Integrated Usability Testing

Andrei Ternauciuc [1], Radu Vasiu [1]

[1] *Politehnica University Timisoara, Bv. V. Parvan, 2, Timisoara, Romania*

Abstract – **It is essential to regularly test the usability of a learning management system, in order to ensure a fast adoption by new users and rapidly shift the focus from the platform to the content and the learning experience. Quantitative testing yields the most reliable results due to the large number of data points acquired, but lacks the in-depth analysis of the qualitative research from a controlled testing setup.**

We are proposing in this paper an integrated usability testing tool, which can replace a certain type of laboratory testing, where the users' actions on the real platform are measured and analyzed.

We conducted tests with the tool and compared the results with a small scale laboratory test using the same scenarios. The results seem to confirm the proposed tool as a viable alternative to the laboratory test.

Keywords – **usability testing, integrated tool, Moodle.**

1. Introduction

Testing the usability of a new product or interface is an essential part of its development. The most robust processes employ different phases for testing the usability during the design stages, thus ensuring that the final release to the public will be as user-friendly and efficient as possible [1]. Large design teams benefit from usability departments or at the very least, usability experts. Smaller development endeavors need to rely on proven methods like questionnaires or small-scale heuristics.

There are many different types of usability tests. There are some which focus on the user-interface and aesthetics (how pleasant the interface is), while others test the functional usability (how easy and efficient it is to use). There are also qualitative tests (focusing on the supervised interactions between subjects and the product) and quantitative tests (which trade detailed and personal impressions for large sets of data) [2].

Each of these types of usability tests recommends a different tool. For instance, the questionnaire is best suited for large scale quantitative testing, while focus groups and structured interviews work best in qualitative testing scenarios [3]. For human-computer interfaces (HCI), screen captures can create heat-maps showing the most used/most efficient places inside the graphical interface for important interactions [4]. And laboratory testing setups can further enhance the analysis, by using a controlled environment to minimize distractions and capture a more detailed picture of the interactions [5].

There is little doubt that each of these tools have their own weaknesses. Using one or another in a specific scenario means weighing the pros against the cons and deciding if the results are accurate or meaningful enough. This means that in a more general setting, using only one tool or metric is not sufficient, a combination of them is required [6].

One of the factors which must be accounted for is the cost of using each of the tools. The most affordable (in time and resources required) seems to be the questionnaire. Once it is designed, it can be easily distributed and replicated with minimal cost. However, its greatest strength –the possibility of reaching a large number of respondents– is limited by the complexity of question items, therefore a delicate balance must be found between the depth of the analysis and expected turnout [7]. On the other end of the spectrum, a laboratory testing, with multiple cameras on the subject and usability experts as well as psychologists on stand-by, can be one of the more exhaustive as well as expensive types of usability tests [8].

All of the above represent general considerations regarding usability testing and are applied to many real-life products or processes, and to virtually all online human activities. Online platforms in general and learning management systems (LMS) in particular, are no exceptions.

What we are proposing in this paper is an auxiliary LMS tool combining some of the advantages of a laboratory testing setup –the efficiency of use for a certain HCI– with those of the questionnaire: repeatability, low cost and relatively large sets of data for accurate interpretation. We are also analyzing the efficiency of this tool by comparing the results it provided with the results of a small scale laboratory testing, using similar parameters for the two tests. Our research hypothesis is that the results of the two different testing methodologies are similar, thus proving the value of our tool.

In the following sections, we will provide a general background for the usability testing of e-Learning platforms. Then we will describe the testing methodologies and detail the technical aspects of the tool we developed. Next, the results of the tests will

be provided, followed by the interpretation of said results. And finally, we will conclude this paper with a synthesis of our findings, as well as possible future work in this field.

2. Background

Alongside factors such as costs and meeting the technical and administrative needs of a certain educational scenario, the usability of a LMS plays an important role in choosing one solution over all the others. It is often a direct measure of the projected adoption of the new teaching and learning tool, as well as its efficiency.

Thacker (2014) conducted such a study when the staff expressed dissatisfaction with their existing Blackboard Learn platform [9]. The controlled laboratory testing environment was provided by Clemson University's usability testing facility. The test consisted of five common tasks each for the Blackboard Learn and Canvas platforms, using a group of five selected subjects from the university staff. The conclusions of this study suggest the adoption of the Canvas LMS instead of the existing Blackboard solution.

