
Support material for the development of TUXEL: A Technique for User eXperience Evaluation in e-Learning

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Abstract: The technology advance led learning institutions to the adoption of new technologies to support the teaching and learning process, such as Learning Management Systems (LMSs). LMSs are specialized platforms that offer various functionalities, such as content store and management, assessment activities and communication between students and teachers. The widespread adoption of these platforms rises the need to evaluate their quality in use regarding attributes such as usability and User eXperience (UX). Several usability evaluation methods have been developed to evaluate LMSs, however, few of them evaluate both attributes. This technical report presents the technique selection process carried out during the development of our technique, called TUXEL (Technique for User eXperience Evaluation in e-Learning).

Keywords: Usability Evaluation, UX Evaluation, Learning Management Systems, Technical Report.

1. Technique selection process for the first empirical study

This section presents the technique selection process for the first empirical study related to usability evaluation techniques identified in our systematic mapping (Nakamura et al. 2017). We defined 4 exclusion criteria (EC):

- **EC1:** Techniques that are not specific (generic) to evaluate LMSs;
- **EC2:** Techniques that are not available for download/consultation;
- **EC3:** Techniques that does not provide the final applicable questionnaire;
- **EC4:** Techniques that were applied only by experts.

Firstly we applied the EC1 and EC2 criteria. These criteria were directly applied on the SQ1 and SQ9 subquestions from the systematic mapping (Nakamura et al. 2017), giving a subtotal of 22 techniques. After, we applied them to EC3 and EC4 criteria (Table 1).

Table 1. Mapping of the techniques according to the exclusion criteria of the first empirical study.

N.	ID	Technique	EC3	EC4
1	S01	Questionnaire proposed by Koohang (2004)		

2	S06	Framework proposed by Ssemugabi and De Villiers (2007)	X	
3	S16	Questionnaire proposed by Zaharias and Poylymenakou (2009)		
4	S17	Framework proposed by Zaharias, P. (2009)	X	
5	S21	Heuristic Evaluation proposed by De Kock et al. (2009)		X
6	S24	UseLearn technique proposed by Oztekin et al. (2010)		
7	S27	Heuristics of Squires & Preece (1999) applied by Lanzilotti et al. (2011)	X	X
8	S31	Heuristics of Squires & Preece (1999) applied by Granić and Ćukušić (2011)	X	X
9	S31	Heuristics of Quinn (1996) applied by Granić and Ćukušić (2011)	X	
10	S32	Heuristics of Reeves et al. (2005) applied by Zaharias and Koutsabasis (2011)		X
11	S32	Heuristics of Mehlenbacher et al. (2002) applied by Zaharias and Koutsabasis (2011)		X
12	S34	Framework proposed by Fetaji and Fetaji (2011)	X	
13	S38	Framework for usability testing proposed by Ivanc et al. (2012) to evaluate mobile interfaces	X	
14	S39	Adapted TAM, proposed by Theng and Sin (2012)		
15	S47	UX evaluation questionnaire proposed by Ssekakubo et al. (2014)		
16	S48	Usability evaluation questionnaire proposed by Yusoff and Mat Zin (2011)		
17	S51	Web-based Educational Environmental Attitude Scale applied by Torun and Tekedere (2015)		
18	S54	Heuristic Evaluation proposed by Mtebe and Kissaka (2015)		X
19	S55	Questionnaire proposed by Alkhatabi (2015)		
20	S58	Questionnaire proposed by Jusus, I. S. et al. (2015), adapted from Zaharias and Poylymenakou (2009)		
21	S59	Usability evaluation questionnaire proposed by Medina-Flores, R. and Morales-Gamboa, R. (2015)		X
22	S61	Framework proposed by Navarro, C.X. et al. (2016)	X	

Within the 22 techniques, 14 provided the final applicable questionnaire (EC3). Since the goal of our technique is to be applied by students (EC4), we selected, to the first empirical study, only the techniques that were applied by them. Within the 14 techniques, only 9 met this requirement (see Table 2).

Table 2. Overview of the selected techniques.

N.	ID	Technique
1	S01	Questionnaire proposed by Koohang (2004)
2	S16	Questionnaire proposed by Zaharias and Poylymenakou (2009)
3	S24	UseLearn technique proposed by Oztekin et al. (2010)

4	S39	Adapted TAM, proposed by Theng and Sin (2012)
5	S47	UX evaluation questionnaire proposed by Ssekakubo et al. (2014)
6	S48	Usability evaluation questionnaire proposed by Yusoff and Mat Zin (2011)
7	S51	Web-based Educational Environmental Attitude Scale applied by Torun and Tekedere (2015)
8	S55	Questionnaire proposed by Alkhatabi (2015)
9	S58	Questionnaire proposed by Jusus, I. S. et al. (2015), adapted from Zaharias and Poylymenakou (2009)

We analyzed these techniques in order to identify those that are most adequate to the comparison purpose. This process included the analysis of the factors evaluated by each technique, its scope and validity.

