The Impact of Usability on Efforts to Bridge the Digital Divide

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ABSTRACT

There is growing efforts to narrow the digital divide both locally and internationally. One such effort is the Digital Doorway project driven by the Department of Science and Technology (DST) and the Meraka Institute of Council for Science and Industrial Research (CSIR). It involves a non-standard computer system housed in a rugged, custom-designed kiosk. The preloaded software applications run on the Ubuntu Linux operating system, but the interface is not standard Linux. The project has mainly focused on providing physical access to computers in underprivileged communities around South Africa, without any formal usability evaluation of the software installed on the system. Our belief is that unless basic usability concerns are addressed in these types of development projects, the dream of the providing effective access may remain just that – a dream. This paper highlights the important role that usability plays in the drive towards narrowing the digital divide. We report on the outcome of a usability evaluation field study conducted on the Digital Doorway. The results suggest that there is a need for in-house usability standards to guide the various developers (in-house or external) who build applications for the Digital Doorway.

KEYWORDS

Digital divide, field evaluation, ICT for development, usability, usability evaluation.

1. INTRODUCTION

In the contemporary information revolution age, the use of information and communication technologies (ICTs) continues to influence every aspect of our lives. With the explosive growth of the World Wide Web and the Internet, the web is becoming an essential portal to access and share information and conduct business transactions. However, many are being excluded from the potential economic and social benefits of new technologies.

To address the problem, international and national initiatives are ongoing to provide access to technologies with the aim of bridging the digital divide. Many of the efforts to narrow the divide have been concerned with the provision of physical ICT devices. Examples of such projects includes the

one laptop per child project [http://www.laptop.org/en/] and the Digital Doorway initiative by the Department of Science and Technology (DST) and the Meraka Institute of Council for Science and Industrial Research (CSIR).The usability of these devices and applications installed on them, however, constitute one of the crucial factors to effectively narrow the divide [Nielsen, 2006].

One measure of the success of these initiatives, among other factors, is the ease of use of the computer devices by users [Davis, 1989; Nielsen, 2003]. It is therefore crucial that designers incorporate usability design principles early on in the design process. When the target user group has special needs this becomes even more important.

Usability is generally defined in terms of an application's effectiveness, efficiency and the satisfaction of the user. Every interactive system should be evaluated to (i) determine the ease of use of the systems' functionalities (ii) assess the user interaction experience, and (iii) identify any specific problems in the system [Dix, Finlay, Abowd and Beale, 2004].

There are several factors contributing to digital divide, among them financial constraints, lack of adequate skills and complexities of the interfaces of ICT devices, i.e. their usability. Currently, research focusing on usability, as an area that can be exploited in the effort to narrow digital divide, is limited. The purpose of the paper is to address this gap.

The Digital Doorway, a non-standard[1] computer system was first deployed in the rural community of Cwili in 2002. Since then, the Digital Doorway project has mainly focused on providing physical computers to underprivileged communities around the country, without any formal usability evaluation of the software applications installed on the systems. We describe here a field usability evaluation conducted to determine how easy the Digital Doorway is to use by users with limited computer-literacy.

The rest of the paper is structured as follows: in section 2, we provide a formal definition of digital divide and describe the different aspects of the divide. Section 3 briefly introduces the concept of usability while section 4 examines previous studies that focused on the digital divide from a usability perspective. In section 5, we provide an overview of the Digital Doorway, the target system evaluated in this study. The discussion on how the Digital Doorway was evaluated to determine its usability, at a local school, and the results obtained from the evaluation is provided in section 6. We discuss the role of usability in the efforts to narrow digital divide in section 7 and conclude the paper in section 8.

2. THE DIGITAL DIVIDE

Digital divide is a multidimensional phenomenon that refers to the disparity in access, distribution, and use of ICTs between two or more populations [Wilson, 2006]. It affects different age and gender

1 Non-standard in this context means systems that do not display standard operating system interfaces or use standard equipments.

groups, communities, races and regions of the world [Camacho, 2005]. The divide can also be seen among different population groups within the same nation. For example, in the United States, white and Asian people are over 20% more likely to own computers than their black and Hispanic counterparts [Cooper and Kugler, 2009]. Closer to home, in South Africa, only 2% of black households had computers in 2001, compared to 46% of white households [Statistics South Africa, 2001][2]. This can be attributed to the legacy of apartheid and economic exclusion which have resulted in huge disparity between the black and white population groups [Martindale, 2002]. The 2007 community survey, conducted by Statistics South Africa, showed general increase in the ownership of household computers from 8.6% of the population in 2001 to 15.7% in 2007 [Statistics South Africa, 2007]. However, the report did not provide a breakdown of household computer ownership among the various population groups.

