A Weighted Usability Measure for E-learning Systems

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Abstract: Currently learning paradigms have been overcome, using information and communication technologies (ICT) to give rise to e-learning domain. Thus, classical classrooms based training has been substituted by online systems working on Internet. The aim of an e-learning system is to fulfill requirements of instructors as well as learners. However, institutions offering courses online have a lack of applying efficient evaluation methods to both teachers and students. Frequent preoccupation concerns with functionalities and interface that a system must satisfy for users needs. In our studied case, learners need to face up to functionality of e-learning infrastructure rather than to acquire knowledge. When users spend more time, resources (software, hardware) unnecessarily, consequently they spend more costs, instead quenching academic thirst. Thus, this research aims to evaluate the usability of e-learning systems, a pondered measure of usability evaluation is proposed as a result of the analysis of the inquiry applied to the system users. We study, evaluate, and compare the usability of two applications, to highlight recommendations for improvement.

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1. Introduction

An e-learning system manages software and hardware resources for engaging learners remotely [9]. This kind of system must be able to support the interaction among students and instructors, keeping track of training and authoring process. Users of this kind of groupware become experts of this activity when a system is well constructed. However, user's preferences may differ from each other. Thus, during the design, it is necessary to take into account not only basic requirements according with users profiles, but also the system should be adaptive according with the development acquired by users during the learning process, and with educational learning content. This point of view is related with the usability of systems.

International Standard Organization (ISO) defines usability as "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use" [8]. Thus, in our context, an e-learning system is the product, while learners and instructors are the specific users. Based on educational background, cultural constraints, and level of computer literacy, learners can be characterized. Specific goal is to achieve certain level of knowledge delivery, enhancing learning quality and increasing user opportunities. The context of use concerns with learning environment, task at hand and user groups. Within the same learning environment, each user can perform different tasks. But, changing the learning environment, and keeping other unchanged parameters, the context of use and hence the users' performance against a specific task, may suffer modifications. It means, system usability can be traduced as a measure of how much a product is effective, easy to employ, and enjoyable. Usability for an e-learning system has additional importance, because users may not be able to concentrate on learning content. Rather, they may spend time in understanding the system itself due to its complex interaction. Ensuring usability is a matter of great concern, so the most effective way of producing such a system is to evaluate usability of the system and if necessary to repeat its design until suitable solution [18].

Interaction among users is an important characteristic of a good parameter of usability. A set of usability attributes is identified in this work. We select some attributes and assigned a weight according with an impact and confirm each one by means of inquiries. Usability evaluation is based on the pondered measure. According to this value (below a certain level), the designer decides to revamp the system, concentrating on specific features which need improvement.

The paper organization is as follows: related works are discussed in Section 2. A usability criteria and an inquiry based on the usability criteria were proposed, that are described in Section 3. Our

approach is applied on two e-learning systems as case studies, as we can see in Section 4. An overall usability measure is obtained taking into account users' information and the pondered usability criteria. Section 5 discusses obtained results. Section 6 recommends improvements based on obtained results. Finally, Section 7 presents conclusion and future work.

2. Related Work

Usability is considered a prime parameter for any system. No matter how well a system is compatible with the predefined set of guidelines to construct it, but these guidelines cannot be used as an alternate of assessment of usability [7]. Additionally, and due to an e-learning system is employed by two types of users: - learners who are characterized by cultural and educational background, abilities, technical expertise, and cognitive aptitudes; and – teachers who have different profile characterized by ability to transmit knowledge, to follows the learning process of students, thus, e-learning systems become a singular studied case.

One effective and popular usability evaluation technique is heuristics as guidelines to set up the design of a system. In e-learning, several heuristics have been adopted from the general context and applied to unveil specific usability problem, thus some research has come up different parameters as a checklist such as that of Nielsen [12]. In, a set of eight golden rules for designing user interface, a revision of Nielsen's ten heuristics is proposed in [19].

