

Research Article

Impact of Low-Cost, On-Demand Information Access in a Remote Ghanaian Village

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Abstract

Technology projects increasingly provide information to people living in rural poverty. However, using information to affect health or farming practices requires overcoming unique challenges, including illiteracy and lack of electricity. This article examines the effects of a low-cost audio computer (“Talking Book”)—a handheld device enabling users to create, listen to, and copy recordings—for improving learning and knowledge sharing in such environments. In northern Ghana, we studied the impact of giving rural people on-demand access to guidance created by local experts. Our evaluation shows Talking Books significantly impact learning, behavior change, and crop yields in a village with low literacy rates and no electricity.

Introduction

Accessing information in developing countries is challenging for the nearly 1.5 billion people who live without electricity (Legros, Havet, Bruce, & Bonjour, 2009) and the 752 million who are illiterate (UNESCO, 2009). The majority of these people live in hard-to-reach rural areas with inadequate roads (Legros et al., 2009; UNESCO, 2005). Information about farming techniques is particularly important because agriculture is a major source of livelihood for most rural people, although they often rely on rudimentary methods (World Bank, 1990).

Agricultural extension interventions illustrate the difficulties in reaching these farmers. Agents travel to villages to increase the productivity of farmers. However, extension services face obstacles, including limited staff who must reach large numbers of geographically dispersed farmers. Agent-to-farmer ratios are extremely high—as high as 1:6,000 in Ghana (GhanaDistricts.com, 2010a)—and the majority of small, marginal farmers worldwide receive only one-third of all extension resources (Feder, Willett, & Zijp, 2001). For the small fraction of rural farmers who are reached, visits are often inadequate for many reasons, including underskilled agents with limited accountability (ibid.) and the inability of illiterate farmers to take notes.

The “Talking Book,” a low-cost audio computer developed by Literacy Bridge, enables local experts to reach remote, rural people with accessible information. The Talking Book is a handheld, durable battery-powered device that enables users to create and listen to audio recordings and copy recordings between devices. It was specifically designed to meet the needs of illiterate rural people without electricity, enabling them to listen to information repeatedly and on demand.

This article reports the findings of a pilot program in a rural village in

Ghana. Local experts recorded farming techniques, health guidance, and other educational information onto 21 devices allocated among residents by a committee of local leaders. The pilot evaluated the feasibility of providing rural villages with health and agriculture information via Talking Books and the effect of the devices on crop production.

1. Related Work

Our focus is on how the illiterate poor in remote areas can learn new health and farming practices—a much narrower problem than is “serving the rural poor with information.” In this section, we compare and contrast ICT projects in this broader category with the Talking Book.

1.1 Mobile Projects

Applications of mobile technology have shown promise for information delivery, particularly with time-sensitive information such as weather, commodity prices, and job postings. SMS has been used to serve literate populations (e.g., <http://www.esoko.com>), while operator-based and interactive voice response projects have attempted to target illiterate people (e.g., Agarwal, Kumar, Nanavati, & Rarjput, 2009; <http://questionbox.org>; <http://freedomfone.org>). However, the form factor and cost structure of mobile solutions present significant challenges to learning scenarios. To affect behavior change, users often must access learning materials multiple times (Chu et al., 2009; Gandhi, Veeraghavan, Toyama, & Ramprasad, 2007), which requires either an unaffordable smart phone or repeat network calls on a basic phone, each call spanning the duration of the lesson. Mobile network rates across sub-Saharan Africa, in particular, put this option out of reach for many. In 2010, the lowest rates exceeded US\$0.20/minute in Kenya (MobileActive.org, 2010a), Nigeria (MobileActive.org, 2010b), and Uganda (MobileActive.org, 2010c). Also, handset energy costs and recharging logistics in villages without electricity may be manageable for accessing small pieces of information, but are less feasible when using a handset to replay audio lessons, especially for learning in groups.

1.2 Radio

The accessibility and affordability of radio provide potential for distributing development information in poor areas (e.g., Panford, Nyaney, Amoah, &

Aidoo, 2001). However, the transmission costs and barriers to open access present limitations to learning, particularly in regions with low densities or multiple languages. Learning content must compete for airtime against music and religious programming.

Community Radio (CR) offers an alternative by focusing on societal issues. In countries with progressive CR regulations, repeated, one-way distribution of learning content is proving feasible in urban and dense rural regions (e.g., Hussain & Tongia, 2007, 2009). Many CR stations accept mobile calls from listeners to add a participatory element (Hussain & Tongia, 2007; Sterling, O’Brien, & Bennett, 2007).

One prior study describes a “rural” CR station with 800,000 listeners in South Asia (Hussain & Tongia, 2007). However, this number of listeners would not be possible in many sparsely populated, rural regions worldwide. For example, the Upper West Region of Ghana covers 18,478 square kilometers and has a population of 576,583 (GhanaDistricts.com, 2010b). With Ghana’s 25-km limit for CR transmission, a typical station would reach about 61,000 listeners in the Upper West region, making it much less cost effective. Another shortcoming of content distribution by radio is the difficulty of collecting metrics on listening statistics and user ratings.

1.3 Infomediaries

Some programs place technology in the hands of a mediator or community knowledge worker—an infomediary who is educated enough to use the technology, but does not need to be an expert in the domain (Gandhi et al., 2007; Grameen Foundation, 2010). This spreads the technology costs over a large number of beneficiaries. More research is needed to better understand these costs relative to the impact on behavior change (i.e., adopting new practices).