Digital divide is not only about the acquisition of computing devices. Other factors that contribute to the widening of the divide includes [Wilson, 2006]:

- *Financial constraints*: This refers to the inability of individuals, communities or governments to acquire ICT devices and sustain payments to service providers. For poor communities, where the primary concern is the ability to feed their families, ICT devices cannot be afforded.
- *Lack of adequate cognitive resources*: Effective interactions requires the user to possess the basic ICT skills that will enable him/her to recognize the need for information, find the information, process and evaluate the information for its appropriateness, and utilize it in a meaningful way.
- *Complex interface designs (usability)*: Even when ICT devices are available, the complexity of the interfaces makes it impossible for the novice user to access the content. Other aspects of usability involve accessibility to people with special needs, such as the disabled and the elderly.
- *Lack of relevant content*: Another factor contributing to digital divide is the lack of content that are locally and culturally relevant. The predominant language of the Internet for example, is still English. According to the 2009 estimate by the Internet World Statistics [2009], English language ranked highest among the top ten Internet users by language, with no African language featuring among them (see Figure 1). From the perspective of a user in a developing country, content access in the local language is one of the critical requirements for bridging digital divide.

2 The latest official numbers issued by Statistics South Africa.

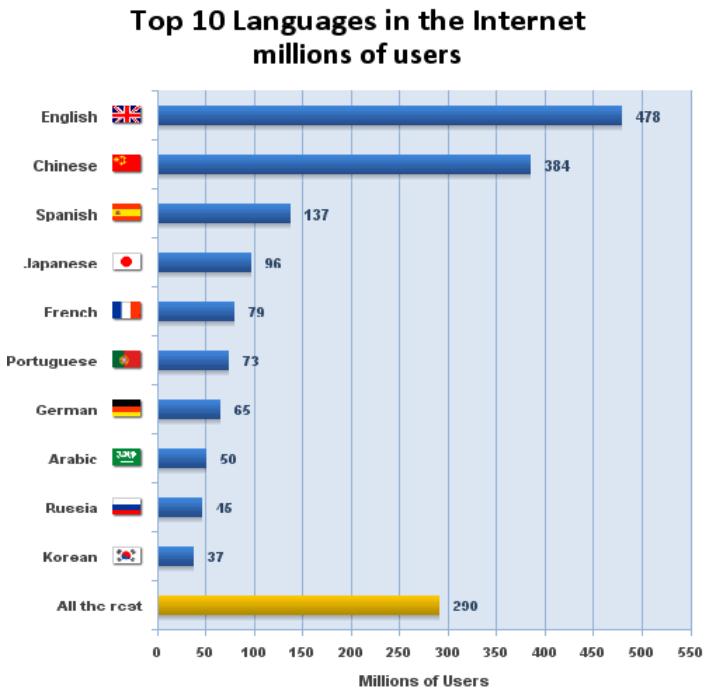

Figure 1: Top Ten Internet Languages [Internet World Stats, 2009]

3. USABILITY

Usability is defined by the International Organization Standardization (ISO) [1998] as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use".

Usability is one of the focus areas of human-computer interaction (HCI), a field of study concerned with the design, implementation, and evaluation of interactive systems taking into account the context of use and the task the user needs to accomplish. Usability cannot be retrofitted into a design later in the development life cycle. Usability specifications should form part of the requirements specification process [Dix et al., 2004].

One method for incorporating usability into the design process involves the use of usability principles. These principles can guide designers so that their design decisions do not negatively affect the usability of the application. Usability design principles can be widely applied to a variety of situations as they impose fewer constraints in terms of how the principles should be implemented [Dix et al., 2004; Kotze and Johnson, 2004]. For example, the principle of feedback states that adequate feedback should be provided to users to enable them determine what they need to do next in order to complete the task at hand. However, the principle is flexible about how to provide the feedback [Kotze and Johnson, 2004; Preece, Rogers and Sharp, 2007]. For instance, feedback could be provided using text, graphics, or audio output or a combination of these, depending on the requirements of the specific user groups.

4. DIGITAL DIVIDE AND USABILITY

A search for research articles using the keywords 'digital divide and usability' and 'ICT for development and usability' do not yield a large harvest. Our search produced only a few studies that reported on usability evaluation of ICT devices and applications deployed specifically with the aim of narrowing digital divide. Below we review those whose findings are most relevant to our study.

Researchers such as Fuchs and Horak [2008] and Gebremichael and Jackson [2006] merely mentioned usability as one of the factors contributing to digital divide. The report by Boeltzig and Pilling [2007] addressed several factors (including usability) that impacted on the ability of specific user groups, such as the elderly and the disabled, to access and make effective use of electronic government services. Shneiderman [2001] provided an overview of the first ACM conference on universal usability held in November 2000, where participants identified universal usability as one of the strategies to narrow the widening digital divide.

brigdes.org [http://www.bridges.org/Real_Access] identified twelve evaluation criteria for determining why development projects aimed at narrowing digital divide sometimes fail to achieve their goals. Among these criteria is the appropriateness of the technology for the intended local community. The measure of technology appropriateness includes energy requirements, security of the devices and the ease of use, i.e. usability, of the interface between the user and the devices.

Liu and Meng [2007] conducted a study on the usability of mobile phone among off-farm workers in China. Off-farm workers are people who leave their farms in the rural areas in search of other forms of employment opportunities in the cities [Nielsen, Smyth and Zhai, 2010].

