THE IMPACT OF GENDER ON THE ACCEPTANCE OF VIRTUAL LEARNING ENVIRONMENTS

K. Milis, P. Wessa, S. Poelmans, C. Doom, E. Bloemen
Hogeschool-Universiteit Brussel
Brussels, Belgium
Koen.Milis@hubrussel.be

Abstract

E-learning systems, or virtual learning environments (VLEs), are systems that use modern ICT technology to support educational and training efforts. This paper discusses the implementation of a new VLE, that supports non-rote learning of exploratory and inductive statistics within the paradigm of social constructivism.

An attempt was made to link the acceptance of the VLE to gender specific elements and learning attitudes. An extensive survey was developed based upon TAM, IS success model and the ATTLS questionnaire and presented to the students.

In this research context, the impact of gender on the acceptance of the VLE could be demonstrated as well as the link between learning attitudes and acceptance. These findings confirm previous research reported in scientific literature.

Keywords
constructivism, technology acceptance, reproducible computing, compendium, computer-assisted learning, statistics education.

1 INTRODUCTION

E-learning systems, or virtual learning environments (VLEs), are systems that use modern ICT technology to support educational and training efforts. This paper discusses the implementation of a new VLE, that supports non-rote learning of exploratory and inductive statistics within the paradigm of social constructivism. More specifically, it focuses on gender based differences in the adoption of the VLE.

The new computational framework that was especially constructed for the VLE allows us to create an electronic research environment where students are empowered to interact with reproducible computations from peers and the educator. The underlying technology was constructed in such a way that it effectively supports social interaction (communication), knowledge construction, collaboration, and scientific experimentation even if the student population is very large. Moreover, the VLE allows us to obtain physical measurements of the actual learning process of students based on detailed information about the use of the statistical software, and the socially constructivist learning activities.

2 LITERATURE REVIEW

2.1 Reproducible Computing and the Compendium Platform

The inability of scientists and students to reproduce empirical research results - published in papers (or other documents)- has received a great deal of attention within the academic community. Some of the most prominent arguments and observations are described in [1], [2], [3], [4], [5], [6], [7]. While several solutions were developed ([5], [7], [8]), none have been actually implemented in education because of technical and practical reasons [9]. In an effort to overcome

these issues, a new Compendium Platform [10] was developed which allows us to create constructivist learning environments ([11], [12], [13], [14]) that effectively support students in non-rote learning of statistical concepts [15]. This solution is based on the so-called R Framework ([16], [17], based on the R language [18]) which supports reproducible computing and allows scientists/educators to monitor actual learning processes [9] and control the quality of the e-learning environment which extends to the actual statistical software [19].

2.2 Gender-related issues

The importance of gender-related issues in educational technology [20], [21], [22], [23], [24], [25], [26], [27], [28], [29], [43]. and statistics [30] has been carefully studied and is undisputed. However, there seems to be no true consensus in the literature about the gender-effects on IT use in education [31]. This comes as a surprise, especially if one considers the importance of the (socially) constructivist. learning paradigm in math-related education ([11], [12], [13], and [14]), and the importance of attitudes towards thinking and learning [32] that are known to be closely related to gender.

2.3 Usability & IT acceptance

A vast body of literature exists regarding the usability and acceptance of ICT. Encouraged by the research of Wixom et al [34], the concepts of “TAM” and the “IS success model” were combined and used to study the usability and acceptance of ICT in this learning environment.

TAM ([35], [36]) was developed to predict and explain human behavior by measuring beliefs such as “usefulness” and “intent to use”. It is a model that is thoroughly tested and used in a wide range of setting in the past. Moreover, several attempts are undertaken to use the TAM model to examine the usability of virtual learning environments, similar to the environment described in this paper [39], [40].

The Delone & Mclean’s IS success model on the other hand identifies more objective system and information characteristics that enhance user satisfaction and the usage and value of an information system [37], [38]. Moreover, it focused more on design attributes and as such is perceived to be helpful for designers to enhance the usability of their system.

3 RESEARCH GOALS

As described in the literature review, there is no consensus in literature about the gender-effects on IT use in education. A possible explanation is sought in the fact that several –sometimes counteracting- variables come into play which makes it difficult for researchers to study the phenomenon. In this respect, we expected two counteracting major effects to model the relation between gender and IT acceptance in this educational and constructivist environment. First, as Galotti et al [32] convincingly demonstrate, females favor connected knowing (emphatic) rather than separate knowing (critical, detached), while males showed a slight, but non-significant difference favoring separate knowing. This seems to suggest that female students perform better in a constructivist environment and benefit the most from the social interaction (communication), knowledge construction, collaboration and the multitude of different information sources offered by the VLE. On the other hand, the gender digital divide does still exist. The generally negative perceptions of women regarding the use of ICT prevent them from fully participating and benefiting in the new information society [41].

