

# ADDRESSING E-GOVERNMENT WEBSITE USABILITY

## *A Users' Centred Evaluation*

Zhao Huang and Laurence Brooks

*School of Information System, Computing and Mathematics, Brunel University, Brunel, U.K.*

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**Abstract:** The challenge of greater users' participation with e-government remains a significant issue. E-government website usability has been found to be one of the major reasons influencing users' interaction, which needs to be addressed when developing e-government. This empirical study evaluates a current e-government website, to identify specific usability problems. Based on the identified problems, the design solutions are proposed, redesigned and evaluated in order to develop a more usable e-government website. The results indicate that with the proposed design solutions provision, the identified usability problems have been addressed. Such improvements may promote overall usability of e-government and make better users' task performance. These are beneficial for designers to further develop their e-government usability.

## 1 INTRODUCTION

Traditionally, government organisations deliver their information and services through three main methods: face to face, telephone and postal/mail services (Brown, 2003). However, such methods are largely influenced by time and space limitations, which sometimes make access to information difficult and block users' engagement. With the widespread use of the Internet and web technology, it can be argued that a fourth method to deliver government services has been created – e-government. This provides all types of government information and services available online. In such an environment, users can interact with government services 24 hours a day, 7 days a week without physical distance requirements. Since these advantages have become apparent, governments worldwide have rapidly developed e-governments, which has now become a global phenomenon (Jaeger, 2003). However, research indicates that the actual use of information and services provided on e-government websites faces a challenge (Donker-Kuijter, 2010). Website usability issue is one of the major reasons for the underuse of e-government. For example, Holden et al. (2003) found that many users do not become involved with government online services because of difficulty in finding their expected information on the site. Generally, website usability refers to how useful and user-friendly the

site is. If websites fail to provide ease of use from a design standpoint and frustrate users interaction with government services, e-government will not be accepted and used by users (Barker, 2009). Therefore, this suggests that e-government may not achieve greater users' participation unless the website usability is recognised and addressed.

However, current research has not paid enough attention to evaluating the usability of current e-government websites, especially identifying specific problems. Even some studies that conduct usability investigation lack empirical evidence to provide concrete prescriptions for the identified usability problems in order to develop more usable e-government websites. Furthermore, an e-government website is used by a wide range of users, who have heterogeneous backgrounds in terms of skills, experience and education. These users may have different usability needs from e-government websites, which may increase the difficulty for designers in identifying users' requirements of usability. In order to overcome this difficulty, a users' centred approach is considered as an appropriate method, which can involve users' participation and address users' point of view. By doing so, it can be beneficial for designers to understand users and their usability requirements. Additionally, it can directly detect the e-government features that can cause users to have the most concerns about usability. Accordingly, there needs

to be more attention directed toward users' evaluation of usability. In this way, it can provide concrete prescriptions for developing more user-centred e-government websites that can generate greater users' participation.

To this end, this study aims to evaluate the usability of current e-government websites in the UK, identifying existing usability problems. Moreover, in order to fulfil a systematic evaluation, based on the usability problems identified, this study proposes a set of design solutions and evaluates the effects of these proposed design solutions on the identified usability problems. This approach addresses design, evaluation and redesign processes in e-government website development, which is also reflected in user centred studies in HCI, where one of the major tasks is with problem detection and solutions provision to develop computer systems (Kossak et al., 2001). To implement the usability evaluation, an experimental study has been designed based on users' perception of Nielsen's set of usability heuristics to conduct a thorough and in-depth e-government websites usability inspection. In addition, in order to reveal users' task performance within the e-government websites evaluated, users' performance is also measured by a number of performance criteria through observation. By doing so, a more comprehensive evaluation, which not only provides an deep insight into e-government website usability, but also show the levels of users' interaction with the specific e-government website, can be carried out.

The rest of the paper is structured as follows: section 2 reviews the theoretical background to indicate the importance of usability to e-government websites. Section 3 describes the detailed design of an empirical study with two linked experiments. Section 4 presents and discusses the results from experiment 1. Section 5 proposes the design solutions in relation to the usability problems identified. Section 6 shows the findings from experiment 2. Conclusions and limitations are drawn and future research suggested in section 7.

