System- and Information-Related Success Drivers of Virtual Learning Environments

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Daniel Müller[1], Melanie Heintz[1], Stefan Strohmeier[2]

[1] IMC, Altenkesseler Str. 17 D3,
66115 Saarbrücken, Germany
[2] Chair for Management Information Systems, Saarland University,
Post Office Box 151150,66041 Saarbrücken, Germany
daniel.mueller, melanie.heintz[@im-c.de],
s.strohmeier@mis.uni-saarland.de

Abstract. Virtual Learning Environments (VLE) constitute a current information systems (IS) category for electronically supported corporate training and development. Frequently expected advantages of using VLE refer, for instance, to the efficiency, individuality, ubiquity, timeliness and learning task orientation. However, a crucial precondition of realising such advantages is an appropriate system design. Hence, the question which specific system- and information-related design characteristics (DC) actually characterise successful VLE is of particular interest for training and development practice. The current paper aims at providing latest insights into a rigorous and relevant model for assessing the impact of particular system- and information-related DC relevant to VLE success. Thereby, researchers and practitioners will be enabled to better understand particular system- and information-related success drivers of VLE. Besides, they can continuously evaluate and improve VLE and have a means for management interventions, task prioritisations as well as effective and efficient resource allocations.

Keywords: Design Characteristic, IS Success Model, Success Driver, Virtual Learning Environment.

1 Introduction

Virtual Learning Environments (VLE) can be understood as electronic Information Systems (IS) for administrative and didactical support of learning processes in higher education (HE) and corporate training settings. Learners are systematically provided by adequate learning resources in the shape of learning content and tools in order to develop intended learning outcomes [e.g. 7]. Thereby, a holistic approach of VLE is pursued, i.e. VLE do exhibit full administrative and didactical functionalities which refer to learning resources in particular. According to a common categorisation in the literature [19], the VLE concept refers to the entire category of technology enhanced learning systems.

The usage of such systems in HE and corporate training and development is commonly justified due to diverse advantages like increased computer mediation of collaboration, respective communication, convenience, (costs, didactic, learning) efficiency, learner control (e.g. adaptability of the graphical user interface and/or the learning sequence), personalisation, ubiquity, task orientation and timeliness of VLE-based learning [e.g. 17].

Such advantages can also explain the ever-increasing adoption and impact of VLE on the design and development of both HE and corporate training programs and curricular [9].

However, the profit of applying VLE strongly depends on their appropriate development, implementation and (continuous) improvement since only such VLE can yield success [11]. In particular, success drivers, simultaneously called design characteristics (DC), can support VLE-related stakeholders such as decision makers, system developers, system implementers, system improvers/evaluators as well as content providers, respectively training and development-related stakeholders in accomplishing development, implementation as well as (continuous) improvement of VLE successfully.

Technically- as well as managerially-oriented literature [e.g. 5, 21] congruently understands DC as a set of those properties which determine VLE success in particular, while VLE success is differently conceptualised as the behavioural intention (BI) to, respectively the satisfaction (SAT) and/or net benefits (NB, e.g. cost savings, reduced search costs, time savings [5]) of using VLE, amongst others. There are different possibilities to categorise VLE DC, while a common categorisation in the literature roughly distinguishes between system-, information-, and service-related DC [5]. Whereas system-related DC refer to VLE core functionalities as such (e.g. *system flexibility*), information-related DC refer to learning content inherent to/provided by VLE (e.g. *information relevance*). Service-related DC [5], however, refer to more human-related VLE success drivers (e.g. *end-user support*), and consequently, do not constitute characteristics of the VLE itself. Hence, service-related DC are out of scope of this study. Given this, it is of particular academic interest to support practitioners in the specification, elicitation and evaluation of relevant VLE DC so that they can develop, implement and (continuously) improve successful VLE [14].

Some latest research attempts to strive for a VLE-specific extension of the updated DeLone and McLean IS Success Model (ISSM) [5] revealed a comprehensive, systematic and exhaustively validated set of well-defined, simultaneously detailed and operative system- and information-related VLE DC [14].

