E-skills: beyond the haves and have-nots

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Abstract: The importance of skills in information and telecommunications technology (ICT) has made e-skills research a national priority in South Africa. Existing e-skills research differentiates between different kinds of e-skills but not between e-skill competencies such as novice, competent and proficient. Towards addressing the bigger question of e-skills classification, the purpose of this paper is to investigate the differences between participants with high e-skills (proficient users) and those with intermediate e-skills (competent users). The paper compares performance and feedback from e-skills competent and proficient participants in a usability study performed on the Website of a distance learning university. The research methods include task based usability testing augmented by eye tracking, and post-test questionnaires. Our findings suggest the need for differentiating e-skills into at least three categories of competency when doing e-skills research. This adds a competency dimension to the existing skills type dimension thus leading to a two-dimensional matrix for representing the e-skills of participants. The findings contribute towards building a theoretical framework to assess and monitor e-skills developments in order to overcome the existing digital differences between population groups in South Africa. Furthermore the lessons learnt can be useful to avoid pitfalls in the recruitment and testing of participants and the analysis of e-skills research. The paper should be of interest to educators, e-learning designers, researchers and policy-makers.

Keywords: e-skills, usability, eye tracking

1. Introduction

E-skills is a national asset, and e-skills research a national priority [1, 2] and yet the concept of e-skills is not well-defined [3]. There are research initiatives from government agencies, educators and trainers, and employers as summarised in the study of Roodt and Paterson [1] on ICT professionals in the South African context and yet a standardised framework for defining and describing e-skills does not exist[3]. Alexander, Lotriet and Matthee [4] found that despite the volume of research generated existing research on e-skills shortages is difficult to interpret, not comprehensive enough and often not credible. They highlight methodological challenges and identify various problems, including the fact that the methods have been mostly limited to surveys while respondent and researcher profiles were not sufficiently explained [4]. Not having adequate information about *who* gathered the data and *from whom* they gathered the data makes it difficult to validate the findings.

Against this background, we seek to provide more insight about the categorisation of e-skills towards developing a standardised framework for classifying e-skills. E-skills have been differentiated horizontally into ICT practitioner skills, ICT user skills and e-Business skills [2]. However, there seems to be no evidence of vertical differentiation other than an oversimplified classification of e-skills participants as haves and have-nots. The purpose of this paper is to investigate if there is a need for a finer grained classification of participants based on e-skills competency. The methodology is interpretivist, aiming to

understand the difference between e-skill competent and e-skill proficient participants by comparing their performance and behaviour in usability testing of e-learning systems. The usability testing was done on an information portal of the College of Science, Engineering and Technology at the University of South Africa. The main contribution of the paper is to identify the need for a differentiated view of e-skills competency. This contributes towards the development of a more concise and coherent framework to define and conceptualise e-skills. E-skills is an essential component of the basic skills set required [3] therefore the work reported in this paper is aligned with the South African Medium Term Strategic Framework [5] towards providing quality education and skills-development for the entire population of South Africa.

The findings on e-skills related performance and behaviour suggest the idea of a two-dimensional e-skills matrix that can be used in building theoretical frameworks of the e-skills context. On a practical level this paper provides recommendations that can be useful to avoid pitfalls in research where participant e-skills vary significantly. The paper is organised as follows: In section 2 a review of literature on e-skills and experts versus novices is given; in section 3 usability testing and eye tracking is discussed; in section 4 the methodology is described; in section 5 the results are presented; in section 6 the findings are discussed and finally in section 7 the conclusions are drawn and contextualised.

