DOES LEARNING SCIENCE MEAN DOING SCIENCE? AN EXPLORATORY STUDY ON THE ROLE OF ICT TOOLS IN SCIENCE CLASSROOM ANCHORED ON LEARNER'S EFFICIENCY MODEL

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Abstract

This paper reports on the authors' experiences in conducting an in-service training course on ICT tools for secondary science educators in the SEAMEO region. It focuses on some of the ICT tools that could be used effectively to promote learning in secondary science classroom. Pre/post-tests using Likert scales were administered to evaluate the participants' perceived levels of knowledge and skills before and after the course activities. The perceived attitude of teachers towards the use of ICT tools in the science classroom was also evaluated. Analysis of data was anchored on a learning efficiency framework. The findings showed that learning efficiency through ICT tools could be improved on the five dimensional constructs of content, feedback, user interface, ease of use and satisfaction. The research activities and findings will serve as guidelines for the future planning of in-service teacher education towards improving teaching and learning of science using ICT tools among educators in the SEAMEO region.

Introduction

As we move further into the 21st century, it must be realized that learners in the Southeast Asian countries should be prepared to meet the future needs of a knowledge-based economy (SEAMEO, 2010). Educators who have direct contact with learners should thus be equipped with a plethora of pedagogies and knowledge of cutting edge technology through 'Continuing Professional Development' (CPD) activities to understand students better and teach more effectively. The advancements of technology education especially ICT-based learning allow teachers to employ various constructivist strategies such as Project-based Activities (PBA) and Problem-based Learning (PBL) that could actively engage learners' interest in science. It is with this premise that ICT has been identified as an important component in the training programmes of SEAMEO RECSAM, a regional training institution for science and mathematics education in the SEAMEO region. The objectives of this research are:

- To evaluate the science teachers' perceived levels of competency and knowledge after their participation in a CPD programme related to the use of ICT tools in science teaching.
- To develop a comprehensive learners' efficiency framework through structural equation modelling (SEM) to conceptualize the role of ICT tools in promoting constructivist science learning.

Review of Related Literature

The very basic question a teacher may ask is, "How do I use ICT to enhance my teaching process and my students' learning?" A teacher may use presentation software and may say that he/she is using ICT to enhance her teaching processes and to that effect enhances students' learning! Education professionals might be asking, is ICT really what we want and what we can do with ICT at hand? What are the varied answers and reasons to this question?

Karasavvidis (2008) said that one of the most significant challenges educators face in the case of technology in education is pedagogical in nature. It is the ability to integrate ICT into the teaching and learning process. ICT integration is interpreted as ICT functioning as an integral or mediated tool to accomplish specific teaching or learning activities to meet certain instructional objectives (Lim & Hang, 2003). It means that ICT is part of the process but not as a mere vehicle of the process. Most governments had been trying their best to integrate ICT into the teaching and learning process in their schools. According to a UNESCO Report (2004), there were different levels of ICT integration in the six countries surveyed and, alongside with it numerous similar experiences of ICT integration were found. An analysis of experiences and best practices with associated problems has generated lessons learned in the following eight components of ICT integration in education: (i) broader environmental context, (ii) policy and regulatory environment, (iii) management and financing, (iv) ICT in schools – policy, vision and strategy, (v) technology infrastructure and connectivity, (vi) curriculum, pedagogy and content development, (vii) professional development, and (viii) monitoring and evaluation (UNESCO, 2004) .

Lim and Hang (2003) said that research studies have shown that ICT facilitates the acquisition of higher order thinking skills by providing cognitive scaffoldings for students as they make sense of the information gathered; allowing experts, teachers and students to communicate their thoughts and interests in subject matters; and simulating real-life situations and problems for students as they explore the connections between concepts and ideas.

