Towards a Decolonized Human Machine Interface for a Rural Solar Bakery Management System

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Abstract

The University of Johannesburg and various stakeholders launched a community engagement project in Gwakwani village in the remote area of Limpopo province, South Africa, where a solar powered bakery was deployed. To ensure the sustainability of the project, bakery staff was educated and trained in the processes of baking and business management processes. One of the biggest challenges around the initiative is that the bakery staff has no prior knowledge of how to operate and manage a small business. This paper presents the development of a bakery management system to assist the staff in the day-to-day management of the bakery. It discusses the human machine interface developed for potential lower literacy levels and experience of the bakery staff in mind. This paper presents the development of the user interface of the management system as well as results from a preliminary training session on how to use the management system.

Keywords: community engagement, decolonized human machine interface, management systems, rural bakery

1. Introduction

The Gwakwani village is located in the remote areas of the Limpopo province in the northern region of South Africa. It has a population of between 70 and 100 people and is known for its remoteness and very basic standards of living with no grid power or municipal facilities. Most of the villagers in the area rely on subsistence farming or

government grants for their well-being. The University of Johannesburg (UJ), the Baking and Food Technology Incubation Center of South Africa (BICSA), and other industry partners embarked on a program to empower the community of the village through various projects. One of the endeavors was a solar powered bakery. This bakery was built with an aim of social upliftment and upskilling the youth in the area. Eight youths received training from BICSA on baking, managing and operating the bakery. These bakers were trained on baking bread and other confectionaries that are sold to the village and its surrounding communities. The bakery currently produces between 120 and 160 loaves of bread per day, assisted by its geographical location with plentiful sunshine-hours. Baking of bread is substituted with the baking of confectionaries, such as scones and cake, baked on demand. The produce are sold to the local community, where the profit is used to pay the bakers monthly salaries and procure new stock.

The bakery created employment, reduced poverty and assisted towards a sustainable economic development of the community. Small enterprises, such as the Gwakwani bakery, play a significant role in the growing of economies in developing countries such as South Africa. The Department of Trade and Industry of South Africa stated that small enterprises employ about half of the formally employed people and have a contribution of 40% of the country's gross domestic product. South Africa is a country with about 36% youth unemployment, therefore these small enterprises play a large role in addressing the issue of unemployment. Unfortunately, many challenges affect the survival and growth of such enterprises, and the biggest of them all is the fact that approximately 3 quarters of all the starting enterprises fail within their first two years of operation. Their development is affected by such factors as lack of finance, managerial skills, equipment and technological skills.

In order to ensure the Gwakwani bakery does not become one of the victims of the failure statistics, education on the management of the bakery must be emphasized. As the staff of the Gwakwani bakery has limited education and no previous business management skills, experience nor background, this poses a threat to the growth of the bakery enterprise. Thus, a bakery management system was developed to help the bakers with managing the daily activities of the bakery. With the bakery staff's educational background in mind, the bakery management system was developed with a decolonized view, considering the utilization of images and symbols rather than text and numbers. This design thus overcomes the barrier of limited reading, mathematical and technological skills of the users. The visuals were chosen to be as close as possible to the actual item that they were presenting and required no textual input from the users as there would be a risk of errors in the input. Its implementation has emphasis on simplicity of the overall system as it is aligned to the low education levels of the users and their background knowledge of the computers and modern technological appliances.

This paper is organized as follows: Section 2 shows the methodology used in the creation of the bakery management system's Human Machine Interface (HMI). The initial prototype and design are shown in Section 3, and the results and analysis of the preliminary training exercise are presented in Section 4. The conclusion of the paper and the future work on the research are discussed in Section 5.

2. Methodology

In order to assist in the sustainability of the bakery, the bakery management system was designed through the utilization of culturally appropriate images and symbols rather than text and numbers. The method discussed in this section shows the methodology followed in the creation of the system that takes into consideration the barriers of limited reading, mathematical and technological skills of the bakers.

