Malaysian Journal of Educational Technology
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Modelling the Determinants of Malaysian Novice Science Teachers in Computer Use

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In Malaysia, there is widespread recognition that computer can play a powerful role in supplementing and complimenting the process of teacher's teaching and learning. Given current recognition of the value of computer integration, as well as the investment costs that technologies represent for schools, this study attempted to build a model that able to investigate the determinants of novice science teachers in the use of computer. It examines the direct and indirect effects of the exogenous and endogenous variables towards with computer use. A total of 178 science teachers completed the questionnaire measuring their responses to learning outcomes (LO), computer attitudes (CA), computer teaching efficacy (CTE) and school environment (SE) and computer use (CU). Structural Equation Modelling (SEM) was used as the main technique for data analysis. Results reported that the four determinants in the research model in this study explain 64.7% of the variance in computer use. Among them, learning outcomes and computer teaching efficacy did not have direct effects towards computer use. Overall, the findings have support most of the existing theories and assumptions that those selected exogenous and endogenous variables affected the computer use among teachers. In short, the study provided wider implications for theory development, practices and policymaking that can be associated with the computer use among novice science teachers.

Keywords Educational technology, technology integration, novice science teachers, structural equation modelling

Introduction

In this Information Age, like other developed countries, there is a clear recognition that technologies can transform conventional education system and bring more advantages and benefits to Malaysians, especially for the younger generation. Malaysian schools have devoted considerable resource to technology. Malaysian schools and colleges have included computer technology as an integral part of students learning experiences and as a way to equip them with the skills and knowledge necessary to succeed in the 21st century. Many ministers have expressed strong desire to use technology in creating classroom-to-classroom connections via the internet as a way to build cultural awareness and foster studying habits. The Ministry of Education in Malaysia had emphasized that public education system, either primary or secondary schools must ensure all students have equal access to computer-based technology support for academic success, regardless of social or economic status.

The push to incorporate and integrate technology in classroom teaching from all levels became much stronger and vital in Malaysian education system after the introduction of Smart School. The Smart School is one of the seven flagships applications underlying Multimedia Super Corridor (MSC) which began its operations in 1997. The objectives of the Smart School are to develop technology savvy individuals and eradicate computer illiteracy. Such strategies began with RM150 million allocated for 1340 schools to develop their multimedia facilities and computer laboratories, thus paving the way for a revised school curriculum. Moreover, the Malaysian government has established various institutions, such as the National Information Technology Council (NITC), the Malaysian Institute of

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

Microelectronics Systems (MIMOS), the Communications and Multimedia Commission (CMC) and the Multimedia Development Corporation (MDC) to encourage the use of computer related technologies in the Malaysian society. Billions of Ringgits have been poured into the educational sector to acquire necessary equipment. Funding efforts over the past few years have dramatically increased the availability of computer technology for teachers and students use in schools across Malaysia.

The study

This study was focused on a single academic subject, science. As not only is science providing authentic contexts and meaningful purposes for literacy learning, it is also providing opportunities to develop a wider range of literacies such as using science as a tool for discovery and contributing to problem solving. There is a growing corpus of research that suggests that the use of technologies improves teaching and learning for Science (Hennessy, Deaney, Ruthven, & Winterbottom, 2007, Higgins, Beachamp & Miller, 2007; Preston & Mowbray 2008; Murcia, 2008a, 2008b; and Murcia & Sheffield, 2010). The use of technologies in teaching could be easier to capture students' imagination and attention if compared to conventional instructional methods. Comparison between contemporary and current scientific knowledge and practices can be done spontaneously by connecting computer with World Wide Web. Besides, it will help the teacher to show the concepts of science in very simple ways. Teachers using technology tools in the classrooms believe that the learner is able to retain the concepts rapidly and provide an apprehensive approach towards Science (Murcia & Sheffield, 2010). Advocates also noted that, technology tools have become very suitable to encourage collaborative and constructive learning which highly emphasized in science classrooms. Furthermore, based on Malaysian science curriculum, science subject in which educational technologies are frequently employed.

In conjunction with the importance of technologies in teaching science, a pre-research study has been carried out to understand the actual use of technology among teachers. Total of 38 novice primary and secondary school teachers involved in this survey. Results revealed that teachers were not making appropriate use of computer in schools and they have scored low level, less than once a month, of computer use in their daily teaching and learning activities. Nevertheless, these groups of teachers had been trained to be computer literate while they were in teacher educational programs.