Indeed, ICT has the potential of enhancing teaching and learning processes. But there is a question on how best ICT could be integrated into these processes. Mlitwa and Van Belle (2010) said that integration also requires the understanding of qualitative phenomena of the application of ICT into social-educational settings. Papert (1997) as cited by Lim and Hang (2003) reiterated that as ICT enters the socio-cultural setting of the school, it 'weaves itself into the learning in many more ways than its original promoters could possibly have anticipated'.

Activity Theory as framework of study

Evaluations of the effectiveness of the integration of ICT into teaching and learning had lead to the development of various frameworks. One of which is Activity Theory that, according to Karasavvidis (2008), is a promising theoretical framework for the study of tensions in an activity system. Activity Theory according to Engestrom as cited by Karasavvidis (2008) provides an indispensable theoretical tool for understanding conflicts and inconsistencies between and within the components of an activity system. Activity Theory can best be explained in terms of its key terms: internalization, mediation, subject, object, tool, transformation (process), rules, community, division of labour, and outcomes (Mlitwa & Van Belle, 2010). The Activity Theory views a research context as a collective work with a common objective between individual and group actors. In other words, teaching and learning is not an individual isolated exercise but a collective activity that is carried out either by individuals or groups (Mlitwa & Van Belle, 2010).

Various researches had been conducted utilizing Activity Theory to best evaluate the effectiveness of ICT integration in the teaching and learning process. Karasavvidis (2008) reported the following aspects that help in understanding the patterns of using online resources in two ways:

1. There are different approaches to learning that different students take. This means that for some students, the engagement with the materials will be very high and more online resources will be considered by them as useful 'learning *sources*'. On the other hand, for other students, this is less likely not to be the case. For such students, more online resources may be interpreted as creating '*more trouble*' in their learning. What is promising is that blended learning has the flexibility to support both types of students while only the most devoted ones will be benefitted from it.
2. 'More' can be 'too much' and can be conveniently ignored by the students- especially if it is not very deeply integrated into the course requirements. While students appear to be in favour of more materials in terms of "more options", some students will simply not view the material. It appears that the majority of students will only view the online resources provided if these are deeply integrated not only into the course structure but - most importantly – into the course assignments. Again, blended learning can offer a very promising solution in this direction.

Kekwaletswe as cited by Mlitwa and Van Belle (2010) found that Activity Theory helps to illustrate an effective analytical tool to interprete the phenomenon of "mobile learning", the technologies, influencing factors and the context in which mobile learning takes place. Furthermore, Karasavvidis (2008) said that the use of Activity Theory suggests that some important insights can be gained from blended learning.

It is very interesting to note the words of Salomon as cited by Lim and Hang (2003): "No tool is good or bad in itself; its effectiveness results from and contributes to the whole configuration of events, activities, contents, and interpersonal processes taking place in the context of which it is been used." (p.54)

Science teachers are concerned about helping students to become critical thinkers, problem solvers and scientifically literate citizens. One of the methods for encouraging students to develop higher order thinking is Project-based Activities (PBA). PBA involves designing learning experiences around projects (Sherman & Sherman 2004). The core idea of project-based learning is that real-world problems capture students' interest and provoke serious thinking as the students acquire and apply new knowledge in a problem-solving context. Adopting a PBA approach can invigorate the learning environment, energising the curriculum with real-world relevance and spark students' desire to explore, investigate, and understand their world.

Hoban (2007) defined Slowmation as 'Slow motion animation' which is a new teaching approach that uses a simple animation process to engage learners in creating their own comprehensive animations of science concepts. He added that this approach simplifies the complex process of making animations to enable pre-service teachers to create comprehensive animations about science concepts. The entire concept is based on more hands-on and minds-on classroom activities which makes students to learn pedagogical concepts in the simplest way. He argues that it is much better than learning through simulation because students are researching information, scripting, storyboarding, designing models, capturing digital still images of small manual movements of the models, and using computer programs such as QuickTime Pro to play the images in a sequence to simulate movement.

