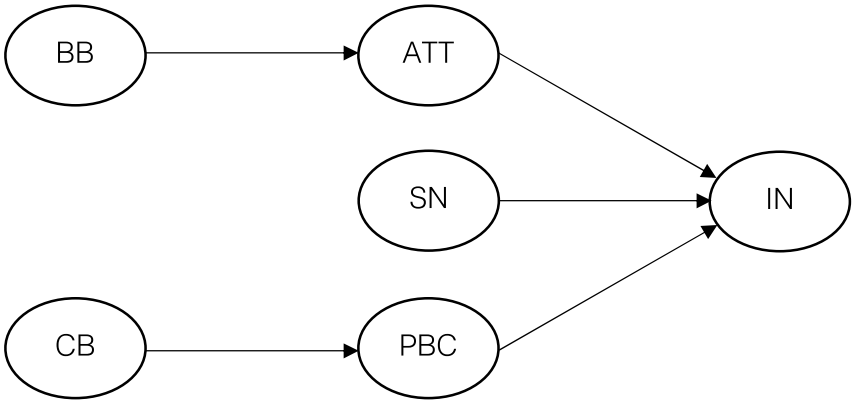


Figure 1 Hypothetical Model of Intention to Adopt and Integrate ICT into Science Teaching.
(ATT: Teacher's perception about the importance of pedagogical use of ICT; BB: Teacher's perception of extent to which school staff hold a shared vision and mission for ICT literacy; PBC: Teacher's self- reported levels of confidence in accomplishing pedagogical use of ICT; CB: Teacher's perception of extent to which various kinds of supports are available; SN: Teacher' s perception that the adoption and integration of ICT in teaching is highly value by their colleagues; and IN: Teachers' priorities for different pedagogical uses of ICT within the next two school year)

Methods

Population and Sample

The empirical data from IEA's Second Information Technology in Education Study (SITES 2006) database was retrieved and used in testing the hypothetical model. There were 23 education systems participating in SITES 2006 including information from roughly 8,000 schools, 13,000 mathematics and 16,000 science teachers. The Thai population, the focus of the present study, were Grade 8 science teachers. The sample comprised 679 science teachers from 465 schools from 13 educational service areas in Thailand using a two-stage stratified cluster sampling design. Explicit stratification variables were school types (public or private), urbanization (urban or rural), and school size (very large, large, medium-size, small, or very small). The implicit stratification variable was the educational service area. Seventy one percent of the respondents were female. Thirty-two percent of the respondents aged between 40-49 years old; followed by 30 percent aged between 30-39 years old. Eighty five percent of the respondents earned a bachelor's degree as their highest level of education. Regarding teaching experience, 56 percent of the teachers had been teaching science for more than ten years. The majority of the respondents (83%) owned a computer at home.

Data Collection

The survey was conducted towards the end of the school year. Each

participating education system appointed a National Center for SITES 2006 to conduct complex sampling, translation, and data collection tasks. The implementation must be in accordance with SITES 2006 guidelines and procedures. The Institute for the Promotion of Teaching Science and Technology (IPST) was appointed by Thai government at the time to be Thailand's SITES center. To ensure high quality and international comparability of data, the natural center has to run several quality control and assurance procedures.

Provided by the national center, IEA's Data Processing and Research Center (DPC) drew school samples, considering national stratification needs. If the selected schools agreed to participate in the study, the national center randomly selected two eligible science teachers using software provided by IEA's DPC. The national center could opt to administer the survey questionnaire online or on paper. The SITES 2006 survey was conducted from March to June 2006. The cleaned data from participating education systems were then weighted and transformed to international database structure; the dataset from different countries consisted of the same variables with the same coding scheme. The SITES 2006 international database and user guide were organized and maintained for public users by IEA aiming to support and promote secondary analysis. The database is accessible on IEA's study data repository website; https://www.iea.nl/data-tools/repository/sites.

