

Evaluating and Testing User Interfaces for Engineering Education Tools: Usability Testing*

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Evaluation of users interfaces for engineering education tools such as E-learning is important to have enhanced real learning experiences in this domain. To this end, in order to have this experience, we conducted usability studies to see its impact. E-learning usability studies require the involvement of real end users. Different users with varying backgrounds and levels of human–computer interaction (HCI) knowledge behave differently when using e-learning tools. To study user behavior in the e-learning context, an empirical usability study on a specific e-learning tool was conducted. The study uses usability evaluation questionnaires collected from two different groups of Software Engineering Students: one group with HCI knowledge and the other without. The objective is to collect the technology enhanced learning experience from the real users to see the impact of engineering education. It is found that end users without HCI knowledge are more satisfied than those with HCI knowledge, as the latter have higher expectations concerning the tool.

Keywords: usability studies; enhanced learning technology; learning experience with software engineering students; technology impact on students

1. Introduction

Universities Currently, many educational institutions are adopting different educational technologies to enhance engineering education. In this context, they use e-learning platforms as a delivery tool for their services. Unusable or inaccessible interfaces cost these institutions billions of dollars in lost revenue, as a significant number of learners are unable to use the tools [1].

Nowadays, most e-learning courses demonstrate weak web design and poor usability. Significant amounts of money are being spent on e-learning throughout the world, but most of the spenders are not checking up on the usability of the provided courses [2]. The reasons for these problems are as follows [3]: (a) a vast majority of learners or consumers are unaware of the need for usability evaluations or do not check whether the course is usable, (b) testing methods are sometimes time consuming and expensive, and/or (c) the budget of an e-learning production does not support usability testing.

Adequate usability in e-learning tools ensures successful and enjoyable learning. If usability issues are not properly considered in an e-learning environment, then this will lead to hurdles for learners. Usability and sound knowledge of the art of instructional design are crucial for the design and development of successful e-learning tools [4]. Indeed, learners cannot benefit from a good instructional design if content is difficult to find, course tools do not work, or navigation is inconsistent. Therefore, usability testing and evaluation are critical in the design and implementation of e-learning environments.

Numerous articles about online course delivery systems have been published that evaluate factors other than usability, which is discussed in only a very few papers [5, 6]. Unfortunately, there are no defined criteria or standards for the evaluation of the usability of an e-learning system.

In this study, literature related to e-learning usability is reviewed and an empirical study on a popular e-learning tool, Blackboard, is conducted by administering a usability questionnaire to real end users in a classroom environment. Blackboard is chosen among many other e-learning tools because students and faculty members at our institution mostly use this tool. The users were selected based on their current levels of experience with Blackboard and their background knowledge or lack thereof in human–computer interaction (HCI). End users with HCI knowledge are harder to satisfy than other users, as they expect more and can find malfunctions more easily. However, both experienced and inexperienced users were satisfied with online assignment submission tool.

The rest of the paper is organized as follows: Section 2 gives background, Section 3 describes the methodology of the study, Section 4 presents results and analysis, Section 5 gives a brief discussion, and Section 6 concludes.

2. Background of this study

2.1 Usability and its attributes

There have been many studies conducted on the user experience and how to design products that meet the expectations of diverse users [7–9].

Usability in e-learning is about the way content is

presented as well as about the content itself [3]. The definition of usability in the ISO 9241 standard is “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.” This definition can be expanded to include additional characteristics such as engagingness, ease of learning, and error tolerance [3]. According to Whitney [10], usability relies on user feedback through evaluation rather than simply trusting the experience and expertise of the designer. Usability evaluation involves watching real-end-users use a product and applying what is learned to improve the product. He also points out that usable interface design should consider three factors: content presentation, user approaches (interaction techniques), and technology.

Investigation of usability attributes is important in online courses, as these attributes are important for the design of a learner-centered interface in an online environment [11]. “Usability is a measurable attribute of a product” [12]. These attributes include efficiency, user satisfaction, and error-tolerance [13]. Learnability is another of the important measures of usability in e-learning, leading to learner-centeredness, iterative design and frequent testing [2]. To measure the usability of e-learning tools, the following characteristics should also be considered: learner profile, satisfaction with the learning content, perceptions, enjoyment, and engagement [3].