The first step was to consider the skills and techniques BICSA taught the bakers in their training. These baking and business processes were used to guide the functionality of the system. The following procedures were identified:

1. Inventory management;
2. Various baking recipes for white bread, brown bread and soft rolls;
3. Stock sales.

These three procedures were included in the first design. Additional skills and processes not included in the BICSA training manual were not included in the first iteration of the system. The identified procedures were used as the first set of requirements to the system. The simplicity of the HMI was also a main consideration in the design of the system.

Remote monitoring of the bakery's operations was considered important to the stakeholders in the Gwakwani community engagement program. Remote access can also enable the project team to monitor the operation of the bakery and update the bakery management system, if required. Since the village does not currently have cellular reception, this requirement was not implemented but was included in the design for future use.

After the design and development of the first version, tests were conducted on the complete HMI to check on its simplicity and usability. People from different technological backgrounds were approached and taught on the main functionalities of the software. The time taken for comprehension of their learning was then recorded and used as a baseline for estimating the simplicity of the final product. The feedback obtained from this study was then used for the next iteration of design.

3. Design considerations

As simplicity and lower literacy levels of the bakers were the main factors to consider, the software utilized as many pictures and icons as practically possible to minimize the reading and language barrier. The User Interface (UI) of the system comprises of two parts; the navigation pane and the user page. The navigation pane does not change and is used by the baker to navigate through the various procedures, whereas the user page changes according to the selection of the baker.

Every image selected for use on these pages were selected based on two criteria:

1. The picture is a well-known image and corresponds to the action that it depicts;
2. The picture is a photo of the actual items that are used in the bakery.

These selections were done to ensure that the users can easily relate the picture to the function of the icon, without the need to learn the meaning of a new, possibly unfamiliar, image.

3.1 Navigation pane

The navigation pane, shown in Figure 1 by the black menu strip at the top of the page, contains a range of symbols for the different subsystems indicated by tabs. It is visible above all the pages, so that the baker can navigate between the various subsystems.

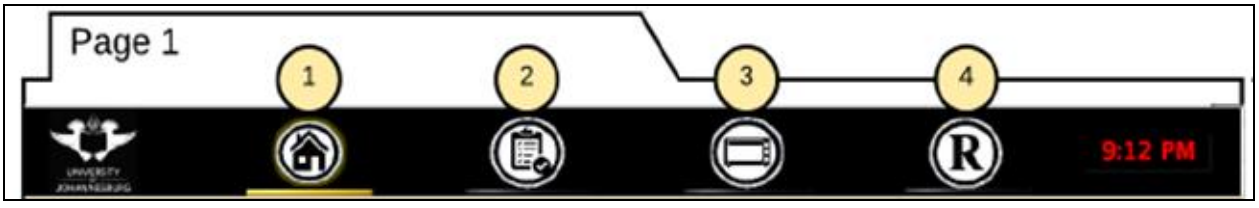


Figure 1. Navigation pane

These icons have been selected in accordance to the functions of the page that they represent:

1. The "house" or "hut" icon depicts that it is a home tab.
2. The "check list" icon represents the inventory management tab.
3. The "oven" icon indicates the baking procedure tab, which includes various baking recipes.
4. The "R" icon, a familiar representation of money in South Africa, is used to indicate the selling of confectionery items.

3.2. Home page

The Home page, shown in Figure 2, is the landing page of the system and is displayed when the program starts executing. This page shows a summary of the inventory status. The available stock quantities are indicated in their familiar units of measurement. There is also the shutting down icon that is on the top left corner as shown in Figure 2. Shutting down the program can be achieved by pressing the icon for at least 3 seconds and the program clears all the virtual memory, sets all values to default and shuts down. The shutdown icon utilised for this purpose is a flat, open hand on the red octagonal background of a stop sign, both familiar images to the Gwakwani residents.

