Predicting instructional effectiveness of cloud-based virtual learning environment

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Abstract

Purpose – Cloud computing technology is advancing and expanding at an explosive rate. These advancements have further extended the capabilities of the virtual learning environment (VLE) to provide accessibility anywhere, anytime where educational resources can be saved, modified, retrieved and shared on the cloud. The purpose of this paper is to examine the predictors of instructional effectiveness of cloud computing VLE by extending the Self Determination and Channel Expansion Theory with external constructs of VLE interactivity, content design, school support, trust in website, knowledge sharing attitude and demographic variables.

Design/methodology/approach – Random sampling data were collected in two waves of nation-wide survey and analyzed with artificial neural network approach.

Findings – SDT, CET, content design, interactivity, trust in website, school support and demographics significantly predict instructional effectiveness.

Research limitations/implications – The study has provided a new paradigm shift from investigating the behavioral intention and continuance intention to the effectiveness of an information system. It advocates that quality of research may be improved by adhering to the basic research methodology starting from rigorous instrument development and validation to future research direction.

Practical implications – The research provides implications to Ministry of Education, the VLE content and service providers, scholars and practitioners.

Social implications – The findings of the study may further improve the quality of living of the society when the instructional effectiveness of the cloud-based VLE is further enhanced.

Originality/value – Existing grid computing VLE studies have focussed on the acceptance of students and teachers and not its instructional effectiveness. Unlike existing studies that examined extrinsic motivational factors (e.g. TAM, UTAUT), this study uses intrinsic motivational factors (e.g. relatedness, competence and autonomy) as well as perceived media richness. Malaysia is the first nation to implement the VLE at a national scale and the findings from this study will provide a new insight on the determinants of instructional effectiveness of the VLE system.

Keywords Self Determination Theory, Artificial neural networks,
Virtual learning environment (VLE), Channel expansion theory, Instructional effectiveness

Paper type Research paper

1. Introduction

The emergence of cloud computing technology and Web 2.0 is one of the revolutionary developments in teaching and learning whereby students and teachers can access, save, retrieve and share unlimited educational resources anytime and anywhere on the cloud. Seeing the huge potential of this technology, the Malaysian government has embarked on the 1BestariNet (*means 1SmartNet*) project to unite the learning

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communities through the high-speed cloud-based virtual learning environment (VLE) known as the Frog VLE. It is the first of its kind where students can attend classes and teachers can deliver their lessons on the cloud. The project aims at linking six million school children from 10,000 schools in an area of 329,847 km^2 with 4.5 million parents and teachers via the high-speed 4G Frog VLE. It is a partnership between Ministry of Education (MoE) and YTL Communications through its subsidiary, the Frogasia. The configuration for the Frog VLE is shown in Figure 1.

For decades, the MoE has implemented a variety of ICT programs like Computer in Education, CAI and Computer Literacy Project in an effort to immerse technology into the classrooms; however, the results are not encouraging. In fact, one billion pound sterling (USD1.6 billion) has been spent for these programs over a decade. Nevertheless, the ICT adoption rate among teachers remain short of expectation with 80 percent of them using ICT for less than one hour weekly (Mahmud and Ismail, 2010). Even with the various immersion courses and training programs, teachers tend to go back to the traditional way of teaching. Hence, with the introduction of the Frog VLE, it is hoped that it may transform the education system from the conventional chalk-and-talk to the more vibrant and innovative virtual and ubiquitous instruction.

So far, the VLE literature has been focussed on the acceptance of the grid-computing VLE from the context of undergraduates and university instructors. Very litte attention has been given to the instructional effectiveness of the system especially from the context of school teachers. The cultural and environmental differences between the university and school settings warrant for a study on instructional effectiveness to be conducted from the context of school teachers. Besides, the findings from the grid-computing VLE may not be the same and applicable in the context of the cloud computing VLE as there are significant and huge differences between the two technologies. Unlike previous studies which used extrinsic motivation theories (e.g. TAM, UTAUT), this study applies intrinsic motivation theory of self-determination and the perceived media richness from channel expansion theory in predicting the instructional effectiveness. The study also incorporated several VLE attributes (e.g. VLE content design, interactivity, trust, knowledge sharing and

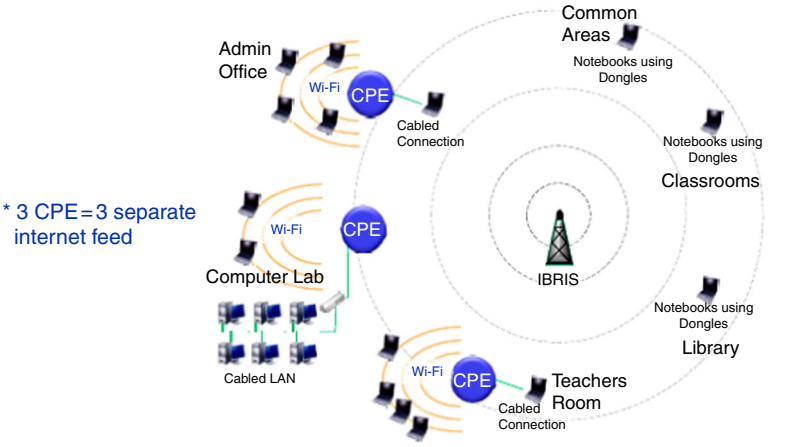


Figure 1.
Configuration of the Frog VLE platform

Note: 1BRIS = 1BestariNet Receiver Integrated System
Source: www.slideshare.net/Fadzliaton/1bestarinet-15720785

school support) that have not been examined in existing studies. On the basis of these motivations, we strongly believe that the findings from this study will provide new understanding on the determinants of instructional effectiveness of cloud computing VLE.

The rest of the paper follows the following structure. We start with the literature review on VLE and theoretical background. Next, the research model development and methodology are explained. Statistical analysis, discussion, theoretical and practical implication are then presented and the paper ends with a conclusion.

2. Literature review

VLE is defined as a cloud computing virtual learning platform of communications that allows students and teachers to access variety of learning tools, course content, assistance, shared documents and many other learning resources. Extensive literature review was conducted to avoid reinvention of wheel. Though there is hardly any study on cloud computing VLE, we managed to find several grid computing VLE studies that used extrinsic motivational theories like TAM, TAM2, UTAUT, etc. To avoid redundancy, these studies were summarized and presented in Table I.

Basically, existing grid computing VLE-related studies have engaged traditional motivation theories such as UTAUT (Sumak *et al.*, 2010), which is an upgraded version of the TAM (Lee *et al.*, 2001; Motaghian *et al.*, 2013; Sanchez and Hueros, 2010) and TAM2 (Van Raaij and Schepers, 2008). The key constructs in these models are perceived usefulness/performance expectancy and perceived ease-of-use/effort expectancy. Even though these theories do have their merits in explaining the behavioral intention of VLE, however, they suffer deficiencies in terms of explaining the important roles played by intrinsic motivation (e.g. self-determination), media richness (e.g. CET), trust in website and knowledge-sharing attitude. Likewise, the three-tier use model (Liaw, 2008), ELSS (Eom, 2012) and ISSM (Motaghian *et al.*, 2013) have focussed mainly on information, system and service quality, usage intention and users' satisfaction. No attention has been given to examining the user-centered constructs of SDT as well as the media-centered CET. Similarly, it also suffers from the deficiency in explaining the roles of VLE task-related attributes of interactivity, content design, knowledge-sharing and trust in website. The essence or benefit of adopting SDT, CET and other VLE-related constructs in this study is that we will be able to provide a more holistic examination on the determinants of instructional effectiveness while addressing the deficiencies existing in the above-mentioned studies.