Different usability evaluation techniques, including gathering information on learner observations, inspections, interviews, questionnaires, and expert reviews, can be applied to evaluate the usability of e-learning products

2.2 Importance of usability in e-learning

Worldwide revenues in the corporate e-learning market will surpass \$62 billion by 2014 [14]. Of these revenues, a projected 15.3 billion will be earned in North America and \$4 billion in Europe. In this context, poor usability will create increasingly disruptive results, for the following reasons:

- Lack of accessibility, as a significant number of learners with visible, learning, cognitive, auditory, or physical disabilities will not be able to use e-learning products (an estimated 8% in the US and 11% in Europe)
- Failure to develop ongoing learner loyalty
- Inability to stimulate learners

Moreover, according to Nielsen [15], if e-learning systems have poor usability, offer a bad user experience, or are slow and awkward to use), then the learner will not come back for a second experience.

2.3 Usability evaluation in e-learning

Usability testing has a direct application within instructional design when it is used as a formative evaluation technique for e-learning products. Hughes and Burke [16] define usability testing as the observation of typical users performing tasks with a product, conducted for the purpose of determining what changes need to be made to the content, presentation, or user interface of that product.

Some researchers [4, 12, 15, 17] recommend that the usability heuristics defined by Nielsen [15] be applied to design and evaluate online learning interfaces with regard to how well they meet certain pedagogical guidelines, since many guidelines for e-commerce users are not directly applicable to online learners. Squires and Preece [18], however, argue that these heuristics fail to adopt an accepted socio-constructivist view of learning that can cope with the integration of usability and learning issues; they propose an approach that adapts Nielsen’s heuristics as a part of a usability evaluation exercise.

Benson et al. [6] list twenty e-learning usability heuristics, some of which are based upon Nielsen’s, and others of which are related to instructional design. They also recommend that evaluators consider the following information before starting evaluation: target audience and learner characteristics; instructional goals and objectives; typical context for using the e-learning program; instructional design strategies used in the program; and the status of the program’s development and possibilities for change. According to them, the above e-learning heuristics form a complete model. However, evaluators may add or delete any specific heuristic based on the type of e-learning program.

Quinn [1] discusses other general e-learning usability issues that should also be considered during the development of e-learning interfaces. These issues include motivation problems; repeat sales and ongoing customer loyalty; internationalization; long transaction times; and relationships between learning simulations and real world experiences. If usability and accessibility are considered during e-learning product development, then time may be saved and money made in the long run, since the product will attract the widest possible range of target learners. Real end users should be involved in usability testing, since after release, it is always more costly and time consuming to redesign an interface.

The usability questionnaire that we used in this study was based on the usability characteristics and questionnaire from [13], which has also been used in other studies. Unlike those studies, we chose to focus on two types of users: those with HCI knowledge and those without.

2.4 Blackboard usability study

The success of any e-learning product depends on how easily and quickly students can use it to accomplish tasks. Hayes [19] argues that specific usability attributes such as ease of learning should be among the criteria for the evaluation of online course delivery systems. He conducts a usability evaluation of two such applications: Blackboard and Web-Course-in-a-Box.

Piguet and Peraya [20] give an analysis of online learning tools such as Blackboard with respect to usability, focusing on two factors within the user–interface interaction: satisfaction and control. Chalk [21] used Blackboard to evaluate the usability of virtual learning systems, and argues that it can be applied to any virtual learning environment with facilities for online instructional materials.

Tselios et al. [22] conducted usability evaluation experiments on distance learning systems. They used two e-learning software tools, Blackboard and IDLE (Instructional Design for Electronic Learning); in order to (a) measure usability and effectiveness and (b) investigate the impact of usability on student performance. The usability evaluation was based on a questionnaire.

Web-based learning is different from traditional web design. In designing online learning tools, the designer should consider the concepts of instructional design strategies and learner experience. Evaluating e-learning usability is a difficult task. A developer should utilize user experiences within the system development lifecycle to study the user interface and build an interactive application [23–30].

