

The Talking Book: Participatory Design of an Icon-based User Interface for Rural People with Low Literacy

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ABSTRACT

The Talking Book is an audio technology for sharing knowledge about health and agriculture among oral cultures in rural settings. As a technology, without a display or mouse; navigation is through audio instructions and buttons labelled with icons. This paper presents the iterative Participatory Design (PD) approach employed in redesigning the iconography of the User Interface (UI). We found that the PD process created a feeling among users of ownership and acceptance of the technology as their own creation. For users, the most suitable icons are not those that denote any function, but those that are simply recognizable, which led to replacing international icons such as arrows, with icons representing local objects such as bowls, trees, and hands. An extensive evaluation showed that the new UI was more user-friendly and better liked. This work contributes a novel interface and highlights the value and the challenges of including users who are less familiar with technology in design.

CCS CONCEPTS

• Human-centred computing • Interaction design • Interaction design process and methods • User interface design

KEYWORDS

User interface design, audio guide, icon-based interface, low literacy, participatory design, user guide

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Figure 1: The Talking Book showing the icons of the new UI design using PD.

1 Introduction

A User Interface (UI) serves as the interaction gateway to a system by a user. An effectively designed UI enriches user experience, enhances usability and promotes technology adoption. However, designing interactive UIs for rural users in the developing world, who are mostly first-time users of technology, has been a long-standing challenge for design researchers [43]. Some of these challenges are due to the low literacy levels among rural user groups, as over 800 million people in the developing world have no literacy [2]. This renders using text-based UIs problematic and unhelpful [10,20,21,28]. Also, unfamiliarity with standard icons and symbols due to lack of technological exposure or technology use renders the concept of internationalization of UI design [35] ineffective as most conventional icons are unsuitable for use in UI designs for rural users. In efforts to overcome some of the UI design issues with rural users relating to language, literacy, and usability, researchers have explored the use of text-free graphical interfaces [6,20,38,40]; speech-based interfaces [16,18,30]; and icon-based interfaces [39,42].

With the advent of interactive Graphical User Interfaces (GUIs) and touchscreen displays, icon-based UIs offer great potential for oral, non-literate and low-tech rural users [12,43]. Research suggests that icons are easier and faster to learn to recognize than

text [4,15,34,44], and reduce both UI and application design complexity [5]. However, icon-based UIs also have application in technologies with no GUI or display. In oral cultures, icons can support user navigation of audio guides by labelling which button to press for a desired action. For such UI designs, the challenge of choosing appropriate and representative icons across socially and culturally diverse rural user groups becomes apparent. In addition, the choice of UI icons must be unambiguous to ensure that they do not create confusion and consequently hamper usability and adoption. Moreover, the audio guides for users must be explicit and address slight differences in language, words, and accent issues common with most multi-cultural rural populations.

In this paper, we discuss the redesign of the user interface for the Talking Book (Figure 1), an oral language technology for sharing knowledge about health and agriculture. Usability challenges with the original UI of the Talking Book (Figure 2) necessitated a redesign of the icon-based UI to improve its usability (Figure 1). The original icons for the Talking Book were not always well understood by users because they were not culturally relevant and therefore not possible to translate into local dialects. We then describe the participatory design approach we employed in redesigning and evaluating the iconography of the new UI. Finally, we reflect on the value and challenges of PD in designing interactive systems for use by non-literate and low literacy users.

2 Related Work

UI design for rural users in the developing world has been researched in domains such as job searching [20], access to health information [22,38], Automated Teller Machines (ATMs) [13,42], and rural microfinance and mobile money platforms [10,28]. Low literacy and illiteracy have been identified as key UI design challenges, as text reliant interfaces are unsuitable for such user groups. In efforts to overcome these challenges, researchers have adopted text-free UIs [6,20,38,40] and speech-based UIs [31–33] for non-literate and semi-literate rural users with varying degrees of success.

Although challenges with literacy can be mitigated by using text-free and/or speech-based UIs, other challenges such as selecting suitable buttons, icons and menus, and various speech detection complexities became apparent [12]. Given the numerous dialectal languages and accents that exist in most rural populations [32], it is technically challenging, costly and complex to develop error-tolerant Automatic Speech Recognizers (ASR) for use in speech-based UIs [25]. Thus, with the advent of interactive GUIs and technologies such as touch screens, UI designs have explored icon-based interfaces with low literacy and non-literate rural users (e.g. with interactive systems such as ATMs [42], iconic tangible interfaces [29], and with directory service systems [39]). Multi-modal user interface designs, combining two or more different interface types, have also been explored [1,6,27].

