An Empirical Investigation on the Effectiveness of Virtual Learning Environment in Supporting Collaborative Learning: A System Design Perspective

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Abstract. This study theoretically develops and empirically tests a model that explains how virtual learning environment (VLE) characteristics can ultimately influence learning effectiveness by directly affecting leaner's control over the learning material and leaner's communication and interaction with peers and instructor. The findings of the empirical study shows that system accessibility, ease of navigation, system interactivity and system support serve different roles in achieving effective learning outcomes. This study also demonstrates the feasibility of incorporating different learning theories into VLE design and how they would inform different perspective of learning.

Keywords: Virtual learning environment (VLE), system characteristics, self-controlled learning, communication-based learning.

1 Introduction

Fuelled by the knowledge economy, the importance of education and training to individual and the society has been widely recognized. In the year 2007, total US education and training market has reached $980.2 Billion [1]. With the swift advancement of computer hardware, software and network technologies, learning is enhanced by various information and communication technological supports. Technology-mediated learning has received increasing attention in the filed of information systems research [2].

To better inform the use of information technology in education, researchers pointed out the necessity to understand the underlying pedagogical assumptions better [3]. In the educational psychology literature, constructivism learning model emphasizes the importance of self-controlled learning, and collaborativism highlights the function of communication-oriented learning. However, most researches have been focused on how to realize a single pedagogical purpose using different technologies and few studies have looked at how effectively information technologies could facilitate various pedagogical goals at the same time. As a sophisticated form of e-learning, virtual learning environment (VLE) are computer-based environments allowing interactions and encounters with other learners and providing access to a wide range of resources [4]. In this study, we will look at how the system characteristics of VLE

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could help to realize different pedagogical approaches informed by constructivism and collaborativism.

2 Literature Review

2.1 Learning Theories and Pedagogical Approaches

Learning theories are widely used and explored to provide guidance for instructional and learning practice. In this section, two well-cited learning theories are reviewed and related pedagogical approaches are discussed.

Constructivism and Self-controlled Learning. Constructivism is a psychological and philosophical perspective stating that individuals form or construct by themselves much of what they learn and understand [5]. According to constructivism, information is not learning; instead, learning involves processing all the instructional inputs to develop, test, and refine mental models in long-term memory [6]. Therefore, learner's self control of processing learning material at their own time and pace contributes to learning effectiveness [7].

Self-controlled learning refers to the ability of learner to exert control over the pace, sequence, and content of instruction in a learning environment [8]. Learning system is usually equipped with learning control mechanisms to facilitate self-controlled learning, such as instructional designs helping learners make their own decisions concerning the aspects of the path, flow, or events of instruction [9].

Collaborativism and communication-based Learning. Collaborativism states that learning emerges through shared understandings of more than one learner [10] as social interaction stimulates elaboration of conceptual knowledge [11]. Hence, the corresponding pedagogical approaches include promoting communication and socialization [3].

According to collaborativism, communications among learners is an important component of effective learning process. This communication process consists of learner's interaction with peer and instructor. Learner-instructor interaction has been shown to significantly affect learning in both regular classrooms and online [12]. Learner-learner interaction could provide support to cognitive and affective objectives of learning [12]. In particular, leaner-learner interaction supports cognitive learning objectives through its ability to instigate, sustain, and support critical thinking in a group of learners.

2.2 System Characteristics of VLE

The principal components of a VLE include systems that can map a curriculum, track student activity, and provide online student support and electronic communication [13]. VLEs could provide "increased convenience, flexibility, currency of material, student retention, individualized learning and feedback over traditional classrooms" [14]. In the field of IS research, system characteristics are shown to be important in predicting user beliefs and technology acceptance [15, 16], which in turn affects the real usage and the success of the information system [17]. With a comprehensive

review of literature on both information systems and educational psychology, we selected four characteristics that are considered to be critical for the system functionality of VLE. They are (1) information accessibility, (2) ease of navigation (3) system interactivity and (4) system support.