1.4 Other “Featherweight” Devices

Other low-cost audio devices have been deployed and evaluated for rural information access (Chu et al., 2009). Devices such as the “Speaking Book” from Books of Hope are affordable (US\$9–\$10), but are limited to 5–15 minutes of audio that cannot be updated. Nor are these devices conducive to locally produced content on a small scale; the minimum order to produce a new Speaking Book is 5,000 units (<http://www.booksofhope.com>).

Global Recording Networks offers a hand-wind



Figure 1. *The Talking Book.*

digital player called the Saber, which is designed for rural use (Global Recordings Network, 2010). Its audio can be updated from a computer, but it has no microphone for direct recording. Its price puts it out of reach of individual ownership; the bulk purchase price is US\$45 each for missionary use and US\$65 for other uses. Commercial digital recorders fall into a similar price range and are less robust (e.g., <http://www.olympusamerica.com>).

None of these options provide the flexibility for audio to be recorded and copied from one device to another without additional hardware or infrastructure. Nor do they include interactive applications or customizable audio instructions for the local dialect.

2. The Talking Book Program

2.1 Contextual Challenges and Resources

Between July and September 2007, members of the research team conducted initial fieldwork to identify the challenges and resources associated with knowledge access within the poorest and most remote region in Ghana: the Upper West Region. This research drove design requirements for the Talking Book device, the content management software, and the associated intervention. Further visits in 2008 allowed for testing and redesign.

Challenges included lack of electricity, lack of formal education for most adults, and multiple languages spoken in the same districts. However, a key resource that was identified was the number of local organizations with experts in applicable areas who spoke the local languages and were familiar with the knowledge and oral culture of the communities. This resulted in requirements for a simple battery-powered audio device with content that could be easily translated as needed by local organizations

and with the capability for anyone to create new content and share it with others.

2.2 Device

The Talking Book (shown in Figure 1) allows users to play, record, and categorize audio recordings and to copy those recordings directly to any other Talking Book.

2.2.1 Navigation

When the device is powered on, spoken instructions lead users through the audio user interface. Users access audio recordings by listening to audio prompts that guide them through the available categories; they respond with key presses, similar to how one would use a touch-tone interactive voice response system. The Talking Book provides a feature to create new translations of these prompts through an “expert mode” that is hidden to simplify the interface for most users. Each device can be loaded with multiple system languages.

When users start the Talking Book, they are greeted with a welcome message and then told to press the right arrow to choose a category. Pressing the left and right arrows navigates back and forth through categories, although the voice prompt does not refer to the left arrow to keep the instructions short and simple. The list of categories might include “agriculture,” “health,” “education,” and “stories” (see section 4.2 for examples of messages and categories used in the pilot study). Organizations create these categories or reuse existing categories (to suit their needs) through either the “expert mode” interface or via a PC-based application that configures Talking Books via USB. Only one category is fixed: the “Talking Book” category, which is a built-in audio instruction manual.

Within a category, pressing the up and down arrows rotates through individual messages. The audio prompt for this action is carefully worded to avoid abstract concepts like being “in a category” (e.g., “Press the up arrow to listen to messages in this category”). Instead, the prompt for the farming category is: “To listen to messages about farming, press the up arrow.”

This navigation structure of categories on one axis (with left/right arrows) and messages on the other axis (up/down arrows) avoids presenting the user with information hierarchies, which were found to be too difficult to navigate for users having no formal education. However, this also limits the number of easily accessible messages to approximately

150 at any one time (typically 10 categories, with about 15 messages in each category). Periodic content updates from other Talking Books can mitigate this limitation by continuously replacing old content with new content.

2.2.2 Features

Users can create their own recordings in any category by pressing the asterisk (or “star,”) after navigating to that category. However, based on feedback from local partner organizations, individual categories can now be locked to ensure some messages are easy to find without interference from accidental recordings.

During or after message playback, the user can press the black circle to choose whether to delete the message or copy it to another Talking Book (by connecting its built-in USB cable to the other Talking Book’s USB receptacle).¹

The Talking Book also supports programmable interactive applications, such as multiple-choice quizzes and embedded “audio hyperlinks,” which allow users to optionally interrupt a message with another short audio clip that might elaborate on a subtopic. However, these features were not utilized in the pilot study to be described.

2.2.3 Specifications

The Talking Book is 12 × 12 × 6.5 centimeters and weighs 225 grams without batteries. Two zinc-carbon, size-D batteries power the device and are sold in rural markets throughout Ghana for US\$0.35–\$0.40. These batteries supply 10–15 hours of typical use, requiring an annual expense of between US\$0.50–\$1.00 per capita (ongoing engineering improvements are expected to double energy efficiency). A built-in speaker enables group listening, while using earphones conserves power. Recordings are stored on an internal microSD flash memory card that provides 35–140 hours of capacity. To improve robustness and affordability, the device has no display.

2.3 Content Management Software

The Talking Book enables development organizations (governmental, nonprofit, and for-profit) to share information with rural communities—typically, information that teaches new practices, but that

also requires repeated listening due to its complexity. The Talking Book also enables rural people to share information with each other and provide recorded feedback to development organizations.

An audio content management (ACM) application enables organizations to arrange recordings by language and category (e.g., livestock diseases or malaria prevention) and track aggregate usage statistics and user ratings for each recording. However, the ACM was not utilized during the pilot study described here.

The Talking Book and ACM work together to allow local organizations to manage content and learn how to improve the content by analyzing usage statistics and user feedback.