## 2 LITERATURE REVIEW

In consideration of a dynamic area of e-government and its application for the general public, e-government can be defined as the use of the Internet, especially web technology as a tool to deliver government information and services to users (Muir and Oppenheim, 2002). The main purpose for e-government is to achieve better government, which

enables easier access, richer information, higher quality services and more enjoyable experience (OECD, 2003). Furthermore, other advantages of e-government include improving the level of public services, increasing cost-effectiveness in services provision (Følstad et al., 2004), promoting user engagement and strengthening trust between government and users (Wang et al., 2005). Since such huge power has been recognized by traditional governments, e-government initiatives are evolving from the national to the local level, and developed worldwide. Thousands of e-governments have now been established which make government information and services available online (Steyaert, 2004). Users can conduct all government services provided by the national and local levels via information presentation, interaction, transaction and integration (Layne and Lee, 2001).

Although there is a rapid development of e-government, a challenging target for e-government of how best to interact with users still remains (Kossak et al., 2001). Among the various reasons, usability has been found to be an important reason influencing users' interaction and adoption of e-government (Baker 2009). In essence, usability is a very broad concept (Gillan and Bias, 2001). It can be simply defined as effectiveness, efficiency and satisfaction (ISO, 1998). However, in order to obtain more comprehensive understanding, usability can be explained by multiple criteria. For example, Flavián et al. (2006) described five elements in relation to usability, which are the perceived ease of understanding the structure of a system, simplicity of use of the website, the speed of locating the item, the perceived ease of navigating the site and the ability of the users to control their movement within the system. Moreover, usability can be used as a measurement related to how useful and user-friendly the system is. As such, it is no doubt that usability is a key factor in determining the computer system quality (Karahoca et al., 2010) and ensuring users' engagement (Sauer and Sonderegger 2009). For example, Anthopoulos et al. (2006) applied participatory design to discover user-oriented e-government services. The study addresses the importance of users' needs in order to guide service delivery improvement. Usability has been found to be the determinant in consideration of users' requirements, because if users failed to access and execute the proper service due to usability errors, their dissatisfaction increased. Such dissatisfaction may prevent users' return to an e-government website, and even that users do not recommend their use to others.

Furthermore, usability has a significant impact on users' preference and attitude. Lee and Koubek (2010) investigated the effects of usability and web design attributes on user preference. The study found that a high level of usability results in a high level of user preference towards the website. In particular, user preference was largely dependent upon web attributes in terms of content arrangement, navigation function, visual organisation, typography and colour usage. Additionally, Casaló et al. (2008) demonstrated that website usability not only has a positive influence on user attitude, but also builds user trust in the website loyalty formation process. Similarly, Barnes and Vidgen (2004) observed users' interaction with an online government tax self-assessment facility. The findings show that users' activities, such as online submission of self-assessed tax returns and information seeking are largely concerned with usability, navigation and site communication. In order to generate greater users' interaction, there is a need to not only understand the usability requirements of users, but provide tailored solutions to improve the usability of e-government websites. These studies suggest that without addressing usability in sufficient level in e-government website design, e-government will not be fully used and accepted by the widest range of users. Accordingly, it is important to evaluate the usability of current e-government websites, identify existing problems and provide proposed design solutions in order to further develop e-government usability.

### 3 METHODOLOGY

Having established that that usability is an important factor in e-government website development, an empirical study was conducted with two linked experiments. Experiment 1 aimed to evaluate usability of a target e-government website. Experiment 2 looked to examine the proposed design solutions regarding the usability problems found in experiment 1. To conduct both experiments, three research instruments were used: the task sheet, the heuristic-based usability questionnaire and the selected e-government website. The task sheet details a set of tasks for participants to perform. A heuristic-based usability questionnaire was developed to identify the participants' perception of usability. The e-government websites were selected as representative of e-government and used to evaluate its usability.