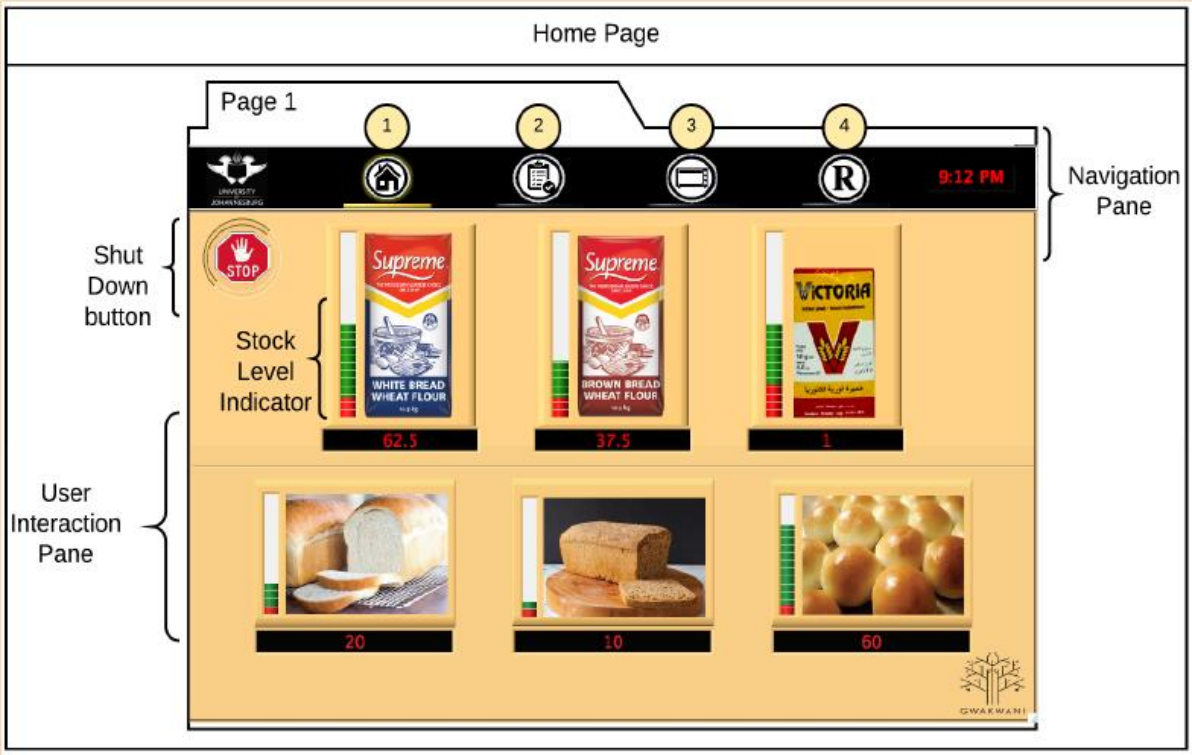


Figure 2. Home page interface

As seen from the figure, the name of the item was not shown; only the image showed the item. This was done to minimize textual content. The selected images used, were of the exact items used in the bakery, so it will be clear to the bakers what it refers to. The filler indicator has a green and red areas. The green is for when the quantities are still high enough for operations, and the red act as a warning to the user to buy some more items when the bakery is running out. This allows the user to instantly get an idea of when a restock will be required as well as the status of each item in the inventory. Beneath each stock item is a number showing the amount of the item in stock in appropriate units. For example, the number 37.5 under the brown wheat flour means there are still 37 full bags and a half filled bag of the flour in stock. As with the ingredients, the page also indicates the stock of baked goods which can be sold. Once again, images of the produce are utilised for easy comprehension.