The Talking Book tracks each time a message is started, each time a message is listened to in full, and each time one listener gives a copy of the recording to another user. When the ACM is connected to a Talking Book, it imports these statistics and reflects the usage of that Talking Book, as well as the usage of every other Talking Book that was at one time connected to it (devices exchange usage statistics every time they are connected).

While usage statistics can give the content author a sense of what is popular, it does not measure whether users are learning and applying what they have learned. To help answer these questions in any given project, the Talking Book provides users the option to answer a survey question after each message, such as “Do you plan to apply what you have learned from this message?” or “Was this message helpful to you?” This allows the ACM to reflect the number of times that users indicated they would apply what was learned and the number of times users thought the message was helpful.

The Talking Book also prompts users after each message to record their feedback about the message, which is then linked, through metadata, with the message that the user was responding to. These feedback messages can be imported into the ACM for review alongside the original message.

2.4 Program

The Talking Book was designed for development organizations to integrate them into their programs to address local needs and context. Our general the-

1. Aside from deletion and copying, other message-specific options (not implemented during the pilot study) include survey questions to log if the user intends to apply what was learned from the message and the ability to record feedback or related ideas about the message.

ory of change is as follows: (a) Residents listen to the recordings, understand the information, and retain the knowledge; (b) they trust the information and find it interesting and compelling enough to change their current practices; and (c) application of the knowledge results in improved livelihood (e.g., better agricultural practices cause increased yield; malaria prevention techniques lead to fewer mosquitoes and outbreaks).

In this process, the Talking Book provides a low-cost way to make locally relevant knowledge available when it is needed and helps content authors learn which messages are most effective.

To maximize the intended outcomes, the implementing organization must first understand the existing levels of knowledge and resources in the communities and why the optimal practices are not currently in use. Next, engaging and informative audio messages must be designed, created, and tested. In the health domain of behavior change communication, a compelling and possibly entertaining message may be necessary to overcome the typical lack of motivation associated with changing an existing behavior to prevent a possible negative consequence. In the agricultural domain, an entertaining message may not be needed—a clear and simple set of steps may be enough to eventually lead most farmers to try a new farming technique. This is especially likely if they can test it on a small parcel of their land, see a positive result within months, and have their neighbors also observe this difference (Rogers, 2003).

Maximizing the intended outcomes also requires planning the Talking Book allocation with consideration for accessibility by opinion leaders and all members of a community. Allocation plans should also consider the frequency of access required for the type of knowledge, depending on whether the purpose of the message is to raise awareness of an idea versus to provide technical information for reference.

3. Pilot Study Overview

A pilot study investigated the impact of a program with the Talking Book in a small village named Ving Ving in the Upper West Region of Ghana. Ving Ving is part of a district of 100,000 people, 95% of whom live in rural areas (GhanaDistricts.com, 2010c). There is no access to electricity, almost all

roads in the district are unpaved, and many roads close during the rainy season. Approximate demographics include the following:

- Population: 970 people, 98 households
- Adult educational level: 77% never attended any school
- Child Education: approximately 450 children of primary school age, with about 200 actually attending school
- Occupation: 100% subsistence farmers
- Main crops: maize, beans, groundnuts, millet, guinea corn, rice
- Agriculture extension visits: once per year
- Access to technology: 10% owned radios, 1.5% owned mobile phones. Weak reception of a single GSM network was available in portions of the village; no data service

In January 2009, local village leaders provided information about their needs, and local experts in agriculture, health, and education produced the relevant Talking Book content.

3.1 Program

During January 2009, a series of four community meetings launched the pilot study. The chief and elders agreed to host the program and create a committee of leaders. The role of the committee was to support the residents, including training new users and managing the devices. Members of the research team trained committee members to use the devices in two sessions, each lasting two hours. None of the participants or content producers were compensated for their involvement. The first meeting was led by local leaders, two members of the research team, and the director of the local Ministry of Food and Agriculture (MOFA) office.

From February through July 2009, one member of the research team made nine visits to the community, each lasting less than two hours. During these visits, he met with local leaders to answer questions, receive feedback, update the device's firmware, and replenish the supply of batteries to be used with Talking Books. The rainy season began in April. In June, additional messages from the MOFA office were added to the device.

In August 2009, the research team visited the community to conduct qualitative, semistructured interviews to ascertain the extent to which users felt

comfortable using the devices, the typical knowledge retained, and the application of the guidance. The team also visually inspected farms where knowledge was applied.

Most harvesting took place in November 2009. In December 2009 and January 2010, the research team conducted quantitative surveys to determine changes in crop production and assess to what extent other factors may have affected production, aside from any changes in farming practices due to the Talking Book.

A total of 21 devices were localized into Dagaare, the local language of Ving Ving. Each device was preloaded with recordings outlined in the content section that follows. Literacy Bridge funded the devices, which were produced in a lot of 100 units at a unit cost of US\$105; unit costs fell to US\$32 in 2010 with a production run of 1,000 units.

Distribution of the devices was left up to the leadership committee. The research team set a requirement that the devices were to be exchanged frequently and fairly (e.g., regardless of gender and social class). The committee discussed options and decided on the following: If a resident wanted to use the device, he or she would approach a committee member to borrow a device for a specified time, up to a maximum of six days.

The village's pilot committee members conducted user training. Over time, however, residents taught each other through peer-to-peer training that consisted of showing the new user how to turn on the device and explaining that they should listen to the instructions that would guide them through both listening to and recording messages. Some peers would also explain a subset of the buttons to provide a little more information. With this guidance alone, users could operate the device immediately upon turning it on and listening to the instructions.