3 Research Model and Hypotheses

Researchers have suggested that technology offers the possibility to accommodate various pedagogical approaches in one integrated system [18]. VLE is believed to offer such flexibility by facilitating both self-controlled learning and communication-based learning. This study will investigate how VLE system characteristics would affect self-controlled learning and communication-based learning, and whether they are helpful in achieving better learning outcomes. The research model is presented in Figure 1 below.

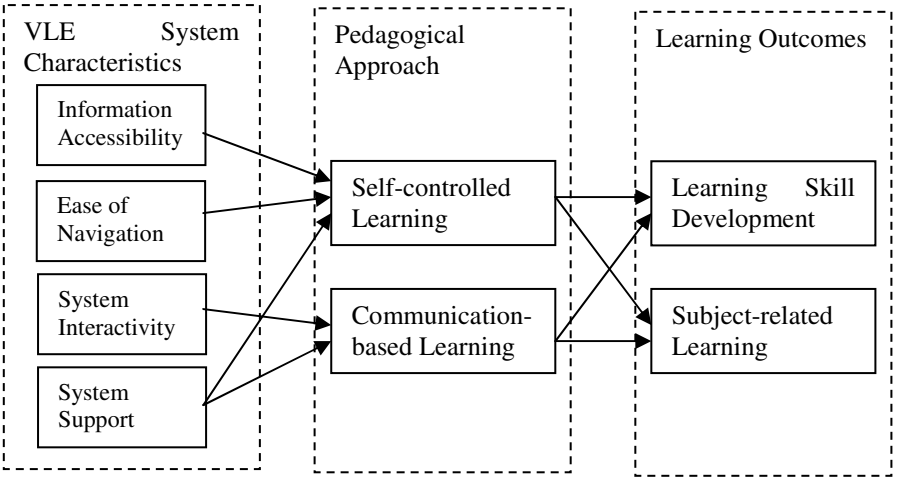

Fig. 1. Research Model

Information Accessibility. Accessibility refers to the ease with which information can be accessed or extracted from the system [19]. Perceived accessibility has been a critical factor affecting information system use and success [20] and information access level has been observed to affect the choice and use of an information system [21]. Researcher noted that information accessibility is an important factor for the study of virtual learning environment [22]. Researchers pointed out that "no matter how well the e-learning system integrates various media and allows for interactivity, the system will not be able to achieve best learning outcomes if it has poor" response time and accessibility [23, p225]. As VLE systems with high information accessibility provide learners with the flexibility to access to relevant information in a short time, learners would have more control of their own learning. Hence, we hypothesize that:

H1. Information accessibility of VLE is positively related to self-controlled learning.

Ease of navigation. The navigation of VLE concerns the evaluations of the links to needed information. Navigability is defined as "the sequencing of pages, well organized layout, and consistency of navigation protocols" [24]. It measures whether there are adequate links; whether the descriptions for links are clear; whether information is easy to locate, whether it is easy to go back and forth in the system etc. [25]. Navigational supports are developed and used to help users easily navigate information and reduce cognitive overhead and disorientation (i.e. becoming ''lost in the hyperspace'') [26]. Navigation is important to VLE as it makes various information and tools easier to locate [27]. Thus, a system which is easier to navigate provides more flexibility in user's preference to locate the information and tools needed, we hypothesize that:

H2. VLE's ease of navigation is positively related to self-controlled learning.

System Interactivity. Interactivity used in this study is defined as the extent to which the system allows participants to act as both senders and receivers of verbal and nonverbal messages and feedback [28].This definition of interactivity is widely used in e-learning studies [23]. The multiple communication platforms provided in VLE let students to share their ideas, learn from one another, "to exchange emotional support, information, and foster a sense of belonging" [29, p. 44]. As stated by Palloff and Pratt [30], the "key to the learning process are the interactions among students themselves, the interactions between faculty and students, and the collaboration in learning that results from these interactions" (p. 5). However, communications and interactions do not just happen; it must be intentionally incorporated into a web-based learning design [31]. Therefore, only when the various communication tools and facilitators are intentionally built into VLE to achieve high interactivity of the system, the communications and collaborations of learners during learning process can then happen.