Masood (2015) used a combination of think aloud protocols, audio recordings, interviews, observations and questionnaires to test the effectiveness of a Moodle-based LMS, with a sample of eight students [10]. The study found the users' preferences of forums over blogs and of external communication tools over the platforms of internal communication mechanisms.

The extensive study done by Kakasevski (2008) focused on Moodle and employed 84 students, as well as eight faculty members and two administrators. Using a combination of questionnaires and experience-based evaluation, the authors were able to assess the platform from the point of view of the standard usability factors: ease of use, efficiency, effectiveness, memorability and satisfaction. They were also able to identify 75 unique usability problems [11].

Many more studies exist which were conducted using consecrated usability testing methodologies. There are also improvements to these methods, such as the use of semiotics perceptions during usability testing [12], or the interpretation of human emotions [13]. Furthermore, specific strategies have been proposed for certain testing scenarios, such as the methodology for testing the usability of a Moodle-based LMS which is used in a blended-learning environment [14], as well as a four perspectives approach to the mobile usability of Moodle [15].

Most of these studies were conducted using a combination of tools, according to specific requirements or limitations. The tests which yielded the most comprehensive quantitative data employed questionnaires, while the qualitative research was mainly conducted using either heuristics, or task-oriented, experience-based evaluations.

We are trying to combine the advantages of both of these approaches, by developing a tool that produces quantifiable data of the qualitative kind, but which can be replicated on a large scale.

3. Testing methodology

The methodologies for the two testing methods are detailed in this chapter. We used a clone of the official e-Learning platform in use at the Politehnica University Timisoara, the Moodle-based Virtual Campus of UPT or CVUPT [16]. This clone used the same core and third party files of CVUPT, as well as the basic configuration, but none of its actual data (users, courses, structures).

We designed a set of simple testing scenarios, which were first implemented in a laboratory setting, then using the integrated testing tool we developed. The results of the tests were subsequently compared in order to detect incongruences.

Volunteers for the tests were selected among the students and faculty with at least two years of experience in using the CVUPT platform. They were divided into four groups:

- Students – laboratory testing
- Students – integrated testing
- Tutors – laboratory testing
- Tutors – integrated testing

There was a total of 24 volunteers, 7 in each student group, and 5 in each of the tutors' groups.

Testing scenarios

We created two sets of tests, one for students and one for tutors. Each test began with a simple pre-test questionnaire. We decided on a 10 item – 7 choices questionnaire, inspired by the system usability scale (SUS), in order to encourage completion [17]. The questions probed previous experience with the CVUPT platform, as well as some subjective issues regarding its ease of use and aesthetic appeal.

While not adhering to the full philosophy of SUS, the role of the questionnaire was rather that of a placeholder for one in the development of the integrated testing tool, and was replicated in the laboratory testing setup.

The four tests for the tutors are described as follows:
- Messaging (sending a private message to the platform administrator)
- Forum posting (creating a new post on the test course forum)

- Adding an assignment (creating an assignment, with requirements, in the test course)
- Student grading (grading students for an existing activity within the course)

The four tests for students were about:
- Messaging (sending a private message to the platform administrator)
- Forum posting (replying to an existing forum post, created by a tutor)
- Assignment upload (completing an assignment by uploading a file in the appropriate section)
- Checking of grades (checking the student user's own grades, in the course, as well as globally)

Each of the scenarios had a series of four or five well defined steps, which were made available to volunteers during the completion of the tests.

Laboratory testing

In the laboratory testing setup, pre-selected volunteers were invited, one by one, into the testing room by the test coordinator. In front of the workstation, they were presented with a sheet of instructions, as well as the pre-test questionnaire and the description of the four tests, each with their own steps. After they completed the questionnaire, they were asked to finish the four tests on the computer, in an order, by completing each of the corresponding steps.

During their work on the computer, the test coordinator measured the time in seconds necessary for the completion of each task, using a stopwatch app on a smartphone. He also noted the missteps, test resets and abandonments.

Integrated testing

For the integrated testing setup, volunteers received the initial instructions via email, including those for accessing the test platform. Once logged in, they entered the test course, where the four usability tests were presented to them via a list in a specially designed block, at the top of the right-hand column. Though properly numbered, they were not required by programming to follow the tests in order, even though the initial instructions email specified so.