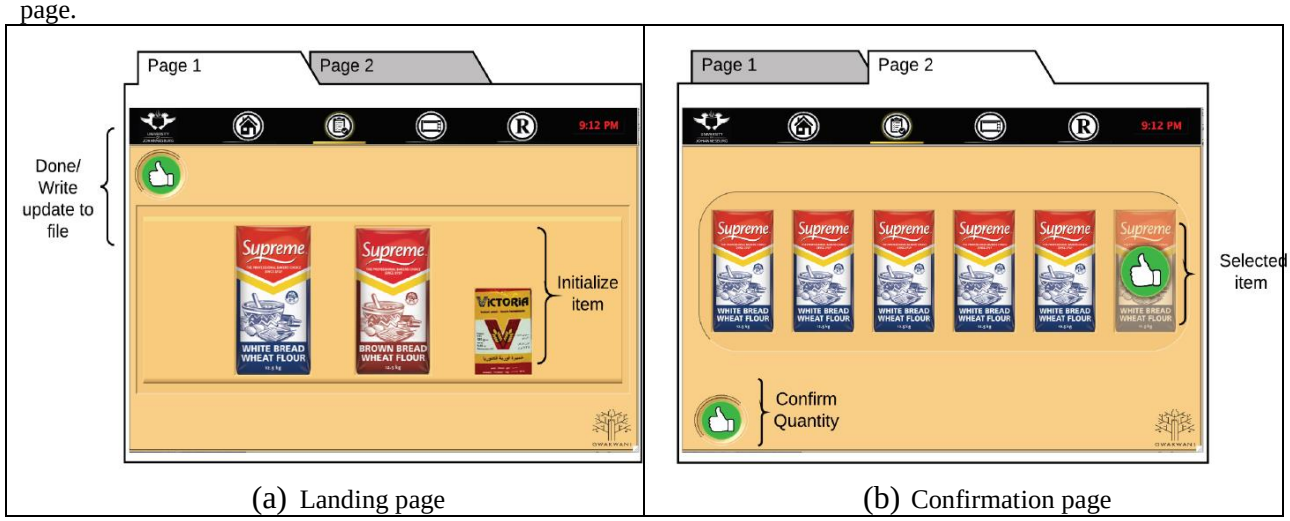
Each time an activity is run, for example, the inventory is updated, the values shown on the home page updates to show the current stock quantities.

3.3. The Inventory system

This tab is used when the baker adds items of ingredients to the stock of the bakery. The landing page of the inventory page is shown in Figure 3(a). On this page, the user clicks on the icon corresponding to the item that needs to be added, followed by the “thumbs up” button for confirmation. The “thumbs up” image on the background of green was selected as it signifies approval.

The selection of one stock item will redirect the user to a confirmation page, shown in Figure 3(b). The confirmation page shows a number of identical images of the stock item and the user must click on an image of a bag for each bag added to the bakery stock. Each selected item will be covered by a thumb up icon as shown in the figure. If a user wants to unselect a selected item, he/she does so by clicking the item again and the thumb up icon disappears. Upon clicking the confirmation thumb up icon that is on the bottom left side of the figure, the system counts the number of

selected items and adds that number to the ones that are already in stock and updates the inventory list on the home page.