However, since the initial research model requires further refinement and validation [14], the main purpose of this study is to validate a revised version of the initial research model, containing system- and information-related VLE success drivers, empirically by means of a large-scale field survey. Such an investigation can reveal more detailed and operative, knowledge about system- and information-related success drivers of learners' current VLE use/refusal so that practitioners are able to better develop, implement and (continuously) improve successful VLE [15, 21].

The paper is structured as follows: After a short presentation of the theoretical foundation, the method as well as corresponding results are presented, which are discussed afterwards. Finally, research- and practice-oriented implications are proposed, and an overall conclusion is drawn.

2 Theoretical Development

As a specific theory of successful VLE is missing at present, the updated ISSM [5, 18] is chosen as a sound starting point as it constitutes an extensively verified and approved theoretical foundation for VLE success measurement purposes. Beyond, many validated measures for the proposed core success dimensions such as system quality, information quality, BI, SAT, and NB already exist which consequently might foster the adoption and comparability of results of the proposed research model [8]. In particular, four well-defined, simultaneously detailed and operative system-related VLE DC are applied. They are derived by means of an expert, respectively learner-oriented Delphi study based on the ISSM success dimension system quality [13]. In particular, the final compilation of system-related VLE DC of this study encompasses system quality, flexible, appealing, transparent, and structured. Based on the ISSM success dimension information quality [5], four information-related DC, derived by means of the above-mentioned Delphi studies as well, are applied [13]. In particular, the final set of information-related DC of this study comprises information quality, relevant, consistent, credible, and challenging. According to the core design principles of the updated ISSM [5], the following constructs are incorporated into the final research model as well: Intention to use, satisfaction and net benefits. Table 1 lists the entire set of constructs and items applied in the realm of this study. In-depth insights into the definition as well as the original sources of each construct, respectively its reflective items can be found at [13, 14]. In general, each construct is operationalised by the use of the generally recommended minimum of three reflective items [10]. Each reflective item in turn is measured on a 5-point, Likert-type rating scale, ranging from 1 (strongly disagree) to 5 (strongly agree). Beyond, one item of BI is measured by the number of months each learner plans to use the VLE [4]. Based on the associations postulated by the updated ISSM as well as the four additional system-respectively information-related sub-dimensions, the following research model is proposed (Fig. 1).

3 Method

An online survey is distributed to all students enrolled in at least one online course of a university's VLE. The university is located in the Southwest of Germany and has implemented a university-wide VLE infrastructure since 2006.

Based on this procedure, 147 completed questionnaires are generated, whereas 82 participants are female and 65 male. The average age of all participants is 24 years.
The research model is analysed using smartPLS (Partial Least Squares [1]), given the large number of constructs of the extended ISSM.