Each of the tests is independent from each other, and once started, must be followed in the precise order of its tasks. Each misstep is recorded in the database, along the correct steps, and properly timestamped.

The description of each task is provided to the volunteer via a modal window in the upper-right quadrant of the page (Fig. 1). In case the user is not in the correct section, a message with two links

allows the reset or the stopping of the test, and ensures the return to the front page of the test course, where all the tests begin and end.
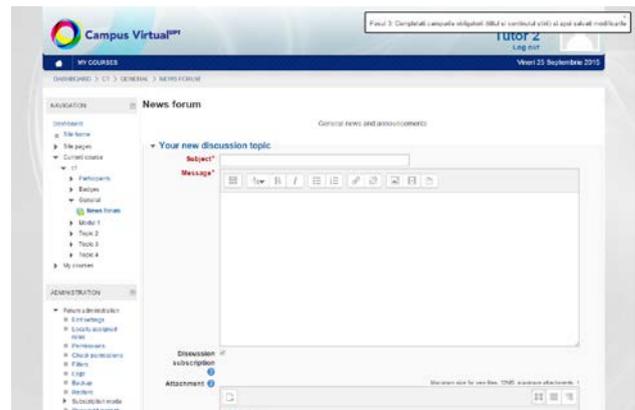

Figure 1. Integrated testing tool: information provided

Evaluation

During the tests, each step was recorded from two points of view: whether it was the correct step in the test workflow, and what was the time passed since the instruction was given (the completion of the previous step).

All volunteers were given the option to quit the current test at any time, and either start the same one from the beginning, or a new one from the other available in the list. The "STOP" and "RESET" operations were logged as well.

At the end of the tests, tables of data containing the number of seconds needed for the completion of each step, as well as the wrong steps, were compiled for each volunteer.

For the laboratory testing, the tables were compiled using the hand-written notes of the test observer. For the integrated testing, the data was extrapolated directly from the database of the test platform.

Interpretation

The results were valued less from the perspective of their absolute value (the usability of the platform). The main focus of the analysis was the comparison of the two sets of data. Our research hypothesis states that there should be small differences between the results of the laboratory testing, and those from the integrated testing tool. This is a direct measure of the accuracy of the tool, since the value of laboratory testing is well established.

4. Implementation

In order to ensure the portability of the tool, we began its development inside the framework of the Moodle LMS. The implementation consists of an

administrator's tool (for managing the tests, the questionnaires and the results), a course block (visible to appropriate users, allowing them to start one of the available tests) and a small template "hack" inserting a widget, in order to ensure, for each of the steps in a test, the proper detection of the location and the display of the corresponding message (the next step, if the current location is the right one, or the possibility to stop/reset the test, if the user is lost).

The tool works with 5 dedicated tables in the platform database. The tables were created using the Moodle XMLDB interface, making them compatible with any database management system that Moodle supports, not only the MySQL database behind the current development platform. These 5 tables are used as follows:

- A table for the tests themselves (called "Templates" in the current application); this table holds general information about the tests: description, creation and modification dates, as well as the target user role for the test.
- One table for the steps in each usability test; the number in the overall order of the steps in each template is stored here, along with the target url and additional information in identifying the correct context, as well as the instructional messages to be displayed in order to proceed to the next step.
- Pre or post-test questions are stored in the next table. Question order, type and text, as well as the corresponding template are the main types of information available for each of the questions.
- The table for responses to the question items holds the identification of the user, the session, the actual response and the timestamp of the completion.
- The logs table, completely separate from Moodle's own logging system, records the user id, step id, url, status (whether correct) and the timestamp.

Administration

In the Administrator>Tool section of the Moodle platform, we created a new tool with the name "Usability testing". Abiding by the guidelines and structures of the framework, this tool integrates with the Administration > Users tree in the navigation block and is accessible only to users with administrator or platform manager privileges.

Once accessed, the interface shows the list of existing tests (or templates), with the possibility of deleting, changing or adding a new template (Fig. 2).

For each template, the administrator can access the list of steps as well as that of questions, and can modify, reorder, delete or add each of these types of items.