3.2 Content

Local experts from MOFA, Ghana Education Service, and Ghana Health Service recorded information on the Talking Books. The 27 messages ranged in length from 30 seconds to seven minutes and totaled 58 minutes. The categories included: agriculture, health, and stories. Information about the content in each of these categories is summarized as follows:

Agriculture content included

- **Fertilizer.** The importance of using animal manure as fertilizer; keeping animals in a confined space to collect their droppings; where to obtain subsidized industrial fertilizer and when to apply it.
- **Soil Preparation.** Creating beds or plow lanes (versus making mounds) for better moisture retention and more efficient use of soil; using a tie-ridge pattern to reduce soil erosion.
- **Planting.** Which month to plant each crop; crop-specific seed grouping and spacing; weeding after planting.
- **Livestock.** How to prevent, detect, and care for sick animals; cleaning animal pens every day to prevent disease.

The messages were spoken in an informal and conversational style by the same MOFA staffers whose jobs required them to convey this information in person. The local MOFA staff members were solely responsible for determining what messages would best complement the existing knowledge and resources in the community. The following excerpt demonstrates the style and detail:

When you finish clearing your farm, the next thing is to find the crops that you would like to plant, and we have them in our office. But if you buy them from the market or from a fellow farmer, you should test them before sowing. Sow at least 10 seeds in a pot or a small box to see if they will germinate and, if they all germinate, know that you have bought good seeds, and if some fail to germinate, it means there's a problem. If about 60% to 90% germinate, then you should sow them at two to three seeds per hole, but we usually prefer two per hole, especially maize, guinea corn, millet, and beans. When you finish sowing, though the days are not over yet, there are certain crops that we should not sow during the month of July. You all know that if you sow crops like maize, guinea corn, [or] millet in July, they will not do very well, but you can still plant crops such as bambara beans, and certain types of beans can still be planted. (Talking Book message recorded by local MOFA staff member, Ghana, March, 2009)

Health content covered nutrition, antenatal care, and health for children under five. Specific topics

included monthly antenatal guidance, an overview of a balanced diet, and sanitation best practices.

Education content included poems, textbook excerpts, and educational storybooks. Topics ranged from community development to solar energy. Recordings of numbers and the alphabet were included to allow students to practice along.

Stories content included local narratives focusing on tradition, culture, and morals. Some recordings were humorous.

4. Evaluation of Device and Program

4.1 Methodology

In August 2009 and January 2010, the research team conducted 37 semistructured interviews with 23 men and 14 women. Questions addressed training, usability, device allocation, knowledge retention, adoption rates, and crop outcomes. The 30–90 minute interviews were conducted in households and in common village areas. A further eight informal video interviews were conducted with five men and three women in which users spoke more freely about their experiences. The research team interviewed the farmers in the local dialect and translated their answers into English.

4.2 Results

4.2.1 Initial Exposure

In general, residents were interested and excited to use the devices. Witnessing peers use the devices and word-of-mouth seemed to play a large role in the initial acceptance. Residents reported discussing the device and the information among each other and with residents in other villages.

The most common requests for additional or different features included lights for use at night, more pronounced buttons for the blind, an embedded radio, solar or rechargeable power, and a smaller pocket-sized version.

4.2.2 Training

A peer or the leadership committee taught residents. Literate residents or residents in school seemed to learn quickly, while illiterate residents required more training to understand how to navigate the audio instructions. Children learned at an impressive rate, typically requiring the least training.

Illiterate users usually required less than 45 minutes of training to be comfortable with listening and recording messages. However, the leaders reported it was common for residents to forget portions of the training the following day.²

4.2.3 Allocation

Despite our equity goals, devices were not used or allocated equally across genders and ages. The devices reached an estimated 34% of households in the village. However, we do not have an accurate count of household members using the devices. Men and schoolboys used the device most often. Women and the elderly used the devices least. The primary reasons that inhibited use included the following:

- Limited awareness by households on the periphery, which reduced the potential uptake, compared to the strong interest in the central part of the community. A few residents thought the devices were only meant for literate people or just for the committee; others were unsure how to obtain a device. However, there was strong interest from those who did not use the device: Of 35 nonusers interviewed, 33 said they wanted to use the device.
- Many residents said there were not enough devices to go around and requested more devices so that more people could benefit. There was one device per 47 residents.
- Some were intimidated because they thought the technology was too complex and feared breaking it.
- Some were hesitant to approach the committee because of existing social dynamics. This seemed to apply mostly to women and the elderly.
- Some thought they would have to purchase batteries if they borrowed a device from the committee; however, the committee seems to have made it clear to those who did approach them that this was not the case.
- When asked about alternative allocation solutions, some residents suggested equally dividing the devices between genders and/or geographic sections of the village.

2. These observations led to changes in the audio user interface that has resulted in new users demonstrating competency for critical tasks with 5–10 minutes of training.



Figure 2. Farmer showing maize planted without animal manure. Picture taken August 2009.



Figure 3. Farmer showing maize planted with manure obtained from confining his animals, as instructed on the Talking Book. Picture taken August 2009 (same day as Figure 2).

Based on these interviews, we believe greater impact and equal distribution could have been achieved by working with a more diverse group of users to market the program. Instead, the pilot program relied on the committee to spread the word. Although the committee as a whole was representative of the community’s demographics, in terms of gender, education, and geography, the most active members were not representative.

4.2.4 Usage

Usage varied greatly, but users typically checked out the devices in one-week increments and reported listening to the device a few times during the week, often in groups. Women commonly reported listening to the devices after dinner with their children. There were some reports of men not sharing the devices with their families.

