Perceived Usability Evaluation of Learning Management Systems: A First Step towards Standardization of the System Usability Scale in Greek

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Abstract—**Perceived usability is an important requirement of educational software, affecting greatly student's learning effectiveness and overall learning experience. Although the System Usability Scale (SUS) questionnaire is considered as a de facto standard for perceived usability evaluation, surprisingly, few studies are reporting results from evaluations related to Learning Management Systems (LMSs). In addition, given that the questionnaire comprises 10 questions presented in English, its applicability in studies involving speakers of other languages is questionable. In this paper, a first step towards standardization of a Greek version of SUS in the context of LMSs perceived usability evaluation is reported. To this end, three studies involving 280 university students in both blended and distance learning education were conducted. Analysis of the results demonstrated the validity and reliability of the Greek version of SUS.**

Usability evaluation; educational software; system usability scale; SUS; learning management system

I. INTRODUCTION

A. Perceived Usability Evaluation of Software

Numerous usability evaluation questionnaires designed to assess the perceived usability of a product and/or software are available at the moment [1–6]. Possibly, the most widely adopted is the System Usability Scale [1]. This is mainly because it is characterized by a number of advantages.

First of all, SUS is very short; it comprises only 10 items to be rated on a five point scale ranging from strongly disagree to strongly agree, among which five are positive statements and the rest are negative. In addition, SUS can provide a single score that ranges from 0 to 100. Thus, it is easy to communicate its results even to non-experts. Moreover, it has been found to be a remarkably robust measure of system usability [6–9]. In addition, SUS has been effectively applied on a variety of software systems and/or devices. In other words, it is "technology agnostic" [7]. Furthermore, the authors of [6] report that a sample of 12 users provides the correct findings (i.e. the same score as a larger sample) 90-100% of the time and a sample of only 10 users, 75-80% of the time.

Another great advantage is that in contrast to other questionnaires, such as SUMMI, SUS is provided free of charge. Thus, a large dataset related to evaluation of products or services using SUS is available at the moment [7]. Such a dataset allows one to compare the results of an evaluation against a plethora of already conducted reviews. Moreover, SUS is proposed to be used as a means for a system's quantitative usability requirements [10]. However, SUS should not be perceived as a diagnostic instrument, since it cannot contribute to understanding the underlying reasons that explain participants' perceptions about the quality of the user experience.

As the method wide spreads, a number of questions related to factors which might influence the users' ratings arise. For instance, Finstad in [11] investigated the verbal administration of SUS to non-native English speakers. He found that they required significantly more assistance in understanding SUS item 8 ("I found the system very cumbersome to use") compared to native English speakers. Such a finding can have implications on the validity and reliability of SUS in cases in which non-native English speakers are involved either because they are the primary target group of the evaluated product/software or a sample of convenience.

Sauro in [12] examined the influence of prior experience with a website on the users' SUS scores. Using a large dataset from 62 websites he found that "repeat users rated the websites as 11% more usable than first-time users" [12]. Moreover, he concluded that "the difference in the usability of websites is much larger, accounting for around 30% of the variation in SUS scores" [12] which was found to be 10 times greater than the variation in SUS scores due to experience.

A large scale meta-analysis study [7] examined SUS data collected across a decade from 206 studies involving 2324 individual surveys. It was found that the mean SUS score was 70.14 with a median of 75 (on a per study basis

69.69 and 70.91, respectively). Moreover, it was observed that no evaluated product received a score below 30, and fewer than 6% of study scores fell below 50. In the same study it was also found that all but statement seven ("I would imagine that most people would learn to use this system very quickly") differed significantly from the total SUS score. In addition, the researchers report that a one-way analysis of variance on the data referring to different type of devices (e.g. cell phones, customer equipment such as modems, GUIs, Interactive voice response systems, and web pages/applications) showed that SUS scores do vary significantly by the type of interface being tested ($\alpha = 0.05$, $p<0.001$). Interestingly, they found a significant negative correlation between SUS score and age ($r=-0.203$, $p=0.03$). However, no significant difference between the mean SUS scores obtained from women and men were observed [7].