2.1 VLE in education

Dillenbourg *et al.* (2002, p. 1) opined that VLE can be recognized by the following features:

- a VLE is a designed information space;
- a VLE is a social space where educational interactions transpire in the environment, transforming spaces into places;
- the virtual space is explicitly represented where the representation of this information or social space may differ from text model to 3D immersive virtual world;
- students are not only active but also actors as they co-construct the virtual space;
- VLEs are not limited to distance education as they also enrich classroom activities;

Table I.
Previous grid computing VLE studies

Researcher(s)	Context of the study (nation)	Sampling technique	Statistical analyses	Theory/model	Major findings
Sumak *et al.* (2010)	Acceptance of Moodle (Slovenia)	Pre-test and pilot test, online survey using convenient sample of 235 undergraduates	SEM	UTAUT	PE and SI affect ATT. SI and ATT affect BI. BI and FC affect AU. R^2 is not stated
Van Raaij and Schepers (2008)	Adoption of CassLearn (China)	A convenient sample of 40 Chinese managers	SEM	TAM2, SN, PIIT and CA	PIIT affects PEOU and CA. CA affects PEOU. PU is affected by PEOU and SN. AU is influenced by PU and PEOU. R^2 for AU is 31%, PU 54%, PEOU 59% and PIIT 10%
Sánchez and Hueros (2010)	Acceptance of Moodle (Spain)	Pre-test, convenient sample of 226 undergraduates	SEM	TAM, technical support and perceived self-efficacy	Technical support affects PEOU and PU. PEOU and ATT affect AU. The R^2 for PU, ATT and AU are 54, 77 and 41%
Chou and Liu (2005)	Technology-mediated VLE (Taiwan)	Convenient sample of 210 high school students	Factor analysis, independent samples *t*-test, paired *t*-test	Learner control, learning performance, self-efficacy, satisfaction and climate	Students in TVLE showed improved learning performance, greater levels of computer self-efficacy, satisfaction and learning climate
Eom (2012)	*e*-Learning management system (USA)	Online survey, convenient sample of 674 undergraduates	SEM	E-learning system success (ELSS)	Self-efficacy affects AU. SQ and InfQ affect user satisfaction. User satisfaction affects system effectiveness. R^2 for AU is 50.9%, user satisfaction 75.4% and system effectiveness 82.1%
Motaghian *et al.* (2013)	Web-based learning system (Iran)	Cluster sampling of 115 university instructors	SEM	TAM, ISSM, self-efficacy and SN	InfQ and SN affect PU. InfQ, SerQ, SN and Self-efficacy affect PEOU. BI is affected by PU, PEOU and SQ. BI directly affects AU. The R^2 for BI is 53% and AU 16

(*continued*)

Table I.

Researcher(s)	Context of the study (nation)	Sampling technique	Statistical analyses	Theory/model	Major findings
Sun and Hsu (2013)	Web-based instruction (Taiwan)	Convenient sample of 42 undergraduates	One-way ANOVA and ANCOVA	Perceived interactivity, ATT, satisfaction and perceived learning	Perceived interactivity affects ATT and satisfaction
Liaw (2008)	Blackboard (Taiwan)	Convenient sample of 424 undergraduates	Stepwise multiple regression	Three-tier Use Model (3-TUM)	Perceived self-efficacy, multimedia instruction and SQ affect satisfaction ($R^2 = 0.613$). PU and perceived satisfaction affect BI ($R^2 = 0.619$). Multimedia instruction, interactive learning activities and SQ affect learning effectiveness ($R^2 = 0.681$)
Lee *et al.* (2001)	Experience, attitude toward computer and awareness on PU, PEOU of ICT (Malaysia)	Sample of 330 private college students	Descriptive analysis (frequency and %)	TAM	Experience and level of studies influence PU and PEOU. PU and PEOU affect ATT. R^2 was no stated since a descriptive analysis was engaged
Poon *et al.* (2004)	Web-based learning (Malaysia)	Sample of 248 undergraduates	One-way ANOVA, χ^2 test	None	Students' behavior and attitude, interactive applications, technology/system, institutional factors and instructors' character have impacts on learning effectiveness

Notes: FC, facilitating conditions; PEOU, perceive ease-of-use; SI, social influence; PU = perceived usefulness; SN, subjective norm; InfQ, information quality; ServQ, service quality; SQ, system quality; ATT, attitude; CA, computer anxiety; BI, behavioral intention; AU, actual use

- VLEs incorporate heterogeneous technologies and multiple pedagogical approaches; and
- most VLEs overlap with physical environments.

VLE comes with a specific view of education, namely the social constructivist paradigm (Oliver and Herrington, 2003). Proponents of VLE find within social constructivism, a theoretical foundation to underpin their work (Maor, 2003). Specific instructional approaches such as scaffolding and coaching appear to be well suited to VLE. There are seven goals of constructivist learning environments (Oliver and Herrington, 2003, p. 113) that can be promoted by VLE:

(1) provide experience in the knowledge construction process;

(2) provide experience in and appreciation for multiple perspectives;

(3) embed learning in realistic and relevant contexts;

(4) encourage ownership and voice in the learning process;

(5) embed learning in social experience;

(6) encourage the use of multiple modes of representation; and

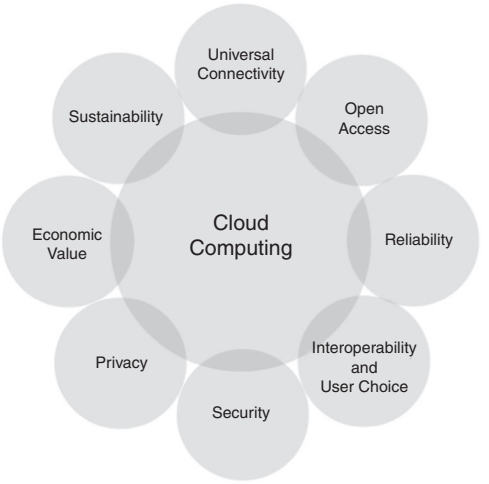
(7) encourage self-awareness in the knowledge construction process.

It is believed that the use of VLE would enhance students' approaches to learning especially within a social constructivist approach in education. A social constructivist approach to learning may be accompanied by changes in the form of assessment to eliminate inconsistencies between teaching methods and assessment procedures (Goodyear, 2002). A VLE may promote students' attainment through immediate feedback, extra support, cooperative revision, etc. "The use of a VLE combined with a more 'active' pedagogical approach, the possibility to collaborate, and given independence to learners, helped to deliver expected pedagogical outcomes and made a difference in learners achievement" (European Schoolnet, 2003, p. 20).

2.2 Cloud computing and typology

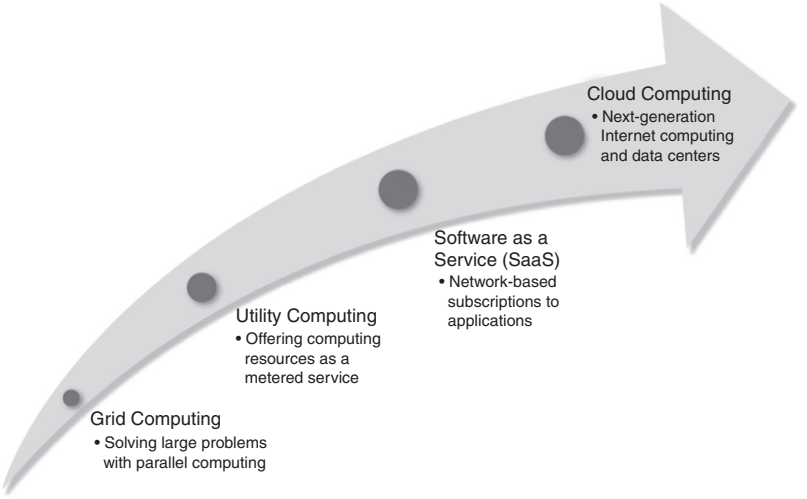
Cloud computing may be defined as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics (i.e. on-demand self-service, broad network access, resource pooling, rapid elasticity, measured service), three service models (i.e. Software as a Service (*SaaS*), Platform as a Service (*PaaS*), Infrastructure as a Service (*IaaS*)) and four deployment models (i.e. Private cloud, Community cloud, Public cloud, Hybrid cloud)" (Mell and Grance, 2011, p. 6). The term cloud computing refers to computing services being delivered over the Internet, on demand, from a remote location instead of residing on a personal desktop, laptop, mobile device or an organization's server. Basically, computing becomes location- and device-independent irrespective of where the information is based or where the computation process takes place to enable computing tasks and information to be accessed anytime, anywhere from any device. The cloud concept means that computing will become an infinite resource, taking on an on-demand, scalable form, with additional network bandwidth, storage and computing capability added as

needed. Wyld (2009) opined that cloud computing has the benefits of rapid scalability and deployment capabilities (i.e. provide just-in-time computational power and infrastructure), decreased maintenance or upgrades, improved resource utilization (i.e. elasticity, flexibility, efficiencies), disaster recovery capabilities, economies of scale and collaboration capabilities, ability to engage in usage-based pricing, reduced IT infrastructure needs (i.e. up-front and support costs), capacity for on-demand infrastructure and computing power, green-friendly (i.e. reduced environmental footprint). The fundamental elements of cloud computing are illustrated in Figure 2. Cloud computing evolved from grid computing (Figure 3).