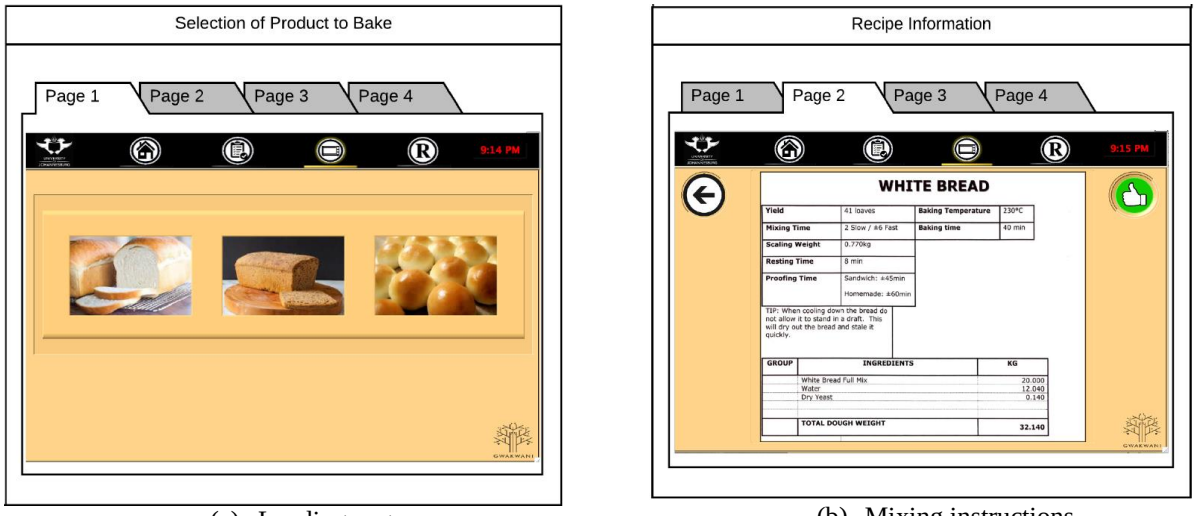
(a) Landing page (b) Confirmation page

Figure 3. The Inventory UI: (a) landing page (b)

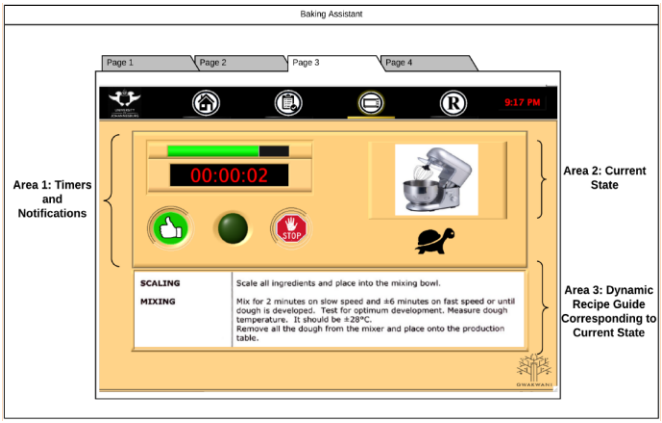
Thus, there is no need to type in the amount of new stock added to the bakery, which helps the users that are not comfortable with numbers.

3.4. The Baking Assistant

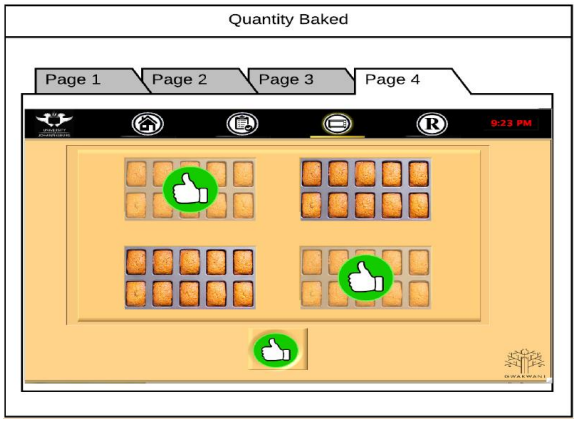
The baking assistant subsystem helps the bakers with the baking process. Its UI is made up of four different pages. Each page presents the user with a different set of information and actions. The first page, shown in Figure 4(a), displays three image buttons, one for each product that can be baked (white bread, brown bread and soft rolls in this case). As previously discussed, the buttons utilises the images of the product to be baked. The user selects the product to be baked by clicking on the corresponding image and the tab control advances to the second page (Figure 4(b)) where the ingredients for the product are displayed to the user.



(a) Landing page (b) Mixing instructions



(c) Baking instructions



(d) Produce count

Figure 4. Baking assistant pages

Once the user has seen the mixing instructions and confirms via the use of the "thumbs up" icon, he is redirected to the next page, shown in Figure 4 (c), where the baking procedure, taken from the BICSA training guide, is displayed. The bakers were trained with this guide so the text is assumed to be familiar to them. This page is broken into three main areas. The first is that of the top left-hand side which displays the timer and a timing progress bar on top. Initially, as the user is taken to the page, a back button appears so that the user may go to the previous pages to either read the instructions first or to change the product. However, once the user clicks the start icon, he or she may not go back again and the back button disappears as the procedure will be underway.