Instrumentation

The measure was selected from SITES 2006's Teacher Questionnaire. Six scales from the original version that match the factors in the proposed model were selected and renamed accordingly as follows; attitude towards pedagogical use of ICT (ATT), perceived behavioral control over pedagogical use of ICT (PBC), intention to use ICT (IN), behavioral belief in pedagogical use of ICT (PBC) and control belief (CB) over pedagogical use of ICT. This made up a total number of 24 items (Table 1). All items were measured on a 4-point Likert scale. Each scale (latent variable) is measured by 3 to 6 indicators (manifest variables). The discussion on the measurement model regarding the validity and reliability was given in the result section.

Data analysis

To validate the hypothetical model of the intention to adopt and integrate ICT into science teaching, structural equation modeling or SEM analysis was conducted. Variables in the SEM may influence one-another, either directly or through other variables as intermediaries. In the SEM, a structure of the covariance

matrix of the measures is generated; the parameters of the model are estimated. This implied model is then compared to an empirical covariance matrix to examine whether the two matrices are consistent with one another. If the model fits the data, the structural equation models can be considered a plausible explanation for relations between the measures. With SEM analysis, latent variables can be constructed and unbiased estimates for the relations between latent constructs are derived since measurement errors are considered in the model building.

To analyze the data, LISREL 9.1 statistical package was used. After defining the data, data screening was carried out. The results showed that there were 603 cases with no missing data from the total of 679. The cases with missing value were treated by matching imputation hence 641 complete cases were included as the number of observations in the subsequent analysis. Due to the SITES teacher questionnaire used ordinal response scales, rather than treating the ordinal variables as if they were continuous variables, ordinal data were kept as they were originally in the analysis to prevent misleading results.

Yang-Wallentin, Jöreskog, and Luo (2010) suggested to use polychoric correlations and fit structural equation models to ordinal data using methods such as unweighted least squares (ULS), maximum likelihood (ML), weighted least squares (WLS), or diagonally weighted least squares (DWLS). In their simulation evaluation, they investigated the behavior of these methods in combination with polychoric correlations when the models are mis-specified and study the effect of model size and number of categories on the parameter estimates, their standard errors, and the common chi-square measures of fit when the models are both correct and misspecified. They found that when used routinely, these methods give consistent parameter estimates but ULS, ML, and DWLS give incorrect standard errors. Correct standard errors can be obtained for these methods by robustification using an estimate of the asymptotic covariance matrix of the polychoric correlations. When used in this way the methods are here called RULS, RML, and RDWLS.

The robust diagonally weighted least squares (RDWLS) was used in this study. In this method, input matrices of polychoric correlation and asymptotic covariance were estimated. In LISREL 9.1, the functionality of LISREL and PRELIS are combined, therefore, it is no longer necessary to estimate an asymptotic covariance matrix with PRELIS and read this into LISREL. The RDWLS computes robust chi-squares and subsequent indices, by correcting for non-normality. The two-step approach suggested by Anderson and Gerbing (1988) was followed. First, measurement model (CFA) relating observed variables to latent variables was developed. The goodness of fit of this model was examined. The research examined

the reliability of the measures and the validation (convergent and divergent) of the indicators in relation to the constructs. Then, the full model was tested. The goodness of fit indices of this model was examined. Particular attention was given to CFI (close to 1) and RMSEA (approximately less than 0.06) indices since there had been evidenced in previous simulation study to be more trustworthy than other fit indexes for ordered categorical data (Finney & DiStefano, 2006; Yu, 2002). There is likely to be a practical problem with using chi-square as a sole measure of fit because of its sensitivity to sample size and its assumption of multivariate normality. The hypothesized model in this study is quite complicated and its categorical data, by nature, deviate from normality.

Results

Descriptive statistics

The percentage of teachers' responses to a number of statements indicating constructs in the model are summarized in Table 1. It was found that the majority of the respondents "very much" agreed with all statements indicating the attitudes towards pedagogical use of ICT (ATT) such as ICT for increasing motivation and fostering students' collaborative and organizational skills. This is in correspondence with their responses to the indicator of ATT's determinant, behavioral belief in pedagogical use of ICT (BB). When asked about their perceived behavioral control over a number of indicators to the intention to adopt and integrate ICT into science teaching such as using ICT to monitor students' progress and evaluate learning outcome; using ICT to give effective presentation, the level of confidence was generally dropped to "somewhat" level. This is consistent with its theoretical determinant, the control belief of the intention to adopt and integrate ICT into science teaching. Among the indicators of the control belief, the majority of teachers did not think that the administrative work arising from the use of ICT in his or her teaching was easy to do at school. When asked about the influence of the subjective norm of the pedagogical use of ICT, the majority of teachers reported that they somewhat co-taught with other teachers but discussed the problems with their colleagues and teachers from other schools a lot. Regarding the intention for the pedagogical use of ICT (IN), the majority gave high priority to most of the indicators, except the indicator, "using ICT to provide opportunity for students to collaborate with and learn from people outside their classroom" to which they gave medium priority.