Table 3 shows the analysis of the 9 selected techniques and the reasons for exclusion. At the end of the analysis, two techniques were selected: UseLearn (Oztekin et al. 2010) and Adapted TAM (Theng and Sin, 2012). We decided to choose Adapted TAM, since it provides, besides the usability evaluation, some constructs related to learner's satisfaction and engagement. We wanted to verify whether these constructs provide useful information regarding usability problems of the evaluated LMS.

Table 3. Analisis of the selected techniques.

ID	Technique	Description	Reason for exclusion
S01	Questionnaire proposed by Koohang (2004)	It allows evaluating the usability perceived by users of the e-learning platform by means of 19 characteristics, such as navigation, control, relevance of information, etc. It also makes it possible to verify the degree of importance perceived by users for each of these characteristics.	The technique does not present separation by factors, which makes it difficult to analyze further the attributes of usability and to compare the data with other techniques. The second part, where students describe the perceived importance of each factor can give the false impression that the system has no usability problems.
S16	Questionnaire proposed by Zaharias and Poylymenakou (2009)	The technique consists of a questionnaire to evaluate the usability of e-learning applications. It is possible to evaluate the platform considering 7 dimensions of usability: Content, Learning and Support, Visual Design, Navigation, Accessibility, Interactivity and Self-	The questionnaires are complex, many related to pedagogical aspects of the course, which can be difficult to evaluate by users.

ID	Technique	Description	Reason for exclusion
		evaluation and Learnability. In addition, the technique also assesses the motivation to learn.	
S24	UseLearn technique proposed by Oztekin et al. (2010)	The technique is composed of 36 questions on a 5-point Likert scale, assessing: error prevention, visibility, flexibility, course management, 'interactivity, feedback and help', accessibility, 'consistency and functionality', evaluation strategy, memorization, completeness, aesthetics and reduced redundancy	
S39	Adapted TAM, proposed by Theng and Sin (2012)	The technique is composed by the following constructs and its variables: - ISO standards for usability (ISO 9241-11): Perceived Satisfaction (PS), Perceived Usefulness (PU) and Perceived Ease Of Use (PEOU); - Engagement in e-learning: Learning By Interaction (LBI) and Making Sense of Learning (MSL); - Self-efficacy: E-Learning Efficacy (ELE) and New Media Efficacy (NME); - E-learning Design and Support: Navigation Structure (NS), User Interface (US) and Personalization and Freedom of Control (PFC).	
S47	UX evaluation questionnaire proposed by Ssekakubo et al. (2014)	It consists of questionnaires used to evaluate the interface of a mobile application called mVULA. The technique verifies usability and utility through an online survey containing closed questions (5-point Likert scale) and open questions.	The scope of the questionnaire is limited to the evaluation of the functionalities provided by a mobile application designed to provide limited functionality options.
S48	Usability evaluation	The questionnaire consists of 11 questions using a scale from	Questionnaire without division by factors, which hinders a more

ID	Technique	Description	Reason for exclusion
	questionnaire proposed by Yusoff and Mat Zin (2011)	1 to 5 (1 - totally disagree, 2 - disagree, 3 - almost disagree, 4 - agree and 5 - strongly agree): ease of use, navigation, of the menus, visual, memorization, learning support, motivation, communication and collaborative learning.	in-depth analysis and comparison of data with other techniques. The questions used are also very general, which only indicate the perception of the user, for example: "The system is easy to use" and "the tasks are easy to execute".
S51	Web-based Educational Environmental Attitude Scale applied by Torun and Tekedere (2015)	The technique evaluates participants' perceptions regarding the effectiveness of web instruction and its resistance to this type of application.	The technique does not allow to identify problems related to the usability of the platform, structure or its functionalities. In addition, the original language is in Turkish, which makes it difficult to carry out a more adequate translation.
S55	Questionnaire proposed by Alkhatabi (2015)	The technique uses checklists to evaluate the usability, practicality, and efficiency of the overall design and of the Tadarus Learning Management System. Each item in the checklist consists of a Likert scale that ranges from 1 (totally disagree) to 5 (totally agree). A comment session was also used for most items in order to obtain qualitative data about users' perceptions. The checklist consists of 3 sub-scales related to: general design, pedagogical design of materials and user satisfaction.	The questionnaire provided in the article presents the same questions for two different factors, which may indicate an error in the technique or in the publication, making its application unviable.
S58	Questionnaire proposed by Junus et al. (2015), adapted from Zaharias and Poylymenakou (2009)	It consists of questions that use a 5-point Likert scale, based on the eight categories proposed by Zaharias and Poylymenakou (2009): content, learning and support, visual design, navigation, accessibility, interactivity, self-assessment and learning ability, and motivation to learn.	Questionnaire adapted from the technique of Zaharias and Poylymenakou (2009) with a simplified language. The technique has, however, one less question than the original questionnaire, with no explicit reasons for its exclusion. The authors also did not present an analysis of factors and validity of the construct after the adaptations, in order to validate the technique.