The authors found that while the study participants were eager to embrace new technologies to improve their conditions, lack of considerations for the special usability requirements of low-literacy users by designers prevented them from taking advantage of the opportunities offered by new technologies. Although over 90% of off-farm workers possessed mobile phones, the majority of the study participants were merely using their mobile phones to make and receive telephone calls. Other useful functionalities, such as the phonebook feature, were never used. Rather than use this feature to store the details of potential employers for example, they wrote these down in pieces of paper, with the risk of misplacement.

A set of representative tasks were given to the participants, for example, changing a phone's ringtone and retrieving previously stored phone numbers. Results from the study showed that participants were unable to interpret the meaning and functionality of the features required to complete the tasks. Majority of the participants required assistance from the evaluator; they made large number of mistakes and spent considerable amount of time to complete the tasks.

In a survey on the use of electronic information systems among low income and underserved Americans, Lazarus and Mora [2000] reported that lack of locally relevant content and usable

interfaces formed part of the barriers to these user groups' taking advantage of the opportunities offered by new technologies.

The studies above all referred to usability as part of the factors that could help narrow digital divide, but few studies have been done to formally evaluate the usability of the applications developed specifically for this purpose. Only the study by Liu and Meng [2007] specifically focused on evaluating the usability. Our aim with this paper is to raise awareness and stir the debate on usability and the role it can play in narrowing the digital divide.

5. OVERVIEW OF THE DIGITAL DOORWAY

This section briefly introduces the Digital Doorway, the target system evaluated in a field usability study. First we provide the background to the development and motivations behind the Digital Doorway project and then describe the features and functionalities of the interfaces and applications selected for evaluation.

The Digital Doorway project is a joint initiative by the DST and the Meraka Institute of CSIR. Digital Doorways are non-standard computer systems housed in rugged, custom-designed kiosks with multiple terminals that can be accessed simultaneously by users. The terminals are equipped with metal keyboards and reinforced touchpad for user input. The robust housing and metal keyboard is necessitated by the need to protect the system against acts of vandalism. The applications and content, which run on the Ubuntu Linux operating system, are preloaded [Gush et al., In Press]. However, the interface does not follow any particular design standard or operating system interface.

The Digital Doorway project is based on the 'hole in the wall' concept from India [Mitra and Rana, 2001], and aims to promote computer literacy through unassisted learning. It is an attempt to narrow the digital divide [Cambridge, 2008; Gush et al., In Press] by installing the computers in underprivileged communities such as schools, police stations and community centres around South Africa. Till date, 206 Digital Doorways have been deployed around the country.

The Digital Doorway provides extensive access to software applications and other resources, the majority of which are open source or third-party applications. These includes the OpenOffice suites, educational games, scientific simulations, Wikipedia documents and Mindset applications – a South African curriculum-based educational program [Gush, Cambridge and Smith, 2004].

Applications developed in-house are sometimes implemented by contract software developers. Currently, the Digital Doorway does not provide support for the use of assistive devices, such as screen readers for visually impaired users. A three-terminal Digital Doorway is shown in Figure 2.

Figure 2: A three-terminal Digital Doorway

This evaluation study focused on the usability of the interfaces and applications developed in-house specifically for the Digital Doorway. The specific interfaces and applications evaluated are: the login screen, the new user registration form, the main desktop, and three educational games - *What-What Mzansi*, *OpenSpell*, and *Themba's Journey*. The following subsections provide brief descriptions of the interfaces and applications evaluated.

1. The Digital Doorway Login Screen

The login screen is the first interface between the user and the Digital Doorway. Users access content by logging in as a guest user, a registered user, or by creating a new user account and then logging in using the newly created account. The main language on the login screen is English, but equivalent information is available in four other South African languages, namely Xhosa, Afrikaans, Sotho and Venda. A guest user can simply access content of the Digital Doorway by typing 'dd1' in the username textbox. A new user account is created by typing 'new' in the username textbox; this will activate the registration form.

2. The New Account Registration Form

Users may chose to create new user accounts by completing a simple electronic form. Items on the form are organized into two main groups – 'Personal Details' and 'User Details'. Within the personal details group, demographic information such as name, age, and gender are provided. User-selected username and password are chosen within the user details group. The form also provides users with hints on the type of data expected at certain fields, for example the password field. The form requires all data fields to be filled, although this is not explicitly specified in the form. After completing the form, the information provided is stored by clicking on the <Register User> button.

3. Digital Doorway Desktop

Following a successful login, applications and content of the Digital Doorway can be accessed by clicking on icons on the desktop or by selecting from the two menu options 'Programs' and 'Resources'. The desktop also provides global volume control either by clicking on a 'volume control'

icon or through a more advanced volume control window. Users can log out of the system by clicking on an 'exit' button (designated by a right pointing arrow ⇒) or from the 'System' menu.

4. What-What Mzansi

What-What Mzansi is an educational quiz game in the form of yes/no questions. Developed to provide content relevant to the South African environment, the program provides two levels of difficulty – <Easy> and <Advanced>. Context-specific instructions are provided when the user clicks on the <?> icon, located at the top right corner of the screen while the <X> icon closes the application. The interface provides three menu options. <About> menu presents the user with information on the Digital Doorway project and its achievements, together with details of the game developers. The questions are asked and answered when <play> is activated, while <hi-Scores> lists the scores of the top ten registered users. On the selection of a difficulty level, a local voice welcomes the player and reads out the questions which can be answered by clicking on <Yes> or <No>. Each session lasts 60 seconds. The score for each question can range from 2 to 10, depending on how fast the player answers it. The interface of What-What Mzansi is shown in Figure 3.