Efforts have been made to synthesize a systematic usability evaluation for e-learning systems [1] along with heuristics based evaluation method, like the concept of abstract task (AT) [1]. AT estimates the conformity of certain attributes of a particular application. AT methodology is more beneficial than those compared to user-testing and heuristic evaluation. Advantages showed by AT over techniques like inspection with user-testing and heuristic evaluation are more convincing. Three dimensions are chosen for comparison: effectiveness, efficiency, and satisfaction.

More advances features provided (Technology), Interaction (among different users groups), Content (learning material), and available Services (TICS) [9] constitute a new framework to guarantee the quality of the system, concerning the evaluation, this paper propose the eLSE methodology. Milano-Lugano Evaluation method, MiLE [21] based on scenario-driven inspection technique, MiLE incorporates profile, scenario, goal concepts, and usability attributes. MiLE fruitfulness is applied to a corporate e-learning platform, finding front-end (learner) and back-office (tutor) usability.

Several empirical studies are performed for usability evaluation that target a particular system and after using any usability evaluation approaches produce empirical results. For example, ISO standard model is applied to Blackboard learning management system [4]. "Relations" is an e-learning program or lesson, whose usability is tested using a specially designed questionnaire distributed among users [17]. The questionnaire is based on "Learning with Software" heuristics [20]. Heuristics combine usability and learning issues as an inspection by experts in human computer interaction domain. But, these heuristics are adopted and enhanced in order to develop questionnaires for lesson evaluation, rather than by experts.

SEMINOLE (SEaMless INtegrated Online Learning Environment) [10] is a customization of an open source learning management system called MOODLE, that is enhanced by web cast and multimedia recording and storage functionality provided by a system called ePresence. Students are able to attend classes remotely, access contents in the form of slides equipped with audio transcription, participate in forums, chat with a teacher and other student and check grades.

3 Usability Criteria

From the point of view of functionality of a system, activities can be divided into setup and execution phases. The definition of required elements to evaluate usability corresponds to the setup phase. These elements are taking into account during the execution phase to perform the evaluation process (see Figure 1). The setup phase starts with an exhaustive literature survey, giving rise to a set of comprehensive attributes, used as a criterion for evaluation. Each attribute has a weight which represents importance related with usability. Simultaneously, an inquiry is synthesized, reflecting the way in which the evaluation is performed.

During the execution phase, a user study is performed based on the prepared questionnaire, giving rise to a raw data for the system evaluation. The usability of the system is evaluated by a statistical process that combines collected data after user survey process with pondered attributes. The attributes are pondered according to its significance within the literature survey (see Table 1). The attributes are measured by means of a questionnaire. Topic questions/answers are listed in Table 2.

TABLE 1: Usability Categories / Criteria Weight ages

Usability Criterion	Referred Material	Weight
Feedback & Interactivity	[1] [11][14] [23]	3
Learning Material	[1][3][4][13][14][23]	4
Assessment	[4][14] [17]	2
Visibility	[1][12][14][17][20][23]	4
Learner Facilitation & Support	[12][14][23]	2
Error Handling & Prevention	[1][12][17][20][23]	4
Collaboration Support	[3][4][5][13]	3