#### 3.1 Task Design

To conduct the evaluation, the participants were required to complete a set of practical tasks on an e-government website. Such tasks are representative activities that users would be expected to perform with an e-government website. Based on relevant studies (Shareef et al., 2011), there are two levels of e-government services. The first level relates to the publishing or static stage, which involves users' one-way communication, such as searching information, downloading forms and publishing information. The second level refers to the interaction stage, which contains two-way communication, such as council tax payment, online service registration and online school application. According to these services categories, the set of tasks have been designed to represent different types of interaction that users normally engage in with e-government (for details of experiment 1 see Table 1). A similar set of tasks were also developed for experiment 2. However, the specific tasks content were different from the tasks used in experiment 1 in order to avoid the influence of experience from the participants' performance in experiment 1.

Table 1: e-Government practical tasks for London Authority 1.

No.	Task	Ser. Category
1	Find the names of the councillors	one-way
2	Find the news about £1.5 million for new local authority housing	one-way service
3	Find the contact details of LA 1, especially the telephone numbers	one-way service
4	Use the search engine on this site to find how to join a local library	one-way service
5	Find the introduction information about LA 1	one-way service
6	Use "A-Z services" to find the parking tickets information	one-way service
7	Sign in the system, and fill in "an online enquiry form" to query how to get a student discount	two-way service
8	Fill in a "compliments form" reporting no street lamp	two-way service
9	Please download the document of council tax 2009/2010	one-way service

#### 3.2 Usability Questionnaire

A heuristic-based questionnaire was used to measure the participants' perception of usability of the target e-government website. The design of this questionnaire is based on Nielsen's set of usability heuristics (1994). The questionnaire design consists of three stages: extension of heuristics, development criteria and usability questionnaire design.

### 3.2.1 Extension of Heuristics

Nielsen’s (1994) set of heuristics (see Table 2) is used as a starting point for evaluating e-government websites usability since a growing number of studies have proven its validity and usefulness (e.g. Hvannberg et al., 2007, Delice and Gngr, 2009). However, such heuristics were developed many years ago and used for general usability evaluation. In order to fit with the particular requirements of e-government websites, there is a need to derive additional heuristics. Evidence from previous studies indicates that where e-government is used by the public, interoperability is important in terms of information and service exchange (Garcia et al., 2005); for example ensuring news is kept current between e-government and government. In addition, since e-government is used by diverse users who have heterogeneous skills, therefore, e-government should support and extend users with different skills to access and complete services. Furthermore, during users’ interaction with online services, e-government should show respect for users at all times (Reddick, 2005). Therefore, the existing heuristics are extended by adding three new heuristics: ‘Interoperability’, ‘Support users’ skills’ and ‘Respectful interaction with users’ (see Table 3).

Table 2: Nielsen’s usability heuristics (1994).

Heuristics	Interpretation
H1 Visibility of system status	To keep users informed about what is going on.
H2 Match system with real world	To follow real-world conventions.
H3 User control and freedom	To make undo and redo functions available during interaction.
H4 Consistency and standards	To keep the same design feature through the site.
H5 Error prevention	To support users to overcome errors.
H6 Recognition rather than recall	To make information easily remember.
H7 Flexibility and efficiency of use	To allow users to tailor frequent actions.
H8 Aesthetic design	To make minimalist design.
H9 Help user recover errors	To indicate the problem and suggest a solution.
H10 Help and documentation	To provide help to support user’s task completion.

Table 3: Extended heuristics.

Extended heuristics	Interpretation
H11 Interoperability	To make all elements work as a whole for user task completion.
H12 Support users’ skills	To support users with different knowledge and background.
H13 Respectful interaction	To present pleased design and treat users with respect.

### 3.2.2 Development Criteria

Although Nielsen’s set of usability heuristics is extended, it is still too general to develop a questionnaire to evaluate usability, so that e-government website usability would be evaluated with enough depth. Furthermore, the lack of detailed analysis may lead to failure in specific usability problem identification. Therefore, associated criteria for each heuristic needs to be developed. Such criteria are developed from relevant usability (e.g. Sonderegger and Sauer, 2010) and e-government studies (e.g. Baker, 2009). These studies reveal a number of elements that affect website usability and users’ perception. Based on the analysis of these elements, relevant criteria are identified and grouped into corresponding heuristics. By doing so, it can provide a step-by-step approach to closely focus on the specific usability aspects. In addition, relevant questions can be precisely developed.