Figure 3: Interface of What-What Mzansi

5. OpenSpell

OpenSpell is an educational spelling game that is available in all eleven South African official languages. It provides three levels of difficulty designated with *, **, ***. The interface, shown in Figure 4, includes an onscreen keyboard used for providing input in spelling exercises. The program provides three menu options. Clicking on <say> brings up a series of pictures of words to be spelt. For each word, a voice in the chosen language speaks out each letter as well as its pronunciation. <Guess> is based on the hangman word guessing game, while the <spell> option tests the users' spelling skills. Spelling exercises is done by clicking letters from onscreen keyboard. Users are given two opportunities to spell words, after which the correct answer is provided.

Figure 4: OpenSpell interface (with the <say> menu active)

6. Themba's Journey

Themba's Journey is a life skills program in the form of a narrative. Themba is a young man who makes a journey from his village to the city of Johannesburg in search of a job. Throughout the narration, Themba is faced with potential life-changing situations that require him to make choices. The user, who assumes the role of Themba, must make these choices for him, for example, whether or not to take drugs. Each decision can result in positive or negative consequences. The interface (Figure 5) provides three menu items. The <Help> menu contains the navigation and game instructions. The main story is narrated within the <Play> environment. Clicking on <Exit> closes the program.

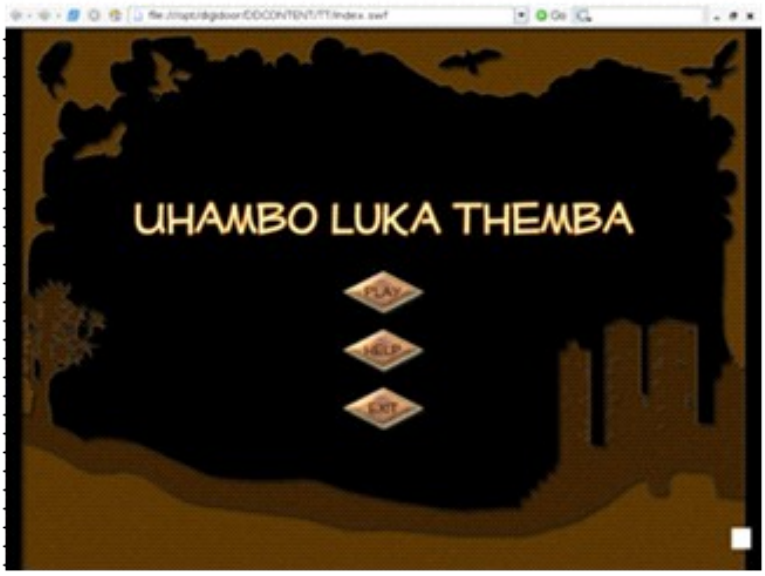

Figure 5: Themba's Journey Interface

6. A FIELD USABILITY EVALUATION OF THE DIGITAL DOORWAY

Designers typically make assumptions about users [Gardner-Bonneau, 2010] and usually develop applications for the so-called average user. The reality is that users are quite diverse in terms of their age, gender, expertise, ability, and nationality [Kotze and Johnson, 2004; Norman, 2001; Shneiderman, 2000]. The validity of designers' assumptions needs to be tested by evaluating with real users.

This section discusses the field usability evaluation conducted at a local school where the Digital Doorway is installed, as well as the results obtained from the evaluation.

1. The Evaluation Environment

We evaluated the Digital Doorway using the field observation method at a local secondary school where the context of the system's use is retained. Our choice of a school as an evaluation venue among other potential centres (e.g. community centre and police stations) having Digital Doorway installed was based on two factors (i) the three applications evaluated were educational games, hence it makes sense to evaluate the usability of the applications among school children (ii) a study on the usage patterns of the Digital Doorway at a number of representative centres around South Africa recorded secondary schools as having the most successful usage [Gush and De Villiers, 2010].

At this particular center, the Digital Doorway is installed in an open area on one of the school's corridors to provide unrestricted access to users. Children from surrounding homes also have access to the Digital Doorway soon after the school closes until 18:00 late in the afternoons. Although the provision of unrestricted access to the system is commendable, there is inadequate provision of shading from sun glare.

Prior to conducting the study, formal approval was obtained from the school principal. Parents/guardians of participants also signed informed consent forms.

Nine learners participated in the evaluation, six of whom were given pre-defined tasks to complete while the other three participants were allowed to use the system as they wished. Of the six participants given pre-defined task, two participants each used one of the educational games. These participants were also required to register a new user account before accessing the applications unless they had a valid account. The other three participants could access the system as a guest if they wished. The profile of the participants, together with the applications they used is provided in Table 1.