Table 1 Scales and Items Descriptive Statistics

Indicators (SITES's variable names)	Levels (percentage)			
	Not at all	A little	Some what	Very much
Attitude towards Pedagogical Use of ICT (ATT)				
BTG08F1: To increase learning motivation and make learning more interesting	-	1.6	18.3	80.1
BTG08H1: To foster students' ability and readiness to set their own learning goals and to plan, monitor and evaluate their own progress	-	3.1	28.8	68.1
BTG08I1: To foster students' collaborative and organizational skills for working in teams	-	1.7	18.2	80.1
BTG08L1: To prepare students for competent ICT use	1.4	7.4	28.2	63.1
Perceived behavioral control over the adoption and integration of ICT into teaching (PBC)				
BTG21J1: I know which teaching/learning situations are suitable for ICT use.	10.6	22.8	43.7	22.8
BTG21L1: I can use ICT for monitoring students' progress and evaluating learning outcomes.	14.4	29.4	37.6	18.6
BTG21M1: I can use ICT to give effective presentations/explanations.	15.0	29.1	36.5	19.4
BTG21N1: I can use ICT for collaboration with others.	13.0	26.9	39.9	20.2
BTG21P1: I can use the Internet (e.g., select suitable websites, user groups/discussion forums) to support student learning.	9.4	16.4	36.6	37.6
Intention for pedagogical use of ICT (IN)				
BTG22A1: To monitor more effectively the progress of my students.	0.6	5.8	39.4	54.1
BTG22C1: To provide better and more interesting lectures/presentations to my students.	0.5	3.4	30.4	65.7
BTG22E1: To provide more activities that address the individual differences among my students.	0.9	6.9	37.2	54.9
BTG22H1: To involve my students in scientific investigations (involving laboratory work)	1.4	4.2	31.5	62.9
BTG22I1: To provide more opportunities for my students to collaborate with or learn from people outside of their classroom, including peers and external experts	2.3	13.8	42.9	41.0
BTG22K1: To provide more opportunities for my students to collaborate with their classmates	0.9	4.2	29.7	65.1
Behavioral belief in pedagogical use of ICT (BB)				
BTG25A1: We discuss what we want to achieve through our lessons.	1.6	11.4	38.3	48.7
BTG25B1: Teachers are constantly motivated to critically assess their own educational practices.	0.8	7.8	36.8	54.6
BTG25C1: Teachers are expected to think about the school's vision and strategies with regard to educational practices.	0.6	5.5	34.7	59.2
Subjective norm of the pedagogical use of ICT (SN)				
BTG27A1: I co-teach with my colleagues.	12.5	21.6	38	27.9
BTG27B1: I discuss the problems that I experience at work with my colleagues.	1.4	9.1	31.6	57.9
BTG27C1: I work with teachers in other schools on collaborative activities.	5.2	21.6	34.7	38.5
Control belief of the adoption and integration of ICT into teaching (CB)				
BTG28B1: My students can access computers easily outside scheduled class time without my help.	11.7	27.4	36	24.9
BTG28C1: The administrative work arising from the use of ICT in my teaching (e.g., booking computer laboratories, changing class schedules) is easy to do in my school.	20.8	33.2	32.2	13.8
BTG26C1: I am able to implement innovations in my classroom according to my own judgment and insights.	2.5	13	46.3	38.2

Note: For IN, "A little" and "Somewhat" are replaced by "Low priority" and "Medium priority" respectively.
"Very much" is replaced by "A lot" in BB, PBC, SN and CB and "high priority" in IN.