2. Literature Review

There is currently no universally adopted definition of e-skills [6]. The European Committee for Standardisation defined e-skills for a end-user project as follows [7]:

- *The capabilities required for effective application of ICT systems and devices by the individual in either a work or personal environment. Individuals apply systems as tools in support of their own activities, which are, in most cases, not ICT. End user e-skills cover the utilisation of common generic software tools and the use of specialised tools supporting business functions. End user e-skills vary in complexity from introductory up to an advanced usage level.*

One categorisation of e-skills, distinguished practitioner skills, user skills and e-business skills as follows: [8]:

- ***ICT practitioner skills***: *These are the capabilities required for researching, developing, designing, strategic planning, managing, producing, consulting, marketing, selling, integrating, installing, administering, maintaining, supporting and servicing ICT system.*
- ***ICT user skills:*** *These represent the capabilities required for the effective application of ICT systems and devices by the individual. ICT users apply systems as tools in support of their own work. User skills cover the use of common software tools and of specialised tools supporting business functions within industry. At the general level, they cover "digital literacy".*
- ***e-Business skills***: *These correspond to the capabilities needed to exploit opportunities provided by ICT, notably the Internet; to ensure more efficient and effective performance of different types of organisations; to explore possibilities for new ways of conducting business/administrative and organisational processes; and/or to establish new businesses.*

Over the past two decades many occupations have experienced a transformation in their operational medium from analogue to digital, this required a change in their skills set for adaptation to the digital environment [1]. Examples of hybrid ICT occupations include photography, digital broadcasting, multimedia and graphical design. The rapid diffusion of ICT in the workplace has moved even further to reach traditional non-ICT occupations and ICT has become so pervasive that finer grained definitions of ICT skills are needed. The

term ***e-skills*** is used to encompass all skills related to ICT activities [9]. According to Miliszewska [10] general ICT skills could be grouped into two categories:

- The use of software and hardware tools (Windows, word processing, spreadsheet applications, presentation software, database applications, Web applications, mobile applications, mobile devices, hardware and software installation, principles of networks), and
- The responsible use of internet services (e-mail, Web browsing, digital authoring, electronic databases, principles of digital communication).

Lanvin and Passman [11] provide yet another classification in distinguishing basic e-literacy skills, general workplace e-skills and top end ICT specialist skills. In this paper the term e-skills will be used to refer to the full spectrum of ICT skills but the participants were selected only on Web browsing skill, as described in section 4.3, and therefore relates to the category of ICT user skills basic or e-literacy skills.

These categories are all task related and make no reference to the competency within the category, i.e. there is no vertical differentiation. Studies of Learning Management Systems usability have shown that ICT experts and non-experts differed in performance and behaviour when using the system [12, 13] but no further differentiation into competency categories could be found in the literature.

3. Usability and Eye Tracking

Eye tracking is based on the fact that a record of a person's eye movements while doing a task provides information about the nature, sequence and timing of the cognitive operations that take place [14]. Eye tracking studies have been used in diagnosing the effectiveness of Website designs with point of interest detection (fixation) and information transmission via eye movement (scan path) as the two main indicators [15]. Based on this relation between cognition and eye behaviour, the trace of navigation pathways and user attention patterns is used to study the cognitive processes involved in activities such as reading [16], picture perception [17], visual search [18] and problem solving [14]. Eye tracking data is mostly used in conjunction with user testing and video recording. Therefore the eye tracking visualisations (usually gaze plots and heat maps) can be triangulated with the user testing and evaluator observations from the recordings as described in the methodology for usability and eye tracking by Pretorius, Calitz and van Greunen [19].

4. Methodology

In this section the methodology is discussed by explaining the method used in section 4.1, the testing procedure in section 4.2 and presenting the participants' profile in section 4.3.

4.1 Method

We conducted a usability study on a College in the University of South Africa's information portal. The study included formal laboratory testing, eye tracking, and post-test questionnaires.

The method for these usability and eye tracking studies were based on the methodology by Pretorius et al. [19]. To counter sampling bias we introduced a screening procedure and purposively selected participants to include different age, language and computer experience groups. Data was collected and calculated as follows: Live video recordings were captured, including the screen, participant's face and mouse/keyboard movements. Notes were taken during the test as well as a full evaluation of the video at a later stage; audio in the form of the participant or the test administer speaking were included with the video files; eye tracking video recordings included a cursor which indicates the participant's eye movements; eye tracking data files; and continuous monitoring of tasks.

Two post-test questionnaires were used namely the System Usability Scale (SUS) [20] and the Usefulness, Satisfaction and Ease of Use (USE) [21] questionnaire.