Given the vital role of technology in teaching and learning for science, and growing concern that many Malaysian novice science teachers lack of interest in it, time has come to review and examine factors that influence computer use among these them. From the findings of this study, science's policymakers and teacher educators can have a better picture on the factors which have the most influential impacts on computer use and thus, design a curriculum that can boost the level of computer use among teachers. Hence, this study seeks to assess the extent to which learning outcomes (LO), computer attitudes (CA), computer teaching efficacy (CTE), school environment (SE) explain the computer use (CU) among novice science teaching in teaching and learning.

Research model and hypotheses development

Computer Attitudes

Several models have explained the relationship between attitudes and intention or actual behavior. Among those notable models are Technology Acceptance Model (TAM)

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

(Davis, 1989), Theory of Reasoned Action (TRA) (Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980), Theory of Planned Behavior (TPB) (Ajzen, 1985) and Multi-Attribute Attitude Model (MAA) (Wilkie & Pessemier, 1973). TAM, TPB, TRA and MAA were based on the relationship of attitude-intention-behavior (actual) constructs. Based on those models and theories, attitudes construct has been the main focus. Ajzen and Fishben (1977) argued that by understanding an individual's attitude toward an object, one can predict his or her overall pattern of response to the object. An individual's attitude represents an individual's personal convictions and feelings towards a specific object or behavior. Generally, a person who believes that performing a given behavior will lead to positive outcomes will hold a favourable attitude toward performing the behavior. On the other hand, a person who believes that performing a given behavior will lead to negative outcomes will hold an unfavourable attitude toward performing the behavior. Based the above statement, the following hypothesis was formulated.

H1. CA will have a significant influence on CU.

Computer Teaching Efficacy

According to Bandura's social cognitive theory (Bandura, 1977), individual with high self-efficacy will have better ability to cope with roadblocks and endure stress related to change. Conversely, an individual with low self-efficacy will be less likely to attempt innovation or follow through as barriers arise. Many previous researchers, such as Gibson and Dembo (1984), Riggs and Enochs (1990), Marcinkiewicz (1994), Torkzadeh, Pfulghoeft and Hall (1999), Gibson (2001), Tracey *et al*. (2001), Bandura (2001), Cassidy and Eachus (2002) and Sugar (2002) have suggested that self-efficacy, by itself, will influence actual performance and practices.

According to the Bandura's theory, there are two dimensions of expectancies of behavior; efficacy beliefs and outcome expectation. Efficacy belief is the feelings of confidence in performing certain task. Outcome expectation was defined as the belief about the consequences that action will produce. Given those two dimensions, this study hypothesized that CTE which includes teacher's personal evaluation on their own capability to use computer for teaching (efficacy beliefs) and learning and personal beliefs in using computer as an effective teaching method to improve student's motivation and performance in learning (outcome expectation) have impact on computer use.

H2. CTE will have a significant influence on CU.
H3. CTE will have a significant influence on CA.
H4. CTE will have a mediating effect towards LO and CA.

Learning Outcomes

In this study, learning outcomes defined as how much the trainees have learnt and retained after undergoing training from the teacher educational training program. Based on previous training transfer models, higher level of training transfer could occur when there were positive learning outcomes (Goldstein & Ford, 2002; Phillips, 1997; Kirkpatrick, 1996; Rouiller & Goldstein, 1993; Baldwin & Ford, 1988; Noe, 1986). Those previous researchers also noted that there was a direct significant relationship between learning outcomes and the actual performance in activities or tasks. This means, learning outcomes can determine the level of actual transfer. For transfer to occur the trainees must be able to generalize the

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

material presented in their training session to their current surroundings and they must be able to maintain their knowledge base over a period of time.

Regarding the impact of learning outcomes towards attitudes, Noe's (1986) model has proven that learning outcomes could change individual's attitudes towards the object. Noe notes that learning outcomes have statistically significant towards behavior change. In Rouiller and Goldstein's (1993) study, which investigated into the influences of the level of learning outcomes on trainees' attitudes and beliefs also noted the same result. From their findings, it was established that individuals who learn more in training were more likely to have positive attitude and self-efficacy toward the behavior and transfer their newly learned behavior on the job. Based the above statement, the following hypotheses were formulated.