Socio-cultural issues and considerations in UI designs have also been investigated and discussed [8,14,26]. Culture may influence the acceptance, or otherwise, of an idea because it distinguishes one’s mental programming. For example, using a cow as an icon that depicts a topic that relates to livestock

information would have different responses in some parts of India than it would in Ghana, as similarly observed by Medhi et al. [20]. Many technologies that have been well-adopted by rural users have resulted from carefully designed processes that recognise the users’ cultural identity. Consequently, the interfaces appropriately influence their perceptions and are easy to use. A more detailed exploration of UI design with low literate and novice users in rural and developing regions has been discussed by Medhi [43]. However, whereas most of the UI designs make use of the GUI, there is a dearth of research exploring icon-based UI design on systems that do not have a GUI or a display.

3 Background

3.1 The Talking Book

In order to spread life-saving information in health and knowledge of best agricultural practices to hard-to-reach rural communities in the developing world, the Talking Book was designed (Figure 2) [36].

The Talking Book is a robust and re-programmable battery-powered interactive audio computer. It stores relevant audio message recordings from topic experts in health, agriculture, business (or any other topic) for users to retrieve, playback and listen to. Users navigate the device through its icon-based buttons, aided by audio guide prompts in their native dialect. The device has an inbuilt speaker for a larger audience. The Talking Book has no internet access, and audio content is refreshed monthly through field agents living in the communities in which the devices are deployed. Users are able to record feedback messages into the device, mostly asking clarifications and questions about the delivered content. Feedback from users is used by the program team to improve the content for the next update of messages on the Talking Book.

3.2 Original UI Design of the Talking Book

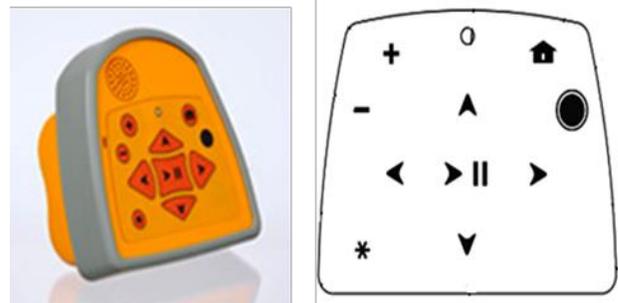


Figure 2: The initial version of the Talking Book used standard audio media icons found on tape recorders, some of which did not have names in local languages, making usability of the device challenging for users

The icon layout on the Talking Book’s original UI (figure 2) included the “plus” and “minus” signs, “asterisk”, “black circle”, “hut/house”, and up, down, left and right “navigation” buttons.

The “plus” and “minus” buttons are for volume control, used for increasing and decreasing the device’s volume respectively. The “asterisk” button is used for recording audio content into the

device; the “black circle” embeds advanced options; the right and left “navigation” buttons were for switching between topics, while the up and down “navigation” buttons were used for switching between messages within a topic. The middle button activated pause or play, and the small “hut/house” was the home button. Most of these buttons also had embedded functions for advanced operations such as deleting a message or switching between audio guides in different local languages.

Some of the icon buttons such the pause or play button in the middle and the “navigation” buttons were inspired by the iconography of standard audio media icons found on cassette recorders and tape players, with which some rural users were familiar. Others such as the “hut/house” button and the “plus” and “minus” icons were imagined to be functionally easy to identify. There was no participatory end-user input into the original Talking Book UI design.

3.3 Audio Guides with UI

The main challenge with the original UI of the Talking Book (figure 2) was principally users’ difficulty in identifying the correct icon buttons on the UI using the audio guide prompts that described and referenced the icon buttons. Identifying icon buttons explicitly with the audio guides was challenging because, most of the UI icons had no exact names in the Dagaare language of the Dagaaba people in the Upper West Region of Ghana. Dagaare was the language in which the user audio guides were created. Therefore, the audio guide prompts that identified icon buttons to users were created based on their appearance and position on the UI. For example, instead of an audio guide saying “*press the asterisk*” to prompt a user to press the “asterisk” icon button, it rather said, “*press the place that looks like a star*” in the native language. This made it difficult for users to identify the icon button since the “asterisk” icon does not look like a star or resonate with the image of the star that most users were familiar with. Similar challenges were identified with the “navigation” icon buttons, “plus” and “minus” icon buttons, and the “black circle” icon buttons. The audio guides for the “navigation” buttons described the appearance of the group of arrows and uniquely identified each arrow by its position from the center button (up, down, left, right). For example, the audio guides identified the up “navigation” icon button as “*the up icon of the four places that look like arrows*”.

