Optimising the effectiveness of questionnaire surveys for usability evaluation of offline e-learning tutorials

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Abstract: Usability of e-learning environments should be based on an interaction design that promotes ease of learning and offers meaningful engagement with the content. To achieve this, their design should take into account principles of learning and of usability. Selection of an appropriate usability evaluation method requires consideration of its cost and effectiveness. The objectives of this study are: to generate a questionnaire for evaluating offline e-learning tutorials, based on a customised usability framework, use the questionnaire in a user-based evaluation of an offline interactive tutorial, and determine the effectiveness of the questionnaire in usability evaluation. Based on a framework of twelve criteria, the questionnaire was developed and deployed in a survey, which demonstrated its effectiveness in evaluating an interactive tutorial. The major problems identified were related to the structure and navigability of the tutorial, as well as weaknesses in its Help system.

Introduction

Advances in information technologies have extended the opportunities for designing interactive, learner-centred, engaging and easily accessible e-learning environments, including interactive e-learning tutorials, which can be an effective means of teaching and learning (Abdollah, Ahmad & Akhir, 2012; El-Tigi & Branch, 1997; Khan, 2002; Asarbakhsh & Sandars, 2013). However, there are challenges associated with these developments. While some of the issues can be attributed to inadequate technical skills on the part of users, others are related to the interface design and interaction design (White, Wright & Chawner, 2006). In designing e-learning there should be an emphasis on developing usable systems, since educational applications require interfaces that enhance rather than distract users from achieving their main goal of learning. Usability can be defined as the effectiveness and efficiency with which users' goals are achieved in a system, to a satisfactory level, for specified users in a specific situation (Dix, Finlay, Abowd & Beale, 2004; ISO 9241-11, 1998; Preece, Rogers & Sharp, 2007). Usable e-learning systems should provide the type of interactivity that promotes ease of learning and offers meaningful engagement with the educational content (Masemola & De Villiers, 2006). To achieve this, e-learning environments should undergo evaluation and subsequent refinement. This calls for application of adequate and appropriate usability evaluation methods. These methods assist evaluators to identify usability problems that should be addressed through design and redesign of these environments (Furniss, Blandford & Curzon, 2007).

Usability evaluation is concerned with gathering information about the usability or potential usability of a system, in order to assess it or improve its interface by identifying problems and suggesting improvements (Shneiderman & Plaisant, 2005). There are various usability evaluation methods (UEMs): analytical; inspection methods such as expert heuristic evaluation; surveys by questionnaires and interviews; observational techniques; and experimental methods that include formal usability testing in the controlled environment of a human-computer interaction (HCI) laboratory (Dix et al., 2004; Nielsen, 1994; Ssemugabi & De Villiers, 2010). Selection of an appropriate UEM requires consideration of its cost and effectiveness (Ardito, Costabile, De Marsico, Lanzilotti, Levialdi, Roselli & Rossano, 2006). There have been several investigations into the

effectiveness of different usability evaluation methods (Freire, Arezes & Campos, 2012; Zaharias, 2006). This paper focuses on the effectiveness of a user-based questionnaire survey that was administered to evaluate an offline e-learning tutorial. To make the work more effective, the study was founded on a theoretical framework consisting of criteria for evaluating offline e-learning tutorials. The criteria were generated from an extensive literature study on usability, learning theories, evaluation, and practical aspects of e-learning (Nyang'or, De Villiers & Ssemugabi, 2013) and were converted to evaluation statements for the questionnaire that was completed by respondents to evaluate the tutorial. The system evaluated was an offline application with the pseudonym *Business English for You (BE-Y)*. *BE-Y* is a CD-based e-learning tutorial that supports adults in learning the English language for business purposes. It was on the offline CD medium, since not all its users had internet connectivity.

Objectives

The objectives of this study were to:

- Generate a questionnaire for evaluating offline e-learning tutorials, based on a customised framework of usability criteria,
- Apply the questionnaire in evaluating an offline CD-based interactive tutorial, and
- Determine the effectiveness of the user-based questionnaire survey in usability evaluation of e-learning.

Literature review

E-learning tutorials

An interactive electronic tutorial is a form of computer-aided instruction or web-based learning that presents structured segments of information and instruction to guide learners, interspersed with examples and interactive exercises (Averill, 2004; De Villiers, 2005). Averill stresses the importance of multiple modes of presentation, such as textual explanations supported by images and animation, as well as audio and video clips for elaboration. These multiple formats support cognition and can help learners to grasp the subject matter and to gain skills. The interactive exercises and multiple-choice questions should test understanding as well as facts. Moreover, the tutorial should provide learner control and permit learners to progress to new educational content after demonstrating their understanding of previous units.