B. Perceived Usability Evaluation of Educational Software

Usability evaluation of educational software consists an obvious requirement prior its integration into the educational practice [13–16]. The latter ascertainment is becoming even more important, if wide adoption of educational technology by students, with a variety of ICT skills, is taken into account. In addition, given the tight time schedules usually imposed to integrate educational technology into the educational practice, usage of reliable usability evaluation questionnaires should be considered as an effective option. However, an initial literature review contrasted the aforementioned suggestion; few studies report effective usage of instruments such as SUS.

For instance, Debevc and Bele in [17] report their findings from application of SUMI on two different e-learning platforms (eCampus and Moodle) used to deliver ECDL e-learning modules. eCampus received higher ratings than Moodle and the authors argue that "SUMI can be used as a quick and simple tool for the global and general evaluation of e-learning content with respect to end users" [17].

Simoes and de Moraes in [18] used SUS to evaluate the usability of the virtual learning environment adopted by the Distance Education Center of the Federal Institute of Espírito Santo – Brazil, which has the Moodle platform as a basis. They found that "the SUS questionnaire is an objective and efficient tool to have a notion about the usability and users' satisfaction" [18]. However, they do not report concrete results about the obtained SUS scores.

Granic and Cukusic in [19] used SUS among other usability evaluation techniques to evaluate UNITE, an e-learning platform to support education in European secondary schools. Students' average satisfaction was 59.36. They also found that there was a significant negative correlation ($r=-0.467$) between the SUS score and age.

C. Aims and Structure

The goal of this paper is twofold: (a) to examine the applicability of the SUS method in the context of the usability evaluation of Learning Management Systems, and (b) to assess the validity and reliability of a Greek version of the SUS questionnaire.

The paper is organized as follows: Initially, the research methodology, the profile of the participants and the design of LMSs which were the subject of evaluation are presented. Subsequently, the research results are presented focusing on the evaluation of the validity and reliability of the Greek version of SUS. The implications of the results obtained are also discussed.

II. METHODOLOGY

A. Research Method

To tackle the aforementioned goals, three studies were carried out. In all studies, university students participated on a voluntary basis and evaluated the perceived usability of their course's Moodle-based LMS by completing SUS. In two out of the three studies, both a Greek and an English version of the SUS questionnaire were used, whereas in the third only the Greek version was used. The Greek version of the SUS questionnaire was prepared by two usability experts who are native Greek speakers (see Table II).

Participants were presented with either the Greek or the English version of the questionnaire based on their self-rated knowledge of English. In addition, the questionnaire comprised SUS items as well as general demographics questions and questions related to students' Internet self-efficacy and usage frequency of the course's LMS. Moreover, an adjective rating was used to collect students' ratings of the LMS perceived usability according to a 7-point scale with different wordings [20]; the worst rating was 'worst-imaginable', whereas the best rating was 'best-imaginable'. In two out of the three studies, the questionnaire was provided to the students through their email address, whereas in the third one the students filled it in while being in the course's laboratory session.

B. Participants and Procedures

The *first study* reported in this paper involved third year University students of the Department of Educational Sciences and Early Childhood Education of the University of Patras. The elective course's title was "Designing educating kindergarten's educational activities with (and for) information and communication technologies". The course involved both traditional lectures as well as a mandatory laboratory session. All learning materials were available at the course's LMS, which was implemented using the Moodle platform (Fig. 1). All students were informed to participate in the study via email. Forty-five out of 51 of the students enrolled in the course completed

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the questionnaire. All of them were female, aged 20 to 38 (mean=21.04, sd=2.73). On a 1–5 scale, their mean self-reported LMS usage frequency was 4.8 (sd=0.4) and their mean Internet self-efficacy was 3.82 (sd=0.71). The process lasted three days, from 16 to 18 January 2012, at the end of the semester and took place after the last lecture of the course.