H5. LO will have a significant influence on CA.
H6. LO will have a significant influence on CTE.
H7. LO will have a significant influence on CU.

School Environment

In this study, school environment refers to the support from administrators, such as non-academic staff, principal and senior assistants and technical support like facility availabilities when adopting computer in teaching and learning process. The study has hypothesized that the higher the support from school environment, the higher the use of computer in teaching and learning. In Goldstein and Ford's (2002) model, the working environment acted as important variable towards actual outcomes. ChanLin, et al. (2006) and ChanLin (2007) noted that the school environment play important role in the use of computer in teaching and learning. Based the above statement, the following hypothesis was formulated.

H8. SE will have a significant influence on CU.

Method

Research Design

The purpose of this study is to modelling the determinants of novice science teachers in the use of computer in teaching and learning. This study employs a structural equation modelling (SEM) approach to develop a model that represents the relationships among five variables in this study: computer attitudes, computer teaching efficacy, learning outcomes, school environment and computer use. Data were collected through using a survey questionnaire comprising questions on demographics and multiple items for each variable in the research model.

Sample Characteristics

Participants in this study consisted of novice science teachers from teacher training colleges in Malaysia. Some criteria were adopted to determine the actual accessible population.

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

Firstly, the respondents must have gone through the training course on full time basis and be fully trained by those training colleges. Secondly, trainee teachers who have gone through combined courses with other higher institutions, such as universities were not eligible for this study. Finally, they must have been appointed as trained teachers and in the meantime were waiting for the confirmation letter from Ministry of Education, Malaysia. These criteria were considered appropriate and relevant in the context of the study as they ensured that the respondents belonged to the fresh graduate group. Participation by the teachers was wholly voluntary. A total of 178 respondents, representing a response rate of 46.3%, completed the survey. This response rate was lower than expected, but it seemed to be the normal rate of mailed survey in Malaysia (Hong & Koh, 2002). Among of these participants, 63.5% (113) were female and the mean age of all participants was 27.3 years (SD = 3.14). The majority of the teachers had access to technologies teaching tools in schools with mean usage 3.04 (SD = 0.89).

Instruments and Data Collection

A structured questionnaire was developed as the mode of data collection. The survey question composed of 5 constructs and 15 items on computer use (CA), learning outcomes (LO), computer attitudes (CA), computer teaching efficacy (CTE) and school environment (SE). Respondents were asked to indicate the items on a four Likert scale whether they strongly disagree (1), slight disagree (2), slight agree (3) and strongly agree (4) with the statements. Each item was coded so that the higher the score, the more positive the level of entire construct. These items were adapted from various published sources. The questionnaires were distributed by post and by personal delivery.

Model Building and Testing: Analysis and Results

In this study, two phases analysis have been carried out. The first phase revealed the preliminary analysis which examined the descriptive statistics of the measurement items, and assessed the reliability and validity of the measure used in this study. This was to ensure the data adequate for structural equation modelling testing. For second phase, assessments on the contributions and significance of the manifest exogenous and endogenous variables towards computer use among teachers have been done.

Preliminary Analysis

A descriptive analysis was preliminarily carried out on variables involved. Computer attitudes, computer teaching efficacy, learning outcomes, school environment and computer use have been identified for their mean and standard deviation (Table 1). All means scores are > 2.5 of the midpoint, ranging from 2.5 to 3.6. This indicates an overall positive response to the scales in the study. The standard deviation (SD) values have proven that a narrow spread around the mean. Multivariate normality can be assessed through the inspection of univariate distribution index values, with univariate skew indexes greater than 3.0 and kurtosis indexes greater than 10 indicative of unacceptable non-normality (Kline, 2005). Skew and kurtosis indices for all scales are under 1.5. Internal reliability was adequate for all measures. The data in this study is regarded as normal for the purposes of structural equation modelling.