Usability evaluation of e-learning systems

Increased technological advancements, diversity of learners and the dynamic nature of learning tasks have made usability evaluation of e-learning applications a major task, which plays an important role in improving the quality of such applications (Zaharias, 2006). E-learning requires a particular form of usability. Traditionally, usability relates particularly to the interface of a system and how easily users interact with it. In the case of e-learning applications, learners must be able to use a system before they can even begin to learn with it. One of the most important goals in the design of an interactive educational system should therefore be the explicit goal of good usability.

Evaluating e-learning systems is different from usability evaluation of commercial ones. Commercial systems are intended for rapid task completion, whereas e-learning applications are intended to support human learning processes through the transfer of information and management of educational interaction (Adebesin, De Villiers & Ssemugabi, 2009; Masemola & De Villiers, 2006). The usability of e-learning systems entails both technical usability and pedagogical usability. Technical usability involves ensuring that there is trouble-free interaction with a system, while pedagogical usability aims to support the teaching and learning processes (Melis & Weber, 2003). To attain pedagogical usability, e-learning designers should consider factors such as learning goals and human learning processes, as well as the usual aspects of system requirements and usability.

User-based surveys using questionnaires

Some researchers believe that asking users directly about a system is one of the best ways to identify usability problems (Ardito et al., 2006; Dix et al., 2004). This is the approach used by survey techniques such as questionnaires and interviews. Questionnaire surveys are established ways of collecting demographic data and users' opinions. In evaluating e-learning, surveys can probe learner-centred issues that are not always obvious to experts conducting heuristic evaluations (HE), for example, whether it is easy for students to learn with a particular educational application. Questionnaires generally incorporate closed- and/or open question

structures, where open questions allow participants to express spontaneous answers, whereas closed questions offer a set of options or Likert scales as responses (Preece, Rogers & Sharp, 2007). Although open questions provide rich data, they are more difficult to analyse than closed questions. Before carrying out a major survey, questionnaires should be prepared, reviewed, and pilot-tested with a small sample of users to avoid potential misunderstanding and to identify unfair questions, where respondents understand the questions, but lack the background to respond (Gillham, 2000; Shneiderman & Plaisant, 2005). Some of the advantages of questionnaires are that questions are predetermined and the same for all users, they can reach a wide group of participants, and they are inexpensive and relatively simple to administer (Dix et al., 2004; Shneiderman & Plaisant, 2005). However, they are not customised to individuals and are less flexible than interviews.

Research method and processes

An evaluation requires both an evaluation method and evaluation criteria. *Business English for You (BE-Y)* has been evaluated previously, using the method of controlled usability testing in an HCI Laboratory (Nyang'or et al, 2013). In a dual-method approach, a questionnaire survey was also undertaken to evaluate *BE-Y*, and this questionnaire evaluation is the subject of the present paper.

Gillham (2000) and Bernsen & Dybkjaer (2009) recommend that, in order to construct a comprehensive questionnaire with an acceptable degree of validity, a set of evaluation criteria based on research should be used as the basis for the evaluation instrument. In line with this, the framework of categories and criteria in Table 1, which was generated from a literature study on learning theories, evaluation, and practical aspects of e-learning (Nyang'or et al., 2013), was used as the theoretical foundation. The table presents these criteria, which were designed for use in evaluating offline, rather than web-based, e-learning tutorials. The evaluation statements in the questionnaire are presented in a subsequent table, Table 2, which includes a column '*Related criteria from Table 1'*, that refers to the associated criteria in Table 1. In some cases a questionnaire item is related to several criteria from different categories and, in other cases, items are not directly related to any criterion, resulting in blanks in that column. Such statements were included as a result of feedback during the pilot study. Statements were grouped according to four categories under investigation, namely: interface design, system interaction, learner-centred instructional design, and the system's navigation and orientation. In addition, primary demographic information and experiences of the respondents were recorded, as recommended by Grant, Malloy and Murphy (2009). Responses were based on a five-point Likert rating scale ranging from 'Strongly agree' (1) to 'Strongly disagree' (5).

Due to logistical reasons, real-world users of *BE-Y* could not be acquired. However, in line with recommendations by Davis and Shipman (2011), participants in both the pilot study and the main survey were representative of the typical user population in terms of background, ages (18-60 years), and occupations. It was also a requirement that they were computer literate. The selection of participants was purposive, with an emphasis on balancing the numbers in terms of gender. The respondents were mainly employees and students in tertiary learning institutions.