In the *second study*, 191 University students of the Department of Educational Sciences and Early Childhood Education of the University of Patras took part. The students attended a compulsory second year course offered in the context of a blended learning approach using Moodle. The course concerned the integration of ICT in Education and took place during the second semester of the academic year 2011–2012. The students were asked to

Figure 1. The Moodle system designed for the course "Designing educating kindergarten's educational activities with (and for) information and communication technologies" (first study).

complete the questionnaire during the second laboratory lesson. Since the students attended the laboratory in groups up to 22 participants, the process lasted four days, from 12 to 15 March 2012. Among the 191 students, 147 completed the Greek SUS version, whereas the remaining 44 reported excellent command of the English language and completed the English SUS version. One hundred eighty-seven out of 191 participants were female, aged 18 to 44 (mean=20.44, sd=3.06). On a 1–5 scale, students' self-reported LMS usage frequency was 3.87 (sd=0.94) and their Internet self-efficacy was 3.47 (sd=0.88).

The *third study* involved 44 students of the Hellenic Open University. The students attended an elective fourth year course offered in the context of a distant learning approach using Moodle. The course entitled "ICT in Education" took place during the second semester of the academic year 2011–2012. The students were asked to complete the questionnaire via email from 18 to 24 March 2012. Twenty-nine participants were male and 15 female, aged 30 to 47 (mean=37.20, sd=4.33). Among the 44 students, 29 completed the Greek SUS version, while the remaining 15 reported excellent command of the English language and completed the English SUS version. On a 1–5 scale, students' self-reported LMS usage frequency was 3.27 (sd=1.0) and their Internet self-efficacy was 4.33 (sd=0.61).

C. Research Materials

The online questionnaire service Survey Monkey (www.surveymonkey.com) was used to create and distribute the questionnaires of the studies. The collected data were organized in Microsoft Excel 2010 and were analyzed using IBM SPSS Statistics v19.0. The materials provided to the students through the Moodle system were organized according to each subject and were available to the students until the end of the semester (or the academic year).

III. Results

Table I presents a summary of the data collected in the three studies evaluating perceived usability of the Moodle LMS. For each study the number of participating students,

Study	Students (N)	Mean SUS Score (0-100)	Mean Perceived Usability Rating (1-7)
1	45	74.50 ± 3.63	5.02 ± 0.20
2	191	70.48 ± 1.83	5.16 ± 0.11
3	44	71.48 ± 4.15	5.11 ± 0.27
All	280	71.29 ± 1.51	5.13 ± 0.09

Note: Numbers after the ± symbol are 95% confidence intervals for the mean

the mean and confidence interval of students' SUS scores and perceived usability ratings are provided. In addition, the cross-studies total number of participating students and the mean and confidence interval of their SUS scores and usability ratings are reported.

Table II presents descriptive statistics of the SUS data collected in the three studies. For each statement, the mean and standard deviation for the raw scores is provided. For the needs of the analyses, the negative statements of SUS (i.e. Q2, Q4, Q6, Q8, and Q10) were recoded so that positive responses are associated with a larger number, like the rest five positive statements.

A. Validity Analysis of the Greek SUS

Validity refers to the extent to which an instrument, such as a questionnaire, measures what it is intended to measure [21]. Similarly to the English version of SUS, the Greek one is intended to measure perceived usability of software. Its validity was investigated following two approaches.

First, the students' SUS scores were compared to their overall adjective ratings of perceived usability. A non-parametric measure of association was used since the assumption of normality was violated; Shapiro-Wilk=0.988, p=0.59. A significant correlation between the SUS score provided by students who completed the Greek version of the questionnaire and the overall adjective rating was found; r_s=0.474, p<0.01. Moderate correlations with absolute values as small as 0.30 to 0.40 are considered large enough to justify the validity of psychometric instruments, such as questionnaires [21].

As a second step to validate that the Greek SUS measures perceived usability, an independent samples t-test was conducted to compare the means of the SUS scores obtained by the Greek and the English version of the questionnaire. Assumptions of normality and homogeneity of variance were not violated; Shapiro-Wilk=0.988, p=0.059 and Levene=0.434, p=0.511 respectively. On average, students filling the Greek version of the questionnaire provided slightly higher SUS scores (mean=71.74, sd=13.01) than those that completed the English version of the SUS questionnaire (mean=69.57, sd=12.29). However, this difference was not significant; t(278)=1.149, p=0.252.