The aim of this research is to take the first step in unraveling the effect of gender on the usability and acceptance of VLE’s by examining whether a difference in the level of acceptance between female and male students could be demonstrated. Moreover, we investigated the effect of gender on the major dimensions of the TAM and IS success model and the effects of gender on connected knowing and separate knowing concepts.

4 RESEARCH DESIGN

4.1 Sample and Procedure

The VLE was thoroughly tested in three undergraduate statistics courses with large student populations. During these courses a large number of physical and survey-based measurements were obtained and studied.

At the time of the survey, students had been using the compendium for 3 months. They had received a hands-on training during the first classes and they were not given any additional lectures or manuals on statistics. The students met every week to receive their assignments and were asked to evaluate the performance of their peers' previous assignments. At the end of the semester (after their final exam in statistics), students were given a printed, anonymous questionnaire concerning their evaluation of the compendium.

After the exclusion of missing values, the sample that we tested in this study consists of 200 respondents (i.e. a response rate of 81%). Students were on average 21 years old, had a degree of economics or a related field and they were preparing for their final master year. All students had received one or more basic statistical courses previously. The level of the statistics course in which they were using the compendium can be considered as intermediate.

4.2 Measurement

The survey presented to the students was constructed to measure concepts related to usability and acceptance on the one hand and separate (critical, detached) and connected (empathic) learning attitudes on the other hand. The first set of measures should give us insight into the difference of use and acceptance between male and female students (Is there a digital gap?). The second set of measures is designed to measure different attitudes toward thinking and learning (Are thinking and learning attitudes of female students better suited for a constructivist VLE?)

Measuring usability and acceptance was done using a questionnaire based upon the combined TAM & IT success models (see supra). 33 questions were posed, requesting an answer on a 5-point Likert-scale. These questions could be clustered into 6 different measures, each of them highlighting a different aspect of usability and acceptance. In the second part of the questionnaire, students were confronted with another set of 20 questions to examine their attitude towards thinking and learning.

The CSUQ usability survey contains the following clusters:

- ***Perceived Ease of Use, Perceived usefulness, Relative advantage and Intention to Use***

These four measures stem directly from the TAM. We used an adapted version of the measures that were proposed by Davis (1989).

- ***System Quality***

In other to measure the quality of hard- and software of the compendium, we choose to use 11 items from the CSUQ questionnaire. The csuq questionnaire was developed by at IBM and is composed of 19 questions **Error! Reference source not found.**.

- ***Information Quality***

Since CSUQ is a broad questionnaire measuring several aspects and dimensions, we also based the information quality measures on the CSUQ questionnaire. We kept 5 items, measuring: the organisation, understandability, effectiveness and completeness of the information (the content) that is provided by the compendium.

- ***Connected Knowing, Separate Knowing***

These two measures were derived from "The Attitudes Toward Thinking and Learning Survey" (ATTLS) as described by Galotti et al [42] in 1999.

- ***Satisfaction***

Students were asked to express their overall satisfaction with the VLE.

4.3 Research Method

From a methodological point of view, we used three, entirely different, methods to investigate the research questions of interest. At first instance, a linear regression model was designed with the variable "overall satisfaction" as proxy for the overall acceptance of the VLE. We assume that if the student is satisfied with the VLE, he or she has accepted the learning environment. All other measures and the gender of the students were used as independent variables. This linear model aims at discovering whether gender has a profound impact on acceptance of the VLE, or whether other measures appear to be of higher importance.

In a next step, the impact of gender on the different concepts measured, was examined using one-way anova techniques. This should provide us with insights on the impact of gender on the different aspects of usability and acceptance.