Chen and Howard (2010) examined the effect of live simulation on students' science learning and attitude. The study also found that the change in student's science learning was significantly influenced by the teacher. The classroom preparation for the simulation experience proved vital to students' attitudes toward science as well as their scientific understanding. Chen, Hong, Sung and Chang (2011) studied the learning performance of students using simulation. The study indicates that the learning performance was higher for learning software utilizing simulative manipulation and visualization yields than for that lacking simulative manipulation, which suggests that learning performance can be enhanced if visualized learning can appropriately integrate simulative manipulation activities.

The constructivist learning theory posits that knowledge is actively constructed by learners rather than transmitted by the teacher; learners are active knowledge constructors rather than passive information receivers (Wang, 2008; Jonassen, 1991). Cognitive constructivists believe learners construct knowledge individually based on their prior experience, supported by new information and communication tools such as WEB 2.0 tools. WEB 2.0 tools are the new wave of innovation in teaching and learning of science. It allows students to do collaborative learning. For instance, blog is used as a learning management system (LMS) where students can share their ideas, prepare digital portfolios, download resources from other websites, give feedback to teacher's contents and so on. Even one can develop an online questionnaire/test/quiz using third party tools such as Zoomerang. The integration of blogs in the traditional teaching and learning process requires preparation and planning on the part of the teacher so that applicable and timely activities could be given to the students (Amold Nicholas, 2010). Another study by Alan (2010) highlighted that Middle East countries such as Israel, Saudi Arabia, United Arab Emirates and Qatar have made substantial investments in web-based learning and concluded that students were motivated by WEB 2.0 tools.

Research Questions, Framework and Data Collection

This section will brief on the research questions anchored on the two objectives of the study with the illustration of the conceptual framework and elaboration on the data collection activities.

Research questions and hypotheses

As stated earlier, this paper aims to report on the evaluation of the science teachers' perceived levels of competency and knowledge after their participation in a CPD programme conducted at RECSAM in April 2011 that was related to the use of ICT tools in science teaching. It also aims to develop a comprehensive learners' efficiency framework through structural equation modelling (SEM) to conceptualize the role of ICT tools to promote constructivist science learning. The following are the research questions.

Research Question 1 (RQ1):

Are there evidences of enhanced perceived levels of competency and knowledge among participants who attended the Regular Course RC-SS-135-3 at RECSAM that focussed on the use of ICT tools in science teaching?

H_0: There is no evidence of enhanced perceived levels of competency and knowledge among participants who attended the Regular Course RC-SS-135-3 at RECSAM that focussed on the use of ICT tools in science teaching.

H_1: There is an evidence of enhanced perceived levels of competency and knowledge among participants who attended the Regular Course RC-SS-135-3 at RECSAM that focussed on the use of ICT tools in science teaching.

The hypothesis is that the participants would have increased their perceived levels of competency and knowledge after they attended the in-service course at RECSAM on the use of ICT tools in science teaching. The variables that reflect the enhanced perceived levels of competency and knowledge are the difference of scores between pre-test and post-test administered before and after the in-service course. This RQ1 is set for the preliminary or exploratory study which leads to RQ2.

Research Question 2 (RQ2):

Do ‘content, feedback, user interface, ease of use and satisfaction on use’ play important roles in ICT tools to promote constructivist science learning and improve learners’ efficiency?

H1: Appropriate ‘content in ICT tools’ will improve the learner’s efficiency

H2: Appropriate ‘feedback through ICT tools’ will enhance the efficiency of ICT tools and improve learner’s efficiency

H3: Appropriate ‘user interface in ICT tools’ will enhance the efficiency of ICT tools and improve learner’s efficiency.