Source: Rayport and Heyward (2009, p. 4)

Figure 2.
Elements of cloud computing



Source: IBM (2009, p. 6)

Figure 3.
Evolution of cloud computing

2.3 Extending self-determination and channel expansion theory

The study extends the SDT and CET theories in predicting instructional effectiveness. Existing studies on grid-based VLE have ignored the underlying justifications behind motivation. By understanding how well a person's psychological needs are fulfilled within the social context is essential in understanding the underlying motivational processes from the psychological perspective (Malhotra *et al.*, 2008). In Frog VLE, there exists attributes of permitting voluntary participation, sharing of ideas with others, freedom of expression and ICT competencies that are closely related to the fundamental psychological needs of autonomy, relatedness and competence; therefore, we argue that SDT (Roca and Gagné, 2008) has its role to play in predicting the instructional effectiveness.

The key elements of SDT are a set of fundamental psychological needs that trigger motivation (Deci and Ryan, 1985). The self-determination continuum (Figure 4) ranges from amotivation (i.e. short of motivation) to intrinsic motivation (Chen and Jang, 2010). The core difference is that intrinsic motivation is self-determined whereas amotivation is non-self-determined (Deci and Ryan, 1991). Extrinsic motivation is a spectrum of four intermediary regulations, namely, external (e.g. compliance), identified (e.g. personal interest), introjected (e.g. embarrassment) and integrated (e.g. entirely volitional) (Deci and Ryan, 2002). The SDT suggests that the adoption of intrinsic or extrinsic motivation depends on the satisfaction of three fundamental psychological needs of relatedness, autonomy and competence (Deci and Ryan, 2000). Relatedness is the yearning to get associated to the other whereas autonomy is the craving for self-regulation and self-initiation of a behavior, and competence refers to the feeling of effectiveness in obtaining desired outcomes (Sørebø *et al.*, 2009). The theory stresses that the three needs can be fulfilled through various acts that can differ individually due to cultural difference; however, these fulfillments are crucial for individual well-being independent of culture (Deci and Ryan, 2000).

Similar to the SDT, the CET has been largely ignored in VLE studies. More importantly, Frog VLE is a media-rich interactive virtual instructional platform that provides media-rich experiences to the users in terms of multimedia functionalities such as video, audio, animation, graphics and numerous forms of media through various channels of communication that are closely related to the CET. Thus, we argue that the CET will have substantial influence in predicting the instructional effectiveness. The CET (Carlson and Zmud, 1999) is an extension of Media Richness Theory (Daft and Lengel, 1986) by integration of the social influence theories. According to the CET, an individual's experiences with the channel will form a schema

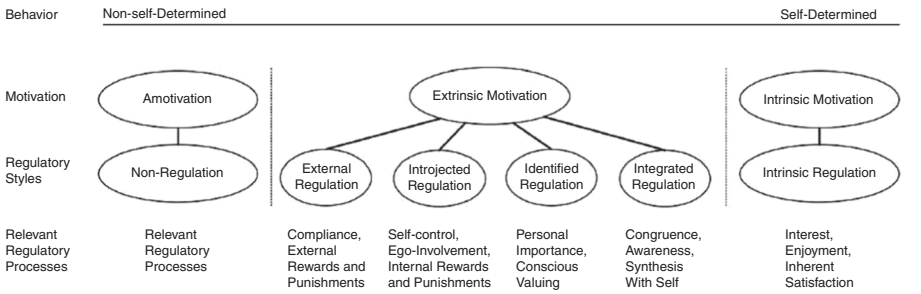


Figure 4.
The Self-determination continuums

Source: Chen and Jang (2010)

of social information processing that can decode or encode rich media efficiently. The perception of media richness is influenced by the experience with the media, the topic, the context of the organization and the communication partner (Carlson and Zmud, 1999). Media richness is crucial for the correct choice of media adoption.

Beside that, experience in knowledge building will affect the perception of media richness (Fernandez *et al.*, 2013). The experience with communication channel will enable an individual to learn the options, applications, characteristics and limitations of the channel, allowing a more effective adoption that can ultimately lead to a rise in perceived media richness, whereas the experience with communication partner will allow interactions and mutual learning using language patterns and messages and hence bring about richer language and messages (Fernandez *et al.*, 2013). The experience with the topic will enable adoption of specialized, regular jargon and easy communication (Timmerman and Madhavapeddi, 2008). Finally, the application of shared cultural references and symbols will permit richer communication through the channel as an outcome of the modernization of the organization knowledge base.

In this study, we have extended both theories to include the demographic variables of educational level, teaching experience and period as well as the VLE attributes of content design, interactivity, school support, knowledge sharing and trust in VLE website, which we will elucidate in detail in the next section.

2.4 SEM vs artificial neural networks (ANN)

Generally there are three statistical tools that we may use, namely the covariance-based Structural Equation Modeling (CBSEM), variance-based SEM (VBSEM) and ANN. The criteria for selection are as follows:

(1) Multivariate assumptions: CBSEM (e.g. AMOS, LISREL, EQS) requires that all multivariate assumptions are met. These include normality, linearity, multi-collinearity, homoscedasticity, outliers and a large sample size. However, VBSEM (e.g. SmartPLS, PLS-Graph, Visual PLS) is robust against non-normality, small sample size and outliers, whereas ANN (e.g. SPSS Clementine, Tiberius, WinNN) is robust against almost all multivariate assumptions including non-linearity (Henseler *et al.* 2009).

(2) Nature of study: CBSEM is suitable for theory testing and confirmation where there are strong theoretical foundations and hypotheses that are driven by model fitness (Jöreskog, 1982), whereas VBSEM is better suited for theory building and obtaining maximum variance explained and is data driven rather than model fit where with less theoretical foundations (Anderson and Gerbing, 1988). However, both are less powerful in terms of prediction power compared with ANN. If prediction is the aim of the study where there is a lack of theoretical foundations and underlying hypotheses, then ANN is the best option (Henseler *et al.*, 2009). Figure 5 illustrates the relationships between these three approaches.