In a final step, an approach is used which attempts to discover the relationships that might exist between computer system usability and attitudes towards thinking and learning. The method employed in this approach is based on [33] and the hypothesis that the relationship between Usability and Attitudes (separate and connected attitudes) may depend on Gender. More precisely, it is investigated if the importance of each Usability item (in relationship with all items of the Attitudes survey) is different (in terms of rank order) for male and female students. The procedure involves the following steps:

- Compute all two-by-two correlations (Kendall's tau) between Usability items and Attitude items for male and female students separately
- Count the number of cases (C_i) in which Usability item U_i is significantly correlated with each Attitude item A_j . This computation is performed for type I errors E_k that range from 1% to 10% with a step size of 1%.
- Compute the percentages of significant cases as follows: $P_{ik} = C_{ik} / 20$. This is done because there are 20 questions in the Attitudes survey.
- Compare each P_{ik} with the corresponding E_k for k=1%,...,10% and for i=1, 2, ...33

It can be shown that the sequence of P_{ik} is an increasing curve in k. The same applies to the sequence of E_k (for each k) which is just a straight line. If $P_{ik} > E_k$ for all k=1%, ..., 10% then it can be concluded that Usability item U_i is related with a positive notion of Attitude[1]. In addition, it is possible to compute the rank order for each P_{ik} for each i=1, 2, ..., 33 at any desired type I error level E_k, and compare the ranks for male and female students. The most interesting information is gained from the items U_i for which males and females have a highly different rank order (one is greater than the expected type I error while other is lower).

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1 For the sake simplicity we do not differentiate between separate and connected attitudes. Psychologically spoken, high scores for A_i correspond to a favorable situation. Also note, that a well-designed computer system (with high Usability scores) should be effective for both, connected and separate students.

There is an additional benefit from the third approach because it effectively protects the researcher from making type I errors. The reason for this is that we explicitly take into account the probability of making type I errors by making a meta analysis of the correlations between each individual U_i and all A_j .

All computations of the third approach were performed with the R language [18]. The source code is available upon request.

5. RESULTS

The linear model was constructed in SPSS, forcing all variables in the model (enter method). The model has a high R^2, which indicates good predictive capabilities (figure 1). The multicollinearity tests performed, revealed no problems (figure 2).

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	,816(a)	,667	,650	,40005

Table 1: predictive value of the model

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	,452	,301		1,500	,135		
	gender	-,046	,061	-,034	-,751	,453	,903	1,107
	intention_of_use	-,081	,051	-,087	-1,604	,111	,619	1,615
	relative_advantage	,087	,046	,120	1,894	,060	,454	2,202
	perceived_usefulness	,175	,059	,187	2,948	,004	,451	2,218
	ease_of_use	,500	,061	,506	8,200	,000	,478	2,091
	system_quality	,285	,083	,182	3,432	,001	,647	1,547
	information_quality	,066	,073	,052	,892	,373	,541	1,850
	separate_knowing	,014	,008	,084	1,783	,076	,829	1,206
	connected_knowing	-,018	,007	-,112	-2,443	,016	,872	1,146

a. Dependent Variable: overall_satisfaction

Table 2: model coefficients

When examining table 2, it is revealing that gender is not significant in the model. Hence, other variables such as perceived usefulness, ease of use, system quality and to a lesser extend connected learning attitudes have a far better predictive value. This indicates that there is no direct impact of gender on the overall satisfaction with the VLE. Hence, there is no significant impact of gander on usability and acceptance. This seems to contradict our assumption that a digital gap still exists between male and female.

As was expected, we could demonstrate an impact of a connected learning attitude on acceptance. Though, in contradiction with the presumptions made, the impact (coefficient) is negative. This seems to indicate that the way in which we designed and use the VLE does not favor connected learning attitudes (or at least not to an extent that it influences the satisfaction of students).

Note that both measures derived from TAM and the IS success model are of importance in the model.

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
intention_of_use	Between Groups	,194	1	,194	,364	,547
	Within Groups	103,055	193	,534		
	Total	103,249	194			
relative_advantage	Between Groups	,195	1	,195	,223	,637
	Within Groups	168,592	193	,874		
	Total	168,787	194			
perceived_usefulness	Between Groups	,491	1	,491	,934	,335
	Within Groups	101,435	193	,526		
	Total	101,926	194			
ease_of_use	Between Groups	,592	1	,592	1,257	,264
	Within Groups	90,913	193	,471		
	Total	91,505	194			
connected_knowing	Between Groups	26,663	1	26,663	1,206	,273
	Within Groups	4755,337	215	22,118		
	Total	4782,000	216			
separate_knowing	Between Groups	115,913	1	115,913	6,406	,012
	Within Groups	3890,308	215	18,094		
	Total	4006,221	216			
overall_satisfaction	Between Groups	,254	1	,254	,557	,457
	Within Groups	88,008	193	,456		
	Total	88,262	194			
system_quality	Between Groups	,112	1	,112	,598	,440
	Within Groups	35,837	191	,188		
	Total	35,950	192			
information_quality	Between Groups	,276	1	,276	,961	,328
	Within Groups	55,418	193	,287		
	Total	55,694	194			

Table 3: anova tests with gender as factor

The regression model demonstrated that there is no direct impact of gender on the overall acceptance and usability of the VLE. Though, possibly gender might have impact on some aspects of usability.