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

Table 1 Descriptive statistics of the study constructs

Construct	Mean	Standard deviation	Skewness	Kurtosis
Learning outcomes	2.75	.91	-.09	-1.28
Computer attitudes	3.63	.48	-1.30	1.22
Computer teaching efficacy	2.52	.73	.02	-.68
School environment	2.53	.90	-.12	-.01
Computer use	2.46	.79	-1.08	-1.07

To ensure the constructs have the high reliability and validity, convergent-discrimination test has been carried out. Underlying convergent-discrimination analysis, item reliability, composited reliability (CR), average variance extracted (AVE) and discriminate validity of each construct have been examined. The item reliability of an item was assessed by its factor loading onto the underlying construct. Table 2 shows all the items in the measurement model ranged from 0.60 to 0.96. A factor loading of 0.50 and above was considered to be a well-defined structure (Hair, et al., 1992).

The composite reliability (CR) of each construct was assessed using Cronbach's alpha. The composite reliability for all the factors in the measurement model range from 0.73 to 0.89 (Table 2) and it exceeds the recommended threshold value (Sekaran, 2003). According to Sekaran (2003), if the value of Cronbach's alpha is coefficient less than .60, the reliability is low, between .60 and .80 is moderate and acceptable, and more than.08 is high.

Table 2 Results for the measurement model

Latent Variable	Item	Factor Loading (>.60)*	Average Variance Extracted (= or >.50)*	Composite Reliability (= or >.70)*
Computer Teaching Efficacy	CTE1	.814	.61	.728
	CTE2	.898		
	CTE3	.601		
Computer Attitudes	CA1	.856	.53	.757
	CA2	.769		
	CA3	.845		

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

Learning Outcomes	LO1	.911	.67	.841
	LO2	.912		
	LO3	.792		
School Environment	SE1	.919	.82	.889
	SE2	.835		
	SE3	.962		
Computer Use	CU1	.687	.65	.731
	CU2	.858		
	CU3	.869		

[a] AVE: Average Variance Extracted = (∑λ2) / (∑λ2) + (∑(1 – λ2)).
[b] Composite Reliability = (∑λ2) / (∑λ2) + (∑ (1 – λ2)).
[c] This value was fixed at 1.00 in the model for identification purposes.
*Indicates an acceptance level or validity.
***p* < .01.

According to Segars (1997), in order to ensure the AVEs index are adequate for testing structural equation modelling, it should equal or exceeds 0.50. Table 2 shows that the AVEs for each measure exceeded 0.50. This means that more than one-half of the variance observed in the items was accounted for by their hypothesized factors. Factor loadings, composited reliability coefficient and AVEs meet the recommended guidelines, indicating that the convergent validity for the proposed constructs of the measurement model is adequate for structural equation modelling.

Table 3 shows the results of testing the discriminant validity of the measure scales. Discriminant validity is present when the variance shared between a construct and any other construct in the model is less than the variance that constructs shares with its indicators. If the square roots of the AVEs are greater than the off-diagonal elements in the corresponding rows and columns, it suggests that the given construct is more strongly correlated with its indicators than with the other constructs in the model (Teo, 2009). The elements in the matrix diagonals, representing the square roots of the AVEs, are greater in all cases than the off-diagonal elements in their corresponding row and column. The values suggest that discriminant validity was present at the latent variables in the proposed research model.

Table 3 Discriminant validity for measurement model

	LO	CTE	CA	SE	CU
LO	(.82)				
CTE	.37**	(.78)			
CA	.42**	.37**	(.73)		
SE	.12*	.01	-.02	(.90)	

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

CU	.14**	.12*	.11	.79**	(.80)

Note: Diagonal in parentheses: square root of average variance extracted from observed variables (items); Off-diagonal: correlations between constructs.
**p* < .05; ***p* < .01.

Test of the Structural Model

In this study, computer program software AMOS18 (Arbuckle, 2005) has been used to test the research model underlying structural equation model approach (SEM). The five absolute fit indices: χ^2 goodness-of-fit statistic, χ^2/df, Goodnees of Fit (GFI), Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and Standardized Root Mean Square Error of Approximation (RMSEA) have been assessed. Absolute fit indices measure how well the proposed model reproduces the observed data. According to Hair, et al (2010), the value of GFI and CFI should more than 0.95 and RMSEA smaller than 0.05 to be considered good fit. For χ^2/df, the value below 3 is considered acceptable. TLI value should greater than 0.90 (Byrne, 2001).