All in all, the Greek version of the SUS questionnaire was found to be a valid instrument for measuring

Item	Greek Version of SUS	Raw Responses Mean	SD	English Version of SUS	Raw Responses Mean	SD
Q1	Νομίζω ότι θα ήθελα να χρησιμοποιώ αυτό το σύστημα Moodle του μαθήματος συχνά.	3.34	0.95	I think that I would like to use this lesson's Moodle system frequently.	3.59	0.79
Q2	Βρήκα αυτό το σύστημα Moodle του μαθήματος αδικαιολόγητα περίπλοκο.	1.87	0.86	I found the lesson's Moodle system unnecessarily complex.	2.00	0.97
Q3	Σκέφτηκα ότι αυτό το σύστημα Moodle του μαθήματος ήταν εύκολο στη χρήση.	3.75	0.89	I thought the lesson's Moodle system was easy to use.	3.74	0.91
Q4	Νομίζω ότι θα χρειαστώ βοήθεια από κάποιον τεχνικό για να είμαι σε θέση να χρησιμοποιήσω αυτό το σύστημα Moodle του μαθήματος.	1.47	0.77	I think that I would need the support of a technical person to be able to use this lesson's Moodle system.	1.66	0.90
Q5	Βρήκα τις διάφορες λειτουργίες σε αυτό το σύστημα Moodle του μαθήματος καλά ολοκληρωμένες.	3.69	0.83	I found the various functions in this lesson's Moodle system were well integrated.	3.47	0.80
Q6	Σκέφτηκα ότι υπήρχε μεγάλη ασυνέπεια σε αυτό το σύστημα Moodle του μαθήματος.	1.89	1.04	I thought there was too much inconsistency in this lesson's Moodle system.	2.14	0.90
Q7	Φαντάζομαι ότι οι περισσότεροι άνθρωποι θα μάθουν να χρησιμοποιούν αυτό το σύστημα Moodle του μαθήματος πολύ γρήγορα.	3.74	0.88	I would imagine that most people would learn to use this lesson's Moodle system very quickly.	3.80	1.03
Q8	Βρήκα αυτό το σύστημα Moodle του μαθήματος πολύ περίπλοκο/δύσκολο στη χρήση.	1.83	0.97	I found the lesson's Moodle system very cumbersome to use.	2.47	1.07
Q9	Ένιωσα πολύ σίγουρος/η χρησιμοποιώντας αυτό το σύστημα Moodle του μαθήματος.	3.39	0.87	I felt very confident using the lesson's Moodle system.	3.78	0.97

| Q10 | Χρειάστηκε να μάθω πολλά πράγματα πριν να μπορέσω να ξεκινήσω με αυτό το σύστημα Moodle του μαθήματος. | 2.10 | 0.90 | I needed to learn a lot of things before I could get going with this lesson's Moodle system. | 2.24 | 1.22 |

perceived usability in the context of LMSs quality evaluation.

B. Reliability Analysis of the Greek SUS

Reliability refers to the extent to which an instrument, such as a questionnaire, yields the same results under consistent conditions [21]. It is most commonly measured using Cronbach's alpha, which is a measure of internal consistency. In the context of this analysis, nine cases were excluded due to missing responses in one or more of the SUS questions in Greek. For the resulting dataset of 212 completed surveys, the 10-item Greek SUS questionnaire had a good internal consistency; Cronbach's alpha=0.777. The only item that slightly increased the overall scale alpha if deleted was Q6 (alpha if item deleted was 0.789).

C. Factor Analysis of the Greek SUS

Given that a study [9] has found that the English SUS consists of two reliable subscales that measure Learnability (items Q4 and Q10) and Usability (the rest items), additional analyses were conducted for the Greek SUS. First, reliability analyses indicated that the aforementioned Usability subscale had good internal consistency (Cronbach's alpha=0.762, N=213). However, the aforementioned Learnability subscale did not have sufficient reliability (Cronbach's alpha=0.531, N=220) to meet the typical minimum standard of 0.70.

In addition, factor analyses using common verimax rotation and two-, three- and four-factors solutions were conducted on the dataset of the 212 completed Greek SUS questionnaires. The results are presented in Table III, along with the reliability of the subscales produced. The results show that the Greek SUS questionnaire does not include any reliable subscales. Thus, all statements in the Greek SUS form a single reliable scale that measures perceived usability. Although tempting, single items or combinations of items should not be used to draw any conclusions.