3. Research model development

The psychology literature has claimed that a person's demographics can predict his/her behavior (Chong *et al.*, 2015). We argue that the educational level of the teacher will affect the instructional effectiveness of the VLE. This is because if a teacher possess high educational level (e.g. Masters/PhD), the qualification will facilitate the effective use of the VLE compared with those with lower educational level as they may have

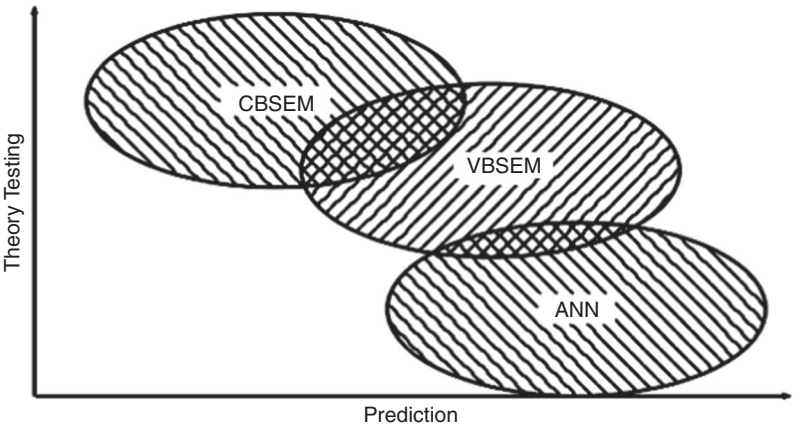


Figure 5.
CBSEM, VBSEM and ANN approaches

Source: Henseler *et al.* (2009)

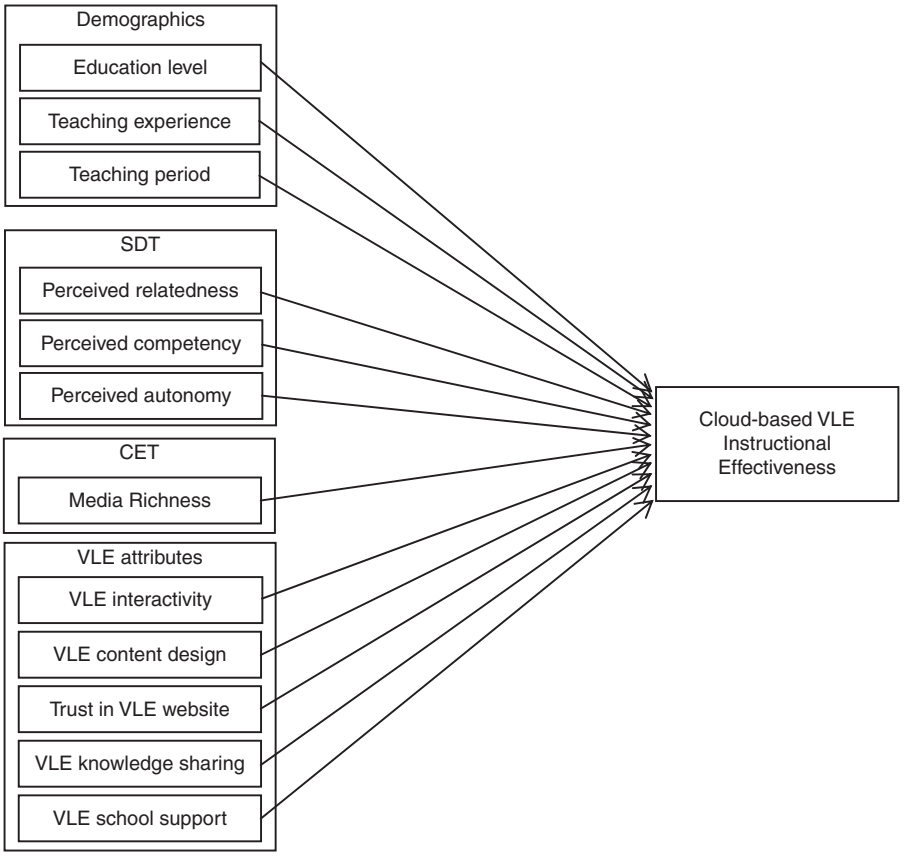
problems in using the most-effective pedagogical approach and the best choice of media, functions or tools in the Frog VLE system. Similarly, those with vast experiences in teaching career will be able to choose the more effective teaching resources to be used in the lesson to suite the needs and wants of their students. A novice or newcomer may not be able to use the VLE system as effectively as the experienced ones, as they do not possess the necessary knowledge on tackling students with different backgrounds and abilities. Experienced teachers will be better able to use the simplest media and tools to make complicated lesson easy-to-understand for the students. In terms of teaching period, we anticipate that teachers with more teaching periods will have lower instructional effectiveness compared with those with lesser periods. This is due to the fact that teachers who are heavily loaded with teaching periods will have higher tendency to face problems in preparing the teaching materials. With the time constraint that they face, the impact is on the quality of the instruction.

Frog VLE is an interactive platform that allows a wide variety of interactions between the users and the system. For example, teachers can search, save, retrieve, print, post, upload, download, share resources and create sites, forum discussion topics, replay e-mails, etc. We argue that when teachers are highly interactive with the system they will be actively creating teaching resources and attending to students' requests. This will eventually enhance the instructional effectiveness of the VLE compared with those who have lower interactivity level. The richer content of the VLE and a higher trust on the VLE website will also encourage teachers to use the system leading to higher interactivity and instructional effectiveness. Lastly, teachers willing to share teaching experiences and schools supporting the implementation of the system will also lead to a high degree of interactivity and ultimately the instruction effectiveness of the system can be uplifted. With these justifications, we proposed the following research model (Figure 6).

4. Methodology

4.1 Population and sampling procedure

As of December 31, 2014, there are 419,820 teachers in 10,154 schools across Malaysia. The sampling frame is the list of 351 Frog champion schools. Out of this, 50 schools



Notes: SDT, Self Determination Theory; CET, Channel Expansion Model

Figure 6.
Research model

were chosen using a simple random sampling technique. After obtaining the approval from the Education Planning and Research Division and all State Education Departments, 1720 questionnaires were posted via self-addressed courier services in first wave (T1) to gather the demographics and independent variables. After a four-month gestation period (Venkatesh *et al.*, 2012), dependent variables (i.e. perceived instructional effectiveness, PIE) were collected during the second wave (T2). Out of these, 1325 and 950 questionnaires were returned in T1 and T2, respectively. However, due to mismatch of reference number, incompleteness and double entries, only 624 questionnaires were usable for the final analysis. The demographic profile of the subjects is given in Table II.

4.2 Instrument development and operationalization of measures

The instrument has been developed through rigorous statistical validations with English-Malay back-translation. The steps involved are shown as in Figure 7. All items were gauged with seven-point Likert scales from 1 (strongly disagree) to 7 (strongly agree), except for age, teaching experience and weekly teaching periods, which were gauged using a ratio scale, gender using a nominal scale and highest education level using an ordinal scale. The list of items and their sources are shown in the Appendix.

	Frequency	%
Highest educational level		
SPM (O-level)	27	4.3
STPM (A-level)	19	3.0
Certificate	2	0.3
Diploma	41	6.6
Advanced diploma	1	0.2
Bachelor degree	492	78.8
Master degree	41	6.6
PhD or doctoral degree	1	0.2
Years of teaching experience		
1-5	146	23.4
6-10	166	26.6
11-15	96	15.4
16-20	99	15.9
21-25	50	8.0
26-30	51	8.2
31-35	13	2.1
36-40	3	0.5
Weekly teaching periods (1 period = 40 minutes)		
0-4	36	5.8
5-9	11	1.8
10-14	29	4.6
15-19	53	8.5
20-24	216	34.6
25-29	221	35.4
⩾ 30	58	9.3

Table II.
Demographic profile

Figure 7.
Instrument development and validation process

4.3 Reliability and validity

We assessed the construct reliability on the basis of Cronbach's α and composite reliability, and Table III shows that both are above 0.70, confirming that the measures are reliable (Leong *et al.*, 2015). All AVEs are above 0.50, confirming convergent validity (Zhou, 2014) whereas the square root of AVE (Table IV) is greater than their correlation coefficients validity discriminant validity (Lee *et al.*, 2014).

4.4 Common method bias (CMB)

To reduce the CMB issue, two separate surveys were conducted at T1 and T2. However, we also performed Harman's Single Factor analysis (Lin and Lekhawipat, 2014) and single factor explains only 40.348 percent of the total variance, implying that CMB is negligible (Hew *et al.*, 2015).