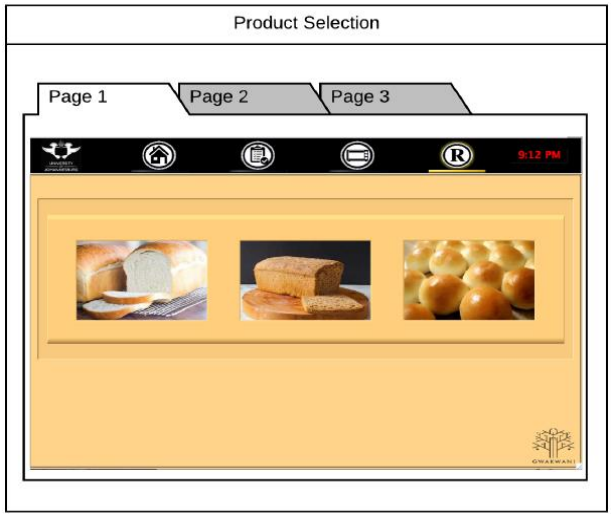
The second area is the top right-hand region of the page. There is a sub-tab control displaying an image relating to what the user is required to do in the current state of the process. For example, on Figure 4(c) is a mixer to show that the user should mix the dough. Underneath it is a picture of either a rabbit or a tortoise. These indicate the speed of the process of mixing the dough; a rabbit is for faster mixing and a tortoise is for slower mixing. Changing from a tortoise to a rabbit, or vice versa is programmed in such a way that there is a beeping sound and a flashing light that starts for 5 seconds prior to the change

The third area of the page spans the entire bottom half of the page. It shows the instructions of what the user should be doing in accordance to the training from the BICSA guide.

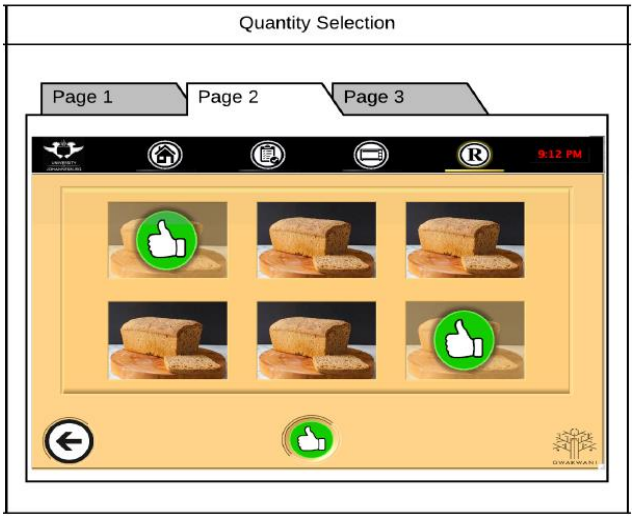
Once the baking step is completed, the guide at the bottom of the page displays the post baking guide as well as a done, "thumbs up" button in the top right hand region of the page. Once the user clicks that button, the UI advances to the final page of the assistant (Figure 4(d)) where four trays of ten units are displayed. Each tray corresponds to the baking pans used for baking. When the user clicks on one tray, a thumbs up icon appears over the tray to confirm that the tray was selected. The user then clicks the number of trays baked in the process and clicks the done button to confirm the amount of baked items to add to the inventory. Upon completion, the UI updates and redirects to the home page and the baking process is completed. The stock level of the baked items is automatically updated on the home page.