For the “plus” button, audio guides identified it as “*the icon that looks like a cross*”, a well-known look-alike object familiar with users. Unlike the “plus” icon, the “minus” icon button, has no well-known look-alike object that its description could be strongly associated with. Therefore, we referred to its location on the UI in reference to the “plus” icon button, which had a close look-alike (a cross); thus identifying the “minus” icon button as “*the icon to the left, and beneath the icon that looks like a cross*”. The “black circle”, identified in the audio guides as “*the large black circle*” was mostly not recognized, as most users thought it resembled a blue moon instead. However, the “hut” or “house” icon button, which we identified as the “*small house at the top right*”, did not pose any problems in terms of identification.

The lengthy positional and look-alike descriptions used to identify most of these icon buttons made the audio guides very long and confusing to most users, largely due to the reasons indicated in [11]. These iconography and usability challenges with the first UI of the Talking Book necessitated a redesign of UI icons to ensure they were easily identifiable and recognized by users with a short phrase in their local language. The icons were not intended to represent a topic, function or anything else. They were only designed to be something quickly identifiable by the audio guide, like a number in a phone Interactive Voice Response (IVR) system, but better for people without literacy or numeracy skills. Thus, our key objectives for the UI redesign were: 1) to develop and customize a new set of easily identifiable icons for the UI of the Talking Book; 2) create and customize an explicit set of audio labels for the new icon buttons, and; 3) address socio-cultural, digital exposure, literacy and age-related usability issues that existed and negatively affected usability in the first UI of the Talking Book.

4 Participatory Design Approach

4.1 Research Team

Best practice in usability research is to have professionally trained usability experts and enumerators for research facilitation to maintain consistency across participating users [22]. Although members of our team had some usability experience in the field, they were not trained experts, and our focus was more on exploring usability with a view to collaborative redesign. All team members in the field were advanced users of the Talking Book and native language speakers. The five-member team undertook an initial training based on the goals of the research. A moderation procedure was developed for testing different UI icon sets across the varying user groups. Research findings in the field were documented by taking notes and pictures.

4.2 Research Communities

The research was conducted in Gozu, Jefferi and Ving-ving communities all located in the Jirapa District of the Upper West Region of Ghana. These communities are representative of our target and final intended users of the Talking Book. We initially deployed a couple of Talking Books only in Ving-ving community for a couple of months. All the communities were relatively small rural communities, with a population of 500-1000 inhabitants. The main occupation in these communities is subsistence farming. Between 10-30% of inhabitants had some level of literacy, but never completed senior high school. All three communities had primary and junior high schools. Across the three communities, technologies such as mobile phones were predominantly used by the youth, with the youth owning over 80% of the mobile phones. Other everyday technologies included radios and cassette recorders. At the time of conducting this research, two of the communities, Ving-ving and Gozu, were not connected to the national grid. These demographic characteristics are largely corroborated by the 2010 Population and Housing Census district

analytical report [45], the ministry of food and agriculture [23], and secondary data obtained from the Jirapa Municipal Assembly.

4.3 Participants

Research participants comprised men, women, and children between the ages of 12-60 years with varying literacy and exposure to technology. Two participant sets were involved in the research:

The first set of participants was involved in cataloguing the usability and iconographic UI challenges with the original UI of the Talking Book. These participants were engaged in the activities in sections 4.4 and 4.5 (iteration I and iteration II). Though this was not strictly a controlled experiment, we ensured fair representation of participants across gender, age, and literacy from across the three study communities. This first set of participants involved over 100 people across the three study communities

The second set of participants was involved in a formally designed comparative evaluation of the newly created UI and the old UI (section 5.3). Participants involved in the initial participatory design process (first set of participants, (No. 1)) were excluded. An equal number of male and female participants was represented considering their ages, literacy and digital exposure to reflect the different user groups in each community. Participants with different educational backgrounds, comprising those who have never been to school, those who attained some level of literacy such as primary education up to tertiary education, were considered. Participants with operational competence with technologies such as a television, radio receivers, cassette recorders or mobile phones also participated in evaluating the final UI design. In all 66 participants were involved in the evaluation study. Table 1 shows the composition of the group.

Table 1: Composition of participants by age, literacy, technology exposure and Community in the comparative evaluation of the old and new UIs in section 5.3

	Gozu	Jefferi	Ving-ving	Total
Age				
12-15yrs	2	2	2	6
16-26yrs	2	2	2	6
26-35yrs	2	2	2	6
36-45yrs	2	2	2	6
46-55yrs	2	2	2	6
56-60yrs	2	2	2	6
Total	12	12	12	36
Literacy Attained				
No literacy	2	2	2	6
Primary Sch	2	2	2	6
Junior High Sch	2	2	2	6
Senior High Sch	2	2	2	6
Total	8	8	8	24
Technology Exposure				
Tech Exposure	2	2	2	6
Overall Total				66