One-way anova tests were performed, using gender as a factor. No significant difference existed between male and female for all the concepts we derived from the TAM and IS success model (table 3). Hence, there is no significant difference in the way females and males perceive the usefulness of the system, the ease of use or the perceived advantage. Moreover, there is no difference in the intention to use the system in the future. Hence, no impact of a possible digital gap could be found.

As far as the learning attitudes are concerned, the anova tests indicate that there is no significant difference in connected learning attitudes between the male and female students that participated in our courses. On the other hand, a significant impact of gender on separate learning attitudes was detected.

The third approach is, as explained before, based on an explorative meta analysis and Kendall's tau rank correlations (see [33] for more details). Table 4 shows a selection of the most prominent differences in rank orders of P_i for female and male students.

Row	Usability item (which is correlated with attitudes)	Female Students	Male Students
1	Overall, I am satisfied with how easy it is to use this website	High importance	Low importance
2	It is easy to find the information I need	High importance	Low importance
3	The software is stable and doesn't crash regularly	Low importance	High importance
4	Learning Statistics with this website is more effective than with a traditional handbook	Low importance	High importance
5	To learn statistics, this website is better than the statistical courses I have had so far	Low importance	High importance
6	Next year, I will probably use the website/software again if I have to do statistical assignments	Medium importance	High importance

Table 4: explorative, meta analysis approach based on Kendall's tau rank correlations

The interpretation of Table 4 is straightforward. The usability items in rows 1 and 2 are strongly correlated with positive attitudes (either separate or connected) for female students (but not for male students). This implies that ease of use and information quality is related to attitudes in the female sub population. For male students, these items are independent of attitudes towards thinking and learning.

In addition, the items that are related to system stability (row 3), statistics learning (rows 4 and 5), and intention to use the system in future (row 6) are strongly related to the attitudes of male students. Attitudes of female students are independent of these usability items.

Both observations in Table 4, are interesting because different aspects of usability are of importance for both types of gender. These strong and remarkable differences can have far reaching consequences for the design and implementation of e-learning systems in education. If system usability is not well-balanced (for instance, with respect to the "usefulness for learning statistics" and the "ease of use" of the system) then we are in danger of obtaining an unfair (dis)advantage for either males or females.

6. CONCLUSIONS, LIMITATIONS AND SUGGESTIONS FOR FURTHER RESEARCH

Based upon literature review, a digital gap was expected between male and female, resulting in a lower level of overall acceptance by female students. The results from the first two approaches clearly contradict the presumptions we started from. The third method is more promising and allows us to discover novel relationships and the gender-specific, ranked importance thereof. On the one hand, the empirical evidence shows that the role of gender is indisputable. On the other hand however – and based on more traditional types of data analysis – it is not easy to discover the gender differences that relate to computer system usability.

If we attempt to summarize the gender-related differences towards usability then the following conjectures can be formulated:

- Female students (unlike males) feel insecure when using new computer systems because they fear that system use is complicated. Therefore their attitudes towards thinking and learning are closely related to perceived usability. Females with high attitude scores are likely to have a favorable perception about usability. Females with low attitude scores might need moral support (from peers or the educator) to help reduce their insecurities.
- Male students (unlike females) are not self-motivated and need a “utilitarian” incentive to engage in computer-assisted learning activities. They need to know that a proposed, computer-assisted learning method really works or is better than alternative ways of learning.

Future research will focus on both conjectures and attempt to find hard evidence. Based on the the outlined explorative meta analysis it is possible to discover relationships between usability, attitudes, perceived learning experiences, actual learning processes based on objectively measured activities, and final learning outcomes by means of examination question that relate to true understanding of statistical concepts rather than rote memorization.

We call upon the research community to take the opportunity that comes with the introduction of the Compendium Platform and related features that allow us to measure actual learning processes within the constructivist and computer-assisted learning paradigm. The use of the Compendium Platform is free of charge for the purpose of research and education. Readers with a genuine interest are invited to contact the authors.

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