As proposed by Olivier (2009), in order to reduce inadequacies in the survey instrument, a pilot study was conducted with eleven respondents prior to the main study. Following the pilot, some of the evaluation statements were adapted to clarify them, while others were added. The subsequent main study involved 57 participants, who were given a CD-ROM with the *BE-Y* software, which they installed on their own computers. Measures were in place for technical support, for example, configuration and installation, so as to avoid practical problems that would hinder the execution of the study. The questionnaire was administered only after the system was installed in the participants' environments and confirmed to be operating satisfactorily. Each participant completed the questionnaire in a time and place of his/her own choice.

Table 1: Framework of criteria for evaluating offline e-learning tutorials (Nyang'or et al., 2013)

	Categories and criteria
1	**Clear learning goals, objectives and outcomes**
	1.1 An e-learning tutorial should have clear and well-communicated learning goals that a learner is to achieve upon completion of a session.
	1.2 The learning goals and objectives should be clearly evident throughout a learning session.
2	**Presentation of domain in a meaningful and engaging way**
	2.1 The tutorial and its content should engage learners with practical activities that are interesting and engaging.
	2.2 Knowledge should be presented in a way that is appropriate to the learning context.
	2.3 There should be a match between the symbols and names used and the learning context in the real world.

3	**Nature of the learning activities** 3.1 There should be activities that support learners in comprehending the new knowledge acquired. 3.2 The system should support active learning in which learners analyse content, and make deductions. 3.3 The learning system should motivate the target users. 3.4 The system should promote learners' creativity by including innovative features. 3.5 Learners should be engaged through attractive content and interaction. This should however avoid causing distractions during learning sessions.
4	**Elicit learner understanding** 4.1 Help should be available to support learners in understanding the learning content and locating what they need. 4.2 New learning content should incorporate existing skills and learners' prior knowledge.
5	**Feedback for formative evaluation** 5.1 Formative evaluation is important in supporting learning and communicating with learners. The system should provide constructive feedback as part of formative evaluation. 5.2 Feedback should focus on improving learners' performance and increasing their confidence in learning. 5.3 The tutorial should guide learners through appropriate questions, exercises and/or activities, and provide responses/feedback aligned to the intended learning objectives.
6	**Support for skills transfer to the real world** 6.1 The learning system should enable transfer of learnt skills to the learners' real world, where they can apply the skills in their everyday activities.
7	**System status should be visible** 7.1 The system should keep the user/learner informed about what is going on. 7.2 An e-learning tutorial should have built-in feedback mechanisms to respond to learners' answers to learning activities and exercises. 7.3 Every learner-initiated action should have a corresponding visual or audio response by the system so that learners can understand the consequences of their actions.
8	**Appropriate learner control** 8.1 Learners need freedom to control the pace of their learning. This gives them a sense of ownership of their learning process. 8.2 Learners should take the initiative for the preferred learning methods, time, place, content (i.e. unit or section), and sequence. This, however, depends on the learning objectives.
9	**Cognitive error recognition, diagnosis and recovery** 9.1 The environment should include some complex situations that require users to construct solutions, since learners learn from their mistakes. 9.2 The system should provide adequate help to guide learners and help them recover from cognitive errors. 9.3 An e-learning system should permit learners to be innovative in addressing challenges encountered during learning sessions.
10	**Active learning and learner motivation** 10.1 The system should engage its learners through suitable content.
11	**System's flexibility, efficiency and navigation**
11.1	11.1 The system should be flexible to the needs of different users, for example novices, intermediate users and experts.
11.2	11.2 There should be shortcuts that are not visible to novice users but that are visible to frequent users, so as to increase their paces of interaction and task completion.
	11.3 Learners should be able to adjust settings to suit their needs.
12	**Help facility** 12.1 Learners should easily access the Help facility. There should be simple and systematic guides to assist learners.

Findings and discussion

After feedback from the participants in the pilot study, certain evaluation statements were re-phrased and statements 1, 3, 13, 27, 35 and 42 in Table 2, were added to the questionnaire. For example, the statement, 'The navigation links are readily available and visible throughout the learning sessions', was added after pilot participants pointed out that, from certain screens, it was not possible to access links to other sections. The researcher realised that there was no statement in the questionnaire relating to this issue and some others and hence additions were made. This emphasises the importance of carrying out a pilot study prior to the main one.

In the main study, 50 of the 57 questionnaires distributed, were returned. This represents an 88% response rate. According to Gillham (2000), any percentage above 40% is considered to be fair, therefore this was a high response rate.