4.4 Identification and Cataloguing of Usability Issues

4.4.1 Iteration I. The activities in this iteration involved the first set of participants. Using PD and contextual interview approaches and principles [37,41,43], we identified, catalogued and ranked the challenges with the iconography and audio prompt guides of the first UI of the Talking Book. In doing so, we requested that users undertake three tasks: 1) First to identify by name the icon buttons on the UI that they could recognize; 2) to locate and playback a message from a chosen topic, and 3) to make alternate new icon suggestions for icons that confused them. The only assistance that was given to participants was showing them how to turn on the Talking Book. We requested them to listen carefully to the audio guides to complete task two and three. The research team then observed and noted the difficulties and challenges encountered in executing the first two tasks. The observed usability challenges were then discussed with each participant to understand the areas that confused them and to solicit suggestions for alternatives (to complete task 3). In the process, participants' challenges, comments, suggestions, and general observations through the process were noted by the research team by taking notes, and in some cases, video recording. At the end of each day out in the field, the research team regrouped and debriefed on feedback on the day's findings. All observations were then merged into a single user study spreadsheet document.

4.5 Designing Suggested Icons and New UI Layouts

4.5.1 Iteration II. The activities in this iteration involved the first set of participants. Our analysis from the usability observations, interviews and testing from iteration I suggested that the "navigation" and "asterisk" icons were the most confusing UI icons to almost all participants. The lengthy descriptions of these icons confused participants in identifying them. Some participants got lost in the middle of the instructions, as they had forgotten what the beginning of the audio guides said. Participants wanted these icons to be replaced with simpler alternate icons they suggested.

Participants who suggested alternate icons mostly expressed their desired icons saying, "why not use a hand instead of 'that thing'" (referring to the navigational arrow icons). Participants' alternate icon suggestions were based on concrete object icons that were very familiar and recognizable. For example, a participant in suggesting an alternate icon for the up "navigation" icons said, "I would prefer if it were a tree because I would know it when the 'machine' (Talking Book), tells me to press it".

As the user instructions were embedded in the audio guides, the purpose of the icons was not to denote a particular function, but simply to be recognizable. Users wanted familiar everyday icons that were identifiable and recognizable with definite names. Even though animals and people are all around these communities, there was no suggestion of animal icons. Always, inanimate objects, tools or hands were suggested.

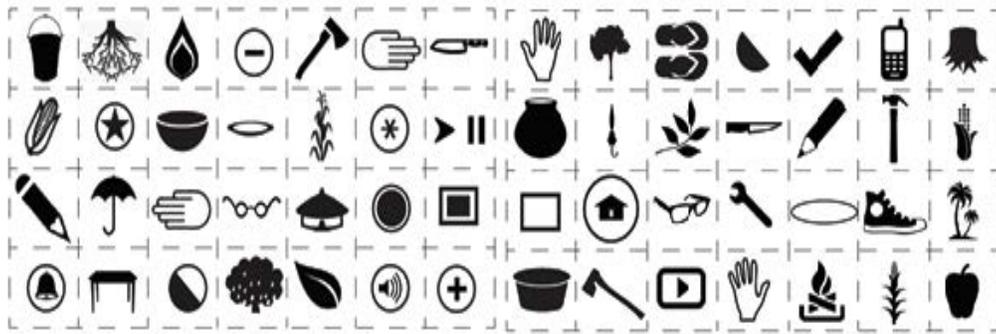


Figure 3: Pool of newly suggested icons by participants (Iteration I)

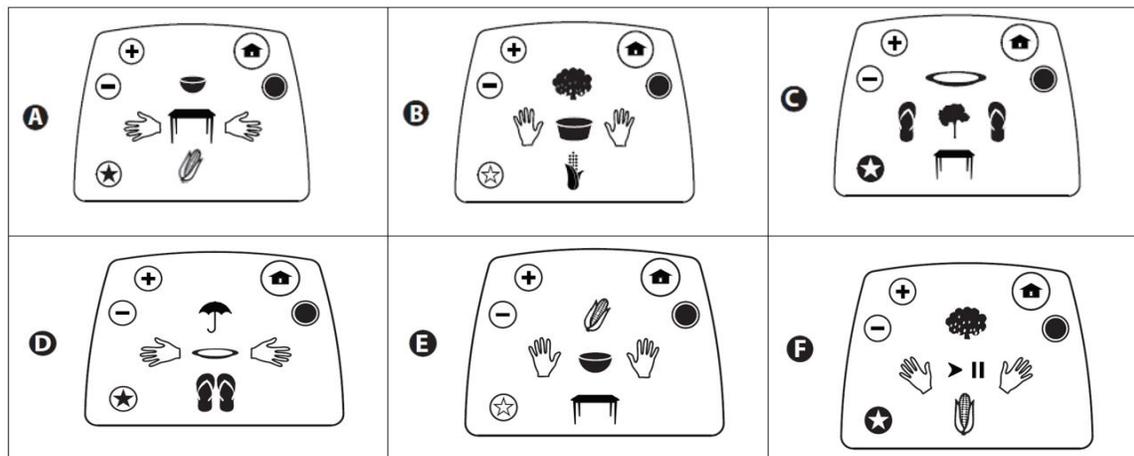


Figure 4: UI icon combinations for evaluation. From A-F, shows the different orientations of the hand icons, along with new UI icon combinations of bowls, corn, table, slippers, trees, umbrella and a star (Iteration II)