3. Methodology

3.1 Participants

One of the first considerations in conducting a usability study is to identify target participants [13]. We selected two groups from different courses each with 30 students: a third-year software engineering course and a first-year computer science course. Both courses were given at our university. The first group, to which we refer as Group A, had experience in human–computer interaction (HCI); the second group (referred as Group B) did not have any experience in the field of software usability.

3.2 Choosing the e-learning tool: blackboard

We chose to look at Blackboard because most of the students at our university have been using it as a supplementary course delivery vehicle for conventional learning. It is also widely used by educational institutions worldwide as an e-learning platform and/or a supplementary tool for traditional teach-

ing and learning. Students at our university use Blackboard mainly for online assignment submission. Other features used are as follows: Course Content and Management Tools including Syllabi, My Grade, Lectures, Glossary, References and Presentations; Assessment Tools including Online Quizzes, Assignments Submission, Self-Test, etc.; and Communication Tools including Mail, Chat, Bulletin Board, and Discussion. Faculties and teaching assistants also use Blackboard for organizing, importing and constructing course materials, as well as other course-related purposes.

3.3 Procedures

The usability questionnaire consisted of closed questions (parts 1–5), answered on a five-point Likert-type scale¹, and open-ended questions (parts 6–7). The completed responses were converted into numbers in such a way that low numbers indicate a positive rating of the tool.

Participants were asked to use Blackboard for online assignment submissions and to record the time required for submission, after which they were given the questionnaire. They were asked to submit it at their convenience.

The first part of the questionnaire was designed to gather information about the participants' experience with Blackboard course tools. The second part was aimed at evaluating the user interface, and the third part was aimed at evaluating the effectiveness, enjoyment, satisfaction and interaction with the content tools (course content). The fourth part was designed to gather information concerning ease of use and effectiveness with the communication tools, and the fifth part was designed to collect data about the time required to accomplish a task and about users' satisfaction with the assessment tools, in particular online assignment submission. The sixth part (open-ended questions) was only given to Group A users and was intended to collect information concerning the redesign of Blackboard (e.g., "Would you like the usability of the above features to be rethought, and how much usability, do you think redesign is needed?"). The seventh part had open-ended questions related to full online course delivery without classroom lectures (e.g., "Would you like to move your course to full online course delivery without classroom lectures?"). The last part was aimed at collecting anonymous comments and suggestions from participants concerning their views on e-learning usability.

¹ The answers ranged from (1) "Extremely easy to use" or "Very satisfied" or "Very quickly" to (5) "Extremely hard to use" or "Very unsatisfied" or "Extremely slow."

4. Results and analysis

We used t-test analysis tools for the analysis, with a p-value threshold of 0.1.

4.1 User profile

As learners' experience is important to the design of an effective e-learning system, we have to understand the characteristics and needs of the real target end users. As mentioned earlier, two groups of participants took part in this study: Group A, with HCI knowledge and Group B, without. Further, 80% of the participants in Group A and 29% of the participants in Group B had used Blackboard extensively, while 20% of the participants of Group A and 71% of the participants of Group B had used Blackboard only a few times. This is illustrated in Fig. 1.

4.2 Characteristics of user interface (UI)

No significant differences were found between Group A ($M = 2.60$) and Group B ($M = 2.73$) for participant ratings concerning ease of logging and ease of learning, $t(29) = 0.5914$, $p = 0.5914$. Significant differences, however, were found between Group A ($M = 3.26$) and Group B ($M = 2.58$) in terms of participants' ratings concerning ease of use. Participants in Group B found Blackboard easier to navigate than did participants in Group A, $t(29) = 3.36$, $p = 0.0049$. The mean value regarding satisfaction with user interface of Blackboard was 3.46 for Group A while it was 2.60 for Group B. By performing a t-test $t(29) = 3.71$, $p = 0.0005$, $\alpha = 0.05$, we identified a negative attitude towards Blackboard; participants in Group B were more unsatisfied with the Blackboard UI than those of Group A. Help and error recovery were not analyzed.