Measurement Model Results

A simultaneous CFA for the measurement model with six constructs was performed. The initial model demonstrated a moderately acceptable with the data (χ^2= 696.75, df = 310, χ^2/df = 2.25, p < .01, RMSEA = 0.07, CFI = .99). After minor modifying model, the final results were improved (χ^2= 464.52, df = 237, χ^2/df = 1.96, p < .001, RMSEA = 0.05, CFI = .99). The results of the measurement model indicate that the factor loadings are generally high, and all are statistically significant. Convergent validity is further evidenced since most indicators' standardized loading on their posited latent construct is greater than twice its standard error. The average variance extracted (AVE) values are higher than .60 except those of subjective norm and control belief. To examine the internal consistency of each scale, Cronbach's alpha was calculated. The Cronbach's alpha values of all constructs are acceptably high.

Table 2 Parameter Estimates of the 6 Constructs' Measurement Model

Constructs	Indicators	Std. Loading	SE	t	Cronbach's alpha	Composite reliability	Variance extracted
Attitude towards Pedagogical Use of ICT (ATT)	BTG08F1	.83	-	-	.77	.90	.69
	BTG08H1	.87	0.06	18.35			
	BTG08I1	.86	0.06	17.27			
	BTG08L1	.75	0.06	14.78			
Perceived behavioral control over the adoption and integration of ICT into teaching (PBC)	BTG21J1	.85	-	-	.93	.95	.80
	BTG21L1	.89	0.03	36.52			
	BTG21M1	.95	0.03	38.49			
	BTG21N1	.94	0.03	37.76			
	BTG21P1	.84	0.03	32.74			
Intention for pedagogical use of ICT (IN)	BTG22A1	.87	-	-	.89	.94	.73
	BTG22C1	.92	0.03	33.92			
	BTG22E1	.86	0.03	31.83			
	BTG22H1	.84	0.04	23.94			
	BTG22I1	.79	0.03	26.85			
	BTG22K1	.85	0.03	28.45			
Behavioral belief in pedagogical use of ICT (BB)	BTG25A1	.86	-	-	.87	.93	.82
	BTG25B1	.94	0.04	27.52			
	BTG25C1	.93	0.04	29.93			
Subjective norm of the pedagogical use of ICT (SN)	BTG27A1	.61*	-	-	.60	.70	.45
	BTG27B1	.77	0.13	9.53			
	BTG27C1	.60	0.11	8.92			
Control belief of the adoption and integration of ICT into teaching (CB)	BTG28B1	.59	-	-	.63	.70	.44
	BTG28C1	.63	0.08	13.16			
	BTG26C1	.75	0.10	11.71			

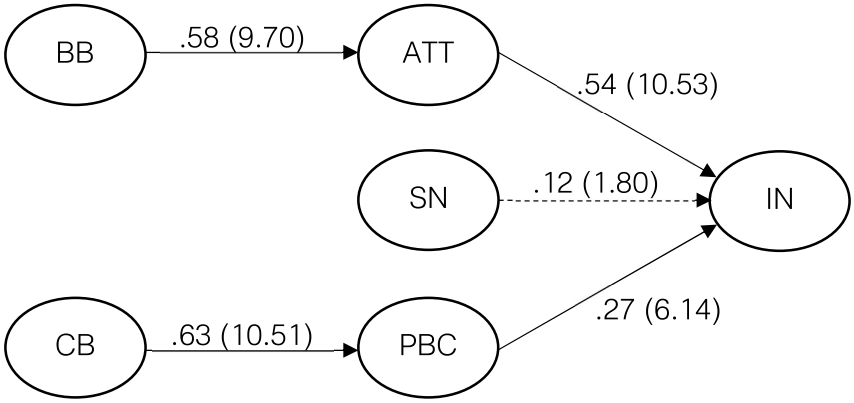
Discriminant validity is assessed by comparing the shared variance (squared correlation) between each pair of constructs against the average of the AVEs for those constructs. The variance extracted estimates should be greater than the squared correlation estimate. This criterion was met in this study as shown in Table 3.