4.2 Conducting the test

One participant was tested at a time. The participant was briefed about the experiment (the specific tasks are discussed in section 5), the equipment, the details of the material to be recorded and then required to complete an informed consent form. During the testing the facilitator sat with the participant and asked questions based on the participant's Website navigation behaviour. Retrospective think aloud (RTA) was used which means that the participants were allowed to complete a task or perform it up to a point where they needed assistance. Then participants were asked questions about each task, for example, what they expected; and what they liked or disliked. The eye tracking analyses was done for the first mentioned sections and not for the sections where participants explained their actions (RTA). After the usability test and retrospective think aloud two post-test questionnaires were administered, then participants were debriefed and given the opportunity to see the eye tracking and video recordings.

4.3 Participants

The intended user group for the information portal Website is prospective and current students as well as academic and administrative staff. Participants were rated only according to their Web browsing skill, as in the second category of Miliszewska's definition [10]. For this usability study, 15 participants were selected (Staff: 5, Prospective students: 5, Current students: 5). The participants included 10 male and five female students. Regarding participants' age, seven were between 21 and 25; one between 26 and 30; one between 36 and 40 and four between 41 and 50.

The mother tongue of the participants were as follows Zulu (3); Sepedi (2); Setswana (2); English (2); Shona (2); Afrikaans (1); Tshivenda (1); SeSotho (1); and Yoruba (1). System experience was also captured: six participants had never used it; three used the system for less than a year; three used it for one to two years; and three used it for more than two years. Regarding Web expertise, the questionnaire had the following options: Never used the Web; *Beginner*: have read pages on the Web; *Novice*: have entered addresses and used bookmarks; *Competent*: can use a search engine to find information; and *Proficient*: know my way around and have done Web transactions like e-banking.

For this study only e-skill competent and proficient participants were selected: eight proficient and seven competent participants to have a total of 15 participants.

5. Results

This section describes the tasks and the results obtained for each task.

5.1 Eye tracking results

Task1: The goal of this task was simply to find the Webpage of the College of Science, Engineering and Technology (CSET). Only six participants found the required page on their 1st attempt. Five of these participants were proficient users. The median time for proficient participants to find the page was 37.1 s; while the time for competent participants was significantly longer at 62.9 s. Figure 1 and Figure 2 shows the heat maps of proficient and competent participants respectively. A heat map shows the fixations of a participant where the "hot" colours indicate areas most fixated by a participant. In Figure 1, the red rectangle illustrates the area where proficient participants searched for this information. The heat map clearly shows that proficient participants searched in the correct place. In Figure

2, once again the area to find the information is indicated by a red rectangle. The competent participants have almost no hotspots on the heat map, indicating that they did not expect to find the information there. What is also clear from Figure 1 and 2 is that both proficient and competent participants tried to find this information in the main menu, especially the middle part of the menu.

Task 2: This task required participants to find advantages and reasons why they should consider studying at this college. Only three participants clicked the correct link; two proficient and one competent participant. Seven participants needed assistance: two proficient participants and five competent participants. This task demonstrated that most participants struggled; but competent participants required more assistance than proficient participants to complete the task.

Task 3: Participants were required to find a specific school on the CSET Webpage. Nine participants found the information on their first attempt. Of these participants seven were classified as proficient and two as competent. Six participants required assistance: one proficient participant and five competent participants. This task demonstrated that competent participants struggled more than proficient participants; and competent participants required more assistance to complete the task.

Task 4: The final task required participants to find a short course of their choice on the CSET Webpage. Not one participant clicked on the correct link to find this information, 14 out of the 15 participants needed assistance. Only one proficient participant did not need assistance, but also failed to find the information on the first attempt. This task demonstrated that when a Website has serious usability problems, all participants struggled, regardless of e-skill level.

5.2 Questionnaire results

The SUS [20] questionnaire consisting of 10 questions, indicates a result that yields a single number out of 100 representing a composite measure of the overall usability of the system being studied. A five-point Lickert scale was used where five was the highest available score and one was the lowest. Table 1 indicates this result for each of the 15 participants.