Table 1: Profile of Field Evaluation Participants

Participants	Age	Gender	Application used
1	17	F	OpenSpell
2	13	M	OpenSpell
3	16	M	What-What Mzansi
4	15	M	What-What Mzansi
5	15	M	(Free Exploration) What-What Mzansi and Four-in-a-row game
6	14	M	Themba's Journey
7	18	F	Themba's Journey
8	15	F	(Free Exploration) Themba's Journey
9	13	M	(Free Exploration) KTuberling and Penguin games

2. Evaluation Process

In a conventional field study, participants are observed as they carry out normal or routine activities using the target system in the natural context of use either at home or the workplace. The natural context allows the observer to see the actual ways in which the system is being used; thus revealing some details that may be difficult to obtain if another evaluation method, such as the heuristic evaluation method, was used [Dumas, 2003].

In this study, we modified the field evaluation by giving some of the participants pre-defined tasks to complete and allowing other participants to freely explore the system. This enabled us to focus the evaluation on the specific interfaces and applications identified for the evaluation while at the same time allowing us to observe the type of applications the learners typically access. A sample pre-defined task list is shown in Figure 6.

To avoid disruptions to learning activities as much as possible, and minimize distractions from noise, evaluation sessions took place in the afternoons well after the official closing hour of the school.

Using the cooperative evaluation style, participants were encouraged to ask questions and assistance whenever they got stuck with any activity. The field evaluation facilitator, for example, provided subtle hints and assistance after allowing participants sufficient time to attempt to locate an interface element without success. This approach is justified since the Digital Doorway is not a transaction processing system where the speed of task completion is a measure of usability.

Nine evaluation sessions were conducted over a two-week period. Each session lasted between thirty and forty-five minutes. The sessions were recorded on video cameras after assurance to participants of their anonymity. The facilitator also took notes of important events as they occurred.

After each session, footage of the evaluation was reviewed and compared with the facilitator's note in order to check for any inconsistency between the two, before preparing for the next day's evaluation session. This was to ensure that data from the sessions were not mixed-up.

Digital Doorway Evaluation: Task list

1. Read the screen instruction on how to register as a new Digital Doorway user if you are not a registered user.
2. Complete the registration form if you are not a registered user, otherwise proceed to step 3.
3. Start the Digital Doorway by providing the requested information.
4. Search for the spelling game '**OpenSpell**'.
5. Remember to provide verbal feedback all the time.
6. Search for and read the instruction on how to play the game.
7. Choose how challenging (difficult) you want the game to be.
8. Learn how to spell a few words.
9. Change the volume to suit your need.
10. Do some spelling exercises.
11. Do a few guessing exercises.
12. Change the language to another one of your choice.
13. Close the Digital Doorway when you are done.

Figure 6. Task list for field usability evaluation (using the application 'OpenSpell')

3. Evaluation Results

Various usability problems were encountered by users and observed by the field evaluation facilitator. All of these were software usability problems except one which was a hardware problem. Some of the problems affected the completion of participants' tasks while others constituted a source of minor irritations to them.

The total number of usability problems found during the field evaluation was thirty-eight. Thirty-four of these were software problems that affected task execution by participants; three were a source of irritation to the participants while two were hardware problems. Analysis of the specific interfaces and application in which the problems were located (Figure 7) showed that six problems were related to the login screen, eight affected the new user account registration form, while six involved the main desktop. In the educational game applications, four problems related to the quiz game, What-What Mzansi, six problems involved OpenSpell while a further six related to Themba's Journey.

As shown in Figure 7, a total of twenty problems were located in the login screen, the new account registration form and the main desktop. This constitutes 56% of the total software usability problems. At least two of these interfaces (the login screen and the main desktop) represent the first areas of contact between the user and the Digital Doorway. This is a concern for a system that aims to promote computer literacy through unassisted learning [Cambridge, 2008]. Successful and meaningful interaction begins with simple, easy to use and intuitive interfaces. We provide the description of the nature of problems revealed by the field usability evaluation in Table 2.