4 Results

4.1 Measurement Models

Table 1. Measurement models: Results overview

Construct	***Item***	***MV***	***St. dev.***	***Loading***
System Quality (SQ) AVE = 0.92 CA = 0.96 CR = 0.97	In terms of system quality, I would rate the VLE highly. Overall, the VLE is of high quality. Overall, I would give the quality of the VLE a high rating.	2.69 2.80 2.80	1.19 1.16 1.10	0.89 0.97 0.95
Flexible (FLE) AVE = 0.79 CA = 0.86 CR = 0.95	The VLE highlights (e.g. via smilies, stars, etc.) the presentation mode I mostly prefer (e.g. audio-, text-, or video-based learning materials). The VLE highlights (e.g. via smilies, stars, etc.) relevant learning materials of this course according to my current knowledge-level in this subject domain. The VLE highlights (e.g. via smilies, stars, etc.) relevant learning materials of this course according to my personal learning goals/tasks in this subject domain. The VLE adjusts the provision of information of this course (e.g. provision of additional explanations in case of a failed examination) according to my current performance in this subject domain. The VLE adjusts the provision of learning materials of this course according to my personal context (e.g. mobile vs. stationary device). I can adjust the VLE according to my personal needs (e.g. adaptation of my personal profile data, customization of the VLE's graphical user interface, etc.). *The VLE allows me to adjust the learning sequence of this course according to my personal needs.* *The VLE allows me to select the learning materials of this course I consider most appropriate.*	2.13 2.06 2.03 2.02 2.17 2.46 2.22 *3.05*	1.12 1.09 1.04 1.08 1.18 1.16 1.09 *1.25*	0.85 0.90 0.91 0.85 0.79 0.65 0.78 *0.49*
Appealing (APP) AVE = 0.87 CA = 0.92 CR = 0.95	The commands within the VLE's graphical user interface are very well-depicted by buttons and symbols. The layout of the VLE's graphical user interface is very friendly. The VLE has a very attractive graphical user interface.	3.12 3.09 2.80	1.02 1.04 1.01	0.88 0.90 0.91
Transparent (TRA) AVE = 0.80 CA = 0.87 CR = 0.92	The VLE allows me to keep an eye on my learning history (here: my completed/passed learning activities of this course). The VLE allows me to keep an eye on my current status in this course. The VLE allows me to keep an eye on my remaining learning activities of this course.	2.96 2.70 2.63	1.08 1.10 1.09	0.71 0.93 0.86
Structured (STR) AVE = 0.79 CA = 0.87 CR = 0.92	The organization of learning materials in the VLE's graphical user interface is very clear. It is very easy to find the learning materials in the VLE's graphical user interface. It is very easy to navigate the VLE's graphical user interface.	2.86 2.83 2.85	1.15 1.17 1.18	0.77 0.84 0.89
Information Quality (IQ) AVE = 0.92	Overall, I would give the learning materials provided by the VLE high marks.	3.18 3.29	1.11 1.13	0.96 0.95

Construct	***Item***	***MV***	***St. dev.***	***Loading***
CA = 0.95 CR = 0.97	Overall, I would give the learning materials provided by the VLE a high rating in terms of quality. In general, the VLE provides me with high-quality learning materials.	3.24	1.15	0.89
Relevant (REL) AVE = 0.79 CA = 0.86 CR = 0.92	The learning materials of this course exactly fit my current knowledge-level in this subject domain. The learning materials of this course exactly fit my personal learning goals/tasks in this subject domain. The learning materials of this course highly improve my knowledge in this subject domain.	3.06 3.07 3.30	0.99 1.04 1.09	0.83 0.96 0.70
Consistent (CON) AVE = 0.80 CA = 0.87 CR = 0.92	The learning materials of this course are without contradictions (e.g. consistent use of defined terms). The learning materials of this course are coherent. The learning materials of this course are presented in a logical order.	3.39 3.41 3.36	1.02 0.91 1.17	0.82 0.94 0.76
Credible (CRE) AVE = 0.88 CA = 0.93 CR = 0.96	I highly trust in the learning materials' author of this course (e.g. teacher, professional institution/organization). The learning materials' author of this course (e.g. teacher, professional institution/organization) is a highly approved source of information. The learning materials' author of this course (e.g. teacher, professional institution/organization) has a very good reputation.	3.90 3.80 3.66	1.09 1.05 1.00	0.93 0.92 0.89
Challenging (CHA) AVE = 0.76 CA = 0.84 CR = 0.90	The tasks contained (with)in the learning materials of this course arouse my curiosity. The tasks contained (with)in the learning materials of this course arouse my ambition. The tasks contained (with)in the learning materials of this course are appropriately tricky.	2.99 3.02 3.37	1.06 1.12 1.02	0.83 0.92 0.66
Behavioural Intention (BI) AVE = 0.92 CA = 0.08 CR =0.96	Assuming I had access to the VLE, I intend to use it. Given that I had access to the VLE, I predict that I would use it. *I plan to use the VLE in the next <n> months (number of months).*	3.46 3.50 *13.8*	1.21 1.24 *15.6*	0.94 0.88 *0.17*
Satisfaction (SAT) AVE = 0.78 CA = 0.91 CR = 0.93	All things considered, I am very satisfied with the VLE. Overall, my interaction with the VLE is very satisfying. Overall, the learning materials I get from the VLE are very satisfying. I am very satisfied with the learning materials I receive from the VLE.	3.22 3.20 2.78 2.87	1.14 1.19 1.23 1.08	0.84 0.85 0.84 0.84
Net Benefit (NB) AVE = 0.92 CA = 0.96 CR = 0.97	Using the VLE improves my performance in my study. Using the VLE in my study increases my productivity. Using the VLE enhances my effectiveness in my study.	2.69 2.55 2.49	1.21 1.25 1.18	0.90 0.94 0.99