Some users recorded their own messages, which were later heard by other users of the same devices. The most common local recordings were stories that taught morals and concerns about local injustices (e.g., how it is wrong that some girls are forced to elope). Many residents enjoyed recording music or programs from the radio to listen to at a later time.

As long as the content was refreshed, either by the research team or through new local recordings, no apparent drop in interest was observed. We believe the novelty of the audio messages was a stronger force than was the novelty of the device itself, suggesting the importance of refreshed content, including local community recordings, but this requires more study.

4.2.5 Learning and Behavior Change

When asked if they had learned anything from the device, a resident’s ability to recite specific details about the health and agriculture guidance confirmed that they had indeed learned and retained the information. Some 91% of residents using Talking Books in their homes (32 of 35) said they had applied a new health or agricultural practice. Some farmers said they did not apply portions of the guidance because they could not afford to do so (e.g., purchasing fertilizer).

In some cases, agriculture guidance was not completely new to a farmer; but behavior change appeared to result when the farmer learned why particular techniques were more effective than were others and how to apply these techniques most efficiently. Even then, 71% of people applying the guidance chose to test it on only a portion of their land. This reduced their risk and allowed them to compare the recommended practice with the traditional practice. Figure 2 and Figure 3 show the results (respectively) of following the traditional farming practice and of applying the Talking Book guidance to a portion of one farmer’s land.

In addition to people who borrowed Talking Books for use in their home, we surveyed 12 other residents who had either learned about the guidance from a neighbor or who had used a Talking Book outside of the home. Only 6 of the 12 had applied what they had learned.

The following two quotes demonstrate the



Figure 4. A Talking Book that had been disassembled by a user.

enthusiasm that farmers had for the information provided by the local agriculture extension office:

What I learned from the Talking Book is about farming. . . . Before this device, I usually sowed my groundnuts in July (instead of June) and I never get a good yield like this, but this year, since I listened to these teachings in this device and planted my crops early, I am very pleased with the prospects of the harvest. It is far better than what I usually get. (Interview with Talking Book pilot program participating farmer, Kamingtanye Gervaise, Ghana, August, 2009)

It taught me that we can plant the crops in beds and lanes, that those methods increase the amount of crops per land area compared to mounds, which waste land and take up a lot of space. Beds also help accumulate water, prevent erosion, and keep the soil within the farm moist. The beds actually make a big difference in terms of keeping the soil moist. Mounds are too high from the ground and they dry up very fast, and our crops suffer during insufficient rainfall. Now, we can still smile during short periods of draught because planting in beds keeps the soil moist for a little while. Since I heard that from this device, I tried it this year, and I am a woman, but people exclaim whenever they see my crops in the farm, and I just keep my mouth shut because I know the harvest is going to be good. (Interview with Talking Book pilot program participating farmer, Dakurah Suglo, Ghana, August, 2009)

4.2.6 Content and Trust

Farming was by far the most popular category, followed by health. Residents were asked whether there was guidance that they did not trust. Of 24 users, 22 said they trusted every message on the

device. Many spoke of how they had never heard of modern practices, and a key component of their trust was that a local authority recorded the messages. The high level of reported trust may also be due to the timing of the survey—many had already applied the guidance and seen the initial results. One farmer said he did not trust the guidance for millet, but that he would adopt it if he saw that it worked for a friend. Another farmer said he did not trust the vaccination messages because he followed the guidance for his fowl and his goats, but all of them still died.

4.2.7 Durability and Maintenance

Throughout the year, the Talking Books became dirty and worn, but no device had a broken or cracked exterior. One device had apparently been disassembled by a user and left in the mud before being reassembled (Figure 4). Dried dirt covered the circuit board, yet the device still functioned properly.

During the pilot study, an electrical design flaw was discovered that caused some users to lose recordings every 2–4 weeks due to file corruption on the memory card. In some cases, devices were rendered inoperable until our staff reformatted and reloaded the card. This technical design problem was fixed after learning about the flaw during the pilot.

4.3 Limitations

The findings may have been biased by the selection of residents interviewed, which was, at times, provided by the village's leadership committee. To mitigate positive bias, researchers emphasized that feedback would be used to improve future pilot programs and would not affect how many devices were brought to the village. In addition, some of the interviews were conducted while American volunteers were present, which may have positively influenced respondents' actions and answers.

5. Evaluation of Crop Production

We collected quantitative data on crop production following the November 2009 harvest using a between-groups design. The interviews took place in January 2010, some 12 months after the Talking Books were introduced.

5.1 Methodology

Thirty-three surveyed farmers had access to information from the Talking Book either by using the device inside or outside their home or by learning

about the messages from a neighbor. We refer to this group as the “treatment group” or “Talking Book users.” Another 40 surveyed farmers did not have access to information from the Talking Book; that is, they neither used a device nor heard about the messages it contained. We refer to this group as the “comparison group” or “nonusers.” This is a nonequivalent control group because users self-selected into the program by checking out a device.

The research team administered 30- to 60-minute interviews using a survey questionnaire. Interviews were conducted in the local dialect, and answers were recorded in English. Information was collected on the following measures:

5.1.1 Crop Production

We asked each farmer about the number of bags³ they harvested in 2008 (the previous year) and in 2009 (the current year) for millet, maize, beans, and groundnuts. We computed total crop production for each farmer in each year by summing crop production for these four crops. Farmers often decide to shift their allocation of land, labor, and other factor inputs between different crops each year. Therefore, total crop production is the dependent variable used to evaluate the impact of exposure to information on the Talking Book. Crop production for each farmer in 2008 was used as a control variable.