	Cross loadings	Average variance extracted (AVE)	Composite reliability	Cronbach's α
PA	0.861-0.863	0.744	0.897	0.828
PC	0.805-0.902	0.748	0.899	0.832
PR	0.869-0.925	0.807	0.944	0.920
PMR	0.859-0.896	0.781	0.962	0.953
VCD	0.879-0.916	0.800	0.960	0.950
VI	0.873-0.925	0.801	0.942	0.917
SS	0.886-0.951	0.866	0.963	0.948
TW	0.958-0.979	0.939	0.979	0.968
AT	0.952-0.975	0.928	0.985	0.981
PIE	0.910-0.941	0.851	0.972	0.965

Notes: $n = 624$. PR, perceived relatedness; PA, perceived autonomy; PC, perceived competence; PMR, perceived media richness; VCD, VLE content design; VI, VLE interactivity; SS, school support; AT, attitude toward knowledge sharing; TW, trust in website; BI, behavioral intention; PIE, perceived instructional effectiveness. The reversed items of PR3, PR6, PR7, PA2, PA4, PA7, PC1, PC5 and PC6 were discarded due to poor factor loadings

Table III. Construct reliability and validity

	AT	PA	PC	PIE	PMR	PR	SS	TW	VCD	VI
AT	0.963									
PA	0.456	0.862								
PC	0.475	0.751	0.865							
PIE	0.360	0.473	0.475	0.922						
PMR	0.449	0.714	0.689	0.540	0.884					
PR	0.674	0.439	0.445	0.306	0.413	0.898				
SS	0.541	0.492	0.473	0.391	0.516	0.487	0.931			
TW	0.520	0.564	0.547	0.441	0.594	0.472	0.495	0.969		
VCD	0.483	0.723	0.676	0.523	0.775	0.451	0.545	0.577	0.895	
VI	0.375	0.661	0.643	0.522	0.781	0.356	0.469	0.565	0.752	0.895

Notes: PR, perceived relatedness; PA, perceived autonomy; PC, perceived competence; PMR, perceived media richness; VCD, VLE content design; VI, VLE interactivity; SS, school support; AT, attitude toward knowledge sharing; TW, trust in website; BI, behavioral intention; PIE, perceived instructional effectiveness

Table IV. Discriminant validity (Fornell-Larcker's criterion)

5. Statistical analysis

5.1 Testing of multivariate assumptions

The p-values of the one-sample Kolmogorov-Smirnov test are < 0.05, indicating non-normality in distribution, and the scatter plot of the regression standardized residual showed a straight diagonal line surrounding the data implying homoscedasticity is achieved. All VIFs are < 5, verifying no multi-collinearity problems (Teo *et al.*, 2015). Pearson's correlation coefficients between the variables are < 0.80, further validating that multi-collinearity is non-issue (Tan *et al.*, 2014). On the basis of the p-values of the deviation from linearity, we found non-linear relationships of effectiveness to content design, interactivity and autonomy (Table V).

Due to the violations on the multivariate assumptions and the existence of non-linear relationships and lack of theoretical foundations, ANN would be the most appropriate statistical approach for this study.

5.2 Overview of ANN analysis

ANN is a huge processor consisting of simple processing units known as neurons that can store knowledge for future use. It resembles the human brain as knowledge can be learned through iterative training process and stored as synaptic weights (Leong *et al.*, 2015). In this study, a multi-layer perceptrons are engaged with the three layers of neurons, namely, the input, hidden and output layers (Leong *et al.*, 2013). The feed-forward-back-propagation algorithm is used with supervised learning process where input data are fed forward from the input layer toward the hidden layer using an activation or transfer function. The hidden layer will then process and send the output to the output layer. During this learning process, the synaptic weights will be adjusted and assign a value between 0 and 1. Using another activation function, the output layer will compute the difference between the actual and the desired output and send these biases in a backward direction to the input layer. This process is iterative until a minimum bias is achieved. Figure 8 depicts a typical neuron.

To evade over-fitting, a tenfold cross-validation was used where 90 percent of the data were being analyzed for learning and 10 percent for testing (Leong *et al.*, 2013). The sigmoid function (Figure 9) was utilized as the activation function and the quantity of hidden units was automatically calculated. The procedure automatically computes the minimum and maximum values of the range and identifies the best number of hidden units within the range by using The Bayesian Information Criterion (BIC). The best number of hidden units yields the smallest BIC based on the training data. To assess the model fit of the ANN (Figure 10), root mean square of errors (RMSE) was computed and sensitivity analysis was used to compute the normalized importance of the predictors.

5.3 Validating ANN models

RMSE was computed as a measure of prediction accuracy (Leong *et al.*, 2015). Table VI indicates that the average RMSE for the training and testing are 0.1069 and 0.1017, respectively. As both values are very consistent, we conclude that the ANN model is reliable and possesses very high degree of prediction accuracy. To further validate the relevancy of the constructs, we also examined the quantity of non-zero synaptic weights directed to the hidden layers. Table VII shows that all predictors are relevant in predicting instructional effectiveness.

	Sum of squares	df	Mean square	*F*	Sig.
PIE × highest education level					
Between groups					
(Combined)	11.121	7	1.589	1.249	0.274
Linearity	3.221	1	3.221	2.532	0.112
Deviation from linearity	7.900	6	1.317	1.035	0.401
PIE × teaching experience					
Between groups					
(Combined)	49.482	37	1.337	1.051	0.389
Linearity	11.539	1	11.539	9.072	0.003
Deviation from linearity	37.943	36	1.054	.829	0.752
PIE × number of weekly teaching periods					
Between groups					
(Combined)	44.886	35	1.282	1.005	0.462
Linearity	9.019	1	9.019	7.071	0.008
Deviation from linearity	35.867	34	1.055	0.827	0.747
PIE × PMR					
Between groups					
(Combined)	268.158	39	6.876	7.624	0.000
Linearity	231.791	1	231.791	257.010	0.000
Deviation from linearity	36.366	38	0.957	1.061	0.374
PIE × VCD					
Between groups					
(Combined)	260.402	33	7.891	8.711	0.000
Linearity	217.031	1	217.031	239.588	0.000
Deviation from linearity	43.371	32	1.355	1.496	0.041
PIE × VI					
Between groups					
(Combined)	253.609	24	10.567	11.695	0.000
Linearity	216.754	1	216.754	239.883	0.000
Deviation from linearity	36.855	23	1.602	1.773	0.015
PIE × SS					
Between groups					
(Combined)	156.251	24	6.510	6.107	0.000
Linearity	120.791	1	120.791	113.301	0.000
Deviation from linearity	35.460	23	1.542	1.446	0.082
PIE × AT					
Between Groups					
(Combined)	124.646	24	5.194	4.642	0.000
Linearity	102.789	1	102.789	91.868	0.000
Deviation from linearity	21.857	23	0.950	0.849	0.668
PIE × TW					
Between groups					
(Combined)	176.829	18	9.824	9.617	0.000
Linearity	154.163	1	154.163	150.914	0.000
Deviation from linearity	22.666	17	1.333	1.305	0.182

(*continued*)

Table V.
Test of linearity

	Sum of squares	df	Mean square	*F*	Sig.
PIE × *PR*					
Between groups					
(Combined)	85.341	33	2.586	2.150	0.000
Linearity	39.339	1	39.339	32.712	0.000
Deviation from linearity	46.002	32	1.438	1.195	0.215
PIE × *PA*					
Between groups					
(Combined)	203.416	31	6.562	6.568	0.000
Linearity	151.349	1	151.349	151.493	0.000
Deviation from linearity	52.068	30	1.736	1.737	0.009
PIE × *PC*					
Between groups					
(Combined)	139.264	31	4.492	4.057	0.000
Linearity	95.716	1	95.716	86.432	0.000
Deviation from linearity	43.548	30	1.452	1.311	0.127

Notes: PR, perceived relatedness; PA, perceived autonomy; PC, perceived competence; PMR, perceived media richness; VCD, VLE content design; VI, VLE interactivity; SS, school support; AT, attitude toward knowledge sharing; TW, trust in website; BI, behavioral intention; PIE, perceived instructional effectiveness

Table V.