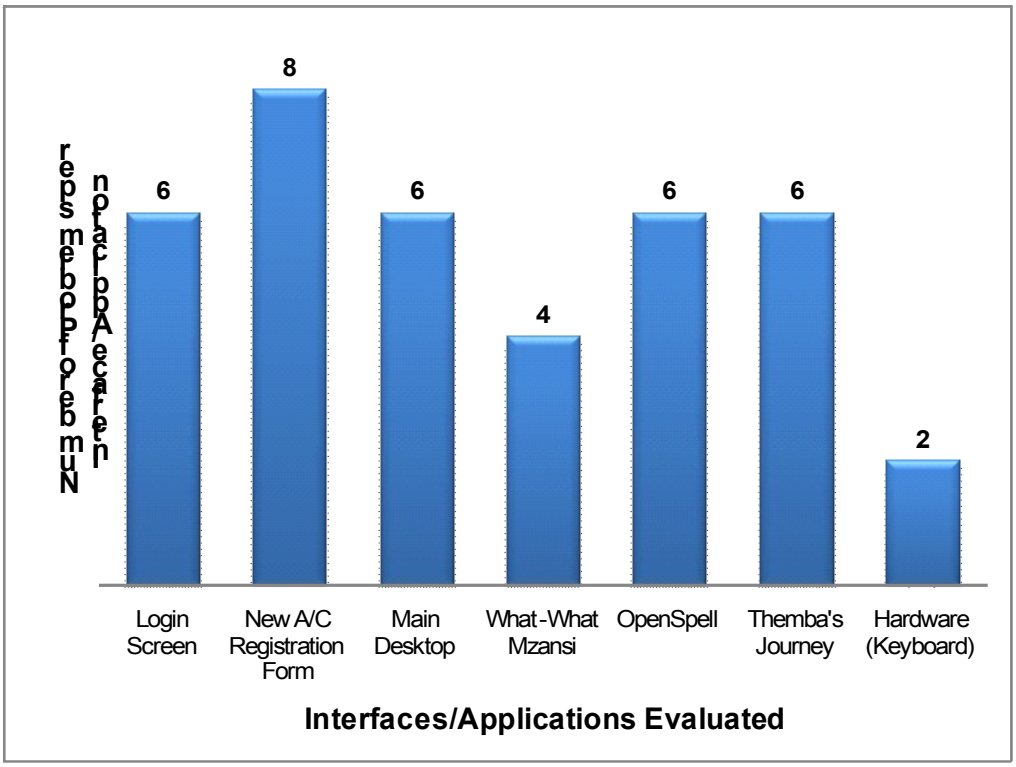

Figure 7. Number of Problems per Interface/Application

Table 2: Nature of Usability Problems

No	Problem Description
	Login Screen
1	Incorrect username and/or password were a common user error. The system returned the same screen over and over without an indication of what the mistake was. Most of the time the field observation facilitator had to inform the participants that the problem was with the username or password they were providing after a number of unsuccessful attempts to log in.
2	The system did not provide login information for users who had just registered or those with existing accounts. The only prompt on the screen is addressed to guest users and those wanting to create new user accounts. Some of the participants typed in 'new' or 'dd1' to log in, while others asked what should be done next before being told that the newly chosen username and password should be used to log in.
3	Participants sometimes confused their surname with a 'username' and typed their surname in the username field, though this was not the chosen username.
4	Some of the participants confused the <Enter> key on the keyboard with the key designated for producing a 'mouse click' effect because the keys were not labelled. However, after pressing one key without the desired effect they then pressed the other.
5	A screen resolution dialog box occasionally appeared and disappeared after a few seconds with the message 'For best picture quality change the resolution to 1024X. 1: Exit 2: Delete.' This made some of participants irritated as they did not know how to handle the information.
6	On a number of occasions, when participants were about to place the insertion point in the Username textbox, the following message appeared on a rollover 'Answer questions here and press Enter when done. For a menu press F10'. While this message did not seem to bother some of the participants in the study, its relevance is questionable.
	New User Account Registration Form
7	Some participants began typing their names only to realize later that the input was not being accepted and needed to place the insertion point within the first field before typing again.

8	Some of the participants input their name and surname in the 'Name and Surname' field without space in between the two. This common error will then bring up the following error message "Your name seems to be incomplete". Participants then spent some time trying to figure out what the problem is, sometimes without success until they were told what the problem is.
9	Participants typically kept the 'home language' and 'preferred language' fields empty only to have error messages urging them to fill the fields. None of the fields in the form is indicated as mandatory.
10	Some participants chose passwords with the length less than six characters. This resulted in the following error message "Passwords must be between 6 and 14 characters". This contradicted the hint provided next to the password field "6 to 12 numbers and letters".
11	While setting the password, a participant received the following error message 'The password contains illegal characters'. This participant could not comprehend the meaning of the error message. She had to ask the field observation facilitator for help.
12	The form did not facilitate the location of an error field. A participant erased his input in the password field accidentally, while trying to correct the name field entry following an error message. The insertion point remained in the password field after clicking on the <Register user> button. Without the participant realising this, he pressed the backspace key on the keyboard (←) several times and erased the wrong field unintentionally.
13	Two participants accidentally clicked on the <Cancel> button while intending to click the <Register User> button. This inadvertent user error resulted in the form being closed without any warning to the participant thereby erasing all the data fields input thus far. The toe buttons <Register User> and <Cancel> are located closely to each other on the form.
14	Three participants were unable to delete the wrong input in form fields until they were told how to. This task can only be accomplished by pressing a left pointing arrow key ←, which is not labelled, on the keyboard. This is actually a hardware usability problem that affected the use of the electronic form.
	Main Desktop
15	Only two of the six participants with pre-defined tasks found the location of the game applications on their own. Other participants unsuccessfully searched for the applications within the <Game> submenu, located in the <Resource> menu, before they were told where to find them.
16	Only three of the six participants with pre-defined tasks were able to locate the volume control buttons on the desktop, the other three required assistance after several failed attempts.
17	Four participants found the background colour to be too dark. On several occasions, they had to shield their faces and the screen with their hands while using the Digital Doorway to overcome the extent of reflection of the sun on the dark background.
18	A participant accidentally clicked on the ⇒ button, used to exit the system, while trying to locate the volume control button and the system was shut down without any warning.
19	Only three of the six participants given pre-specified tasks were able to log out of the system on their own without requiring assistance. One participant discovered the ⇒ button accidentally following an attempt to increase the volume output. The other two participants specifically asked for help following failed efforts to exit the system on their own. Of the three participants that explored the system as they wished, two knew the location of the ⇒ button while the other participant asked for help after unsuccessful attempts to exit on her own.
20	After clicking on the required game application icon, the screen will flicker and return to the Digital Doorway home page. Participants needed to click the icon several times before the game application was opened. This was frustrating to participants.
	What-What Mzansi
21	The two participants given pre-defined tasks using this application could not find the game instructions as required in the specified task. Intuitively, the two participants clicked on <about> menu option to search for the game instructions without success. This is because this menu contains information on the application developers and Digital Doorway project history and achievements.