2. Technique selection process for the second empirical study

We used the same exclusion criteria defined in the first study with some modifications. Given that we did not want to limit our results to techniques that were applied to students, we replaced EC4 with the following “techniques that are based on inspection approach”. Table 4 shows the mapping of the techniques according to the exclusion criteria.

Table 4. Mapping of the techniques according to the exclusion criteria of the second empirical study.

N.	ID	Technique	EC3	EC4
1	S01	Questionnaire proposed by Koohang (2004)		X
2	S06	Framework proposed by Ssemugabi and De Villiers (2007)	X	X
3	S16	Questionnaire proposed by Zaharias and Poylymenakou (2009)		X
4	S17	Framework proposed by Zaharias, P. (2009)	X	X
5	S21	Heuristic Evaluation proposed by De Kock et al. (2009)		
6	S24	UseLearn technique proposed by Oztekin et al. (2010)		X
7	S27	Heuristics of Squires & Preece (1999) applied by Lanzilotti et al. (2011)	X	
8	S31	Heuristics of Squires & Preece (1999) applied by Granić and Ćukušić (2011)	X	
9	S31	Heuristics of Quinn (1996) applied by Granić and Ćukušić (2011)	X	
10	S32	Heuristics of Reeves et al. (2005) applied by Zaharias and Koutsabasis (2011)		
11	S32	Heuristics of Mehlenbacher et al. (2002) applied by Zaharias and Koutsabasis (2011)		
12	S34	Framework proposed by Fetaji and Fetaji (2011)	X	X
13	S38	Framework for usability testing proposed by Ivanc et al. (2012) to evaluate mobile interfaces	X	X
14	S39	Adapted TAM, proposed by Theng and Sin (2012)		X
15	S47	UX evaluation questionnaire proposed by Ssekakubo et al. (2014)		X
16	S48	Usability evaluation questionnaire proposed by Yusoff and Mat Zin (2011)		X
17	S51	Web-based Educational Environmental Attitude Scale applied by Torun and Tekedere (2015)		X
18	S54	Heuristic Evaluation proposed by Mtebe and Kissaka (2015)		
19	S55	Questionnaire proposed by Alkhatabi (2015)		X
20	S58	Questionnaire proposed by Jusus, I. S. et al. (2015), adapted from Zaharias and Poylymenakou (2009)		X
21	S59	Usability evaluation questionnaire proposed by Medina-Flores, R. and Morales-Gamboa, R. (2015)		X
22	S61	Framework proposed by Navarro, C.X. et al. (2016)	X	X

A total of 4 usability inspection techniques were selected. We analyzed each technique in order to verify its adequacy to the study (see Table 5). At the end of the process, we selected the Heuristic Evaluation proposed by Mtebe and Kissaka (2015).

Table 5. Overview of the analysis of the techniques.

N.	ID	Technique	Reason for exclusion
1	S21	Heuristic Evaluation proposed by De Kock et al. (2009)	The technique focuses on the evaluation of a Web service for assignments, which limits its scope.
2	S32	Heuristics of Reeves et al. (2005) applied by Zaharias and Koutsabasis (2011)	A study conducted by Zaharias and Koutsabasis (2012) demonstrated that the inspectors (who are expert evaluators) faced difficulties to match some problems to the heuristics. Given that students, who usually do not have previous experience with inspection, compose the population of our study, we did not consider this technique.
3	S32	Heuristics of Mehlenbacher et al. (2002) applied by Zaharias and Koutsabasis (2011)	A study conducted by Zaharias and Koutsabasis (2012) demonstrated that the inspectors (who are expert evaluators) faced difficulties to match some problems to the heuristics. Given that students, who usually do not have previous experience with inspection, compose the population of our study, we did not consider this technique.
4	S54	Heuristic Evaluation proposed by Mtebe and Kissaka (2015)	

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