According to the majority of the participants (70%), Blackboard did not have a consistent format; at times the navigation was confusing, and at times the interface had inadequate results, for

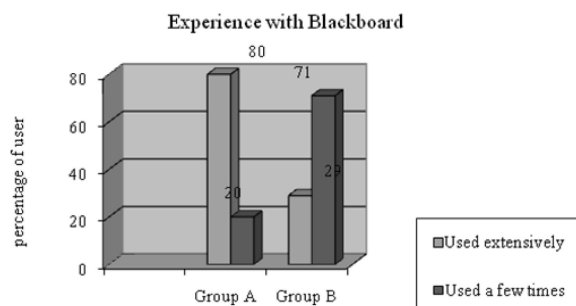


Fig. 1. Respondents' experience with Blackboard.

example when clicking the back button multiple times.

4.3 Course content tools

Course content tools help students prepare for their next class and strengthen their understanding of the course. At our university, course content posted in Blackboard is used as a supplement to classroom teaching and learning. This feature is essential to delivering any e-learning course.

There were no significant differences found between Group A ($M = 3.0$) and Group B ($M = 2.90$) in participants' ratings regarding organization and presentation of information, $t(29) = 0.486$, $p = 0.628$. There were also no significant differences found between Group A ($M = 2.76$) and Group B ($M = 2.60$) in participants' ratings for effectiveness, enjoyment, and interaction with course content, $t(29) = 0.926$, $p = 0.443$. Finally, there were also no significant differences found between Group A ($m = 2.80$) and Group B (mean = 2.70) in participants' ratings concerning ease of finding information in the course content, $t(29) = 0.593$, $p = 0.630$.

Most of the participants (80%) found the Blackboard course tools effective in helping them to study. However, only 68% of the participants were satisfied with the course content.

4.4 Communication tools

Online communications tools such as discussion forums; mail, chat, and Whiteboard allow students to engage in lively communication with other learners as well as their instructor. In the present study, there were significant differences found between Group A ($M = 1.8$) and Group B ($M = 2.50$) in terms of participants' ratings of the effectiveness and ease of use of the communication tools, $t(29) = 3.36$, $p = 0.00023$. According to most of the participants (87%), these communication tools are effective, helpful, and satisfactory.

4.5 Assessment tools/assignment submission

Online Assignment Submission allows participants to submit course assignments and receive feedback from the instructor or teaching assistant. We found no significant differences between Group A ($M = 2.46$) and Group B ($M = 2.50$) for participants' rating regarding satisfaction with the online assignment submission, $t(29) = 0.27$, $p = 0.90$. There was a strong correlation between time required to submit assignments and the perceived ease of use of the tool. The value of the Pearson coefficient (r) was 0.8520 for Group A and 0.8353 for Group B. Both values are considered high, indicating a strong correlation between time required for submission and perceived ease of use. This correlation can be clearly seen in Figs. 2 (a) and (b).

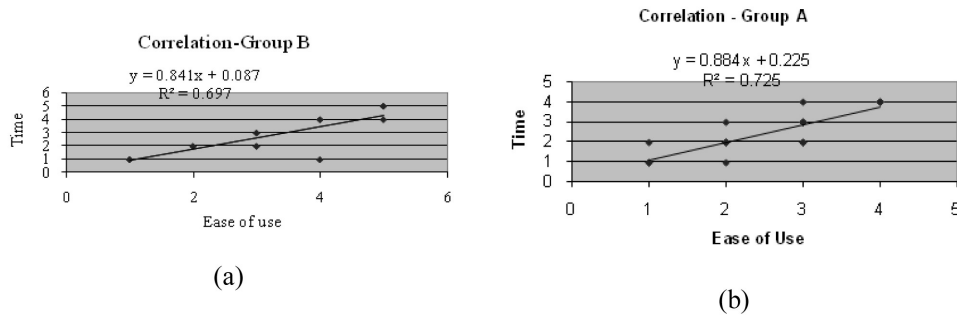


Fig. 2. Correlation between required time and ease of use of the assignment submission process.