Prior to testing the measurement models for reliability and validity (Tab. 1), they are analysed for unidimensionality deploying exploratory factor analysis (EFA). Two items do not exceed the recommended threshold of 0.50 [20], and thus, are excluded from the subsequent procedure (Tab. 1, *cursive-labeled*). To test the measurement models for reliability, Cronbach's Alpha (CA), the Composite Reliability (CR), and the Average Variance Extracted (AVE) are applied [12]. In particular, all models exceed the recommended limit value of 0.70 for CA and CR [12, 16] as well as the

threshold of 0.50 for AVE [6], indicating satisfying construct reliability. At the same time, the corresponding AVE values confirm the items to show adequate convergent validity [6]. Discriminant validity is found to be satisfactory as well, since the square root of the AVE for each measurement model is larger than the correlations of that measurement model with all other constructs (Fornell-Larcker criterion) [6].

4.2 Structural Models

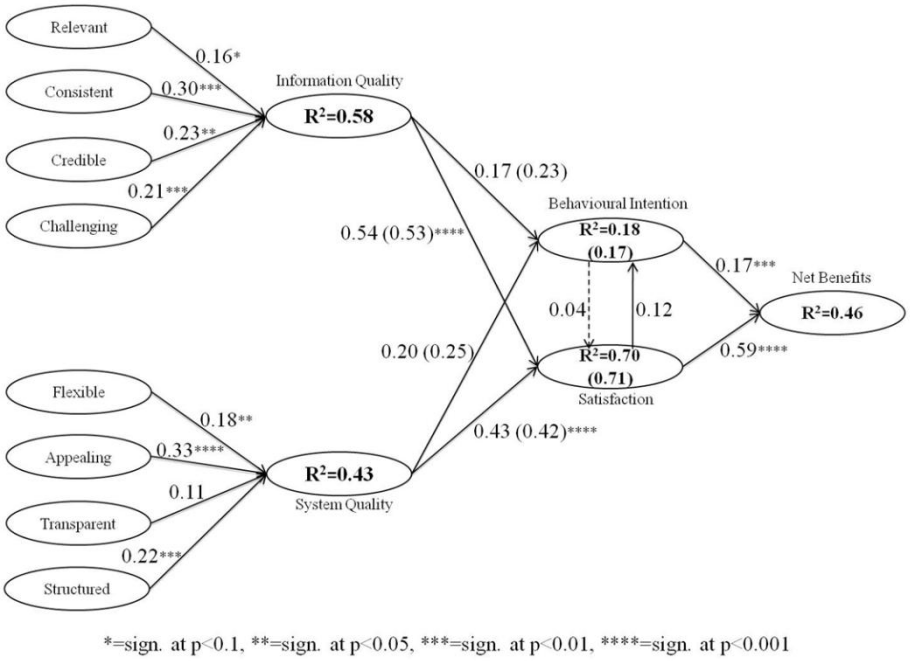

Fig. 1. Structural models: Results overview

Since there is a mutual influence between BI and SAT (Fig. 1), two separate models are tested. The first model assumes an influence from SAT to BI, whereas the second model works from BI to SAT (Fig. 1, information in brackets). The quality of the structural models is assessed on squared multiple correlations (R^2) and the cross-validated redundancy measures (Q^2) [3]. In particular, Figure 1 reveals for SAT substantial, for IQ, SQ, SAT as well as NB medium, and for BI weak R^2 values [2]. Furthermore, the results do not show any significant differences between the two models (Fig. 1). As distinct from R^2 values, Q^2 assesses the predictive relevance of the model. In particular, Q^2 is generated by use of the blindfolding procedure, whereas positive values confirm the models' predictive relevance [2]. The analysis shows positive values for IQ (Q^2=0.22 in model 1, and Q^2=0.22 in model 2), SQ (Q^2=0.24 in model 1, and Q^2=0.24 in model 2), SAT (Q^2=0.41 in model 1, and Q^2=0.41 in model 2), BI (Q^2=0.10 in model 1, and Q^2=0.08 in model 2), and NB

(Q^2=0.10 in model 1, and Q^2=0.10 in model 2), so that the predictive relevance of each model can be approved. Finally, except the relationships between TRA and SQ (0.11 n.s.), IQ, respectively SQ and BI as well as BI/SAT and SAT/BI (0.04/0.12 n.s.), all hypotheses postulated can be approved at least at the $p<0.01$ level, applying a bootstrapping procedure with 200 samples (Fig. 1).

5 Discussion and Implications