Interestingly, participants did not suggest any changes for the “plus”, “minus” and “black circle” icon buttons, though none of them had definite names in the native languages in which the audio guides were created. Participants in executing the tasks that we required of them did not require the use of these icons significantly. This most likely explains why, although these three icons had no exact names, participants did not suggest changes for them. We also noted that participants easily familiarized with the “plus” icon for increasing the volume. Some participants, however preferred the “black circle” to be referred to as “a blue moon”, and not the “*the big black circle*” as referenced by the audio guides. All the newly suggested alternate icons were designed by one of the research team members into a pool of icons shown in figure 3, using the concept of design after design discussed in [3] for prototyping.

We printed large paper copies of the pool of suggested icons in figure 3 and discussed with participants to ideate new UI icon combinations. Participants were required to make their new UI design, combining these icons and replacing them with existing icons that confused them. Several different combinations were realized and the most common combinations were designed into six UIs, A-F (figure 4). Paper prototype designs of the UI icon layouts A-F (figure 4) were then made, laminated, and pasted over

the original Talking Book UI with glue. We created new audio guides for the new icons and tested further with participants across the three study communities to finalize the UI icon combinations participants preferred and to ultimately design the new UI icon buttons combinations shown in figure 4.

5 New Icons and UI Evaluation

5.1 Old UI Icons Maintained

The “hut” or “house”, “plus”, “minus” and the “black circle” icons were retained from the old UI design. We observed that the “plus” icon was one of the icons that participants easily recognized and used quite often to increase the volume of the device. When we queried participants about replacing the “plus” icon with the “bell” or “speaker” icons that some users suggested from figure 3, most of them preferred having the “plus” icon for the simplicity in its name, as they could easily recognize and identify it as a cross-like icon.

The previous “hut” or “house” icon was redesigned to look like a modern house, with doors and windows based on participants’ input. One important improvement was to have solid black color filled shapes for the new icons rather than a thin icon boundary

outline as contained in the original UI. This solved the confusion of the “black circle” being thought of as a blue moon to actually being identified as a “black circle”

5.2 New UI Icons Introduction

The four “navigation” icons of the original UI design were all replaced with four new icons; a “tree”, two “hands”, a “bowl”, a “table” and a “star”. These were the brand new icons introduced. The next sections explain how each of these icons was arrived at.

5.2.1 The Tree Icon. The “tree” icon, used to navigate through different messages within a selected topic beginning with the first message, was one of the first icons suggested by participants. Three tree icon suggestions from UI designs B, C and F in figure 4 were considered to arrive at the final tree icon on the new UI. The “tree” in design C has no indication of fruits; while the trees icon in designs B and F have fruits illustrated by white dots. A tree icon with fruits makes it obviously a tree. Since we intended to give a unique uniform solid black-filled layout to all the icons, we designed the final “tree” icon to have the fruits hanging beneath the leaves, similar to a fruiting mango tree as can be seen from figure 1 and figure 5. Although some participants said trees with roots showing were more recognizable, overall, it was not a needed feature for the final UI tree icon.

5.2.2 Right and Left Hand Icons. The “hand” icons used to navigate across different topics such as health, agriculture or business, were very popular with both young and old participants. The “hand” appeared in all the suggested UI designs in figure 4 except in design C, where the “hand” icons are replaced with “slippers”. We needed to have two arms performing opposite functions, as you would have with two opposite “navigation” icons. However, how to position the hands was an issue. We observed that it was easier for participants to identify the “hand” icons as right and left if the icons were vertically placed as the Talking Book is usually held or placed vertically during operation. This made the “hand” icons on A, D and F unsuitable. Participants wanted the “hand” icons to be designed to match their own right and left hands, making it easier for them to identify which “hand” icon was right or left reflecting on their own hand’s position. Participants suggested the fingers in the “hand” icon be spread out to make it obviously a hand as shown in figure 5 and figure 1.