Figure 2. The administration interface

Currently, the two main pieces of information that control the way the tool identifies the current context (and therefore step in the usability test), and the way the response message is displayed, respectively, can only be recorded in a raw, json-based format. For future improvements, we expect to simplify this procedure.

In accordance with prior research, we decided that the pre and post questionnaires need to be comprised of simple questions, with either free-text responses, or a simple scale with a configurable number of points (7 by default), per the System Usability Scale (or SUS) philosophy.

The administration section of the tool is also the place where the users' responses to questionnaires and measured interactions can be accessed and evaluated.

The HOOK.JS Widget

Since the CVUPT platform on which the development application is based uses a custom-built template, we chose to use the header part of the template as the entry point of the usability test widget. This is necessary because there is no universally loaded user-developed extension in Moodle, and we wanted to create a framework for usability tests in all the areas of the platform, not just courses or other popular sections of the application. The small Javascript file titled HOOK.JS is only loaded when a usability test is under way (a state flagged by custom session variables), and uses AJAX calls in order to minimize impact on loading times.

The purpose of the widget is to send the current url to the decision block and expect a response.

Depending on the response, the file then calls upon the Trip.js jQuery library and creates a highly customizable message (usually in the style of a tooltip), providing the user with instructions [18].

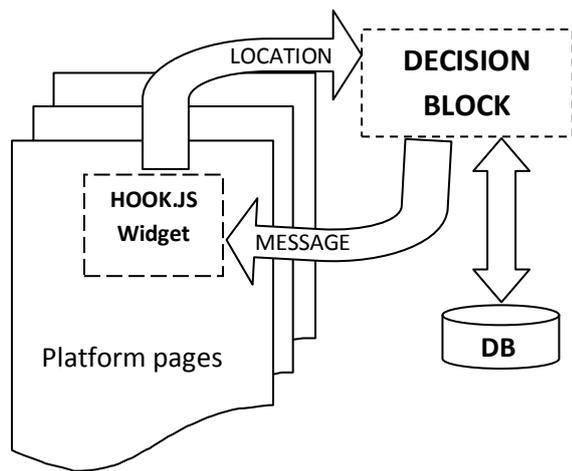The working principle is illustrated in Fig. 3.

Figure 3. Working principle for the Integrated Testing

Since the whole tool is adaptable to the Moodle environment and this file is run entirely on the client computer, a dedicated AJAX call inside the widget requests any custom language strings existent on the server, but only loaded on demand. This is only done for system language queries, since messages pertinent to the tests are stored in the database and localization would require further development of the tool and of the tests.

Course block

The purpose of the course block is to provide a starting point for the usability test by listing all the available templates for the current user, according to the user role (Fig. 4). Once started, this block can also provide a way for the user to prematurely stop the current test.

The reason why this block was not used as the entry point for the widget is that Moodle blocks are not ubiquitous. There are some areas (profile editing, for instance), where blocks aren't allowed. Modifying the template was thus the most reliable solution.

While not strictly needed, this extension was developed in order to provide a more open way of starting a usability test, as well as increasing the visibility of the extension in the case of a production environment.
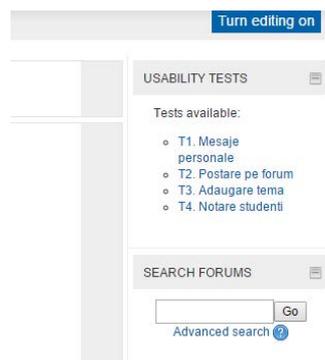

Figure 4. The course block

5. Evaluation

As stated prior, the focus of the results evaluation was not on the absolute values of the tests, but on the relation between results obtained in a laboratory setting and the results from the integrated testing tool. This is the reason all the results from the laboratory testing are presented side-by-side with the data obtained from the integrated testing tool.

Questionnaires results

All participants began testing by completing an initial questionnaire. Each of the questions from the two questionnaires (one for students and one for tutors) was identically presented in the laboratory testing, as well as in the integrated testing setup. Respondents had a scale from 1 to 7 to rate a certain aspect of their prior experience with LMSs in general, and the CVUPT platform in particular.

Table 1. presents the questions and the results' averages for the laboratory (LAB Av.) and integrated testing (Int.T. Av.) student volunteers.