22 At the start of the application, some of the control buttons and the character that reads out instructions and questions were hidden from user's view. A full screen mode is activated by clicking arbitrarily around the taskbar. None of the two participants who used this application for the pre-defined task knew how to get the full screen view of the game. One participant, who explored the Digital Doorway as wished, chose What-What Mzansi. This participant was able to change to a full screen view without requiring any help.

23 Context-specific instructions are provided when a user clicks on <?> icon. However, none of the three participants who used this application accessed the information. Non-utilization could be (i) because they did not understand the functionality of this icon and (ii) because they never had the opportunity to select the icon as the questions were read immediately after the welcoming words. The main priority of these participants was to listen to the question and answer them.

24 One of the terminals used for the evaluation sessions had unusually large icons. This resulted in non-visibility of a number of control buttons, in this instance a right pointing arrow '>' used for forward progression. This made it impossible for the participants to repeat the level which they had just completed as required following poor performance.

OpenSpell

25 In similar pattern to the participants who used What-What Mzansi, the two participants that were required to use this application could not find the game instructions. Both participants clicked on the <about> menu option to search for the game instructions, without success. This is because this menu contains information on the application developers and Digital Doorway project history and achievements.

26 The two participants who used this program selected the <spell> menu option when asked to learn the spelling of a few words. However, this functionality is provided within the <say> menu option.

27 Only one of the two participants was able to associate the * symbols with the level of difficulty. The other user did not know how to set the difficulty level.

28 The quality of the voice output was poor even when volume was at the highest. Participants frequently had to keep their ears close to the screen.

29 One of the terminals used for the evaluation sessions had unusually large icons. This resulted in the taskbar covering the control buttons <Repeat> <Erase> <Enter> almost completely. One of the participants who used this terminal had to ask what should be done to 'enter' her input for a spelling exercise. On two occasions, the participant needed to erase incorrect inputs but due to none visibility of these buttons, she clicked on the <Enter> button. This was taken by the system as an incorrect answer. She was then prompted to try one more time as the application interpreted this as an incorrect answer.

30 When asked to do some spelling exercises, both participants first attempted to use the keyboard to provide their input, only to realize later that they can only use the onscreen keyboard.

Themba's Journey

31 The default language for this application is Xhosa. To access an English version, the user must hover the mouse on speech bubbles. The three participants who used the application (two with pre-defined tasks and one as a free system explorer) did not know how to get the English version until they were told.

32 Too much effort was required by participants to move the pointer around the speech bubbles in order to read English versions.

33 Application background was very dark. Participants had to shield their faces and screen with hands. The dark background is made worse because the Digital Doorway is located in an open space with excessive natural lighting and glaring of the sun.

34 Navigation instructions were provided in the <Help> menu. Although the participants read the instructions at the start of the session, they had forgotten about the functionality of some of these buttons, in this instance the <Skip> button by the time they were actually needed.

35 At the second crossroad, which was having the options 'Walk' and 'Take taxi', the 'Walk' option could not be executed. A participant had to select the 'Take taxi' option against her wish.

36 The main exit button was non-functional. Participants had to close the application with the browser exit button i.e. the <X> button.

Keyboard

37 The primary purpose of the study was to evaluate a selection of interfaces and applications, however, the evaluation revealed a number of keyboard keys that were not functioning. These were: letters 'K', 'L', 'O', and 'P'. This affected the choice of passwords selected by some participants.

The field usability evaluation identified problems that impacted on the successful completion of user tasks. Many of these were flagged as potential usability problems during an expert heuristic evaluation of the Digital Doorway [Adebesin, Kotze and Gelderblom, 2010], for example, the use of unintuitive icons and symbols. Others were not recognized as problems by expert evaluators because they were a direct consequence of the environment of use. An example of this kind of problem was the dark background, which was exacerbated by the reflection from the sun.

Other usability problems experienced by participants in the field usability evaluation revealed the Digital Doorway's lack of error tolerance. This is a concern for a system that aims to promote computer literacy through unassisted learning and system exploration. For example two participants in this study unintentionally clicked on the <Cancel> button in the new account registration form. This button is located closely to the <Register User> button. Without any warning message, the form was closed, thus resulting in the loss of all the data provided by the participants. On another occasion, a participant accidentally clicked on the arrow button (⇒), used to shut down the system, while attempting to increase the volume for audio output. The system shut down without any warning, the participant had to log in again in order to complete the specified tasks.