5.2.3 The Bowl Icon. The “bowl” icon is used to pause or play a message. We agreed on the final “bowl” icon considering the “bowl” icons in designs A, B, C, D and E of figure 4. Participants suggested the “bowl” icon in design B of figure 4 as a more common bowl in use today, against the bowl icon in designs C and D, which participants said resembled plates that were not common. The “bowl” icons in designs A and E of figure 4 were similar to traditional clay bowls, which participants thought were no longer common and could confuse younger users. Ultimately, the bowl icon in design B of figure 4 was selected. However, to make it more obvious and not mistaken as a water basin, participants suggested we add handles to uniquely identify it as a bowl, and differentiating it from a water basin by name (figure 5).

5.2.4 The Table Icon. The “table” icon used to navigate different messages within a selected topic beginning with the last message was popular, as the tables are very common in most families.

Every home has a table, either for a schoolchild, for dining or for some other use. Some users had a concern it could make the device look more as if it was for schoolchildren while others felt that there was no such concern since the device was meant to be a learning tool. Most participants felt that having a table as an icon depicts the educative role the Talking Book plays with the provision of health and agricultural information. Each icon had to be centered over the button’s center to optimize the actuation of the button. For all the icons, this was simple, but for the table, we had some challenges. The center of the whole table icon would put the actuation point under the tabletop. However, participants always press the table top, not the part underneath the table, which was actually the center of the whole icon. Therefore, in the final “table” icon button design, we shifted down the icon to align the top of the table with the center of the button.

5.2.5 The Star Icon. The “asterisk” that was on the original UI design and described as “*the icon that looks like a star*” was suggested by participants to be redesigned to look like the star on the Ghana national flag, as most participants were familiar with the black star in the national flag. The star also has a definite name in the native language in which the audio guides were created. It is used to record user messages into the Talking Book.

5.2.6 Audio Guide Prompts. During the evaluations, we made useful improvements to the audio guides that help the user navigate the Talking Book more easily. Previously, when the “right arrow” button was pressed after the device was turned on, the audio guide would say “*to learn about agriculture, press the up arrow, to learn from a different topic press the right arrow*” (if agriculture was set as the first topic on the Talking Book).

We observed that this was a challenge for most participants, especially aged participants without literacy. Most of such participants forgot which category they were in when listening to the instruction on the next icon to press. To improve this, we altered the audio guides to refresh participants’ memory about the current topic they were in by mentioning the name of the topic first, before proceeding with the rest of the audio guide prompts saying; “*agriculture, to learn about agriculture press the tree, to learn a different topic press the right hand*”. This improvement also helped participants to make a quicker decision to either select that topic or quickly skip to the next topic.

We also added an audio help menu as a topic dedicated to orientating what the Talking Book is about and how to use it. The topic contained instructional messages on how to perform all operational tasks on the Talking Book. Participants found this useful, particularly for new users, as they could learn and figure out how to use the device on their own.

5.3 Comparative Evaluation of New and Old UIs

In order to measure how successful the new UI icons and improved audio guides were, we comparatively evaluated participants’ success rate with both UIs (figure 5). We measured success by having participants complete three tasks with both UIs: 1) Retrieving and playing back a message from an agreed topic without any assistance, 2) Recording a message in the “user

feedback” topic of the Talking Book, and 3) answering a survey question after listening to a message.

Our estimated time for completing the two tasks was between 10-15 minutes across all user groups. Once a user was successful with these three tasks, we counted it as a success. If a user failed either of the tasks, it was considered a failure. Sixty-six (66) participants were comparatively evaluated on both UIs. Thirty-six (36) participants were randomly selected across different age and evaluated on both the old and new UIs. The participants were selected from across the three communities that were engaged in the participatory design of the new UI icons of the Talking Book.

Thirty participants (30) were randomly selected across different education level and evaluated on both the new and old UIs. The results from these trials are indicated in Table 2 and Table 3. None of the participants involved in the evaluation participated in the earlier participatory design process that created the new UI. An equal number of male and female participants were evaluated on the two UIs from across the three research communities as indicated in Table 1 of the participants’ section of the paper



Figure 5: Old and new TB UIs for comparative evaluation

Table 2: Comparative success of Old vs New UIs by Participants Age

Success with OLD UI by Age (2 participants, male and female were evaluated in each age group)				
Age Group	GOZU Community	JEFFERI Community	VING-VING Community	Total
12--15yrs	1	1	2	4
16--25yrs	1	0	1	2
26--35yrs	0	1	1	2
36--45yrs	1	0	1	2
46--55yrs	1	1	0	2
56-60yrs	0	0	0	0
Total	4	3	5	12
Success of NEW UI by Age (2 participants, male and female were evaluated in each age group)				
Age Group	GOZU Community	JEFFERI Community	VING-VING Community	Total
12--15yrs	2	2	2	6
16--25yrs	2	2	2	6
26--35yrs	2	2	2	6
36--45yrs	2	2	2	6
46--55yrs	1	2	2	5
56-60yrs	1	1	1	3
Total	10	11	11	32