The *Mean* column in Table 2 represents the average of the responses per statement on a Likert scale of 1 (strongly agree) to 5 (strongly disagree). Since all the respondents answered all the questions, the frequency (50) is not shown in the table. The average of the mean of all the statements is 2.6 and standard deviation is 0.5. This mean value of 2.6 shows that the usability of *BE-Y* is neither very poor nor very good, but close to average (where average is the mid value, 3, and good values are those around 2.0). One would anticipate that a system designed for the vital functions of teaching and learning would have good usability, with mean scores below 2.0 for its categories and the overall mean. Yet as shown in the table, the application had relatively poor usability with respect to category D (System navigation and orientation) with a mean score of 2.8. The other three categories: A, B and C, had mean category scores of 2.5, 2.6 and 2.6 respectively, also indicating that the usability was rated low.

With respect to individual statements, the worst rated was Statement 43, about the system's tolerance for user errors related to learning (i.e. cognitive errors), with a mean rating of 3.6. The lack of support for deep learning within *BE-Y,* Statement 34, was the second worst with a rating of 3.5. On the positive side, the highest rated statement was Statement 32, that BE-Y supports different approaches to learning. This had a mean rating of 1.4. Close to that, the rapid opening of the home page, Statement 13, and the use of animations in the system, Statement 27, both returned high ratings of 1.5. The scores for these three statements indicate areas of strengths in *BE-Y* as an e-learning environment.

Table 2: Questionnaire items and mean ratings

#	Evaluation statement	Related Criteria from Table 1	Mean
A	***General interface design***		
1	The navigation links are readily available and visible throughout the learning sessions.		2.5
2	The name of the system is appropriate.	2.3	2.0
3	The system's contents are interlinked (without dead ends).		2.7
4	There are similarities between this system and others that I have come across.	2.3	1.8
5	The system enables me to control the pace of learning.	8.1	1.6
6	This system allows me to customise it to support my personal learning needs.	11.1; 11.3	2.5
7	The section for frequently asked questions (FAQs) is useful.	4.1; 12.1	2.3
8	I would prefer using *BE-Y* to classroom teaching when learning the English language for Business use.	1.2; 5.3	2.6
9	The online Help facility is useful.	9.2; 12.1	2.3
10	The system motivates me to learn.	3.2; 3.3; 10.1	3.4
11	I feel encouraged to participate.	3.5	3.2
12	The graphical presentations (icons) are easy to interpret.	2.3	2.9
	Mean of Category A		**2.5**
B	***System interaction***		
13	The home page of the system opens quickly.		1.5
14	It is easy to understand the functions of the menu items.	2.3	2.7
15	The functions that I expect to find in the menu items are present.	2.3	2.6

16	The menu items of the system are well organised.	2.2	2.9
17	*BE-Y* is highly interactive.	2.1	2.9
18	I need not recall the system interface during learning sessions.	2.3	2.7
	Mean of Category B		**2.6**
C	***Learner-centred instructional design***		
19	There is a well-designed feedback mechanism within the system.	5.2; 7.2	2.7
20	I am able to search for content that I cannot initially find easily.	5.3; 9.2; 12.1	2.8
21	This system engages me.	2.1; 3.1; 3.5; 10.1	3.0
22	The system provides the learning contents in a consistent manner.	2.2	2.7
23	Compared to books, the system has up-to-date contents.	10.1	3.0
24	The learning goals and objectives are made clear within the system.	1.1; 1.2	2.4
25	The learning content is current and accurate.	10.1	3.0
26	The learning contents are presented in a way that supports learning.	2.2	2.5
27	The animations aid learning.		1.5
28	The audio interface (voice) improves learning.	7.3	1.7
29	This system presents the content in small understandable chunks.	2.2	2.7
30	The system's content is relevant for learning English for business.	10.1	2.6
31	The learning activities enable me to practice the learnt skills.	2.1	2.3
32	*BE-Y* supports different approaches to learning.	2.1; 3.1; **11.1**	1.4
33	The system has flexibility in addressing needs of different learner.	11.1; 11.2; 11.3	3.1
34	*BE-Y* supports deep learning.	4.1	3.5
35	The fact that learning materials are provided on multiple windows, supports learning.		3.2
	Mean of Category C		**2.6**
D	***System navigation and orientation***		
36	It is easy to explore the different parts of *BE-Y*.	**7.1**; 11.1	2.8
37	It is easy to get back to the home page.	7.1; 11.1; **11.3**	3.0
38	The system's navigation setup enables me to access different contents easily.	11.1; 11.2; 11.3	2.4
39	There are different ways of accessing the functions of the *BE-Y*.	11.1; 11.3	2.3
40	I generally find it easy to use the system.	11.1; 11.2	2.6
41	It is easy to know where I am in the system.	7.1; 7.3	2.6
42	*BE-Y* can supplement classroom learning of English language for Business.		2.7
43	The learning tasks have tolerance for user errors that are related to learning, i.e. cognitive errors.	9.1; 9.2; 9.3	
44	*BE-Y* supports me when I make usability errors.	9.1; 9.2; 12.1	3.2
	Mean of Category D		**2.8**
	Mean of all the all statements		**2.6**
	Standard deviation of all values		**0.5**