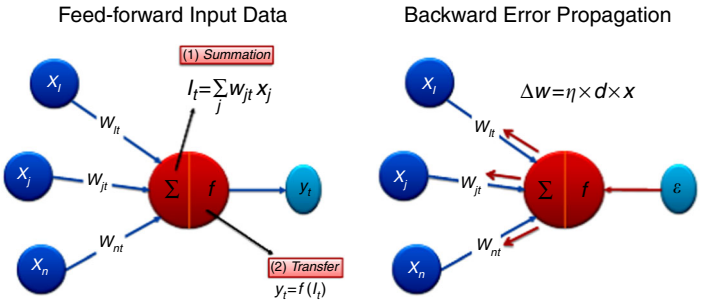


Figure 8.
Artificial neuron

Source: www.saedsayad.com/artificial_neural_network.htm

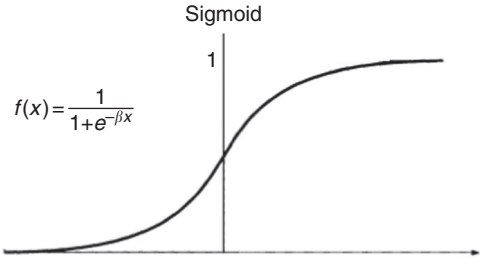


Figure 9.
The sigmoid function

Source: www.saedsayad.com/artificial_neural_network.htm

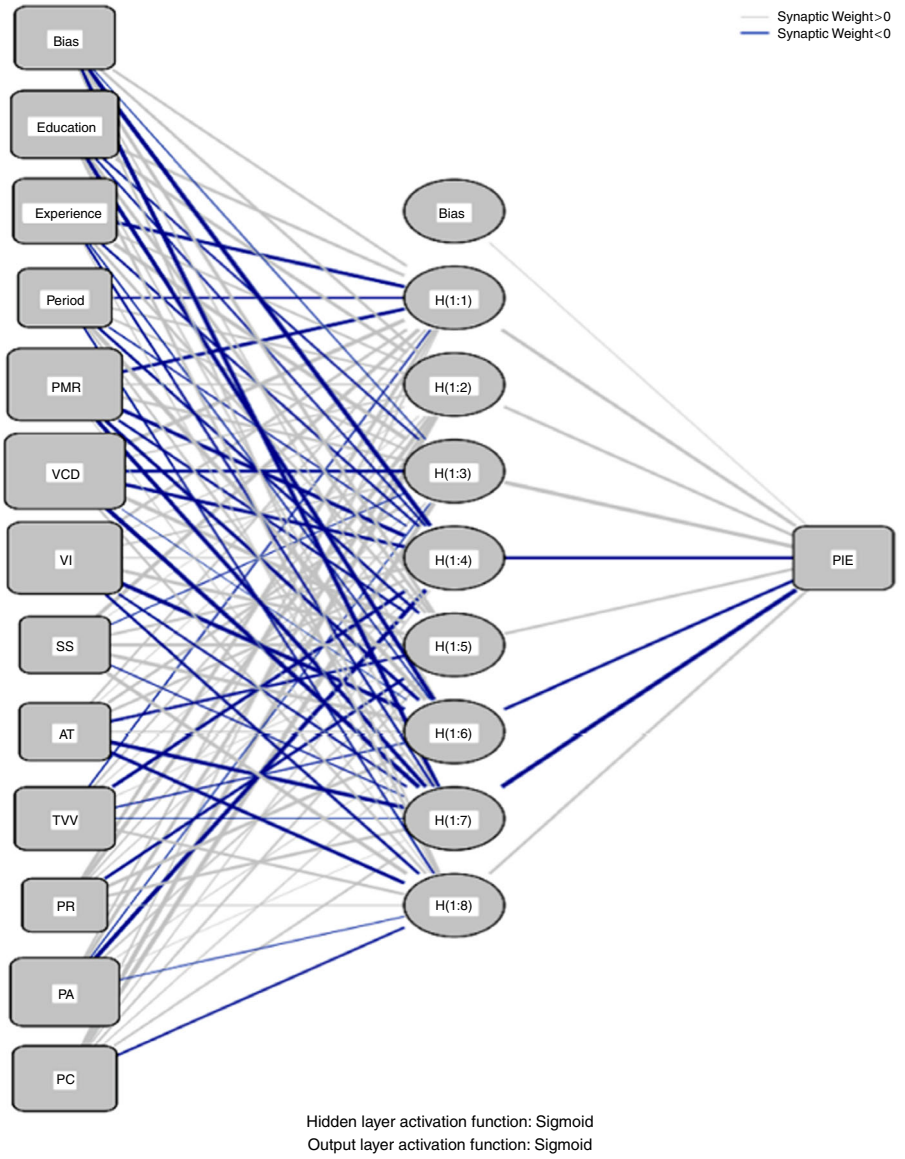


Figure 10.
The ANN research model

5.4 Sensitivity analysis

To assess the normalized importance of the predictors, sensitivity analysis was used. First, the average relative importance of ten neural networks is calculated. Then the normalized importance of each predictor is computed as the percentage of the average relative important to the largest average relative importance among the predictors over ten neural networks. Table VIII shows that the normalized importance ranges from 27.9 to 100 percent.

Neural network	Training n	Training SSE	Training RMSE	Testing n	Testing SSE	Testing RMSE
NN1	557	6.328	0.1066	67	0.424	0.0796
NN2	560	5.830	0.1020	64	0.787	0.1109
NN3	561	5.754	0.1013	63	0.927	0.1213
NN4	562	6.710	0.1093	62	0.618	0.0998
NN5	562	6.748	0.1096	62	0.589	0.0975
NN6	559	6.577	0.1085	65	0.486	0.0865
NN7	556	6.461	0.1078	68	0.636	0.0967
NN8	561	6.148	0.1047	63	0.909	0.1201
NN9	562	7.143	0.1127	62	0.773	0.1117
NN10	567	6.397	0.1062	57	0.494	0.0931
		Average RMSE	0.1069		Average RMSE	0.1017
		Standard deviation	0.0035		Standard deviation	0.0139

Table VI.
RMSE for training and testing process

Notes: n, number of data; SSE, sum of squares error

Construct	NN1	NN2	NN3	NN4	NN5	NN6	NN7	NN8	NN9	NN10
ED	/	/	/	/	/	/	/	/	/	/
TEX	/	/	/	/	/	/	/	/	/	/
TP	/	/	/	/	/	/	/	/	/	/
AT	/	/	/	/	/	/	/	/	/	/
PA	/	/	/	/	/	/	/	/	/	/
PC	/	/	/	/	/	/	/	/	/	/
PIE	/	/	/	/	/	/	/	/	/	/
PMR	/	/	/	/	/	/	/	/	/	/
PR	/	/	/	/	/	/	/	/	/	/
SS	/	/	/	/	/	/	/	/	/	/
TW	/	/	/	/	/	/	/	/	/	/
VCD	/	/	/	/	/	/	/	/	/	/
VI	/	/	/	/	/	/	/	/	/	/

Table VII.
Predictive relevance analysis

Notes: / denotes more than 1 non-zero synaptic weight linked to the hidden layer; ED, educational level; TEX, teaching experience; TP, weekly teaching periods; PR, perceived relatedness; PA, perceived autonomy; PC, perceived competence; PMR, perceived media richness; VCD, VLE content design; VI, VLE interactivity; SS, school support; AT, attitude toward knowledge sharing; TW, trust in website; BI, behavioral intention; PIE, perceived instructional effectiveness

The data are then further analyzed using Pearson's correlation analysis (Sexton *et al.*, 2002). The analysis revealed a negative relationship between teaching period and PIE and positive relationships for other predictors of PIE.