H4: Appropriate ‘ease of use of ICT tools’ will enhance the efficiency of ICT tools and improve learner’s efficiency

H5: High ‘satisfaction on use of ICT tools’ will improve the learner’s efficiency

Conceptual framework of the study and Research model

The following are the variables identified relevant to the framework of study:

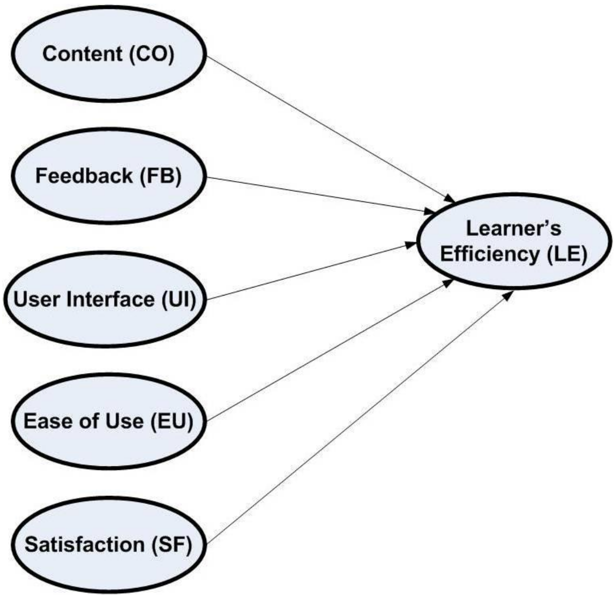

Figure 1. Conceptual framework for Learner's Efficiency (LE) Model.

Dependent variable — Efficiency of ICT tools and/or Learner's Efficiency. The dependent variables were derived from existing literatures and adapted for discussion in the analysis of items in the instruments.

Fourteen survey questions or instrument items were used to measure the following 5 independent variables in this study.

Independent variable (1) — Content (CO). The content is related to the quality and effectiveness of the knowledge transmission. The materials used to illustrate the features of ICT tools are easy to understand, must also be simple and clear for the learners. In line with the past literature, the aforementioned hypothesis H_1 is developed.

Independent variable (2) — Feedback (FB). The students can effectively communicate through online tools for feedback (for instance through Blog, Wufoo, and so on). In line with the past literature, the above hypothesis H_2 is developed.

Independent variable (3) — User Interface (UI). The ICT tools with user interface (including Blogger, Wordpress) introduced are well-designed with 'drag and drop' option. In line with the past literature, the above hypothesis H_3 is developed.

Independent variable (4) — Ease of Use (EU). The software introduced in the course is easy to use because of its features and 'drag and drop' facilities in the menu. In line with the past literature, the above hypothesis H_4 is developed.

Independent variable (5) — Satisfaction (SF). Satisfaction relates to perception of being able to achieve success and feelings about the achieved outcomes from the course. In line with the past literature, the above hypothesis H_5 is developed.

Sampling, instrument, variable measurement and data collection activities

The target population of this study were teachers working in schools in the Philippines. A total of 98 hardcopies of surveys were distributed to these participants of the ICT tools workshop in June 2011. Out of the 98 survey forms distributed, 82 were received (83.7% response rate) while 16 were incomplete. Therefore the total usable questionnaire in this study was 82 which included 31 male (37.8%) and 51 female (62.2%), and with 64% teachers with a Masters degree and the rest Bachelors degree (36%). Hair, Black, Babin and Anderson (2006) stated that the appropriate minimum sample size for a research is to have 15 observations for each independent variable. As there are 5 independent variables measuring learning effectiveness of ICT tools in this study, a minimum sample size of 75 is needed. Since there were 82 respondents involved in this study, the sample size for this research was considered adequate.

The first part of the study in response to RQ1 involved an in-service training Regular Course entitled RC-SS-135-3 that was held at SEAMEO RECSAM in April 2011. This CPD programme focussed on the use of ICT tools in science teaching. All thirteen participants from the eleven SEAMEO countries participated in this study. Prior to the training programme, a pre-test was administered to the participants to identify their prior knowledge and levels of competence in relation to ICT tools for science teaching. After the conduct of training course, a post-test was administered to the participants to explore their enhanced perceived levels of knowledge and competency on various topics introduced in the course.