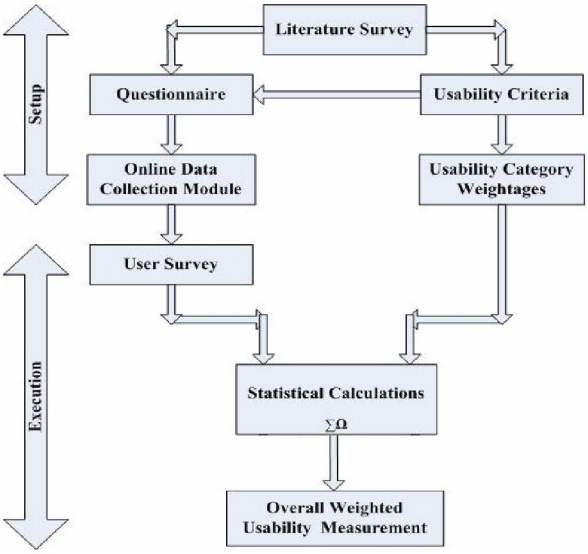

Fig 1. Activity Flow Diagram

Online Data Collection Module (DCM) is presented as a web page where questionnaire to evaluate a particular e-learning system is displayed. Questionnaire responses of participants are stored at the database for further processing (see Figure 2). DCM presents questions against five ordered scale (strongly agree to disagree). Questions, name and, e-mail of participants are also stored.

TABLE 2. Features and Questions

Features	Relevant answers
Feedback & Interactivity	• Using this system, I feel to be in a classroom, interacting with instructors. • Performing some system functionalities, I have appropriate feedback. • Encouraging and multimedia feedback (sound, animation, icons) is properly provided, guiding me to complete knowledge process.
Learning Material	• Enough material and understandable is provided, enhancing my learning. • Language used in the material is appropriate, with examples. • Learning content is updated frequently.
Assessment	• Assignments/quizzes are available for the learned knowledge. • I have to use the learned knowledge to solve my assignments/quizzes.
Visibility	• Important lessons/topics/options are easily visible and accessible. • The interface shows only those options at a time that are needed. • Individual sections are clearly distinguishable from others. • Always I am able to know course/topic/action I am currently working with. • For each new topic, it is easy browsing the system content.
Learner Facilitation & Support	• I can choose multiple learning paths whichever suitable to me. • Learning is enhancing by the well structuring courses and planning. • Support is provided to complete all tasks.
Error Handling & Prevention	• There is not technical error within the system. • Error messages are clear presented that even a layman can also understand. • When errors occur (solving a quiz), undo/redo activity can be performed.
Collaboration Support	• Support (email, chat, discussion forum) are available for learners and instructor communication. • Secure communication is guaranteed, so messages are always delivered. • Communication with others is possible (to solve assignments). • System awareness provides me knowledge about actions taken by others.[15][16]

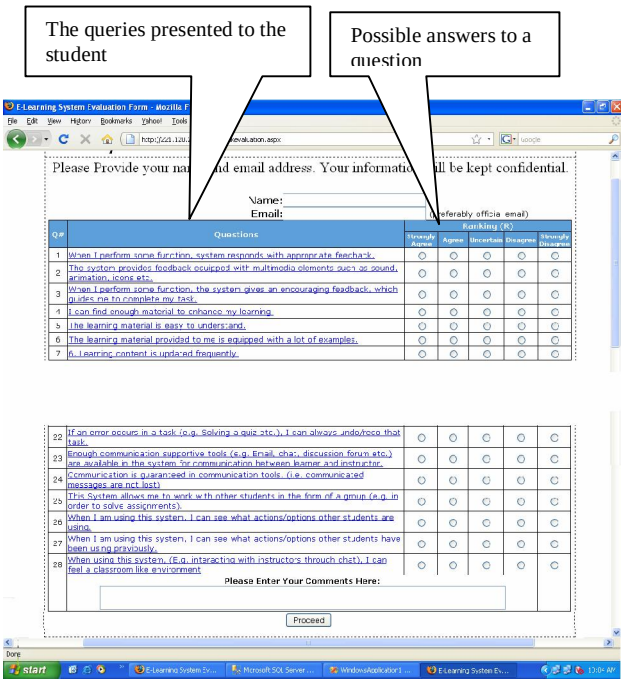

Fig. 2 Data Collection Module (DCM)

4 Case Studies

Virtual University (VU) (http://www.vu.edu.pk) is the first public-sector university based on information and communication technology for conducting e-learning education in Pakistan. Students are at remote location, with diverse backgrounds and level of computing skill. To cater with needs, provide better interaction of remote students and instructors, and delivery of content to student*s in a better way, VU uses the Virtual University Learning Management system (VULMS). VULMS is continuously in development to support, easy to use, it has a functionally rich interface for online learners. The interface of VULMS provides tools for students and instructors. But our focus is only on the student interface because an interactive and usable student interface plays a significant role in learning process.