IV. CONCLUSIONS AND FUTURE WORK

In this paper, the validity and reliability of a Greek version of SUS was investigated in the context of LMSs perceived usability evaluation. To this end, three studies involving 280 university students in both blended and distance learning education were conducted. Students were asked to evaluate the perceived usability of their course's Moodle-based LMS by completing SUS and providing a 7-point scale adjective rating. They were presented with either a Greek or an English version of the questionnaire based on their self-rated knowledge of English.

Analysis of the results showed that the Greek SUS questionnaire is both reliable and valid. First, a significant correlation (r_s=0.474, p<0.01) was observed between the SUS scores of the Greek questionnaire and a concurrent 7-point scale which measures overall perceived usability [20]. In addition, no significant difference was observed between the SUS scores obtained from the Greek (mean=71.74, sd=13.01) and the English (mean=69.57, sd=12.29) version of the questionnaire. Furthermore, reliability analysis demonstrated the internal consistency (Cronbach's alpha=0.777) of the SUS in Greek. In addition, it was found that the Greek SUS forms a single scale that measures perceived usability and does not include any reliable subscales.

TABLE III.   TWO-, THREE- AND FOUR-FACTORS SOLUTIONS AND DERIVED SUBSCALES' RELIABILITY ANALYSES FOR THE GREEK SUS

Item	Component	
	1	2
Q1	**0.781**	-0.096
Q2	**0.485**	0.356
Q3	**0.652**	0.339
Q4	0.124	**0.648**
Q5	**0.642**	0.293
Q6	0.032	**0.537**
Q7	**0.648**	0.107
Q8	0.280	**0.598**
Q9	**0.812**	0.078

Item	Component		
	1	2	3
Q1	**0.782**	-0.099	0.032
Q2	**0.462**	0.184	0.388
Q3	**0.645**	0.431	0.033
Q4	0.108	**0.736**	0.099
Q5	**0.626**	0.208	0.259
Q6	-0.015	0.057	**0.836**
Q7	**0.654**	0.291	-0.168
Q8	0.244	0.341	**0.567**
Q9	**0.799**	-0.053	0.267

Item	Component			
	1	2	3	4
Q1	**0.668**	-0.167	0.393	-0.136
Q2	0.244	0.139	**0.740**	-0.004
Q3	**0.668**	0.381	0.160	0.005
Q4	0.143	**0.726**	0.115	0.036
Q5	**0.670**	0.173	0.136	0.304
Q6	0.060	0.098	0.101	**0.953**
Q7	**0.752**	0.241	-0.100	-0.046
Q8	0.056	0.321	**0.719**	0.197
Q9	**0.710**	-0.112	0.422	0.134

Q10	0.072	**0.765**

No	Subscale Items	Alpha
1	Q1,Q2,Q3,Q5,Q7,Q9	0.789
2	Q4,Q6,Q8,Q10	0.573

Q10	0.049	**0.804**	0.199

No	Subscale Items	Alpha
1	Q1,Q2,Q3,Q5,Q7,Q9	0.789
2	Q4,Q10	0.531
3	Q6,Q8	0.382

Q10	0.071	**0.801**	0.179	0.103

No	Subscale Items	Alpha
1	Q1,Q2,Q3,Q5,Q7,Q9	0.783
2	Q4,Q10	0.531
3	Q2,Q8	0.503
4	Q6	N/A

The research presented in this paper has several limitations. The sample includes mainly students from a Department of Social and Humanities Studies with specific characteristics. Therefore, further investigation in different contexts and levels of education is required for the generalization of results. Future work also includes investigating relationships (if any) between SUS scores and a) various students' characteristics (e.g. gender, age, ICT competence) and b) the education delivery method used, such as blended learning or distance education.

Finally, the degree of contribution of various interaction characteristics to the SUS score requires further examination. In specific, findings from studies related to how learners form their goals, which navigation strategies they follow in web-based learning environments [22, 23], what criteria they use to evaluate information, how they adapt to any given learning environment [16, 24], and how different structuring of the learning material influences their learning effectiveness [25] could provide a deeper insight about the factors that influence the SUS score of LMSs and update existing educational usability evaluation practices [13–15].

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