The second part of the study in response to RQ2 involved a five days hands-on and minds-on training workshop conducted by one RECSAM participant from Philippines who attended the RC-SS-135-3 course and implemented her multiplier effects activities upon completion of course as one of the requirements of CPD. In addition, the data collected from this activity was also used to develop a comprehensive learners' efficiency framework using structural equation modelling (SEM) to conceptualize the role of ICT tools to promote doing science. The following topics were included in the workshop: (1) Simulation concepts: Demonstrate the use of simulations in science teaching and learning (for instance using PhET simulation from URL: phet.colorado.edu); (2) Slowmation (i.e. Slow animation): Demonstrate the use of slow animation techniques in science teaching and learning; and (3) Web 2.0 Tools: Demonstrate the use of various Web 2.0 tools in science teaching and learning.

A survey instrument was designed to develop a research model based on the framework identified as shown in Figure 1 with hypothesis testing activities. Following the advice from Toral, Barrero, Martinez-Torres, Gallardo and Duran (2009), the majority of the items were developed for each construct from review of past literatures. The survey consists of 47 questions to measure the constructs relevant to this study. Each question was measured by five-point Likert scale. For instance, '1' denotes 'strongly disagree', '2' denotes 'disagree', '3' denotes 'neutral', '4' denotes 'agree' and '5' denotes 'strongly agree'. In order to ensure that the survey items used to measure the variables are reliable, the reliability analysis using Cronbach's Alpha (CA) was applied. The analysis of data showed that all the CA values are greater than 0.70, that is, Content (0.871), Feedback (0.789), User Interface (0.891), Ease of Use (0.867), and Satisfaction (0.917). Table 1 shows one of the items for each dimension in the questionnaire.

Table 1
Dimensions and an Item for each Dimension of Instrument with its Reliability and Validity

Dimensions (No. of items) (Reliability)	Item	Factor Loading	AVE	CR
Content (3 items) (0.871)	The materials used to illustrate the features of ICT tools are easy to understand.	0.891	0.815	0.769
Feed-back (3 items) (0.789)	Feedback can easily be given through online comments for ICT tools.	0.762	0.805	0.760
User Interface (2 items) (0.891)	The ICT tools introduced are well-designed.	0.874	0.893	0.868
Ease of Use (2 items) (0.867)	The ICT tools introduced help me to design and use teaching and learning activities in my classroom.	0.799	0.806	0.781
Satisfaction (4 items) (0.917)	I am satisfied with the ICT Tools introduced	0.871	0.844	0.812

Data Analysis and Discussion of Findings

Research Question 1 (RQ1):
Are there evidences of enhanced perceived levels of competency and knowledge among participants who attended the Regular Course RC-SS-135-3 focusing on the use of ICT tools in science teaching?

The observed t test between pre- and post-test score is 2.273. Since the value of t is 15.947 at p=0.000 < 0.05, the mean difference (2.273) between the pre-test and post-test is statistically significant. Since the sig. of p=0.039 is less than 0.05, hence the null hypothesis 1 is rejected. Therefore, it can be inferred that the Regular Course RC-SS-135-3 was effective to improve the participant's perceived levels of knowledge and competency on ICT tools.

Research Question 2 (RQ2):
Do 'content, feedback, user interface, ease of use and satisfaction on use' play important roles in ICT tools to promote constructivist science learning and improve learners' efficiency?

To assess the extent and the specific nature of 'learner efficiency', the different dimensions of the roles of ICT tools were taken into consideration. A structural and measurement model taking into account all dimensions, must be defined. Up to 5 dimensions were identified, including Content (CO), Feedback (FB), User Interface (UI), Ease of Use (EU), and Satisfaction (SF) as shown in Table 1, were considered in order to assess learner's efficiency.