Table 1: SUS Questionnaire Results

Web experience	SUS questionnaire results								Median
Competent users	30	30	37.5	45	62.5	60	65	77.5	52.5
Proficient users	30	42.5	57.5	57.5	65	70	85	-	57.5.

The SUS median score for all participants was 54.33 (standard deviation 17.64). This is a low score and corresponds with the usability testing results to confirm usability problems in the system. When the data of proficient and competent participants were compared; proficient participants indicated a median of 52.5 where competent participants indicated a median of 57.5. Proficient users scored the Website lower than competent users, even though proficient users experienced less usability problems than competent users.

Figure 1: Heat map of proficient participants

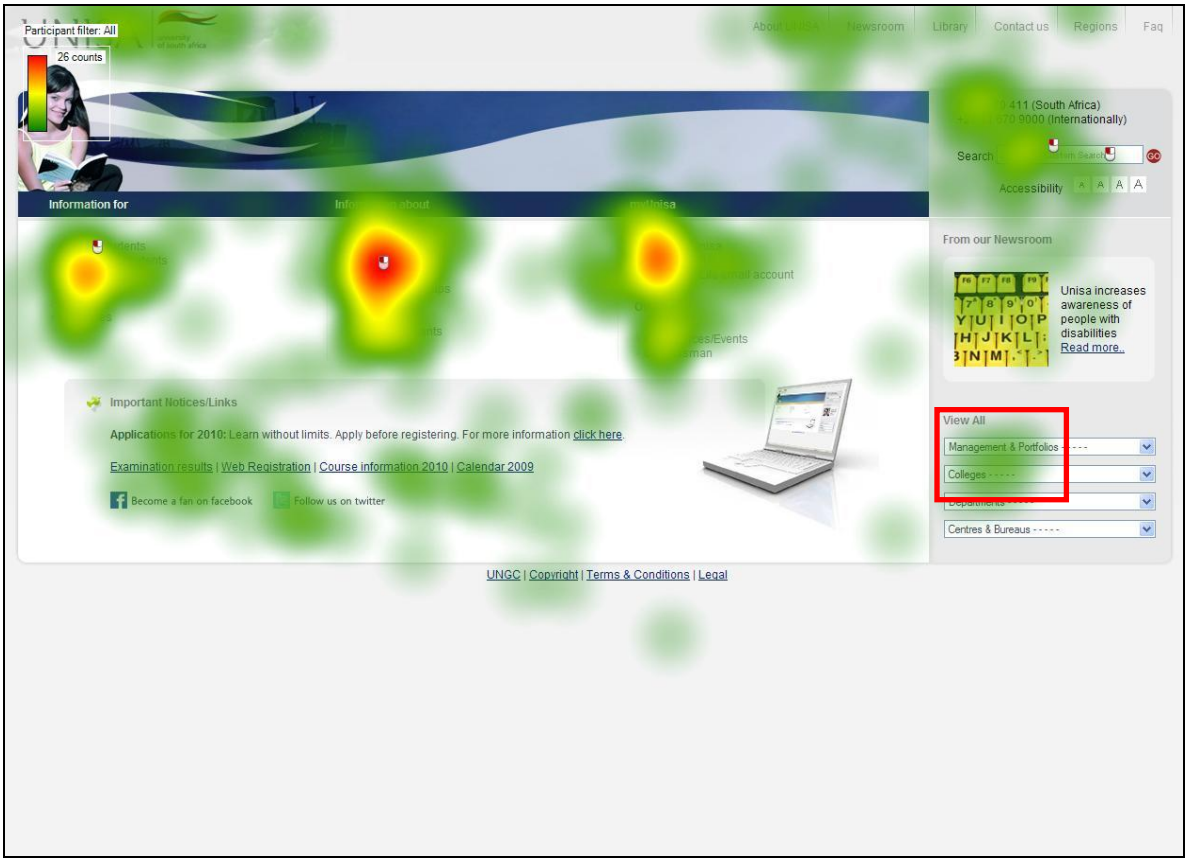

Figure 2: Heat map of competent participants

The USE questionnaire [21] results are calculated by grouping 30 questions into four categories: usefulness, ease of use, ease of learning and satisfaction. A seven-point Lickert scale was used with seven was the highest (best) rating and one as the lowest.