Table 3 Results of Discriminant Validity Examination

Constructs	Squared Correlation (Average variance extracted for each pair of a construct.)				
	PBC	IN	BB	SN	CB
ATT	.12 (.69, .80)	.39 (.69, .73)	.18 (.69, .82)	.16 (.69, .45)	.16 (.69, .44)
PBC		.17 (.80, .73)	.09 (.80, .82)	.08 (.80, .45)	.42 (.80, .44)
IN			.23 (.73, .82)	.15 (.73, .45)	.20 (.73, .44)
BB				.33 (.82, .45)	.33 (.82, .44)
SN					.36 (.45, .44)

Full Model Analysis

Beck and Ajzen (1991) suggest that to predict behavior, it may sometimes be sufficient to consider only intentions. The structural model has the same indicator structure as the measurement model but included direct paths from attitudes, norms and behavioral control to intentions and from behavioral beliefs to attitudes and from believed control to perceived behavioral control. The structural model provided a good fit to the data (Chi- square = 449.08, df = 239; χ^2/df = 1.87, $p < .001$; RMSEA = 0.05; CFI = .99). Attitudes (β = .54, $p < .01$) and perceived behavioral control (β = .27, $p <$ .01) were significantly related to intentions. However, the relationship between subjective norm and intention was not significant (β = .12, $p > .05$). These three determinants collectively explained 52% of the variance in intentions. Behavioral beliefs (β = .58, $p < .01$) and control belief (β = .63, $p < .01$) were significantly related to attitude and perceived behavioral control respectively. Behavioral beliefs could explain 34% of the variance in attitude and control belief could explain 40% of the variance in perceived behavioral control. The direct effects from attitude, subject norm, perceived behavior control to intention is .54, .12, and .27, respectively. Mediated by attitude, the indirect effect from behavior beliefs to intention is .31. The indirect effect of control belief mediated by perceived behavior control on intention is .17.



Chi-Square = 449.08, *df* = 239, *p*-value < .01, RMSEA = 0.05

Figure 2 Fitted Model of Intention to Adopt and Integrate ICT into Science Teaching. (Standardized coefficients with t value in the parentheses. Dashed lines denote nonsignificant relationships)

Discussion

The findings of this study confirm the theory of planned behavior and are consistent with a number of previous studies that have applied this theory to explain performing a particular behavior (Harding et al. 2007; Stone et al. 2007). Attitude toward pedagogical use of ICT and perceived behavior control pedagogical use of ICT were positively associated with the intention to adopt and integrate ICT into teaching science. Behavioral belief and control belief have positive correlation with the attitude toward and perceived behavioral control over pedagogical use of ICT, respectively (Hou, Lin, Shen, & Zhou, 2022). A notable finding of this current study was support for the attitude. It could predict the intention better than perceived behavioral control and norm of pedagogical use of ICT.

This finding is consistent with the study of Demirci (2009) that discovered that Turkish teachers who had negative attitude towards Geographic Information systems (GIS) as neither fulfilling their needs nor their students' needs would not integrate the technology into teaching Geography. If teachers' attitudes were positive, they could provide useful insight and showed intention to adopt and integrate ICT into teaching and learning process (Bahcivan, Gurer, Yavuzalp, & Akayoglu, 2019). The finding also corroborates that of Drent and Meelissen (2008), who conducted a large-scale survey with Dutch teachers in 2008. Their findings indicate that the attitude toward computers has a direct and strong influence on the innovation use of ICT by the teachers. This study found that perceived behavioral control over pedagogical use of ICT positively related to their intention to adopt and integrate ICT into science teaching. This confirms a number of previous studies just to name a few (Yuen & Ma 2008; Peralta & Costa 2007). These studies found that

teachers' judgment of their capability to use a computer influenced their intention and use of ICT in classroom.