### 3.2.3 Usability Questionnaire Design

A usability questionnaire was designed for capturing the participants’ perception of usability. The reasons behind choosing a questionnaire are that it can drive the participants directly to the research topics, which enables the participants to clearly see the focus. In addition, with an anonymous response style, it encourages respondents to offer their truthful reply. Furthermore, using a questionnaire can ensure that the same questions are delivered to each participant and their responses can be obtained quickly. In order to capture users’ perception of usability before and after the redesign and to control the variables to support comparative analysis, the same questionnaire is used for the participants in both experiments 1 and 2.

## 3.3 e-Government Website Selection

Among a variety of e-government websites, a local e-government website in the UK is selected in this study for a number of reasons. Firstly, the local level of e-government website is the closest level to users. Secondly, local e-government websites are frequently used by the general public, since local e-government provides more information and focuses on the needs of users in accessing information and services (Reddick, 2009). Thirdly, the local level of e-government can significantly indicate the effect of e-government on users (Tolbert and Mossberger, 2003). Fourthly, previous studies show the big challenges at the local level of e-governments (Yang and Paul, 2005) and its website design (Henriksson

et al., 2007). Thus, the local e-government website (London Authority 1) is used in this study. This London Authority 1 contains rich information and provides a variety of government services available on the site.

### 3.4 Participants

To conduct heuristic evaluation, Nielsen and Molich (1990) found that three participants can detect half of the major problems. Furthermore, Virzi (1992) suggested that 80% problems can be identified with between 4 and 5 participants and 90% of problems can be found with 10 participants in usability evaluation. Moreover, Dumas and Redish (1999) argued that additional participants are less and less likely to reveal new problems and pointed out that the most appropriate number of participants is between 6 and 12. As such, 12 participants were recruited to take part in the evaluation, participating in both experiments 1 and 2. These participants were recruited in public places, such as local libraries, leisure centres, universities, and found to be enthusiastic to do the evaluation. The participants found in public places can be assumed to be representative of the public and that they do normally use an e-government website.

### 3.5 Experimental Evaluation Procedure

In both experiments, each participant follows the same evaluation process: free-flow inspection, task-based interaction and usability questionnaire. Free-flow inspection allows users to freely look through the e-government website many times. They can focus on either the overall website or the specific website elements. As such, users can build their initial interaction with the e-government website and their general perception can be developed. Then, task-based interaction requires the participants to complete a set of tasks. While the participants perform these tasks, their performance was observed according to a number of performance criteria, including the amount of online help required; time spent completing tasks; number of steps to finish tasks and number of successful tasks completed. Having completed all tasks, the participants are asked to fill in the usability questionnaire to indicate their judgment of usability of the target e-government website.

## 4 RESULTS OF EXPERIMENT 1

As indicated, the aim of experiment 1 is to evaluate usability of the target e-government website. The following section presents the results in terms of users' perception and performance. The former uses the results from the questionnaires to indicate usability assessment, while, the latter is measured by a set of performance criteria to indicate the level of users' interaction with the target e-government website. To conduct data analysis, the one-sample T-test is considered as an appropriate technique for experiment 1. More specifically, the one-sample T-test is applied to determine whether there is a significant difference between users' perception of overall usability and specific usability features. If a difference is indicated, then the mean score of the specific usability features is greater than the mean score of the overall usability features and these can be seen as 'usability strengths'. Similarly, where the mean score of the specific usability features is less than mean score for the overall usability features, then these usability elements have been selected as the 'usability problems'. In addition, a lower mean score indicates a more serious problem. Statistical analysis of the data is conducted using SPSS for windows (version 13). The significance value is defined as less than 0.05.

### 4.1 User' Perception

Generally, the target e-government website appears to be clear and fairly straightforward, and it is easy to operate the e-government website. Each page always follows the same display format, which is helpful to build website consistency. The site's functionality supports users to complete most tasks. A title on every page clearly indicates the subject of the content, so that users can quickly capture the subject information of the page and locate information to meet their needs. Moreover, key information is always placed in a central location on the page, which can support users quickly searching for information. Furthermore, it is quick to change the particular data in a previous section so users do not need to retype all the data when they go back. In addition, forward and backward choices are always available within the different fields of the site, so that users can easily guide their movement in information searching.