3.5. The Sales System UI

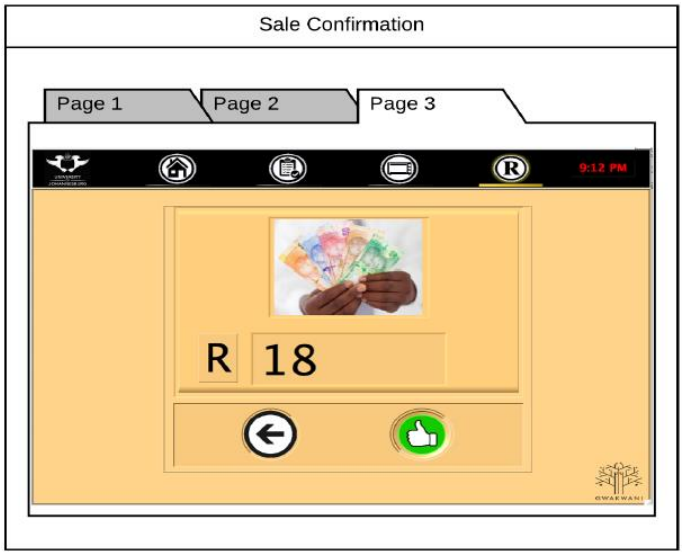
This UI is built on an embedded three-page tab sub-control. The first page (Figure 5(a)) presents the user with three pictures, each representing a specific selling product that is in stock. The user begins by clicking on this picture and triggers the tab control to proceed to the next page (Figure 5(b)). The page presents the user with 6 images of the item they have selected. The user selects the number of items to sell and clicks the done button. As with the inventory system, a baker who is uncomfortable with counting and addition would be able to make a sale by simply clicking on a different icon for each item handed to the customer. Once the baker selected the final amount of bread sold, the third and final page, shown in Figure 5(c), is displayed to show the the cost of the sold item. Once the customer has paid, he/she confirms by clicking the done button. Hereafter the stock levels are updated and the UI redirects to the home page to show the updated stock items.



(a) Landing page



(b) Selection page



(c) Confirmation page

Figure 5. Sales System UI

5. Usability testing

One of the main design considerations of this system was to make it easy to understand and operate, even for a baker who was uncomfortable or unfamiliar with reading, counting or selling. The usability of the system was therefore a vital factor that determines the success and uptake thereof. Hence, it was very important that the usability of the system be analyzed to determine if it can be easily understood by many, especially those with little technology experience.

A simple test was conducted to check on the usability and simplicity of the system. In this test, random people were introduced to the system and trained on the how to use it. Their level of understanding on how to use technological devices was recorder and divided into four classes/groups. These four groups are defined in Table 1.

Table 1. Details of the groups of the surveyed people

Group	Technology level
1	No previous technological experience at all. Never used any piece of information communication technology
2	Do not possess any prior exposure to computers and only used basic cell phones
3	Previously used a computer but do not own one. Only use basic cell phones
4	Average to best computer users. They own their own computers and use them regularly.

Each person was individually introduced to the system and trained on each of the various procedures by the researcher. After they felt secure about the utilization of the system, the researcher asked each person to perform certain tasks. The tasks included actions like adding a certain number of bags of flour to the inventory, selling any given number of loaves of bread, or indicating if any stock levels are running low. The time it took for each person to fully understand the application and perform the required actions correctly was recorded. The results for the training session is shown in the Figure 6.