5.1.2 Change in practices and inputs

Of each of the four crops, we asked about changes in practices from 2008 to 2009 for the following factors: human labor, land farmed, animal labor, use of pesticides, and use of fertilizer. For each answer, the response was coded as: -2 (*large decrease*), -1 (*little decrease*), 0 (*no change*), +1 (*little increase*), or +2 (*large increase*).

For example, a farmer reporting that the amount of human labor used to farm millet did not change from 2008 to 2009 would be assessed as a 0. We computed total changes in these factors for each farmer by summing changes across all crops.

5.1.3 Demographic Information

We also collected data on several demographic variables, including the farmer’s age, gender, years of schooling, and neighborhood within the village.

5.2 Results

Surveys were collected from 73 farmers. Four farmers were excluded from the analysis due to concerns

about the accuracy of the data. Two additional farmers were excluded after identifying these cases as extreme outliers. The means and standard deviations of all variables are provided in Table 1 for both groups. The average total crop production for farmers in the comparison group declined from 2008 to 2009 by approximately two bags, while the average production for Talking Book users increased by approximately three bags. Paired sample *t*-tests showed that the Talking Book group significantly increased total crop production ($t[28] = 3.79$, $p < 0.01$) from 2008 to 2009.

Independent *t*-tests show that there are no significant differences in the 2008 crop production reported by farmers between the comparison and treatment groups. This suggests that the two groups were not different in terms of crop production prior to the intervention. We also found no significant difference between the groups in education, gender, or geographic region. However, farmers in the treatment group were younger on average than were farmers in the comparison group ($t[61] = 2.21$, $p < 0.05$). This is consistent with our qualitative research, which showed younger residents were more likely to check out the devices.

Lastly, the difference between the groups on *change in pesticide use across all crops* was very close to significance ($t(60) = -1.90$, $p = 0.06$). At a marginal level of significance, Talking Book users increased their use of pesticides from 2008 to 2009 more than did nonusers. This provides limited evidence that the recordings on the Talking Book explaining the importance of pesticides made a difference in pesticide use for farmers in the treatment group.

We further compared the two groups using an Analysis of Covariance (ANCOVA) with total crop production in 2008 as a covariate in a standard pretest-posttest design. The results in Table 2 show that exposure to information on the Talking Book significantly increased total crop production in 2009 ($F = 13.48$, $p < 0.001$) after controlling for crop production in 2008.

5.2.1 Regression Analysis for Total Crop Production

To understand how Talking Books impacted crop production relative to other measured variables, Table 2 provides regression estimates with *total crop production 2009* as the dependent variable, while

3. A bag can contain approximately 190 liters of crops.

Table 1. Descriptive Statistics of the Comparison and Treatment Groups.

	Comparison Group			Talking Book Group		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation
Crop production 2008	38	17.01	16.05	29	13.80	10.10
Crop production 2009	38	15.16	13.64	29	16.66	10.03
Δ crop production	38	-1.85	5.81	29	2.85	4.05
Percentage change in crop production	38	-0.05	0.40	29	0.48	0.73
Δ human labor across all crops	35	3.20	3.60	27	2.74	2.58
Δ animal labor across all crops	35	0.57	1.79	27	0.74	1.26
Δ pesticide use across all crops	35	0.46	0.85	27	0.89	0.93
Δ fertilizer use across all crops	35	0.34	1.00	27	0.37	0.97
Δ land use across all crops	35	1.31	3.92	27	1.56	2.45
Gender (0 = Male; 1 = Female)	38	0.13	0.34	29	0.14	0.35
Age	35	45.34	15.85	28	37.07	13.22
Number of years of schooling	32	0.88	2.15	25	1.68	3.11

Table 2. Regression Estimates for All Crops Production 2009.

Variables	Model	
Intercept	2.67	(3.52)
Region 1	-0.28	(1.75)
Region 2	-0.74	(1.60)
Gender	2.09	(1.87)
Age	-0.07	(0.05)
Number of years of schooling	0.09	(0.30)
Crop production 2008	0.80**	(0.06)
Δ human labor across all crops	0.14	(0.24)
Δ animal labor across all crops	0.42	(0.57)
Δ land use across all crops	0.16	(0.22)
Talking Book information	2.75*	(1.35)
N	57	
df	46	
F	36.72***	
Adjusted R ²	0.86	

Notes: Unstandardized coefficients with standard errors in parentheses.

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

controlling for the effects of *crop production 2008*, *region*, *gender*, *age*, *number of years of schooling*, *changes in human labor*, *changes in animal labor*, and *changes in land use*. Crop production 2008 is a significant ($B = 0.80$, $p < 0.001$) predictor of crop production in 2009. None of the other control

variables are significant. Access to Talking Book information is a significant ($B = 2.75$, $p < 0.05$) predictor of total crop production in 2009 after controlling for all other factors.

These results suggest that—after controlling for the effects of 2008 total production, changes in human labor, changes in animal labor, changes in land use, the age of farmers, the number of years of schooling, the region, and gender—farmers with access to information from the Talking Books produced 2.75 additional bags of crops compared to the crop production of nonusers. The approximate value of these additional bags was US\$89, based on market prices at the time of the survey (just after harvest, at relatively low prices). This represents, on average, an 18% increase in overall crop production for 2009. However, for many farmers in the Talking Book group, an additional 2.75 bags represents a lot more than an 18% increase.