However, the results obtained from the questionnaires also indicate a number of usability problems (see Table 4). Among them, the most serious usability problem found is that users are

confused by links that have many different colours. Link colour is used to present different resources within the site. Links with limited colours can visually help users distinguish between the resources, so as to easily identify relevant subject information. As indicated by Kappel et al. (2006), users with limited colour vision can quickly recognise the differences among subjects. In contrast, failure to provide limited link colours can visually influence resource recognition, so that users may feel it difficult to locate target information among subject content.

Table 4: User' perception of usability problems.

Usability problems	Mean (SD)
Confusion by links that have many different colours.	2.58 (0.669)
Significance	T=-6.511, P=0.000
Subject categories are presented without a logical order.	2.83 (1.030)
Significance	T=-3.386, P=0.006
Links already visited are not clearly marked.	2.92 (1.084)
Significance	T=-2.952, P=0.013
Information is unbalanced between breadth and depth.	3.00 (0.853)
Significance	T=-3.412, P=0.006

(SD=Std. deviation)

The next usability problem is that subject categories are presented without a logical order. A logical order is used to indicate a sequence of information organization, which supports users having a sensible way to scan subject. It assists users' understanding of the overall subject arrangement and reduces memory load problems. Brinck et al. (2002) suggested that when topics are arranged with a particular order, users are able to easily locate items; remember items of interest viewed previously. On the contrary, when subject categories are presented without a logical order, users may feel it is difficult to find target subjects among the categories.

Furthermore, the usability problem found is that links already visited are not clearly marked. Marking visited links is used to support users' ability to distinguish which parts of the site they have already visited and which parts remain to be explored. As such, it can help users to locate information during information searching. As indicated by Nielsen (2000), visited links that have been clearly marked can provide a sense of structure and location in the site and enable users to quickly find the subject information. However, failure to mark visited links can weaken navigational recognition, which results

in users visiting the same place repeatedly, or even abandoning searching purpose prematurely.

Finally, a usability problem found is that the information arrangement is out of balance between breadth and depth. Breadth and depth are used to distribute e-government content by designing a number of subject categories and a number of information levels. A medium condition of breadth and depth is considered as an optimal trade-off, which can help information retrieval (Larson and Czerwinski, 1998). It is because the appropriate number of categories displayed can keep content from getting cluttered and reduce the chance that users are confused by a vast number of options. While, as the moderate levels of information is designed, it can avoid over-length subject information through the site so that users can follow a short path into the site in order to find the detailed information. However, as suggested by Larson and Czerwinski (1998), unbalanced breadth and depth can cause problems in information acquisition. In such conditions, users are frustrated by increasing levels of depth or feeling lost in content space, when there are a large numbers of categories. As such, the problem that information arrangement is out of the balance between breadth and depth in London Authority 1 may cause more difficulties and errors for users searching for available information resources on a page and locating detailed information through multiple information levels.

## 4.2 Users' Performance

Having provided the participants' perception of usability, in order to indicate the level of the participants' interaction with the e-government website, users' performance is measured based on a set of performance data, including the amount of online help required; average time spent completing all tasks; average number of steps to finish tasks and ratio of successful tasks completed. More importantly, this performance measurement in experiment 1 will be used as the baseline to compare users' performance in experiment 2. Table 5 presents the participants' performance with the target e-government website. Overall, all participants are able to complete most of the tasks assigned. In addition, during their performance, the participants' required some assistance through online help information. The time spent and the steps used for completing all tasks are 16.209 (minutes) and 50.167 (number of steps) with standard deviation of 8.102 and 16.297 respectively.

Table 5: Experiment 1: users' performance results.