Table 3: Comparative success of Old vs New UIs by Participants Education

Success with OLD UI by Educational level and Technology Exposure (2 Participants, male and female in each category)				
Category	GOZU Community	JEFFERI Community	VING-VING Community	Total
No Literacy	0	0	0	0
Primary Sch	1	1	1	3
Secondary Sch	0	1	1	2
Tertiary Edu.	1	0	1	2
Tech Exposure	2	1	2	5
Total	4	3	5	12
Success with NEW UI by Educational level and Technology Exposure (2 participants, male and female in each category)				
Category	GOZU Community	JEFFERI Community	VING-VING Community	Total
No Literacy	1	1	2	4
Primary Sch	2	2	2	6
Secondary Sch	2	2	2	6
Tertiary Edu.	2	2	2	6
Tech Exposure	2	2	2	6
Total	9	9	10	28

6 Results

Since each participant tried both Talking Books, the data consist of paired binary (success/failure) data. We are interested in testing whether the proportion of participants successful with the new UI is greater than the proportion of participants successful with the old UI. A suitable statistical test for such data is the McNemar test on paired proportions [19]. The null hypotheses is that the proportions are equal and the alternative hypothesis is that the proportion of successful participants is greater with the new UI than the old UI (i.e. a one-sided test). Due to the small sample size, the exact McNemar’s test was used (i.e. it does not rely on any approximation of the distribution of the test statistic).

Two independent datasets were collected (referred to here as the “age” and “literacy” datasets). In the first dataset, 2 participants were selected across 6 age categories (Table 1) and 3 communities, resulting in $2 \times 6 \times 3 = 36$ participants. In the second dataset, 2 participants were selected across 4 literacy levels and exposure to technology (Table 1) and the same 3 communities, resulting in $2 \times 5 \times 3 = 30$ participants. The 2 participants in each category consisted of 1 male and 1 female. The statistical analysis was performed with the exact 2x2 package of the statistical software package R [9].

The age dataset gives a p-value of 5.5×10^{-6} and the literacy dataset gives a p-value of 1.5×10^{-5} . Finally, combining the two independent data sources gives a p-value of 1.4×10^{-10} . With p-values very close to 0 there is overwhelming evidence that the probability of success with the new UI is greater than that with the old UI. These results indicate that the newly designed UI had a significant impact in the easy usability of the Talking Book across various user groups evaluated.

7 Reflections and Discussion

Though the primary goal was to change the iconography of the Talking Book and improve its usability, a number of key observations and reflections were drawn from the process, which we believe may be very useful in guiding icon-based UI design for low literacy or non-literate users.

7.1 Participatory Design Creates Value and Sense of Ownership

The original UI design of the Talking Book made the wrong assumption that the “navigation” icons would be easily usable for most populations in the developing world as they were similar standard audio iconography used with most multimedia applications, such as cassette recorders, which were not new to rural regions. However, the potential of PD was brought to bear when mundane everyday icons were the desired icons for users.

In addition, for the participants, taking part in the process gave them a sense of ownership and acceptance of the Talking Book. They felt empowered and expressed a feeling of creating the device themselves as corroborated in other PD research with rural populations [24]. This feeling served as motivation and cleared the perception that the Talking Book was another “geeky” technology only tech-savvy people could use. We believe that engaging end-users in a participatory process for rural UI design would not only help design usable technologies but will create sustainable programs, as users would accept the technology as their own creation and would continue using it.

7.2 Familiarity and Recognizability Matters, not Functional Association of Icons

We observed that the driving force for suggesting UI icons for participants was based on how easily recognizable, identifiable and familiar the icon was locally and not the function the icon should perform. As observed with the tree icon, participants wanted fruits to hang from the tree to visually and physically make it obvious, a factor in iconography Kurniawan [17] referred to as the visual, physical distinctiveness of an icon. Icon familiarity was also observed with the “plus” icon which though did not have a native name, could easily be likened to a cross which most participants were familiar with from churches and traditional culture.

Only a few participants associated one or two icons with functional meanings. This was the sense we got with the “bowl” and “tree” icons. Some participants thought that once you selected the “bowl” icon, you access messages on healthy food preparation, and others felt you would get market information about selling grains. The second thought was because bowls are used as a scale to sell grains in rural markets. With the “tree” icon, a few participants thought selecting it relays information about mangos, while others thought selecting it would give information about agriculture in general. These different functional views of icons could cause usability problems since the Talking Book provides a variety of agricultural extension messages, health messages, business and other related messages that any program design may require. Though a few participants had these icon-function

orientations, overall we did not find a strong association of relating an icon to what its function could be. Majority of participants said it was only important to easily identify the icons from the audio guides with one user commenting: *“The Talking Book with the hands is easier to use, I always know which icon to press...”*. For non-literate and rural users, an essential consideration of iconography design would be concrete simple, object icons that participants are familiar with mundanely, culturally or societally with a simple non-ambiguous name.