H3. System interactivity of VLE is positively related to communication-based learning.

System Support. System support refers the technical support and support personnel that help learners, facilitators and professors to use and access the learning environment [32]. Once online learning is ''up and running'' there is a continued need for technical support. Lack of technical support is often seen as a barrier to designing, developing, and delivering any web-based learning systems [33]. Prior studies have stressed the importance of providing high quality of support service [34] in an e-learning system. Support is necessary to ensure the stability and reliability of the system, to reduce errors in operating the system and prevent system breakdown, so that learners can use VLE smoothly without any disruption. Thus, learners will feel more easily to control over their own learning time, pace and material. The reliability of VLE functionalities is guaranteed with good system support, including all the functionalities facilitating interaction among learners and interaction with instructor. Thus, we hypothesize that:

H4. System support of VLE is positively related to self-controlled learning.
H5. System support of VLE is positively related to communication-based learning.

Self-controlled learning is important because learners best know their own instructional need, so that they can construct their own knowledge in the context of their own needs and experiences [7]. Therefore, based on the assumptions of cognitivism, technologies are widely used to provide structured knowledge representation, personalize learning systems [35] and information seeking through search engine [18] to enhance learner's control over their own learning. Hence, if learners perceive higher self control of learning in a VLE, it will be helpful in achieving better learning effectiveness in terms of improvement in learning skill and subject-related knowledge. Thus, we hypothesize that:

H6. Self-controlled learning is positively related to learning skill developments.
H7. Self-controlled learning is positively related to subject-related learning.

The quality of interaction determines whether real learning takes place [36]. Collaborativism implies that learning is a socially mediated process and all learning is mediated by tools such as language, symbols, and signs [37]. Interaction with members in the VLE is proofed to play a crucial role in knowledge acquisition and the development of cognitive skills, and that interaction is intrinsic to effective instructional practice and individual discovery [38,39] Picciano [40] found that students' perceived learning from online courses was related to the amount of discussion actually taking place in them as well as their interaction with instructors. Hence, we hypothesize that:

H8. Communication-based learning is positively related to learning skill developments.
H9. Communication-based learning is positively related to subject-related learning.

4 Research Methodology

Survey method was adopted for this study, as survey enhances generalizability of results [41]. More specifically, we use Web-based survey as it allows more flexibility in approaching more subjects and is has fast speed in returning completed questionnaires [42].

4.1 Operationalization of Constructs

Where available, all constructs were measured using questions adapted from prior studies to enhance validity [43]. Elsewhere, new questions were developed based on a review of the previous education and information systems literature. All items were measured using a seven-point Likert-type scale with anchors from "Strongly disagree" to "Strongly agree".

4.2 Survey Design and Administration

A Web-based survey is designed for this study. Two public universities using virtual learning environments in daily teaching practices are selected as the target for sending

out the survey invitation. In total, 1000 emails were sent out to students randomly selected from the universities. 143 students responded to the survey, with 110 completed the survey. The response rate is 14.3%, and the abandonment rate is 23%.

5 Data Analysis

Partial least squares (PLS), as a structural equation modeling (SEM) technique, was used to assess both the research model and the psychometric prosperities of the scales.

5.1 Measurement Model

The measurement model of PLS is assessed by examining the convergent [44] and discriminant validity [45] of the research instruments. In PLS, three tests are used to determine the convergent validity of measured constructs: reliability of items, the composite reliability of constructs, and the average variance extracted by constructs. The assessment of the measurement model is reported in Table 1.

Table 1. Assesment of meaasurement model

Measures of Constructs	Composite Reliability	Cronbach's Alpha	Variance Extracted
IA	0.907362	0.862908	0.715363
NAV	0.928741	0.885010	0.812999
SI	0.902677	0.857283	0.698735
SS	0.934101	0.904586	0.780622
SCL	0.935967	0.914162	0.745664
CBL	0.927766	0.896270	0.762828
LSD	0.957367	0.944707	0.818250
SRL	0.894806	0.844337	0.684029

To ensure the discriminant validity, the squared correlations between constructs should be less than the average variance extracted for a construct. Table 2 reported the results of discriminant validity, which was checked by comparing the diagonal to the non-diagonal elements; all items fulfilled the requirement.