Figure 5 shows the percent change in total crop production from 2008 to 2009 for each group. Talking Book users had an average percentage increase in total crop production of 48%, compared to a decrease of 5% for nonusers.

For robustness checks, we tested five alternative regression model specifications. In the first two alternative models, the results are the same if we replace the dependent variable with either *difference in production across all crops* (change score from 2008–2009) or *percentage change in production across all crops* (between 2008 and 2009). We also

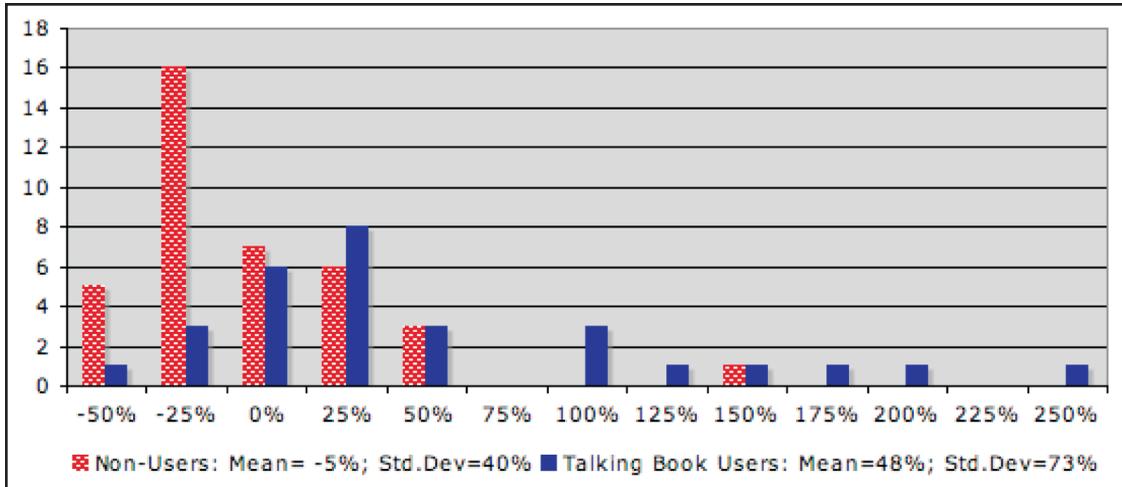


Figure 5. Comparing Users and Nonusers by Distribution of Percentage Change of All Crops from 2008 to 2009.

left *change in pesticide use* and *change in fertilizer use* out of the analysis because, as previously noted, some messages recommended increasing the use of these factors and significantly impacted the use of pesticides. In the third alternative model, including these two factors as independent variables did not impact the results. In the fourth alternative regression model, we replaced the summation factors for *change in human labor*, *change in animal labor*, and *change in land use* with values of the factors weighted by 2009 crop production for each of the four crops. Using weighted values may be more appropriate because changes in these factors should only make an important difference for crops that represent a substantial portion of a particular farmer’s overall plantings. Again, the results were the same.

Given the limitations of our measures for changes in farming practices and inputs from 2008 to 2009, in the fifth alternative model, we ran the regression analysis after excluding data associated with any extreme changes in input factors. For each farmer, we removed any millet, maize, beans, or groundnuts crop production associated with either a large increase (+2 on our scale) or large decrease (-2 on our scale) in an associated input factor. This robustness check tests the effect of access to Talking Book information in the absence of any substantial changes in human labor, land farmed, animal labor, use of pesticides, or fertilizer use. The results are nearly identical to the original analysis. Talking Book

users harvested 2.49 additional bags of crops in 2009 compared with nonusers, after controlling for all other factors discussed previously.

5.3 Limitations

The biggest limitation to these results is that Talking Books were not randomly allocated to users; instead farmers opted in to the treatment group by checking out devices from the leadership committee. Therefore, Talking Book users and nonusers may have differed in unobserved ways that impacted their change in harvests from 2008 to 2009.

We found no significant difference in 2008 crop production between the groups, but farmers who chose to use Talking Books may have been more motivated that year to improve their crops relative to farmers in the comparison group. Strong motivation might have led to more care and effort put into any farming practice. If this was the case, improvements made by our treatment group might not fully transfer to a less motivated group.

Due to the allocation issues mentioned earlier, it is also possible that farmers who checked out the devices had more resources than did farmers in the comparison group. If this was the case, Talking Book users may have been better able to implement some of the recommended practices. For example, they may have owned more animals to produce more manure or had more discretionary income to purchase fertilizer or rent an animal to plow lanes.

Our measures of changes in farming practices and input factors were another potential limitation.

We found no significant difference between Talking Book users and nonusers with respect to changes in various inputs aside from the marginal significance for Change in Pesticide Use Across All Crops. However, the categorical and subjective measurement of these factors (*no change, large increase, little increase, large decrease, and little decrease*) may have masked the role of these factors. More precise and objective measures would improve understanding of the relative contribution of these factors (e.g., surveying land use by measuring hectares for each crop planted in each year).

Another limitation is that the data from this evaluation were self-reported by farmers who may not have accurately recalled their 2008 production or precisely measured 2009 production. Talking Book users may have been more inclined to report improvement because they may have believed that is what the interviewers wanted to hear. The presence of a local committee leader during each interview should have prevented patently false reports, but may not have mitigated small exaggerations intended to please the interviewers.

6. Discussion

In evaluating the potential of the Talking Book program to improve productivity of farmers throughout the poorest regions of the world, we consider three questions: Is it effective, is it accessible to all groups and is it financially sustainable?