6. Discussion

Since the normalized importance of all predictors was greater than 10 percent, we concluded that all predictors have significant relationship with effectiveness. On the basis of the normalized importance, autonomy (100 percent) was found to be the most important predictor of effectiveness followed by interactivity (85.2 percent). This indicates that teachers' autonomy plays a very important role in determining the level of instructional effectiveness. This intrinsic motivation will enable the teacher to use

Table VIII. Sensitivity analysis

	Relative importance											
	ED	TEX	TP	PMR	VCD	VI	SS	AT	TW	PR	PA	PC
	0.065	0.095	0.030	0.195	0.071	0.097	0.025	0.067	0.062	0.060	0.210	0.022
	0.067	0.067	0.026	0.133	0.096	0.171	0.039	0.051	0.058	0.028	0.185	0.079
	0.097	0.080	0.021	0.083	0.098	0.150	0.022	0.045	0.072	0.033	0.239	0.061
	0.019	0.030	0.040	0.031	0.016	0.204	0.057	0.062	0.186	0.100	0.187	0.068
	0.022	0.066	0.086	0.161	0.044	0.111	0.164	0.044	0.086	0.039	0.028	0.150
	0.022	0.024	0.055	0.168	0.031	0.167	0.069	0.128	0.102	0.044	0.082	0.105
	0.052	0.050	0.038	0.152	0.049	0.132	0.087	0.011	0.086	0.014	0.226	0.101
	0.018	0.064	0.032	0.109	0.144	0.166	0.023	0.054	0.117	0.020	0.168	0.085
	0.016	0.018	0.091	0.028	0.246	0.030	0.060	0.181	0.087	0.098	0.120	0.024
	0.080	0.063	0.087	0.130	0.120	0.172	0.042	0.028	0.046	0.022	0.198	0.013
Average relative importance	0.046	0.056	0.051	0.119	0.092	0.140	0.059	0.067	0.090	0.046	0.164	0.071
Normalized relative importance (%)	27.9	33.9	30.8	72.4	55.7	85.2	35.8	40.8	54.9	27.9	100.0	43.1

Notes: ED, educational level; TEX, teaching experience; TP, weekly teaching periods; PR, perceived relatedness; PA, perceived autonomy; PC, perceived competence; PMR, perceived media richness; VCD, VLE content design; VI, VLE interactivity; SS, school support; AT, attitude toward knowledge sharing; TW, trust in website; BI, behavioral intention; PIE, perceived instructional effectiveness

the VLE without any external pressures or interferences, allowing them to use the system in their own ways to achieve their intended instructional objectives. The result further advances the works of Sørebø *et al.*, (2009), Roca and Gagne (2008) who found the indirect effect of relatedness on intention to use e-learning.

Higher interactivity may lead to higher instructional effectiveness. This finding further complements the work by Balaji and Chakrabarti (2010) who found significant effect of interactivity on perceived learning of online discussion forum. The interactivity in the VLE may instill a sense of social connectedness between the teachers and the students, which leads to the establishment of productive relationships among the students and collaborative exploration of the subject.

Media richness (72.4 percent) as the third strongest predictor indicates that when the media richness perception is higher, the instructional effective will also be higher. This has further enriched the work of Saeed and Sinnappan (2009) on the effect of media richness on intention to use blog, podcast and Second Life. A richer media will enable teachers to communicate faster and comprehend equivocal messages, which lead to higher instructional effectiveness.

Besides that, the higher the level of content design (55.7 percent), the better the instructional effectiveness will be. It further advances the finding by Lee *et al.* (2009) on the indirect effect of content design on e-learning. When the content design is tailored to the needs of the teachers in terms of ease-of-use, novelty, innovativeness and compliance to the syllabus, students will be easily enticed, immerse themselves in the instructional process leading and understand the content for better instructional effectiveness.

The higher the trust in website (54.9 percent), the higher the level of instruction effectiveness will be. This is a newly developed relationship that has further advanced the current literature on trust. When there is a sense of trust with the VLE, teachers will feel comfortable and confident to teach especially in integrating various online resources into the instruction for better instructional effectiveness.

Competency (43.1 percent) implies that if the teachers possess high degree of competency, they will be able to improve the instructional effectiveness. It has complemented Roca and Gagné (2008) who found indirect effect of trust on continuance intention to use e-learning at the workplace. Since VLE involves certain fundamental competencies, teachers who have mastered these competencies would be able to fully use the available functionalities in order to create effective instructional websites for better instructional performances.

Knowledge sharing attitude (40.8 percent) implies that if teachers have high propensity to share their knowledge, the instructional effectiveness will excel. This is consistent with Chow and Chan (2008) who found that attitude toward knowledge sharing directly affects intention to share knowledge. When teachers are willing to share their knowledge, especially the best practices and innovative approaches in using the VLE, the quality of instructional will be much better.

School support (35.8 percent) showed that when administrators are highly supportive, the instructional process will be more effective. This newly developed relationship means that support from the school authorities in terms of moral and material will definitely boost teachers' intention to use the VLE, which will eventually lead to higher quality of instructional websites as teachers are provided with adequate facilities.

Teaching experience (33.9 percent) may also increase the instructional effectiveness. This result further advanced the work of DeLone (1988) who found that user experience directly influences system usage. The experienced teachers will have more creativity in

designing effective websites for more effective teachings compared with the inexperienced ones.

Teaching period (30.8 percent) has a negative effect on effectiveness. The new association is in line with the heavy teaching workload that has hindered teachers' intention to use the VLE. With fewer periods, teachers will be able to have more time and energy to prepare the websites for better results.

Higher educational level (27.9 percent) will lead to higher instructional effectiveness. This has advanced the work of Leong *et al.* (2011) on intention to use mobile entertainment. Since VLE requires some technical competencies and knowledge, teachers with high academic qualification will be able to understand the technical terms and jargon in navigating the VLE.

Finally, relatedness (27.9 percent) indicates that teachers need to get connected with their counterparts in order to raise the instructional effectiveness. This finding has enriched the works of Sørebø *et al.* (2009), Roca and Gagne (2008) on the intention to use e-learning. To increase instructional effectiveness, teachers need to obtain the best teaching approaches from their counterparts through online or offline connections.

7. Theoretical and practical implications

This research applies ANN in predicting the PIE of cloud-based VLE. It has several theoretical implications. First, it has successfully extended the SDT and CET models with demographics and VLE attributes. All predictors were found to be relevant and the least important predictor was able to provide 27.9 percent normalized importance compared with the minimum 10 percent variance explained as recommended for the quantitative study. The integrated SDT-CET model will be able to contribute to the VLE literature to close the existing gap on instructional effectiveness. Both linear and non-linear relationships were captured by the neural networks. More importantly, the identification of the non-linear relationships between PIE with VCD, VI and PA will provide new theoretical contribution compared with the trivial linear relationships between predictors and dependent variables. The findings from this study will enable scholars and researchers to gain better understanding and insight on the drivers of PIE from the context of the cloud-based VLE in comparison with the traditional grid-based VLE. Subsequent studies may use the results from this research as a theoretical foundation to establish new theories on instructional effectiveness of VLE.

The study also offers several practical implications to the MoE, VLE providers, school administrators, educational officers and teachers in upgrading the level of instructional effectiveness throughout the country. First of all, more autonomy should be given to teachers as it is the most important predictor of PIE. For example, dongles may be given to teachers for them to access the VLE anywhere, either at school or home. They should also be allowed to have greater storage size for them to have more freedom in data storage. Second, more motivation should be given to teachers who actively interact or use the VLE system. Teachers with high degree of interactivity should be rewarded with "Yes" credit (monetary reward), Frog credit (reward points) or certificate of recognition. Third, more effort and resources should be provided for the R&D of VLE improvements in terms of enrichment of the media richness and VLE content. For example, the latest media technologies (e.g. voice navigation, synthesized speech, 3D animations, Virtual Reality, etc.) can be incorporated into the VLE system. The Curriculum Development Centre may design more VLE content for teachers to use, thus saving the time in preparing the content. This can also be done via smart partnership between MoE and the textbook publishers whereby the educational

courseware from these publishers can be incorporated into the VLE platform and their websites can be linked with the VLE system.