7.3 Iconography Can Create a Perception for the Technology

During the UI design, even though some UI icons were popular, they could not be selected. For example, the “slippers” icon, though common, could not be selected because it gave a perception that the Talking Book was a toy for children, according to the views of some adult participants. This viewpoint could be because kids play around with old and worn-out slippers and use them to create toys. The “umbrella” icon, which was also popular and well known, could not be used because it had political connotations and could potentially link the device to a national political party that has the umbrella as its symbol. A couple of participants cheekily asked if Talking Book was from the National Democratic Congress party (the party in government at the time), on seeing the “umbrella” icon on some of the prototype UIs.

It was also interesting how some participants associated the Talking Book as an educative technology because of the “table” icon. As observed by Davis [7], the acceptance and use a technology is a factor of a user’s subjective norms, and can be fueled by perception. Similarly, iconography can create a strong perception about a technology. Thus, in choosing icons for UI designs, care must be taken about what perception and mindsets the icons reflect on the users as this can affect the adoption and use of the technology.

7.4 Audio Guides must be Explicit and Unambiguous

Also, for rural technologies that use audio guides, user instructions must be explicit and should include quick reminders to help guide users as observed by Medhi et al [21], and Plaque & Prabaker [33]. We observed that most non-literate users could not remember the last topic they had heard when navigating between topics. This was more pronounced with older users. Usability with the new UI improved for users without any literacy due to the improvement in the audio guide prompts and the easy identification of the UI icons. One of the fundamental usability challenges was the lengthy audio guides that confused users. Thus, explicit audio user instructions are important for easy usability with icon-based UIs that use audio guides.

7.5 Limitations and Future Works

We acknowledge that the use of one UI before the other during the comparative evaluation of the new and old UIs could potentially bring about the issue of learning bias. However, irrespective of whichever UI a participant started with, the results

always showed that participants were more successful with the new UI as there were several instances where a participant who started with the new UI and were successful, still failed with the old UI. This suggests that the effect of bias could not have significantly altered the outcome of successes. In addition, the UI icons were different, and audio user guides that identified them were different as well, as shown in figure 5.

We also acknowledge that our research did not involve a rigorous icon evaluation as is typical in some user experience design research. We did not rigorously evaluate each icon, and measuring the number of failures, attempts before successes etc. The objective of our research was to develop a UI that was usable by the different user groups of the Talking Book. The challenges that necessitated the redesign of the UI of the Talking Book solely had to do with the UI icons and the audio guides, and not with the fundamental design of the device. Thus, our research focused on these two issues.

Our future research will try to understand how the new UI icons are received by different cultures across Ghana and Africa, with the Talking Book being piloted in East Africa. The results from this study show that the Talking Book requires localization and contextualization of its UI icons across different cultures. However, as the Talking Book coverage expands, we will observe which UI icons reflect universality across different cultures and why.

8 Conclusion

While it might be argued that it would have been desirable to start from scratch, there are always pragmatic issues to consider in design, such as the cost and resources available to do so. Worldwide, people adapt and appropriate technologies designed and manufactured elsewhere, particularly when the core technology design and manufacturing facilities are not available to them. Interface redesign, as opposed to whole product redesign, is a necessary endeavour that can improve the existing design and help to foster reflection on how a design that has greater scope might be done in future. For example, rather than only exploring icons through PD ideally designers would begin by exploring with communities the problem to be solved, the 'top level' content needed and culturally or linguistically suitable ways for how it might be represented, segmented, arranged and packaged. We reflect that even when PD does not have the opportunity to start from the beginning it is still a worthwhile endeavour.

Through this research, we were able to redesign and customize the iconography of the Talking Book for three culturally diverse user groups in Ghana. The new UI design improved the usability of the Talking Book across non-literate, low literate and aged users. We also noted the enormous potential PD has for improving, customizing and adapting Iconography and UI design, especially for rural and non-literate users, as buttressed by this research. UIs designed without user PD can affect the ease of use and adoption of most ICT intervention systems designed for rural people. Researchers and designers will have vast icon choices when they include end users in the design loop of icon-based UI for rural use. Also, our reflections based on this study suggests that, for icon-based UI design with rural technologies, researchers

and designers need to collaborate in choosing icons that are familiar with users, consider the perception sets the choice of icons could create for the technology and create explicit audio guides for easy usability.

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