The research model as illustrated in Figure 1 was analyzed using 'Structural Equation Modelling' (SEM). The data analysis was conducted following the steps: (i) Investigating the assumptions of multivariate analysis, (ii) Examining the measurement models for each factor using confirmatory factor analysis (CFA), and (iii) Testing the research model using SEM. The above-mentioned steps are discussed in the following subsections.

I. Investigating the assumptions of multivariate analysis

The skewness and kurtosis of the variables fall within the acceptable ranges of (± 1), therefore the data is normally distributed (Garson, 2007). The correlation coefficients for the independent variables were less than 0.90, thus confirming that multicollinearity did not exist.

II. Examining the Measurement Model using Confirmatory Factor Analysis (CFA)

The measurement model included 19 items explaining five dimensions: content (CO), feedback (FB), user interface (UI), ease of use (EU) and satisfaction (SF).

In relation to this study, the CFA indices for all the five dimensions are above 0.9 levels which implied the evidence of unidimensionality (Al-Hawari & Ward, 2006).

As shown in Table 2, the square root of the average variance extracted (AVE) on the diagonal of all latent constructs exceeded the benchmark of 0.7 (Nunnally, 1978), implying that the measurement is acceptable.

Table 2

Latent Constructs Correlations using 'Structural Equation Modelling' (SEM)

	CO	FB	UI	EU	SF
CO	1.000				
FB	0.298**	1.000			
UI	0.374**	0.547**	1.000		
EU	0.289**	0.557**	0.455**	1.000	
SF	0.261**	0.434**	0.322**	0.344**	1.000

N = 82; ***p* < 0.01; Diagonal elements (in bold) are the square root of the AVE.

III. Testing the research model using Structural Equation Model (SEM)

The structural model has a well fit as determined from the Chi-square index (χ = 1.319; *p*-value = 0.267 > 0.05) as well as other indices (GFI = 0.991; AGFI = 0.934; CFI = 0.994; NFI = 0.977; RMSEA = 0.052). All the model-fit indices exceeded their respective common acceptable levels, recommending the structural model displayed to represent an acceptable model fit to the data. (Hair et al., 2006)

Hypothesis testing

The statistical significance of all the structural parameter values was examined to determine the validity of the hypothesized paths. The analytical results revealed that content [Critical Ratio (CR) = 3.162; p < 0.01], feedback (CR = 3.659; p < 0.01), user interface (CR = 3.221; p <0.01), ease of use (CR =2.987; p<0.01) and satisfaction (CR =3.661; p<0.01) were found to have a significant and positive relationship with learners efficiency.

In reference to the analytical results of the data as presented in the preceeding paragraph, the following are revealed:

- Appropriate 'content in ICT tools' improved learner's efficiency;

- Appropriate ‘feedback through ICT tools’ enhanced efficiency of ICT tools and improve learner’s efficiency;
- Appropriate ‘user interface in ICT tools’ enhanced efficiency of ICT tools and improve learner’s efficiency;
- Appropriate ‘ease of use of ICT tools’ enhanced efficiency of ICT tools and improve learner’s efficiency; and
- High ‘satisfaction on use of ICT tools’ improved learner’s efficiency.

Conclusion

Summary and research implications

In this study, learner efficiency has been modelled using Structural Equation Modelling (SEM) Analysis of Moment Structures (AMOS). Learners’ efficiency is positively impacted when the ‘content’ is transmitted through adequate ‘user interface’, when the interaction with instrumentation equipment and tools easy and adequate to the students’ level, and when they feel motivated by the work they are required to do. The model distinguishes five pure independent variables: content, feedback, user interface, ease of use and satisfaction of the workshop course.

The ‘content’ dimension is improved by planning new ICT tools in the classroom. The ‘user interface’ dimension is improved through the application of a learning management system while the ‘ease of use’ dimension is enhanced using multimedia technologies and contents to improve the learning processes. The inclusion of collaborative and cooperative hands-on minds-on activities improves competences like teamwork and collaboration skills. Finally, the ‘feedback’ dimension is promoted by having a forum (http://forum.sp3aceman.net).