As part of testing of the structural model, several models were computed. Firstly, assessment on the null hypothesis model (M0). The null hypothesis model (M0) indicated that all the determinants to be uncorrelated. Second, tested the direct effect model (M1); LO → CU, CA →CU, CTE→CU, SE → CU and all other paths were set to zero. Next testing was fully correlated model (M2); LO → CU, LO →CA, LO→CTE, CA →CU, CTE→CA, CTE→CU, SE → CU, SE →CTE, and SE→CA.

Table 4 shows that some statistics shown in M0, M1 and M2 did not reach the minimum thresholds typically requested for an acceptable fit. These findings suggested that an improvement in the model was still possible to reach an acceptable fit model. Testing for partial correlated model (M3) has been carried out. Based on the minimum thresholds for acceptable model's fit, modified model was built as depicted in Figure 1. Only significant structural paths were retained in this rival model. Estimation of this modified model showed much better fit statistics, which reached minimum thresholds for acceptable model's fit (χ^2 = 6.311, p<0.01; χ^2/df =1.26; GFI=.99; CFI=.99; TLI=.99 and RMSEA = 0.04).

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

Table 4 Fit indices and comparison of alternative models

Model	χ^2	*df*	GFI	CFI	TLI	RMSEA	χ^2/df	$\Delta\chi^2(df)$sig	Comparison
Null model									
M0	264.307**	10	.00	.00	.00	.38	26.43		
Direct model									
M1	75.742**	6	.84	.73	.54	.26	12.62		
Fully correlated model									
M2	14.634*	2	.97	.95	.75	.19	7.32	(4), 61.11**	M2 vs M1
Partial correlated model									
M3	6.311(ns)	5	.99	.99	.99	.04	1.26	(3), 8.32 **	M3 vs M2
Multi-Group									
M4	18.815(ns)	15	.96	.98	.98	.04	1.25		
(Constrained model)									
M5									
(Unconstrained model)	10.009(ns)	10	.99	.99	.99	.02	1.00	(5), 8.80 (ns)	M5 vs M4

*p<.05; **p<.01

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

Finally, for validating the model (M3), multi-group analysis has been done. A multi-group analysis was carried out to verify whether significant differences exist between two random samples underlying same model. This analysis consisted in comparing a constrained model, in which the paths of the measurement and structural models were constrained to be equal, against an unconstrained one, in which the structural weights and structural residuals were estimated freely and the paths were not constrained to be equal, respectably. Results showed that there was no significant different between two models (Constrained Model: χ^2 =18.815; χ^2/df =1.254; GFI=.96; CFI=.98; TLI=.98 and RMSEA = 0.04; Unconstrained Model: χ^2 =10.009; χ^2/df =1; GFI=.99; CFI=.99; TLI=.99 and RMSEA = 0.02). This concluded that the multi-group testing also proven the M3 model was invariant across groups. Which those validations, it was also considered worthwhile to evaluate the research hypotheses based on M3 model (Figure 1).

Hypothesis Testing

Table 5 shows parameter estimates for the significant hypothesized paths. All hypotheses, except H2 and H7, were supported by the data. The exogenous variable, learning outcomes, did not significantly influence computer use but was a significant influence on computer attitudes (β=.17, p<.01) and computer teaching efficacy (β=.29, p<.01). Computer teaching efficacy was a significant influence on computer attitudes (β=.17, p<.01) and computer attitudes has a significant influence on computer use (β=.20, p<.01). Finally, computer use was found to be influenced by school environment (β=.70, p<.01).

Table 5 Hypothesis testing results

Hypotheses	Path	Path coefficient	Results
H1	CA→CU	0.203**	Supported
H3	CTE→CA	0.167**	Supported
H4	LO→CTE→CA	0.093**	Supported
H5	LO→CA	0.170**	Supported
H6	LO→CTE	0.289**	Supported
H8	SE→CU	0.700**	Supported

*p < .05; **p < .01.

Computer attitudes were found to be significantly determined by learning outcomes and computer teaching efficacy, resulting in an R^2 of 0.232. That is, learning outcomes and computer teaching efficacy explained 23.2% of the variance in computer attitudes. Computer teaching efficacy was significantly determined by learning outcomes and the percent of variance explained was 13.4% (R^2 = 0.134). Computer use was significantly determined by computer attitudes and school environment resulting in an R^2 = .652. That is, the combined effects of learning outcomes, computer attitudes, computer teaching efficacy and school environment explained 65.2% of the variance of computer use.