Table 2 depicts the scores for the different categories per participant and the median for each category of the respective groups.

Table 2: USE Questionnaire Results

Participant number	Web experience	USE			
		Usefulness	Ease of use	Ease of learning	Satisfaction
1	P	5	5	6.5	4
2	P	4	5	6	4
3	C	5	6	6.5	6
4	P	5.5	7	7	6
5	P	3	4	3	3
6	P	1	1	1.5	1
7	P	1	1	1	1
8	C	5	4	4.5	5
9	P	3	4	4.5	3
10	C	4.5	4	5.5	5
11	C	5	5	6.5	4
12	P	3	3	5	3
13	C	3	3	3	1
14	C	5.5	5	5.5	5
15	C	4	3	4	3
Median	**-**	**4**	**4**	**5.5**	**4**

The ease of learning had the highest score, leaning more towards the top end of the scale. The usefulness, ease of use and satisfaction category all had a score of four out of seven. As with the SUS questionnaire, when this data was compared between proficient and competent participants, proficient participants indicated lower scores than competent participants (Table 3). Only ease of use had the same score between competent and proficient participants.

Once again, proficient users scored the usability of the Website lower than competent users, even though proficient users experienced less usability problems than competent users.

Table 3: USE indicators for Competent and Proficient Participants

USE indicators	Competent Participants	Proficient Participant
Usefulness	5	3
Ease of use	4	4
Ease of learning:	5.5	4.75
Satisfaction	5	3

6. Findings

The usability test results provide evidence that e-skill proficient participants generally performed better than e-skill competent participants. The heat maps in Figure 1 and Figure 2 provide a visual illustration of the trend that proficient participants looked at the correct

location to find information while competent participants did not. The usability test results also showed that competent participants needed more assistance to complete tasks than proficient participants. If a measurable difference exists between the performance and behaviour of e-skill competent and e-skill proficient groups then this should be considered when designing e-skills research. The findings suggest that having only two categories, namely experts and novices is not adequate. Given the observed difference between competent and proficient users there should be at least three categories of e-skill competency namely novice, competent and proficient. Adding the new dimension of e-skills competency to e-skills types imply the need for a two-dimensional e-skills matrix to classify participants.

The questionnaire results (both USE and SUS) showed proficient users score the Website lower than competent users, despite the fact that competent users had more problems than proficient users in using the system. This supports earlier findings that different e-skill participant groups provided different results (proficient users being more critical) in usability studies [22]. The proficient participants provided more reliable questionnaire results while the competent participant behaviour uncovered more usability problems.

7. Conclusions

The paper investigated Web usability performance and behaviour by comparing the participants competent in e-skills with those proficient. The results showed e-skill proficient users doing noticeably better than the competent users. Earlier research identified a difference between expert and novice e-skill participants [12]. The findings from this study suggest that e-skills classification needs to be differentiated beyond the existing tendency to classify people as *having* or *not having* e-skills to identify at least novice, competent and proficient e-skill participants. Earlier findings that participants with higher e-skills provide more reliable feedback in questionnaires [12] was corroborated while participants with lower e–skills provided valuable usability information from the analysis of the video's and eye tracking. This confirms earlier findings on the importance of using participant groups with different competencies [22, 23].To summarize, the lessons learnt are that:

- e-skills cannot be classified by task only but also need to be classified by competency.
- participants' e-skills competency may influence their performance and feedback behaviour and therefore e-skills competency has to be considered as part of the biographical information in selecting participants.
- participants should be selected from different e-skills competency group by using a screening questionnaire in recruitment of the participants

The study is limited by the fact that only Web browsing skill, as a subset of e-skills was studied. The number of participants used was satisfactory for a usability study, where five to eight participants are deemed sufficient [24, 25]. Future work will include a wider set of e-skills in the research design towards refining the idea of an e-skills classification matrix with types of skills on the horizontal axis and competency on the vertical axis. We also need to research the use of e-skill indicators [26] in identifying e-skills competencies.

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