7. USABILITY AS STRATEGY TO BRIDGE THE DIVIDE

The benefits of usability are enormous – easy to use interfaces, reduced error rate, less user frustration and ability to transfer knowledge from one application to similar ones, to name a few. Although concerns for interface usability are essential for all users, it is even more the case when the target user groups are inexperienced and underserved. These are the users groups where the gap of digital divide is widest. Inadequate design decisions by developers could negatively impact on these user groups' ability to take advantage of the potential social and economic benefits of new technologies.

The results presented in Table 2 demonstrated the significant role that usability evaluation, especially with real users, can play in the drive to narrow digital divide. As discussed in section 2, digital divide is not only about the acquisition of ICT devices. Other aspects of the divide, which were revealed by the field usability study, are the following:

- *Lack of relevant content in the local language:* The availability of relevant content in the local language is one of the critical requirements to bridge digital divide [bridges.org, n.d; Wilson, 2006]. Although Themba's Journey, one of the educational applications evaluated in this study, is provided in Xhosa and English languages, the usability of the English equivalent is affected by poor design decision that required users to hover the mouse pointer over speech bubbles to access the content. Another application, What-What Mzansi, is currently available

only in the English language. Although the participants in this study were school children who understood English, the same cannot be said for other children in other rural South African locations.

- *Lack of cognitive resources and inadequate interface design:* In order to take advantage of potential benefits of ICT, the possession of basic ICT skills is essential. When users are lacking in these basic skills, effective interaction requires interfaces that are simple and intuitive.
    - The field usability evaluation showed the Digital Doorway's lack of concern for users in this regard. For example, only two of the six study participants given predefined tasks could locate the educational games What-What Mzansi, OpenSpell, and Themba's Journey. The first intuition of the participants was to check for these applications in the <Game> submenu, where even an experienced user would have expected to find them. However, these applications were placed inside a desktop folder named 'new_content'.
    - Other examples relating to inadequate interface design in the Digital Doorway is related to the use of symbols that do not adequately convey their functionality, even to the experienced users. (i) In OpenSpell, the educational spelling program, users are allowed to set the level of difficulty for the game. However, the method of implementation for this support in form of *s is flawed as designers cannot reasonably expect users to associate this symbols with the level of difficulty. Furthermore, nowhere in this application were users provided with instructions that could help them in determining the meaning of this symbol. (ii) On the desktop, the exit button is represented by a right pointing red arrow (⇒). The interpretation of the function of this symbol would have been difficult, even for the experienced user.

In a development environment such as the one in which the Digital Doorway project team operates, applications are typically implemented by contract and visiting developers. To overcome the problems identified during our usability evaluation, well-established usability guidelines could provide a solution. Although there are several well-established usability guidelines, for example the usability principles by Dix et al. [2004] and design principles by Norman [Norman, 2001], these basic principles have not been followed by developers due to lack of clear guiding principles and policies on usability and standardization. As an example of the standardization issue, in the education games What-What Mzansi and OpenSpell, users can exit the two applications by clicking the <X> button provided in a browser window, while the life skills program, Themba's Journey, provides an <Exit> button to close the application. Such inconsistencies will not allow users to transfer knowledge from one application to another.

Another reason could be that the developers are unaware of the existence of such usability guidelines or that they find them overwhelming. In such cases, a solution could be the establishment of in-house usability guidelines that are specific enough for the types of applications being implemented and which can provide guidance to these developers. There should also be processes in place to ensure that the guidelines are followed.

In addition to establishing in-house usability guidelines and standards, usability evaluation should be conducted with real users to assess the extent to which they can effectively use the system to accomplish their goals. As stated in section 1, there has been no usability evaluation of the software applications installed on the Digital Doorway over the past eight years. Efforts to bridge digital divide should not be concentrated only on providing physical access to technologies. Without proper usability, content that may potentially be of benefit may not be utilized.

When people do not possess the basic ICT skills to access the software, the interface should be particularly supportive and should facilitate learning by exploration. It should be tolerant of user error and designers should make every effort to hold the user's attention. An intuitive, easy to use interface will enable the underprivileged to take advantage of the economic and social benefits offered by new technologies.

8. CONCLUSION

In this paper we presented the results from a field study conducted to evaluate the usability of the Digital Doorway, a non-standard system deployed as part of the global efforts to narrow digital divide. We described the type of problems encountered by real users when using computer systems and demonstrated that lack of usability undermines the cost and effort to provide the underprivileged with technology. We cannot hope to narrow digital divide simply by making ICT devices available to disadvantaged people and not pay proper attention to the content. The usability of the interfaces of these devices is as important as the provision of the devices themselves.

In situations where applications are implemented by contract developers, as it is sometimes the case with applications installed on the Digital Doorway, the establishment of appropriate in-house usability guidelines will ensure that usability concerns are addressed by developers.

Our hope is that this paper will provide the impetus for people involved in projects aimed at narrowing digital divide to ensure that the devices are effectively utilized by the target user groups through the appropriate incorporation of basic usability principles in the design.

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