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

To test and estimate confidence intervals for the indirect effect, Bootstrapping Test have been conducted. Table 6 shows the standardized total effects, direct and indirect effects associated with each of the endogenous and exogenous variables toward computer use. A coefficient linking one construct to another in the path model represents the direct effect of a determinant on an endogenous variable. An indirect effect reflects the impact a determinant has on a target variable through one or more other intervening variables in the model. A total effect on a given variable is the sum of the respective direct and indirect effects (Teo, 2009).

Table 6 Direct, Indirect and Total Effects of the Research Model

Outcome	Determinant	Standardized estimates [a]		
		Direct	Indirect	Total
CTE (R^2 = .134)	LO	0.366**	-	0.366**
CA (R^2 = .232)	LO	0.327**	0.093**	0.420**
	CTE	0.253**	-	0.253**
CU (R^2 = .652)	LO	-	0.051**	0.051**
	CTE	-	0.031**	0.031**
	SE	0.798**	-	0.798**
	CA	0.122**	-	0.122**

**p<.01
[a]200 samples bootstrapping test with 95% of Confidence Interval (CI)

Based on the results shown in Table 6, the most dominant determinant of computer use among novice science teachers is school environment, with a large total effect of 0.798. According to MacKinnon (2008), standardised path coefficients with values near to 1 are considered large values impact. This followed by computer attitudes, learning outcomes and computer teaching efficacy with total effect of 0.122, 0.051 and 0.031, respectively. Together, these four determinants accounts for 65.2% of the variance in computer use.

For testing mediating effect, Bootstrapping Testing has been conducted to estimate confidence intervals for the indirect effect (mediator) (Hayes, 2009 & Preacher et al., 2007). From bootstrapping test result, it has confirmed that computer teaching efficacy mediate the relationship between learning outcomes and computer attitudes (indirect effect = 0.01, 95% Confidence Interval (CI), Lower Bound = 0.043, Upper Bound = 0.175, $p < 0.01$). Additional test via Sobel test also revealed that the indirect effect is significant (Sobel statistic = 3.46, SE = 0.01, $p = 0.00$). Thus provided support for Hypothesis 8.

Discussion and implications

The findings of this research offer several important implications for the research and practice of computer integration among novice science teachers. As anticipated, computer attitudes, computer teaching efficacy, school environment and learning outcomes have direct

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

and indirect effects towards the levels of integration of computer in teaching and learning for science. Together, the variables in the research model in this study explain 65.2% of the variance in computer use among novice science teachers towards computer use in teaching and learning. Overall, the findings have support existing theories and assumptions that those selected exogenous and endogenous variables affected the computer use among them. Using structural equation modelling, data also indicated that the resulting model is an adequate fit to the observed relationships among the factors that influenced science teachers in computer use in teaching and learning.

The discovery of the importance of learning outcomes towards the actual performance by previous studies has proven that learning outcome is one of the major predictors for computer use. But, the results gathered from this study contradicted previous findings by Goldstein and Ford (2002) and Phillips (1997). The findings showed that learning outcomes was not a direct predictor for computer use in the modified model. The results only indicated that learning outcomes have positive impacts on computer attitudes and computer teaching efficacy. Henceforth, in this regard, it is very important to take a constructive step to identify the root of the problems which lead to the statistically insignificant relationship between learning outcomes and computer use among novice Malaysian science teachers. The ineffectiveness in the implementation and irrelevant syllabi and level of complexity that were taught in the teacher educational program might be one of the reasons that led to the respective results. This early indication and realization will help policymakers and teacher educators to develop a better and more comprehensive approach toward educational technology, especially in designing the curriculum for teacher educational program. Updating the National Educational Technology Standards in teacher educational programs from time to time is vital as technology continues to grow and develop rapidly, especially in this Information Age. The findings serve as guidelines to prepare and update courses for pre-service and in-service teachers for appropriate knowledge and effective use of computer in teaching and learning.