	Mean	Std. Deviation
Online helps required	0.000	0.000
Steps used	50.167	16.297
Successful tasks completion	1.065	0.088
Time spent for all tasks	16.209	8.102

## 5 DESIGN OF THE PROPOSED SOLUTIONS

The findings in experiment 1 indicate a number of usability problems that have been identified in the target e-government website. These problems suggest that usability has not been considered in sufficient detail in e-government website design. For an e-government to be accepted and used by the widest range of users, the e-government website should improve its usability to support users' interaction with e-government. As indicated by Garcia et al. (2005), improving usability of e-government can enhance service effectiveness and users' satisfaction, which may involve more users' participation. As such, it is important to develop more usable e-government websites that can meet different users' requirements. In this vein, this study takes further action by providing the proposed design solutions in relation to the usability problems found in experiment 1.

*Usability problem 1 (UP1): Users are confused with links that have many different colours*

A limited number of link colours can visually help users to distinguish resource differences so as to easily identify relevant subject information. Conversely, links with many different colours hamper resource recognition, which may result in users' difficulty with information identification. As such, designers of e-government websites should consider applying the minimum number of link colours, thereby supporting users' subject recognition during information seeking. One proposed design solution is to reduce link colours used in London Authority 1. In this way, it may reduce users colour visual confusion and visually support users when locating information objects. Figure 1a presents an example of links that have many different colours in London Authority 1. Whereas, Figure 1b shows that some link colours are reduced in the redesigned London Authority 1 website.



Figure 1: UP 1 and the Proposed Design Solution.

*Usability problem 2 (UP2): Subject categories are presented without a logical order*

A logical order is used to show a sequence of information arrangement, which helps users quickly scan subject information to identify objects and reduce memory load problems. Similarly, failure to present subject categories with a logical order hinders information arrangement, which may lead to complexity of information seeking.

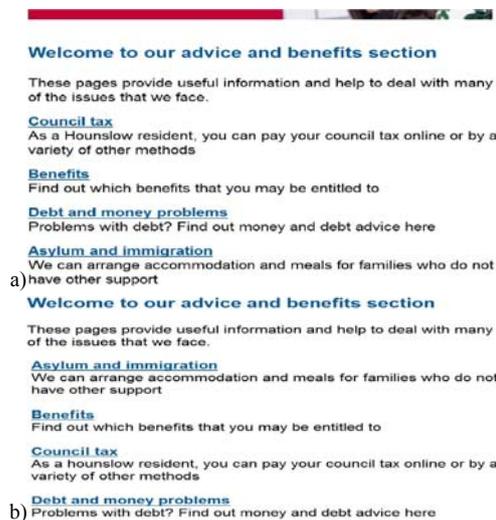


Figure 2: UP 2 and the Proposed Design Solution.

Accordingly, designers of e-government websites should consider organising subject categories in a particular order in order to support users identifying a sensible way to scan subject information. One proposed design solution is to arrange subject categories in an alphabetical order on each page of

London Authority 1. In this way, users may quickly understand the overall subject arrangement and easily identify relevant information to meet their needs. Figure 2a shows that initially, the subject categories are randomly presented on London Authority 1. However, Figure 2b indicates an example of the subject categories that are organised and presented in an alphabetical order.

*Usability problem3 (UP3): Links already visited are not clearly marked*

Marking visited links is used to indicate which parts of the site users have already visited and which parts remain to be explored. It can help users build the sense of structure and location in the site, and navigate them quickly to their target information. However, when visited links are not clearly marked, it weakens the site's navigational recognition, so that users may very likely visit the same page repeatedly and have difficulty locating information. Therefore, designers of e-government websites should consider providing an approach that will help users recognise the unvisited and visited links within the site during the information seeking process. One proposed design solution is to mark visited links in italics within London Authority 1. As shown in Figure 3a, initially, the visited links in London Authority 1 have not been clearly marked. However, Figure 3b shows that the visited links are clearly marked in italics on the site.



Figure 3: UP 3 and the Proposed Design Solution.

*Usability 4 (UP4): Users get lost due to being given too many choices during information seeking*

An appropriate number of options can be used to keep content from getting cluttered and reduce the chance that users are confused by a large number of choices. Hence, it helps information retrieval. On the

contrary, an excessive number of choices may cause difficulty in information acquisition (Nielsen, 2000), so that users may feel frustration when searching for information in a particular content space. Therefore, designers of e-government websites should consider providing an approach that will allow users to feel comfortable with the number of subject options. One proposed design solution is to design a drop-down menu for each subject category that visually hides its sub options. When users move the mouse to the subject category, a type of stretch sub list is used to present the various sub options associated with this subject category. In this way, the number of choices is visually reduced on the page, which is not only helpful in preventing content from getting cluttered, but also beneficial for users to read and locate information (see Figure 4a and 4b).