The qualitative data spontaneously provided by respondents in open-ended sections of the questionnaire offered further valuable insights on usability problems. Twenty five (25) different problems were identified in this manner. Table 3 lists, in descending order, the eight problems that were mentioned by 20% or

Table 3: The most frequently identified problemsin BE-Y (in descending order of frequency)

#	**Problem**	*f*	*%*
1	The Help facility is limited in its content and capability.	14	28
2	Instructions on how to perform some tasks are not visible.	12	24
3	The system does not keep the learners informed about what is going on (i.e. lack of feedback)	12	24
4	The feedback does not improve learners' performance and confidence to learn.	11	22
5	The system restricts the interface to be used, that is, some learning content lacks an audio interface.	11	22
6	There is no clarity on what function an icon is supposed to perform.	11	22
7	The presentation of knowledge in the chapters of BE-Y is not appropriate to the learning context.	10	20
8	The system lacks shortcuts for frequent or expert users	10	20

more of the respondents. The *f* column shows the number (frequency) of respondents who identified a problem and the *% c*olumn shows this number as a percentage of the 50 respondents who participated in the survey.

The table shows that the majority of the problems encountered (Problems # 1, 2, 3, 4 & 6.), namely, five of the eight (63%), were related to the *Help* facility and the *feedback* mechanism of the system. Certain statements (lack of shortcuts, uncertainty on meanings of icons, and restricted options from which to select) relate to *learner control*. This means that the poor help facilities, lack of feedback and rigid learner control mechanisms inherent in the system contributed substantially to inadequate usability.

Conclusion

This section refers back to the research objectives near the beginning of this paper. The first objective was to generate a questionnaire for evaluating offline e-learning tutorials, based on a customised framework of usability criteria. The *evaluation statement* column in Table 2 shows that most of the 44 items were generated from the framework in Table 1. These items formed the main component of the questionnaire that was used to evaluate BE-Y, an offline e-learning tutorial. Of the 44 items, 38 were directly derived from the framework and the other six were included as a result of the pilot study. The questionnaire items were placed into four categories related to learning or usability design, namely, general interface design, system interaction, learner instruction design, and system navigation and orientation. Since the questionnaire was mainly based on criteria that originate from the literature, its validity as an instrument was enhanced. It was strengthened further by being tried out in the pilot study. These approaches contributed to the effectiveness of the survey.

Secondly, the study sought to apply the questionnaire in evaluating *BE-Y*, a CD-based interactive educational tutorial for learning business English. A user survey was conducted on *BE-Y*, with 11 participants in the pilot study and 50 during the main study. The results of the study are presented in Tables 2 and 3 and discussed in the previous section. The findings show that the usability of *BE-Y* was neither very poor nor very good, but around average, although it orientated more towards the inadequate side. The qualitative data collected in the open-ended sections of the questionnaire point to the facts that the main causes of poor usability of the tutorial were related to inadequate help facilities, inadequate feedback mechanisms and poor learner control of the its navigational features.

Finally, the study aimed to determine the effectiveness of the user-based questionnaire survey in evaluating the usability of an e-learning system. The mean values in Table 2 were used to determine not only the degree of usability of individual items but also the degree of usability of the different categories involved in learning and usability design. For example, it was established that the lowest usability of *BE-Y* was with respect to its navigation and orientation. In addition, the participants' spontaneous responses in the open-ended sections of the questionnaire helped in identifying 25 different problems they had experienced in working with *BE-Y*. The problems included a combination of usability- and learning-related issues. These findings go some way in showing the effectiveness of involving end-users in questionnaire surveys for evaluating e-learning systems.

The results presented in this paper correspond well with the findings of the earlier usability study via controlled usability testing in an HCI Laboratory (Nyang'or et al., 2013). That previous study had determined that *BE-Y* lacked good usability, which contributes to the reliability of the present research. The two main problems identified during usability testing in the earlier study, were 'lack of good navigation and orientation' and 'poorly organised menu items'. This corresponds well with the findings of the present research, in which the category 'System navigation and orientation' received the lowest ratings with regard to usability.

Furthermore, the findings of evaluation via usability testing and via questionnaire survey complement each other since one method can produce the type of findings that the other cannot, showing the value of applying more than one method in usability evaluation studies.

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