From the results, it has been corroborated that computer attitudes have positively influenced the use of computer science among teachers. Therefore, it goes to show that computer attitude has an important role to play in influencing teachers' use of computers. The finding is in line with previous findings in Western settings. Henceforth, in this regard, the Ministry of Education and the related government departments should do more in terms of encouraging positive computer attitudes among teachers. Since many findings from the previous researches and the results of this study have indicated that computer attitudes have significant impact on teachers' use of computer, schools should provide training, funding and support required for this process. By strengthening staff training in technologies, schools can help encourage more positive attitudes toward computers, especially to reduce teachers' anxiety towards computers in general. The school boards of management should ensure that in-service technology training program to be a part of their yearly activities. By meeting the needs related to technology integration and helping to instil more favourable computer attitudes will directly assist in the integration of computer into the teaching and learning activities.

It was also further revealed that computer teaching efficacy purely mediated the relationship between learning outcomes and computer attitudes. This result has provided additional insight about how individual's learning outcomes interact with computer attitudes among teachers. Teachers with high efficacy belief and outcome expectancy will encourage higher computer attitudes and lead to better use of computer in teaching and learning among novice science teachers. This finding could be a new contribution to the educational field. Due to the importance of computer teaching efficacy in simulating higher use of computer among teachers, the Ministry of Education or related government departments should pay

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

extra attentions to increase the employees' belief and confidence in using computers in teaching and learning. This can be achieved by the schools through the increased in-service staff training and educational program which might foster a feeling of positive computer teaching efficacy. Upon seeing the positive impact technology-enhanced activities that had positive impacts on their students learning outcomes, it would encourage teachers to re-examine and modify their beliefs regarding the use of technology in teaching and learning.

It was also conclusively reported that school environment has very strong impacts on computer use. This is consistent with previous research by ChanLin, et al. (2006) and ChanLin (2007). The significance of school environment in enhancing the use of computer in teaching and learning could be due to the fact that teachers need administrative and technical support to encourage them to use the computer. Teachers need strong and enthusiastic leadership from principal in order to achieve higher confidence and belief in the use of computers. Technical support is vital when teachers are having difficulties in operating the computer based technologies equipment. Having knowledgeable people and willingness to answer questions are critical in overcoming the obstacles of using computer. In the Malaysian schools, especially in the rural areas, lack of availability of computers and software, and incompatibility between the software and hardware are very common situations. The government should inject more financial support and attention to rural schools which with intention to minimize the digital divide between the urban and rural schools. Training for principals is vital in ensuring that they are conscious of the importance of computer in teaching and learning. Through training, they would be able to know how to encourage (giving coaching, feedbacks and leading) teachers to use computers. School districts should look for different funding resources to make computer technologies available for each teacher and in each classroom. Principals or headmasters should give motivation and support to their staff and encourage them to use computers although at the initial level it could be very difficult.

Limitations and direction for future research

Although care has been taken to ensure that the methodology in this study is sound, there are limitations. It is important to state the limitations of the study to frame the above discussions and recommendations. Firstly, the population of this study was only novice science teachers. Therefore, the findings derived from the analyses might not adequately reflect the perceptions of the whole population of novice Malaysian teachers. Secondly, the questionnaire used in this study may not be able to measure all aspects for the variables concerned. Thirdly, in this study, it is assumed that external factors would not affect the levels of learning outcomes. Finally, this study is the timeliness of the data and finding process. At the time of this writing, the data was collected more than a year old. Thus, during this period of time, there may have been some changes in syllabi and curricula in teacher educational training program. However, the main findings of this study will remain true regardless of the aforementioned changes.

In the area of inquiries on technology integration among teachers, there is always ample room for additional research. A comparative study could be conducted across different subject to determine whether there are different findings especially regarding the relationship between learning outcomes and computer use. A comparative study that is carried out across different subject like mathematics, English language and others might be able to determine whether the low relationship between learning outcomes and computer use is due to the inadequacy in the implementing stage or irrelevant syllabi that are being taught. Moreover, it should be replicated by using a larger sample, so that the results can be more

Malaysian Journal of Educational Technology
Vol.11, No.3, September 2011, 40-55

generalized as a whole. Since technology will continue to grow and develop rapidly, a replication of this study might be conducted periodically in order to examine education technology trends. Thus, teacher educational programs would be able to update courses and provide appropriate knowledge and skills for the pre-service or in-service teachers.

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Vol.11, No.3, September 2011, 40-55

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