However, the results did not confirm the hypothesized relations between SN and the intention. This is consistent with the previous studies conducted by Cuban (1999) and Hansen and Jensen (2007). They found that the effect of subjective norm was insignificant and very low in the full model. They explained that a potential cause for the insignificance of the relation between SN and intention may be the involvement of "individualism" that could affect peoples' decision making. Striving for individualism leads to the rejection of dependency (Pchiffman & Kanuk 2004). People holding this value are less likely to incline to follow the guidance of other people in order to reinforce their feeling of independence and self-identity. The relationship between subjective norm and intention in this study may be moderated by individualism. For those lacking individualism, the subjective norm may influence the intention but for people holding this value and positive attitude towards pedagogical use of ICT, they would adopt and integrate ICT into their teaching regardless the subjective norm (Admiraal et al., 2017). The subjective norm was more relevant to the individuals who could access the collective self in a prominent manner. This collective self is dependent upon interpersonal bonds to others. People showing affiliation to in-group membership would be more concerned about the adoption and integration of ICT into teaching and the impact of subjective norm may be more pronounced on the intention. If the teachers lacked interpersonal skills, they could not build relationships, gracefully collaborate with other teachers so they could neither be influenced nor be influenced by their peers. In addition, teachers may not be aware that their influence is what can make the difference in their teaching practice. They may be very humble to show off, regarding this as a good manner in public, especially when working with senior teachers or prefer to stay in the safe zone when working in a team. This is quite common value and practice among Thai people.

Implication of the Study

It was evidenced in this present study that the behavioral belief influenced science teachers' attitude toward pedagogical use of ICT. That means that the more the teachers belief in the impact of ICT in their teaching practice and students' learning, the more positive attitude toward pedagogical use of ICT and in turn, more likely they would intend to adopt and integrate ICT into their science lessons. To enhance teachers' behavioral belief of pedagogical use of ICT, in professional development, they should be given a role of learners. They should witness and directly experience the desirable consequences of the pedagogical use of ICT; more

interesting, fun and engaging than a plain lesson. Alternatively, they are asked to watch the video of an effective ICT driven science lesson and encouraged to critically reflect upon and exchange ideas with fellow participants on whether and how ICT were adopted and integrated into science lesson and its effectiveness regarding students' learning. In addition, they should be encouraged to try it themselves—designing a lesson and have a micro teaching and get instant and constructive feedback from the instructors and other participants. Technical difficulties and related issues in using ICT should be brought about. Tips and techniques to deal with these problems and challenges should be discussed so the participants are, in advance, well equipped and feel best prepared for the coming reality and uncertainty when they return to school. This would boost their perceived behavioral control of ability to use ICT in classroom, another significant determinant of the intention to adopt and integrate ICT into teaching.

Factors that demote the use of ICT include lack of support from the school principals, lack of allotted time to implement the work plan and lack of financial and human resources. These uncontrolled realities seriously diminish teacher's perceived behavior control and in turn lessen the intention to adopt and use ICT. To resolve such constraints and limitations, it is advisable for the professional developers to invite administrator and school/district education leader to participate and contribute inputs throughout the process of the design and implementation of the professional development program so they would gain senses of ownership, leadership and responsibility and would follow up and facilitate the teachers' adoption and integration of ICT in teaching on site. They would build a collaborative working environment in school, so the subjective norm would matter and take effect. Like target teachers, these school principals and head teachers should be empowered so they would appreciate pedagogical use of ICT, build capacity and have commitment to promote, support and sustain the implementation of the educational innovation.

References

Admiraal, W., van Vugt, F., Kranenburg, F., Köster, B., Smit, B., Weijers, S., & Lockhorst, D. (2016). Preparing pre-service teachers to integrate technology into K–12 instruction: Evaluation of a technology-infused approach. *Technology, Pedagogy and Education, 26*(1), 105–120. https://doi.org/10.1080/1475939x.2016.1163283

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhi & J. Beckmann (Eds.) *Actionócontrol: From cognition to behavior*, (11-39). Springer.

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior.* Prentice Hall.

Anderson, J. C., & Gerbing, D. W. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 103*(3), 411- 423.

Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta- analytic review. *British Journal of Social Psychology, 40*, 471–499.

ASEAN (2011). Master plan on ASEAN connectivity: One vision, one identity, one community. Retrieved from http://www.aseansec.org/documents/MPAC.pdf.

Becker, H. J. (2001, April). *How are teachers using computers in instruction?* Paper presented at the Annual Meeting of the American Educational Researcher Association, Seattle.