Table 2. Discriminant validity of constructs

Construct	IA	NAV	SI	SS	SCL	CBL	LSD	SRL
IA	0.8458							
NAV	0.4463	0.9017						
SI	0.1369	0.3597	0.8359					
SS	0.3035	0.4350	0.4214	0.8835				
SCL	0.2904	0.4649	0.1869	0.4478	0.8635			
CBL	0.1498	0.2573	0.3904	0.1711	0.1787	0.8734		
LSD	0.0435	0.2284	0.3219	0.2211	0.4070	0.4295	0.9046	
SRL	0.2047	0.3840	0.1868	0.2436	0.4653	0.4074	0.6272	0.8271

5.2 Structural Model

The path coefficients and explained variances for the model were calculated using a bootstrapping procedure. Each hypothesis corresponded to a path in the structural model. Hypotheses were tested at the 5 percent significance level. The results of hypotheses testing were summarized in Table 3.

Table 3. Summary of hypothese testing

Hypothesis (path)	Path Coefficient	*t*-Value	P-value	Hypothesis supported?
H1. IA → SCL (+)	0.063	0.638	0.524824	No
H2. SN → SCL (+)	0.309	2.705	0.007939	Yes
H3. SI→ CBL(+)	0.387	2.675	0.008635	Yes
H4. SS → CBL (+)	0.008	0.067	0.000080	Yes
H5. SS → SCL (+)	0.294	4.102	0. 946706	No
H6. SCL → LSD(+)	0.341	3.012	0.003233	Yes
H7. SCL → SRL(+)	0.405	3.631	0.000433	Yes
H8. CBL → LSD(+)	0.369	4.146	0.000068	Yes
H9. CBL → SRL (-)	0.335	2.822	0.005682	Yes

6 Discussion and Implications

Based on the findings, system characteristics of VLE is shown to have positive influence on self-controlled learning and communication-based learning, which are positively related to learner's skill development and subject-related knowledge. In particular, system's ease of navigation and system support lead to better self-controlled learning and system interactivity is positively related to communication-based learning as predicted. However, information accessibility is not shown to affect self-controlled learning. This may because that with the fast development of network technology, the variation in loading time of various VLE components is quite small and thus will have minor influence on learners. System support is not proofed to influence communication-based learning as predicted. One possible reason is that it is less difficult to communicate with peer and instructor using the channels provided by VLE than to search, locate useful and relevant information in VLE. Hence, high system support may not be necessary for learner interaction.

This study advances theoretical development in the area of technology-mediated learning in general and VLE research in particular. It demonstrates that VLE system factors derived from IS theories have positive impact on pedagogical approaches derived from learning theories, and in turn lead to different learning outcomes. The results of this study shed light on how different system quality factors serve different educational goals.

This study also demonstrates the feasibility of having different educational approaches in one VLE. Although different educational theory, such as behavirosm, cognitivism and constructivism, has competing assumptions and goals, VLE provides a space to accommodate all these educational needs. This is consistent with previous research effort in proposing an integrated learning platform [18]. As this study has

also shown the effectiveness of different system features, system designer and course manager can emphasize different features to serve different goals.

7 Conclusion

This study theoretically develops and empirically tests a model that explains how VLE system characteristics can ultimately influence learners learning effectiveness by directly affecting leaner's control over the learning material and leaner's communication and interaction with peers and instructor. This study also demonstrates the feasibility of incorporating different learning theories into VLE design and how they would inform different perspective of learning.

In a future characterized by volatile environments, effective leverage of learning technology would be a factor differentiating more effective from less effective teaching and learning. As an advanced form of e-learning, the design and implementation of VLE need to align with pedagogical approaches and guided by educational theories. As educational institutes invest more resources in VLE, it is imperative that research on the alignment of VLE design with educational needs, such as this study, continue to generate findings that inform practice.

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