Table 1. Questions for students and averages of responses

Question	LAB. Av.	Int.T. Av.
Estimate your familiarity with online educational platforms (MOOCs, LMS, etc.)	3.28	4.57
How long have you been using the CVUPT platform? (years)	2.42	2.57
How often do you use CVUPT in your university courses?	5.28	5.57
Estimate your rhythmicity in using CVUPT.	5.14	5.42
Estimate your ease of use of the CVUPT platform	6.28	6.42
Estimate the variety in using different communication tools available on CVUPT	4.57	5.28
Estimate the variety of course resources found on CVUPT	5.85	5.42
Estimate the variety of evaluation methods used by tutors in CVUPT	5.14	5.28
How friendly do you find the interaction with the platform?	6.57	5.85
How pleasant do you find the graphical interface of CVUPT?	5.71	5.85
Averages	**5.02**	**5.22**

The questions for the tutors were very similar, adapted to the point of view of the course creators and the managers (Table 2).

Table 2. Questions for tutors and averages of responses

Question	LAB. Av.	Int.T. Av.
Estimate your familiarity with online educational platforms (MOOCs, LMS, etc.)	6.2	5.6
How long have you been using the CVUPT platform? (years)	5.8	5.4
How often do you use CVUPT in your work with students?	6.2	5
Estimate your rhythmicity in using CVUPT.	5	5
Estimate your ease of use of the CVUPT platform	5.8	5.6
Estimate the variety in using different communication tools available on CVUPT	6	5.6
Estimate the variety of course resources available on CVUPT	5.8	5.8
Estimate the variety of evaluation methods available on CVUPT	5	5.2
How friendly do you find the interaction with the platform?	5.6	5.6
How pleasant do you find the graphical interface of CVUPT?	5.6	5.6
Averages	**5.7**	**5.44**

Student testing results

The four student tests were marked with ST1, ST2, ST3 and ST4, while the corresponding steps were marked from s1 to s5, and from s1 to s4, respectively.

The results of the actual tests take into account the time it took to complete each of the intermediary steps (in seconds), as well as the wrong location (noted with a "w"), abandonment ("a"), skipped steps ("s") for the laboratory testing, and wrong location ("w"), reset (marked with "R"; this resets the current step to number 1, but keeps the same testing session) and test stop ("S"; this clears the session and allows the start of a new one) for the integrated testing, respectively.

The average time in seconds needed for the completion of each step, as well as the markings described above, are presented in Table 3.

Table 3. Student testing results

Test	Step	LAB. Av. Time (s)	Extra	Int.T. Av. Time (s)	Extra
ST1	s1	15.50	6w	12.98	2w+1S
	s2	13.50	1w+2a+1s	11.64	5w+4R
	s3	14.67	1a+1s	8.50	
	s4	10.67	1w	12.29	1w+1R
	s5	6.33	1a	13.71	1w+1R
ST2	s1	15.50	1w	13.71	3w+3R
	s2	11.67	2w	7.29	
	s3	10.00	2w	20.57	
	s4	10.50	1w	27.57	
	s5	13.20	4w+2a	14.71	
ST3	s1	8.29	1w	5.57	
	s2	13.29		11.43	
	s3	33.50	1w	41.57	1w+1R
	s4	5.33	1a	8.57	
ST4	s1	7.57		6.43	3w+1R
	s2	12.57	1w	16.14	
	s3	11.14		10.43	
	s4	7.29		6.43	
Sum		**220.51**		**249.55**	

Tutor testing results

The four tutor tests were marked with TT1, TT2, TT3 and TT4, while the corresponding steps were marked from s1 to s5, and from s1 to s4, respectively.

Similarly to the student testing, the recorded times for the completion of the steps, as well as extra markings with the same meaning ("w" is for wrong step; "a" is for abandonment; "s" means the step skipped; "R" is for test reset and "S" is for test stop) are presented in Table 4.

The total time of the evaluation was chosen for summarizing instead of the average, as a measure of the heterogenic nature of the individual items (steps).