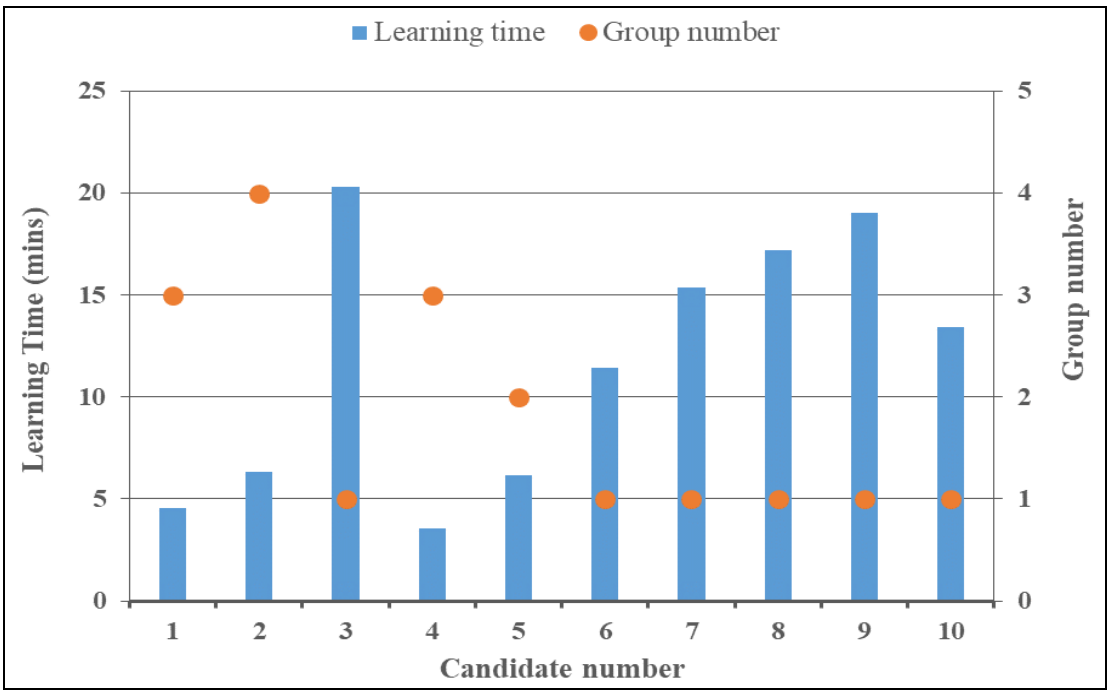


Figure 6. Learning time and group number of the candidate

Results from Figure 6 show that it took a maximum of approximately 20 mins for person with the lowest computer literacy (group 1) to understand the working of the software. It can be seen that people with higher levels of technology experienced and understood the system within few minutes. In cases where a person was totally unfamiliar with technology, an average of 15 minutes was required. The results show that the software is easy to learn as it took an average of about 10 minutes across all groups to understand and operate the system.

6. Future work

The solution proposed in this paper is the first design iteration for the rural bakery management system. The solution has been designed in such a way that it can allow further expandability of the system functionality to match the progression of the bakery operation complexity. Additional recipes, inventory items, parallel baking process assistants and financial management system that matches the business model of the bakery span the areas of possible future works of the prototype. Future deployments of rural solar bakery such as that of Gwakwani open doors for potential large scale deployment.

Future endeavors of similar nature could be packaged alongside the developed HMI and can be put into use in multiple communities to aid in the management and operation of these cooperatives bakery start-ups.

Future expansion to match developing business models and functionalities while maintaining the simplicity of the system will be a major challenge going forward. Although significant future developments will be needed for large scale deployment, the HMI has been designed to accommodate these efforts and hence there exists a very real potential for commercial use of the project solution through future community outreach programs.

7. Conclusion

The purpose of this paper was to present and discuss the development of a bakery management system designed for the managing a rural bakery in Gwakwani, South Africa. The system was based on the use of images and icons instead of words and numbers and its development was motivated by decolonised methods of communication. It was developed in order to assist the bakers who were unfamiliar with technology or uncomfortable with reading or writing in the day-to-day management processes of a bakery. The user interface of the system is unique as it does not follow the general rules of a management system. The introduction of Information Technology and simultaneous education of business management skills, through the use of this software provides the end users with the opportunity to learn skills that are vital in the modern day economic environment. The utilisation of similar systems can assist the sustainability of small, informal businesses in their daily operations. One of the fundamental pillars of engineering is to better the standard of living of the general population and by developing tools to help those in need of opportunity, innovations such as these fortify this pillar.

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Biographies

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