After logging in, students are able to visit their registered courses and profile, submit assignments and quizzes, participate in discussions, communicate by mail, etc. Figure 3 shows important options for interaction, as well as courses currently registered by a student. A course is allocated to each registered student, containing information about content: description, outline, frequently asked questions, related links, downloads and grading scheme of the course. A distinctive feature of VULMS is the availability of Graded Discussion Board (GDB) and Moderated Discussion Board (MDB). Both intend to access the understanding of a student subject by reviewing his comments on a topic related to the course. Instructor can review student posted messages about specific topic. Depending on validity of student comments, instructor can grade them.

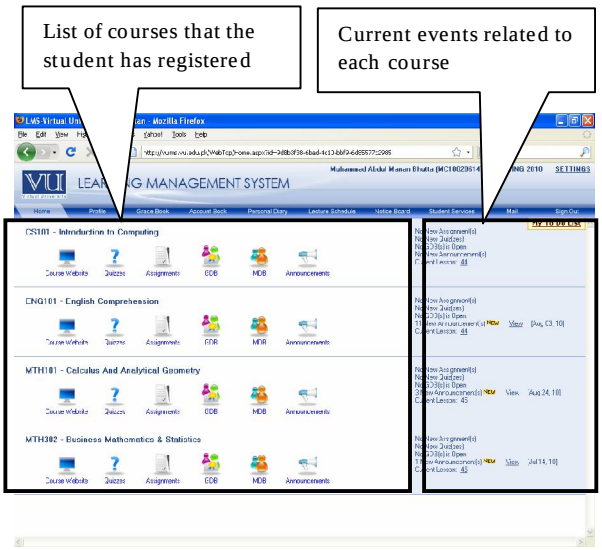

Fig. 3 Virtual University Learning Management system (VULMS)

The eFront (http://www.efrontlearning.net) e-learning system has been selected, because eFront provides facilities for both learners and instructors, and conduct courses at colleges, university, and business organizations. eFront is object-oriented and ajax-enabled multiple-language learning platform that is SCORM [2] Compliant and LDAP [22] Supportive.

Due to compliance with SCORM, eFront can interoperate with other SCORM compliant learning management system. In order to perform the respective transaction, individual interface is provided for administrator, instructors, and students. We are concerned with the student interface. Figure 4 shows a screenshot view of the eFront system when a user is logged in. This page shows options and material related to a course that a user registers. The left side of screen contains a pane which has options like theory, tests, and forums related to the course, main course page, change lesson, etc. Some other are: lessons, announcements, events, comments, and messages at forums related to the selected course.

5 The Usability Measure for eFront and VULMS

The overall weighted usability measure refers to a quantitative assessment of usability of an e-learning system taking into account several factors: responses from participants of survey,

relative importance of each usability criterion, and number of questions in each usability category.