Table 4. Tutor testing results

Test	Step	LAB. Av. Time (s)	Extra	Int.T. Av. Time (s)	Extra
TT1	s1	12.00		10.63	w+S
	s2	12.20	5w	10.75	
	s3	12.25	2w+s	4.50	w+R
	s4	15.40		9.83	
	s5	9.80	2w	10.50	w+2R
TT2	s1	8.20		16.80	
	s2	5.40		8.00	
	s3	20.80		19.10	
	s4	8.40	w	7.80	
TT3	s1	16.80		6.00	2w+R
	s2	20.00	5w+a	17.40	w+R
	s3	35.75	4w	57.40	
	s4	8.50	w	10.80	w
TT4	s1	32.80		22.90	
	s2	15.20	2w+r	5.30	
	s3	23.40		39.10	w
	s4	5.25	s	4.00	2w+S
	s5	6.40	w	5.40	
Sum		**268.55**		**266.21**	

Final considerations

The questionnaire that the volunteers completed during the laboratory testing ended with a free text query, inviting them to share with the organizers any other thoughts regarding the tests.

While none of the volunteers chose to write anything there, the same question was asked informally of the volunteers who worked remotely, using the integrated testing method.

They were asked to evaluate the testing procedure, and the general impression was positive. Even though some appreciated the friendly interface and the ease of use of the testing method, some observed errors in the way the initial questionnaire was displayed. Upon scrutiny, the problem was identified as the lower resolution screens that some of the volunteers were using (from laptops or notebooks), problem which did not occur with usual desktop resolutions. Steps were taken to correct the issue.

6. Discussions

The stated purpose of this paper was, from the very beginning, the comparison of the two sets of data: the one obtained from the classical laboratory test, and the other one, provided by the proposed integrated testing tool. The absolute value of either

two tests is less relevant for the goals within this research.

By looking at the four averages provided by the questionnaires, differences emerge: the average for the laboratory testing of students (5.02) is lower than that of the integrated testing tool (5.22), while the average for the laboratory testing of tutors (5.7) is higher than that for those who completed the test remotely (5.44). However, the deviations are not very significant considering the small sample sizes, and the different directions of variance suggest no correlation between the form of delivery of the questionnaire and the results.

Considering the average total times it took students from the controlled environment to finish all tests and comparing them to the average time it took remote students to complete the tasks, one can observe the 30 extra seconds it took for the remote students to finish. Which can be significant by only looking at the numbers.

But by comparing the average times for each of the intermediary steps, a few of them stand out: the average time for step 3 of Student Test 2 (ST2) is almost double (10 seconds difference) for the remote students, compared to the ones in the laboratory. Similarly, step 3 of ST3 sees an extra 8 seconds for the remote users. We chose to single out these two steps because they involve the creation of text (ST2 requests posting in the forum) or the upload of files (ST3 requires an upload of a file to an assignment). Both of these operations were completed in a hurry by the students present in the laboratory, and without the delay associated with fluctuating internet connections or non-standard computing systems. And while the length of the text respondents input in the text fields was not measured, this can be avoided in the future with more precise instructions. This is of course only one possible explanation.

Still, the difference raises the issue of the impact technology has on the results. While all the laboratory tests were conducted on the same computer, remote users logged on using their own, uncontrolled terminals. Maybe a short automatic diagnostic at the start of the integrated test would identify potential issues with connectivity or speed, and reject those applications from the start.

The less than two seconds difference between the total times for the two sets of tutors (268.5 for those tested in the laboratory, and 266.21 for remote users) confirms our original hypothesis without the need for extra discussions.

Since the value of the laboratory testing of usability is well known [19], comparing the efficiency of custom alternatives aimed at significantly reducing costs is desired. And while remote testing scenarios have been analyzed, both in synchronous and asynchronous setups [20], they do

not allow the large scale implementation our tool aims to provide.

7. Conclusions

The purpose of this study was to propose an integrated usability testing tool which combines the advantages of quantitative testing (scalability, easily interpreted sets of numerical data) with those of a particular type of laboratory testing, in which the actual use of an online platform by regular users can be assessed.

We tested the tool and compared the results with those from a small scale test in a controlled environment, using the same testing scenarios.

The results of the two sets of data were similar enough to declare our initial research hypothesis as valid.

And with the previously listed advantages, we are confident in the use of the integrated usability testing tool in large scale remote testing scenarios where the focus is on the users' actions rather than on their opinions.

Future work in this research will focus on the refinement of the tool, from the administrative and aesthetic, as well as from the functionality points of view. Large scale testing would also be required to further prove the value of the proposed testing methodology.

Acknowledgements

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