4.6 User interface (UI) redesign

The participants in Group A ($M = 3.1$) were less satisfied than those in Group B ($M = 2.6$) with Blackboard over all, $t(29) = 1.63$, $p = 0.0702$. As a result, when giving feedback concerning a hypothetical redesign of the system, 20% of them suggested a complete redesign, 27% suggested a major redesign, 40% suggested a moderate redesign, and 13% suggested minor changes as shown in Fig. 3. The above results may stem from the fact that Group A had a more experience with usability.

4.7 Participants' recommendations in answers to open-ended questions

As mentioned above, the last two parts of the evaluation questionnaire consisted of open-ended questions asking our subjects about the possibility of full online course delivery without classroom lectures (part 6) and soliciting general comments about e-learning usability (part 7).

The majority of the students (98%) did not want full e-learning course delivery without classroom lecture; they wanted e-learning course delivery as a supplement to classroom teaching. Instructional design issues should be considered in the event of the design or implementation of a fully e-learning course without classroom.

In the following, we summarize some anonymous comments from both groups:

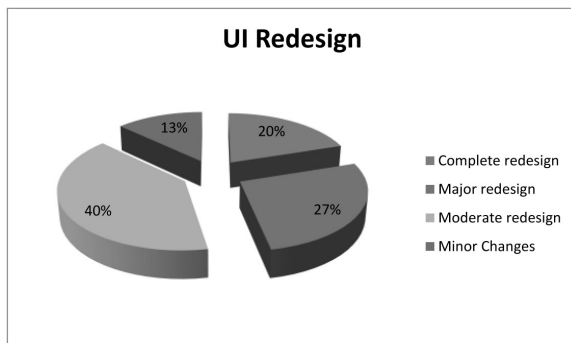


Fig. 3. User's view on redesigning the UI.

- Not satisfied with user interface.
- Easy to learn, easy to use, enjoyable.
- Frustration and confusion with navigation.
- Error message after pressing back button.
- Slow, disappointing.
- Insecure but it has already been solved.
- Supports classroom lectures effectively.
- Consider UI usability in future redesign.
- Make it easier to maintain up-to-date information about courses.
- Accessibility issues should be considered.
- Difficult to download some kinds of files.
- Universal access and usability should be considered.

Some of the participants' comments are directly quoted:

"I am really frustrated with the navigation facility of Blackboard, very disappointing. I advise that Blackboard should have more usability studies and apply the findings from these studies to future design."

"Slow, user interface is junky. Try to improve speed and user interface."

"Instructional design guidelines as well as usability should be considered while designing and constructing course content."

"I am very satisfied with the online assignment submission tools."

5. Discussions

Participants in both user groups pointed out some navigation difficulties in the Blackboard user interface. They were not satisfied with this feature. Users in Group A (users with HCI knowledge) were less satisfied than those in Group B.

Real end users' experience is very important to the design and development of a successful, usable e-learning tool. In addition, it is essential to involve a good number of end-users with HCI knowledge if the goal is to find malfunctions during the development process. The results achieved from the present study, and specifically the variation between groups of end users, may improve if usability tests are taken into consideration during the design and develop-

ment process. However, our results might also have been different if faculties and teaching assistants had been included in the study. In any case, it may be concluded that users with HCI knowledge are more observant regarding the user interface and therefore are able to find malfunctions more easily, while users without HCI knowledge are more easily satisfied because they have fewer expectations.

In both groups, there was a strong correlation between time required in submission and perceived ease of use. Most of the usability ratings from both groups were statistically significant, and there was a generally positive assessment of Blackboard, except on the issue of navigation.

6. Conclusions

As e-learning environments continue to increase in importance, it is important to understand the usability constraints on them. There is little doubt that these constraints impact the student learning experience. Blackboard in particular is becoming increasingly popular, so it is essential that we assess the usability of its user interface. This is particularly pertinent for users with no or little HCI knowledge. This paper can provide an important contribution to the field, and our findings should gain importance in the future as this type of learning becomes more accepted, since they address a critical aspect of e-learning: potential usability barriers. In future work, we may wish to examine grades in both high-HCI and low-HCI courses using Blackboard and correlates these with questionnaire results.

Acknowledgements—This work was supported by the Research Center of College of Computer and Information Sciences (CCIS), King Saud University through the research project no RC120908. The authors are grateful for this support.

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