Limitations and future directions of the research

There were some potential limitations for this study. First, the research data for the second part of the study has been collected from the workshop in Philippines by ex-RECSAM’s participant. Second, the sample size is relatively small, hence difficult to make generalization. Third, the framework included only 5 dimensions and there may be more constructs that are relevant to use of ICT tools for science teaching that had not been identified.

A similar type of study could also be replicated in other countries and even conduct cross-country analyses to compare if the results are consistent in the SEAMEO region. Perhaps other dimensions such as learner community, previous experience and learner responsibility could also be included. The future model may also incorporate some moderators such as age, gender, culture to see if there is any influence on learner’s efficiency.

References

Alan, S. W. (2010). Review article: Effectiveness of web-based learning in the Middle East and North Africa (MENA) region. *Proceedings of the Seventh International Conference on eLearning for Knowledge-Based Society, 16-17 December, Bangkok.*

Al-Hawari, M., & Ward, T. (2006). The effect of automated service quality on Australian Banks’ financial performance and the mediating role of customer satisfaction, *Marketing Intelligence & Planning, 24*(2), 127-147.

Amold Nicholas, E. S. (2010). Blog as a learning space: Creating a Text of Talk. *Proceedings of the Seventh International Conference on eLearning for Knowledge-Based Society, 16-17 December, Bangkok.*

Chen, Y.-L., Hong, Y.-R., Sung, Y.-T., & Chang, K.-E. (2011). Efficacy of simulation-based learning of electronics using visualization and manipulation. *Educational Technology & Society*, *14*(2), 269–277.

Chen, C.-H., & Howard, B. (2010). Effect of live simulation on middle school students' attitudes and learning toward science. *Educational Technology & Society*, *13*(1), 133–139.

Garson, D. (2007). Testing of assumptions, key concepts, and terms. Retrieved from http://www2.chass.ncsu.edu/garson/pa765/assumpt.htm.

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2006). *Multivariate data analysis* (7th ed.). New Jersey, USA: Pearson Education.

Hoban, G. F. (2007). Using slowmation to engage preservice elementary teachers in understanding science content knowledge. *Contemporary Issues in Technology and Teacher Education*, *7*(2), 75-91.

Johansson, D. H. (1991). Objectivism versus constructivism: Do we need a new philosophicalparadigm? *Educational Technology Research & Development*, 39, 5-14.

Karasavvidis, I. (2008). Activity Theory as a theoretical framework for the study of blended learning: A case study. *Proceedings of the 6th International Conference on Networked Learning*. Retrieved from http://www.networkedlearningconference.org.uk

Lim, C. P., & Hang, D. (2003). An activity theory approach to research of ICT integration in Singapore schools. *Computers & Education*, 41, 49-63.

Mlitwa, N., & Van Belle, J. (2010). A proposed Interpretivist Framework to research the adoption of learning management systems in universities. *Communications of IBIMA,* 1-11.

Nunnally, J. (1978). *Psychometric theory*. New York: McGraw Hill.

SEAMEO. (2010). *Report: Status of ICT integration in education in Southeast Asian countries*. Bangkok: SEAMEO Secretariat.

Sherman., & Sherman. (2004). *Science and science teaching. Methods for integrating technology in elementary and middle schools* (Second ed.). New York: Houghten Mifflin Company.

Toral, S. L., Barrero, F., Martinez-Torres, M. R., Gallardo, S., & Duran, M. J. (2009). Modeling learner satisfaction in an electronic instrumentation and measurement course using structural equation models. *IEEE Transactions on Education*, *52*(1), 190-199.

UNESCO. (2004). *Integrating ICT into education: A collective case study of six Asian countries.* Bangkok: UNESCO Bangkok. Retrieved from http://www.unescobkk.org/?id=5828.

Wang, Q. (2008). A generic model for guiding the integration of ICT into teaching and learning. *Innovations in Education and Teaching International*, *45*(4), 411–419.