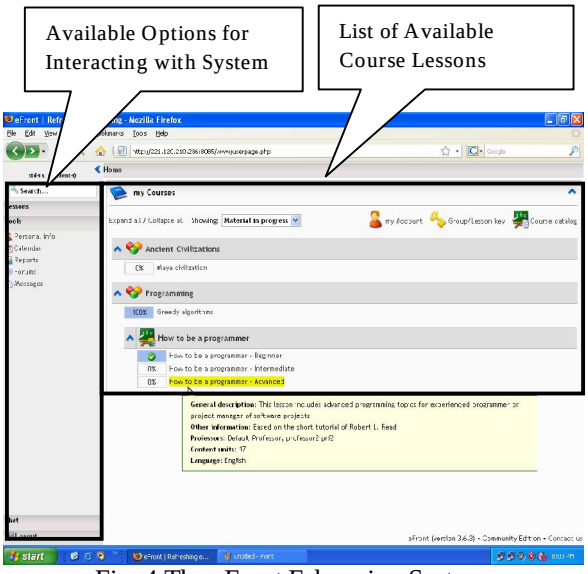

Fig. 4 The eFront E-learning System

A quantitative measure is necessary because qualitative usability evaluation only provides subjective information for analysis. A true measure of usability is not provided. An objective measure of usability evaluation can be extinguished by exploiting a quantitative measure. This quantitative measure is calculated based on the data collected during evaluation. The elements involved in the calculation of overall weighted usability measurement are:

Ni = Number of questions in usability category 'i'
Wi = Weight assigned to category 'i'
Mij = Median of responses to question 'j' in category 'i'
Si = Summation of medians of category 'i' = ∑ Mij over j
T = total Weight = ∑ (Si x Wi)
R = Normalizing Factor = ∑(Ni x Wi)
Overall Weighted Usability Measure = U = T / R
=> U = ∑ (Si x Wi) / ∑(Ni x Wi)

The total weight obtained by multiplying sum of medians and weight of a particular usability category makes that more importance is given to a usability category having more weight. The total weight serves as usability measure, although this factor is not within the range of 1 to 5. The normalizing factor is responsible for bringing the result within this range. Thus, 'U' provides an overall weighted usability assessment.

5.1 Pondered Usability Measure for eFront

At first glance eFront seems pretty good system. Thanks to the usability evaluation conducted, we see some problems in fulfilling certain parameters. Many participants' comments assert that "the system is not easy to use for beginners". Participants of survey are students from a university registered in Masters in CS program, and about 70 students out of them were registered in Human Computer Interface course. Although fewer number of participants may have sufficed, but increasing this number is beneficial for more effective user testing [6]. Students filled the online questionnaire through Online Data Collection Module. These responses were used to measure "U. We save the official identification of participants, usability criterion, and questions measuring that usability criterion respectively. 'U' is calculated as follows:

Si = Summation of medians of category 'i' = ∑ Mij over j
Si à S1 =14 , S2 =19 , S3 = 8, S4 =16 , S5 = 19, S6 =10, S7 = 16
T = Weighted Total = ∑ (Si x Wi)
T à ∑(14*3, 19*4, 8*2, 16*4, 19*2, 10*4, 16*3) = 324
R was calculated as 89, hence
Overall Weighted Usability Measure = U = T / R
ð U = 324 / 89 = 3.64
Note that the usability measure is graded out of 5.

5.2 Pondered Usability Measure for VULMS

After the usability evaluation of the VULMS system, it is found that overall participants are satisfied with the system in spite of facing problems in fulfilling certain usability criteria. This is also evident by several comments received by participants stating that "Overall VULMS is a good learning management system". Participants for the usability evaluation are those students under e-learning paradigm exclusively. They are the students of virtual university who are used to exploit VULMS for their ongoing education and any kind of interaction with their instructors or other students. The online questionnaire was presented to these 73 participants. We calculate 'U' as follows:

Si = Summation of medians of category 'i' = ∑ Mij over j
Si à S1 =15 , S2 =20 , S3 = 8, S4 =16 , S5 = 20, S6 =12, S7 = 18
T = Weighted Total = ∑ (Si x Wi)
T à ∑(15*3, 20*4, 8*2, 16*4, 20*2, 12*4, 18*3) = 347
Note that R was calculated in section 4.3 as 89, hence
Overall Weighted Usability Measure = U = T / R
ð U = 347 / 89 = 3.90
Note that the usability measure is graded out of 5.