Bahçıvan, E., Gürer, M. D., Yavuzalp, N., & Akayoğlu, S. (2019). Investigating the Relations Among Pre-Service Teachers' Teaching/Learning Beliefs and Educational Technology Integration Competencies: a Structural Equation Modeling Study. *Journal of Science Education and Technology, 28*(5), 579–588. https://doi.org/10.1007/s10956-019-09788-6

Cuban, L. (1999). The technology puzzle: Why is greater access not translating into better classroom use? *Education Week, 4*, 68.

Demirci, A. (2009). How do teachers approach new technologies: Geography teachers' attitudes towards Geographic Information Systems (GIS). *European Journal of Educational Studies, 1*(1), 43-53.

Drent, M., & Meelissen, M. (2008). Which factors obstruct or stimulate teacher educators to use ICT innovatively? *Computers & Education, 51*(1), 187-199.

Finnay, S. J., & DiStefano, C. (2006). Non-normal and categorical data in structural equation modeling. In G.R. Hancock & R. O. Mueller (Eds.), *Structural equation modeling: A second course.* Information Age Publishing.

Goldstein, G. (1997). *Information technology in English schools: A commentary on inspection findings 1995-6.* Coventry: NCET/OFSTED.

Hansen, T., & Jensen, J.M. (2007). Understanding consumers' political voting decisions: A Theory of Planned Behavior *Approach. Innovative Marketing, 3*(4), 86-93.

Hou, M. Lin, Y. , Shen, Y., & Zhou. (2022). Explaining pre-service teachers' intentions to use technology-enabled learning: An extended model of the Theory of Planned Behavior. *Frontier in Psychology, 13*, 1-13.

Kijtorntham, W., Andhivarothai, P., Kaewkor, S., & Yamtim, W. (2012). Scenarios of Thai pre-service teacher education in the next 20 years: Applying of futures wheel technique. *Journal of Research Methodology, 25*(3), 275-294.

Law, N., Pelgrum, W.J., & Plomp, T. (Eds.). (2008). *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study.* CERC- Springer.

Marcinkiewicz, H. (1996). *Motivation and teachers' computer use.* Paper presented at the Proceedings of selected research and development presentations at the 1996 National Convention of the Association for Educational Communications and Technology, ED 397 818.

Ministry of Information and Communication Technology (MICT). (2011). *Executive summary of the Thailand ICT Policy Framework: 2011-2020 (ICT 2020).* Retrieved from http://www.ict2020.in.th

Osborne, J., & Hennessy, S. (2003). *Literature review in Science and the role of ICT: Promise, problems, and future directions.* Futurelab Series

Peralta, H., & Costa, F.A. (2007). Teachers' competence and confidence regarding the use of ICT. *Educational Sciences Journal, 3*, 75-84.

Plomp, T., Anderson, R. E., Law, N., & Quale, A. (2009). *Cross-national information and communication technology: Policies and practices in education (2nd ed.).* Information Age Publishing.

Preston, C., Cox, M. J., & Cox, K. (2000). *Teachers as innovators: An evaluation of the motivation of teachers to use information and communications technologies.* Mirandanet.

Sutton, S. (1998). Predicting and explaining intentions and behavior: How well are we doing? *Journal of Applied Social Psychology, 28*(15), 1317-1338.

Veen, V. (1993). The role of beliefs in the use of information technology: implications for teacher education or teaching the right thing at the right time. *Journal of Information Technology for teacher education, 2*(2), 139-153.

Williams, D., Coles, L., Wilson, K., Richardson, A., & Tuson, J. (2000). Teachers and ICT: current use and future needs. *British Journal of Educational Technology, 31*(4), 307-320.

Yang-Wallentin, F., Jöreskog, K. G., & Luo, H. (2010). Confirmatory factor analysis of ordinal variables with misspecified models. *Structural Equation Modeling: A Multidisciplinary Journal, 17*(3), 392-423.

Yu, C.Y. (2002). *Evaluating cutoff criteria of model fit indices for latent variable models with binary and continuous outcomes* (Unpublished doctoral dissertation). University of California, Los Angeles.

Yuen, A. H. K., & Ma, W. W. K. (2008). Exploring teacher acceptance of E-learning technology. *Asia-Pacific Journal of Teacher Education, 36*(3), 229-243.