The main purpose of this study is to validate and apply a revised research model, containing system- and information-related VLE success drivers, empirically by the use of a large-scale field survey. As theorised, *relevant*, *consistent*, *credible*, and *challenging* are important drivers of *information quality* (R^2 = 0.58), whereas *flexible*, *appealing*, *transparent*, and *structured* are verified to constitute crucial determinants of *system quality* (R^2 = 0.43) Both, *information* and *system quality* show significant relationships to BI (R^2 = 0.18) and SAT (R^2 = 0.70), which in turn do have a (highly) significant effect on NB (R^2 = 0.46) in the sense of an overall success variable. However, as distinct from theoretical amalgamations of the ISSM and the Technology Acceptance Model (TAM) [22], the ISSM itself does not facilitate strong predictions of BI, but explains high levels of the variance for SAT and NB. Hence, based on the findings of this study, future research attempts should keep working on and refine promising theoretical amalgamations of the ISSM and TAM whilst drilling out VLE DC as well as (dependent) VLE success variables such as NB towards improved levels of detail, and levels of expressiveness and operativeness [5]. Beyond, future research attempts should concentrate on carving out undiscovered interrelationships amongst VLE DC in order to reveal cumulative effects of DC bundles on particular dependent variables inherent to the ISSM, amongst others. With a particular view to practice-oriented implications, the research model provides VLE-related stakeholders such as decision makers, system developers, system implementers, system improvers/evaluators as well as content providers, respectively training and development-related stakeholders with a relevant set of system- and information-related VLE success drivers. In particular, the research model may facilitate system evaluators in the assessment of VLE system and information characteristics which could lead to improved levels of task prioritization and resource allocation from a decision maker viewpoint. At the same time, the proposed research model can help VLE stakeholders to better understand the relative importance of particular DC. For example, the information provided by a VLE should always be *consistent*, *credible* and *challenging*. On the other hand, the provision of this learning content in the VLE's user interface should be *appealing* and *structured*. Hence, the proposed research model can serve as a checklist to asses in how far the VLE under consideration as well as its inherent learning content fulfill the requirements postulated. Refining and customising such a checklist towards individual HE and/or corporate training settings, and subsequently, considering the list may lead to practical VLE development, implementation and improvement processes which may minimise learner resistance, increase learner SAT, NB, and thus, overall VLE success.

6 Conclusions

The main purpose of this study is to validate and apply a revised research model, containing system- and information-related VLE success drivers, empirically by the use of a large-scale field survey. As theorized, more detailed and operative knowledge about system- and information-related success drivers can be revealed so that practitioners are now able to better develop, implement and (continuously) improve successful VLE [15].

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