5.3 eFront vs VULM – Comparing evaluations

The value of overall weighted usability measurement for the two systems revealed that VULMS enjoys a higher level of user satisfaction as compared to eFront. However, a relative comparison of two systems in individual usability category may expose useful information. A system can be more usable as compared to the other in a certain parameters, even if the overall measure is less that other system. To determine which parts of the system should be emphasized. The average of medians for each usability criterion is presented in Table 3.

Table 3 shows that eFront is slightly inferior to VULMS in terms of usability evaluation. However, the usability criteria of assessment and visibility were evaluated to be equally well-fulfilled by both systems. So, there is more need to concentrate on categories other than assessment and visibility. All other usability criteria need attention in case of eFront specially collaboration support.

6 Improvement of e-Leaning System Usability

A redesign of eFront system is highly recommended because lower usability measure is obtained. The redesign should focus on those features that have been shown to produce low usability measure. For instance, collaboration support when treated individually should be seriously considered.

Visibility, assessment, and learning material should also be taken into account. The learning material, for example, was reported as lacking enough examples to develop better understanding. This problem, however, can simply be eliminated by including more examples related to current learning material. Same is the case with enough number of assignments/quizzes for assessment.

TABLE 3: Comparison of Individual Usability Criterion Evaluation

Usability Features	**eFront**	**VULMS**
Feedback / Interactivity	14/4 = 3.5	15/4 = 3.75
Learning Material	19/5 = 3.8	20/5 = 4
Assessment	8/2 = 4	8/2 = 4
Visibility	16/4 = 4	16/4 = 4
Learner Facilitation & Support	19/5 = 3.8	20/5 = 4
Error Handling and Prevention	10/3 = 3.33	12/3 = 4
Collaboration Support	16/5 = 3.2	18/5 = 3.6

The collaboration support was bad evaluated because unavailability of online communication tools and the present/past awareness features. So, communication tools like a instant messenger should be included. Present/past awareness can be improved by making the status of current and previous activities of others, making it visible to concerned users, displaying the status of lessons in that how many users have read this lesson, displaying comments of others on a particular lesson, displaying poll responses (if any) by other students, most frequent activity on the system, etc.

Interactivity and feedback of the system should also be redesigned as stressed by users responses. This can be done by including multimedia and multimodal feedback in which different senses are simulated for feedback to be recognized and interpreted more easily. Specifically, along with visual and textual feedback, appropriate sound should be used in order to notify the occurrence of an event. Animation and graphical elements should be added in order to make the feedback more interactive. Finally, the technical errors handling problem can be eliminated by testing. For this purpose, testing techniques from software engineering should be used as a complement.

VULMS was proved to be more usable according with pondered usability measure. However, there is room for improvement in this system as well, as indicated by the low individual usability measure of collaboration support attribute. This feature was underrated because of the lack of present/past awareness elements. The recommendations in this regard are the same as those for eFront. However, students also complained that the system does not allow them to work in collaboration. To support such kind of activity, students should be allowed to discuss and share content online. They should be able to communicate online and modules should be developed that allow them to post comments, request for help, share files, and create new discussions on certain topics in which other students may also participate.

VULMS and eFront systems are just used as case studies for usability evaluation. The recommendations in this regard can equally be applied to any e-learning system.

7 Conclusion and Future Work

In this research, a pondered usability measure for e-learning system evaluation has been proposed. Evaluation is performed in user testing by means of a specially designed questionnaire. Each usability criterion is also applied individually based on responses to known what particular usability criterion needs further improvement.

To validate our approach, e-Learning system domain was selected, applying the methodology on two cases: eFront learning system and Virtual University Learning Management System (VULMS).

Elements and statistical formulae involved in the calculation of overall usability measure under consideration were described, pondered usability measure was calculated for each system, as well as a comparison of obtained results. Based on this criterion, VULMS is better than eFront. Criteria and designed questionnaire can be used to evaluate usability, so designers of this system have the possibility to decide whether the system needs improvement.

Currently, we are evaluating the instructor profile, as well as we are formulating an inquiry ad hoc according with the obtained result from learners.

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