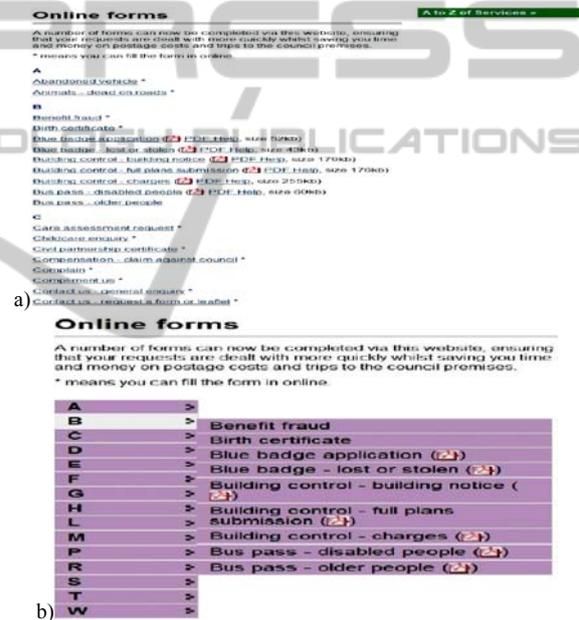


Figure 4: UP 4 and the Proposed Design Solution.

## 6 RESULTS OF EXPERIMENT 2

Have provided the design solutions above, to investigate the effects of the proposed design solutions on the usability problems found, experiment 2 is conducted. This section provides the results of experiment 2 in terms of users' perception and performance. In order to control the variables under the same conditions between experiments 1 and 2, the same research instruments used in experiment 1 are used in experiment 2; including the questionnaire, the task sheet, the participants and the procedure. However, in order to avoid the

participants learning from their experience with experiment 1, the tasks designed for experiment 2 focus on different service activities, but remain the same type of tasks as used in experiment 1. The results obtained from the participants' perception and performance is analysed by using a paired-sample T-test.

### 6.1 Users' Perception

Table 6 reveals users' perception in experiment 2. Regarding the specific usability feature of links having many different colours, and subcategories not being present with a logical order, a significant difference is found between experiments 1 and 2. However, although no significant difference is indicated between experiments 1 and 2 with respect to the usability problems of visited links not being clearly marked and many choices being given during information seeking, the results still show that the participants' assessments are influenced after the design solutions have been applied to the redesigned London Authority 1.

Table 6: Experiment 2: user' perception results.

	Experiment 1	Experiment 2
Confusion with links that have many different colours.		
Mean	2.58	4.33
Std. Deviation	0.669	0.492
Significance	T= -8.042, P=0.000	
Difficult to choose the option in subcategories because no logical order of sub options is used in subcategories.		
Mean	2.83	4.17
Std. Deviation	1.030	0.577
Significance	T= -4.000, P=0.002	
It clearly indicates which choices/links are already visited because they have been marked.		
Mean	2.92	3.58
Std. Deviation	1.084	1.165
Significance	T= -1.685, P=0.120	
I sometimes get lost due to being given too many choices over sequences.		
Mean	3.00	3.75
Std. Deviation	0.853	1.215
Significance	T= -1.567, P=0.145	

In other words, for each specific usability feature, the participants' assessment is significantly changed in experiment 2. As indicated earlier, the proposed design solutions have been applied to the target e-government website in experiment 2. The results show that the usability problems perceived in experiment 1 have been improved in the redesigned e-government website. Therefore, the findings suggest that the proposed design solutions have improved the usability problems identified in experiment 1. In addition, it increases overall users'

perception of usability of London Authority 1.