Fourth, to build trust to the VLE website, YTL may strengthen the security features (e.g. firewall, encryption, cryptography, IDS and etc.) of the VLE platform as well as collaboration with antivirus corporations such as Kaspersky, Symantec, AVG, etc. to provide online scanning facilities to all teachers when files are uploaded or downloaded from the system. This will further promote the trust of teachers in using the website. Next, teachers may be called for a VLE competency course or training from time to time to improve their competency in using the system. An online tutorial can also be provided as an alternative to reduce financial burden of MoE. The level of competency should be evaluated through online tests and reward and recognition may be given on the basis of the grades obtained. Besides experienced teachers in each school, it is also recommended that Frogasia should provide a moving clinic in the form of a special design bus to be stationed at each state so that schools that require their assistance and support can call upon them to give on-demand training to teachers with low competency.

Since knowledge sharing is among the important predictors, MoE may encourage more knowledge sharing sessions through seminars, conferences, talks and dialogues for teachers to share their knowledge and experience in using the VLE. Due recognition may be given to teachers who are willing to show and share their expertise and knowledge with others. For example, prize and certificate may be awarded to these teachers and their contribution may be taken into consideration for promotion and annual appraisal. Besides that, principals and headmasters should also give their full support in implementing the VLE. This can be done by establishing a corner of recognition for the most active user or the Frog teacher of the month, or by ensuring that more publicity is done in the form of banners, brochures or during the school meetings. Alternatively, they may try their best to reduce the teaching periods of the teachers so that more time can be allocated in preparing the instructional resources. This is because there is a negative relationship between teaching period and PIE, and with fewer periods, the level of PIE can be uplifted.

To foster better connectedness among teachers, FrogAsia may use social media such as Facebook, Twitter or Instagram as platforms for teachers to get connected. Last but not the least; MoE may encourage teachers to upgrade themselves by providing more scholarships and study loans. With higher educational level, teachers will be able to provide better instructional effectiveness as they will have more pedagogical and ICT skills. Similarly, as experienced teachers are able to provide higher instructional effectiveness, it is suggested that the inexperienced teachers should be exposed to the usage of the VLE system through visits to the top champion schools. Winners of the 1Bestarinet Teacher Award may be invited to give talks and share their experiences with these novice teachers on the know-how of the best Frog VLE practices.

8. Research implications

The first research implication is the use of ANN in identifying the determinants of VLE instructional effectiveness. Previous VLE studies used to focus on behavioral intention or continuance intention instead of instructional effectiveness. Linear models such as SEM, PLS or MLR were used without validating the linearity in relationships. This may provide a new paradigm shift from intention or continuance intention to the effectiveness of using an information system. Second, the rigorous instrument

development and validation procedure may be used as a guideline for future studies in non-English speaking countries. This study advocates that a study should start from the instrument validation instead of just adopting or adapting items from existing studies if there are cultural differences. Third, previous studies were conducted mainly from the perspective of undergraduates using grid-based VLE. However, this study was conducted from the perspective of the teachers from the context of cloud-based VLE. Finally, unlike existing studies that mainly combined constructs taken from the established IS theories such as TAM, TPB, UTAUT, ECT, etc., the study emphasized that in order to obtain holistic understanding of the effectiveness of a system, task-specific constructs should be included.

9. Limitations and future studies

Since this study was done in Malaysia, the findings may not be generalized to other geographical regions. Hence, it is suggested that in future, cross-nation studies should be conducted to examine the cultural differences. A longitudinal study may also be conducted to investigate the effect of time on the instructional effectiveness of the cloud-based VLE.

10. Conclusion

The study has further extended the SDT and CET theories and closes the research gaps on instructional effectiveness from the new context of the cloud-based VLE that has been ignored previously. Due to the deficiencies in terms of intrinsic motivations and task-related attributes, SDT, CET and VLE-related constructs were integrated and the results showed that all predictors have significant effects on instructional effectiveness. Hopefully, the findings from this study may provide useful insight for practitioners and scholars in raising our understanding about cloud-based VLE as well as improving the instructional effectiveness of the VLE.

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Appendix

Construct	Items	Source
Perceived relatedness (PR)	PR1: I really like the people I work with PR2: I get along with people at work PR3: I pretty much keep to myself when I am at work PR4: I consider the people I work with to be my friends PR5: people at work care about me PR6: there are not many people at work whom I am close to PR7: the people I work with do not seem to like me much PR8: people at work are pretty friendly toward me	Sørebø *et al.* (2009)
Perceived autonomy (PA)	PA1: I feel like I can make a lot of inputs in deciding how I use VLE in my teaching profession PA2: I feel pressured at using VLE in my teaching profession PA3: I am free to express my ideas and opinions on using VLE in my teaching profession PA4: when I am using VLE, I have to do what I am told PA5: my feelings toward VLE are taken into consideration at work PA6: I feel like I can pretty much use VLE as I want to at work PA7: there is not much opportunity for me to decide for myself how to use VLE in my teaching profession	Sørebø *et al.* (2009)
Perceived competence (PC)	PC1: I do not feel very competent when I use VLE in my teaching profession PC2: the other colleagues tell me I am good at using VLE in my teaching profession PC3: I have been able to learn interesting new skills in VLE through my profession PC4: most days I feel a sense of accomplishment from working with VLE PC5: as a teacher I do not get much of a chance to show how capable I am in VLE PC6: when I am using VLE I often do not feel very capable.	Sørebø *et al.* (2009)
Perceived media richness (PMR)	PMR1: the VLE features allow me to give and receive timely feedback PMR2: the VLE features allow me to tailor my teaching to my own personal requirements PMR3: the VLE features allow me to communicate a variety of different cues (such as emotional tone, attitude, or formality) in my teaching PMR4: the VLE features allow me to use a rich and varied language in my teaching PMR5: I could easily explain concepts using the VLE features PMR6: The VLE features help me to communicate quickly PMR7: the VLE features help me to better understand others	Fernandez *et al.* (2013)
VLE content design (VCD)	VCD1: the level of difficulty of the learning contents is appropriate VCD2: the content of assignments is easy to understand VCD3: the amount of learning contents is appropriate VCD4: the delivery schedule of learning contents is flexible VCD5: VLE provides individualized learning management VCD6: VLE provides a variety of learning methods	Lee *et al.* (2009)

(*continued*)

Table AI. List of items and sources

Construct	Items	Source
VLE interactivity (VI)	VI1: interacting with VLE is like having a conversation with a sociable, knowledgeable and warm representative from my school	Chen *et al.* (2007)
	VI2: I feel as if VLE talked back to me while I was navigating the VLE	
	VI3: I perceive the VLE to be sensitive to my needs for information	
	VI4: my interaction level with the VLE was high	
	VI5: I do not interact with the VLE much	
School support (SS)	SS1: my school is committed to a vision of using VLE in teaching	Lai and Chen (2011)
	SS2: my school is committed to supporting my efforts in using VLE for teaching	
	SS3: the school strongly encourages the use of VLE for teaching	
	SS4: my school will recognize my efforts in using VLE for teaching	
Attitude toward knowledge sharing (AT)	AT1: sharing of my knowledge with other teachers is always good	Chow and Chan (2008)
	AT2: sharing of my knowledge with other teachers is always beneficial	
	AT3: sharing of my knowledge with other teachers is always an enjoyable experience	
	AT4: sharing of my knowledge with other teachers is always valuable to me	
	AT5: sharing of my knowledge with other teachers is always a wise move	
Trust in website (TW)	TW1: I think the VLE website is secure	Hsu *et al.* (2014)
	TW2: I think the VLE website is reliable	
	TW3: I think the VLE website is trustworthy	
Perceived instructional effectiveness (PIE)	PIE1: I believe that I could improve my teaching by using the VLE	Limniou and Smith (2010)
	PIE2: I believe that I could improve students' performance by using the VLE	
	PIE3: I believe that the students could better understand the content of their subjects through the use of VLE	
	PIE4: I believe that I have control of teaching by using the VLE	
	PIE5: I believe that the VLE is the best way for teaching and learning	
	PIE6: Overall, I believe that students will be more self-motivated if they have access to the VLE	

Table AI.

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