### 6.2 Users' Performance

Given that the usability problems have been improved by the proposed design solutions in the redesigned London Authority 1, and in order to reveal the level of users' interaction with the redesigned London Authority 1, users' performance in experiment 2 is also measured based on the same performance criteria used in experiment 1. By focusing on such criteria, it comparatively analyses performance results before and after the proposed design solutions have been applied in experiments 1 and 2 respectively. The detailed results are presented in the following subsections.

Table 7: Experiment 2: users' performance results.

	Experiment 1	Experiment 2
Total time spent completing tasks		
Mean	16.209	10.009
Std. Deviation	8.102	2.334
Significance	T=2.523, P=0.028	
Number of steps to finish tasks		
Mean	50.167	40.333
Std. Deviation	16.297	4.1141
Significance	T=2.046, P=0.045	
The amount of online help required		
Mean	0.000	0.000
Std. Deviation	0.000	0.000
Significance	T= N/A, P= N/A	
Successful tasks completion		
Mean	1.065	1.000
Std. Deviation	0.088	0.000
Significance	T= N/A, P= N/A	

Table 7 shows the participants' performance in experiments 1 and 2. As indicated in Table 7, the results of the Paired-Samples T-test reveals a significant difference in terms of the time spent completing all tasks between experiments 1 and 2 (T=2.523, P=0.028). More specifically, the participants in experiment 2 use less time to complete all tasks, compared with experiment 1.

In addition, a significant difference in terms of steps used for all tasks completion is found between experiments 1 and 2 (T=2.046, P=0.045). In detail, the participants in experiment 2 take fewer steps to finish all the tasks than those who are in experiment 1.

The results of Paired-Samples T-test show that the difference in terms of number of online help actions required for all tasks completion is not significantly different between experiments 1 and 2. However, according to the mean score, it emerges that the participants in experiment 2 required less

online help to complete all the tasks compared with experiment 1. Similarly, although the difference in terms of number of successful tasks completion is not significant between experiments 1 and 2, the mean score also indicate that the participants finish more tasks in experiment 2 than experiment 1.

Based on the performance results, it seems that the participants' performance with the redesigned London Authority 1 is significantly enhanced in experiment 2. These are also reflected in the results of users' perception, which reveal that the proposed designed solutions on the redesigned London Authority 1 have improved the usability problems identified in experiment 1. A possible explanation is that since the proposed design solutions have improved the usability problems, it increases the overall users' perception of usability, which in turn, makes for better users' performance. This is also supported by previous studies (e.g. Amoako-Gyampah, 2007; Baker, 2009), which suggested that the overall users' perception of usefulness and ease of use has positively influenced users' performance and intention to use the technology.

## 7 CONCLUSIONS

This study has evaluated the usability of one existing UK e-government website, which uncovered a number of usability problems. This suggests that this e-government website has much room to improve its usability. As such, this study offers and assesses a set of proposed design solutions regarding the usability problems found for the target e-government website. The results show that the proposed design solutions have improved the usability problems identified. More significantly, after the proposed design solutions have been implemented in the redesigned e-government website, users' task performance has been also significantly improved. Accordingly, it suggests that the proposed design solutions may improve the overall users' perception of usability of the target e-government website, which makes for better users' performance. Therefore, it is important to show that usability of e-government websites meet users' needs, so that users' interaction with e-governments may be promoted. To achieve this goal, this study conducts a user centred approach, which can help understand the usability requirements of users. In addition, this study combines usability evaluation and redesign of an e-government website, which provides guidance for designers to identify existing usability problems and offer specific prescriptions for further usability

improvement of e-government websites. The final target is to develop more usable e-government that can generate greater users' participation in e-government.

However, there are also some limitations in this study. For example, this study only evaluates one e-government website, as an example. Further research may be conducted with more distributed e-government websites in the UK. Another limitation relates to the redesigned e-government website in experiment 2. The redesigned e-government website is based on the target e-government website used in experiment 1, keeping the same structure, layout and content. However, the redesigned e-government website does not include all the website pages from the target e-government website. This may influence users' general perception when they conduct a free-flow inspection. In addition, this study applies a set of extended heuristics to evaluate usability of current e-government websites. In order to support designers' usability knowledge and skills for e-government development, there is also a need to conduct future study to develop usability guidelines that contain detailed usability design features, specifically for the development of better e-government websites.

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