6.1 Effectiveness: Talking Books Lead to Behavior Change

A farmer's ability to recite the details of what they heard showed that they were using the Talking Book to learn new information. In our postharvest survey, 91% of farmers using Talking Books in their homes reported that they had applied the guidance. Further support that farmers learned and applied the information is provided by the significant improvement in their crop production. Our quantitative measurements appear to support the qualitative feedback from farmers. Given these three outputs of our program (learning, application, and resulting production), we believe the Talking Book serves as an effective conduit through which illiterate residents in remote villages can learn and apply new health and agriculture practices.

6.2 Accessibility: The Program and Device Require Work to Reach All Groups

Although most users comfortably operated the device after training, some of the least educated users still had difficulty. Usability improvements are important to reduce training time and ensure that the built-in audio instructions serve the needs of the least educated users; recent audio user interface updates have shown dramatic reductions in required training time.

In terms of access, women and elderly residents were the least likely to use the Talking Book. It seems that our steps to increase diversity in the committee may not have been adequate. Some residents assumed the devices were intended for educated young men, as represented by the committee leaders. Future programs should make a greater attempt to ensure the most active members of the committee reflect the diversity of the village. However, overcoming existing social structures within communities, particularly for women, will be challenging going forward. For example, programs that do not provide batteries may disproportionately hurt women whose husbands manage household finances (Sterling, O'Brien, & Bennett, 2007). Furthermore, even when programs increase the percentage of households reached by the device, we cannot assume devices will be shared equally within the home (Quisumbing, 2004). Increasing women's access to these devices will be important as this project develops, because while women play an active role in farming in rural areas, they are often excluded from extension services (Gautman, 2000).

6.3 Sustainability: Return on Investment Is Promising

The cost of the pilot program (devices, training, support, transportation, batteries) was approximately US\$2,480, but with the current Talking Book price at US\$35, the same program now costs approximately US\$1,000. A conservative estimate shows Talking Book use was associated with US\$2,946 of increased crop value,⁴ a return of nearly 3 times the investment within one season. If the same practices are applied in future years, the return on the original investment will continue to accrue.

Some 75% of farmers expected to sell their surplus at a local market, and many of those planned

4. Calculated from: US\$32.46 (weighted average of price per bag at deflated postharvest prices) × 2.75 bags per farm (attributed to Talking Book in regression) × 33 farms (reporting having applied Talking Book guidance).

to use the cash to invest in agriculture inputs like seeds, animals, and labor. Other plans for spending the cash from the sale of surplus production included payments for health insurance, home improvements, and school fees.

However, crop value does not equate to net income; we have not factored in transportation costs to get the extra crops to a market or the opportunity costs of marketing and selling the extra crops.

These numbers show the Talking Book can be a cost-effective intervention to NGOs and government organizations. The alternative for an agriculture extension office may cost an average of US\$20–\$30 each time an agent visits a rural village,⁵ which does not allow residents to reference the information when they need it, particularly illiterate residents who cannot take notes.

7. Future Work

Some questions for future research include the following:

- What is the optimal number of devices per community, and what is the best allocation method to reach maximum benefit? How does the type of access (in home, outside the home, word-of-mouth) impact behavior change?
- How does a user's social network impact trust and adoption? What is the impact of distributed peer comments about the agriculture and health messages?
- What types of information are most effectively conveyed in audio form to illiterate audiences?
- How can organizations learn from usage metrics, user ratings, and recorded feedback to improve their content?
- How does training of content authors on instruction and learning principles—like personalization, coherence, signaling, segmenting, and pretraining (Mayer, 2008)—impact behavior change and adoption of practices?

We also believe that there is an opportunity to leverage other related technology projects to enhance the impact of the Talking Book. For example:

- Talking Books could leverage existing mobile networks to improve content distribution from remote areas.
- Talking Books could equip infomediaries with detailed information and the ability to collect verbal feedback.
- Talking Books could serve regions without community radio (CR), share content with CR, and complement existing efforts by collecting stories and feedback.
- Future Talking Books will allow remotely programmable recording of any radio broadcast without user interaction. This may provide a cost-effective means of regional content distribution depending on the density of devices and the fee charged for airtime by commercial or community radio stations during the cheapest available time slot.

Conclusion

This article presents the results of the Talking Book pilot study in the Upper West Region of Ghana. The goal of this pilot was to evaluate the impact of giving rural people access to locally relevant guidance—information they could listen to repeatedly and when they need it.

Residents showed great interest in the devices and were able to learn how to use them. Learning to use the device was generally easier for those with more education. Some were intimidated by the device's complexity, but our research suggests this could be reduced with strong support from peers and software user interface improvements. Collaborating with local authorities to build buy-in was critical to success, as was having a strong community leader to monitor program implementation. Equitable allocation was a challenge because the devices became valuable—an issue that is likely to recur when devices are shared among a community. Future programs should make adjustments to broaden awareness of the program and ensure that women, the elderly, and other marginalized groups have more access.

We found that 91% of farmers who checked out Talking Books (a) learned the health and agriculture information, (b) trusted the information provided by

5. Based on a single agriculture extension agent making 40 village visits in one month at a monthly salary of \$530 (typical for this district), plus fuel costs.

familiar local sources, and (c) applied what they learned. Although there are limitations in our quantitative research, Talking Book users reported significantly improved productivity relative to nonusers. Collectively, our evaluation shows that on-demand access to information can considerably impact the lives of rural, illiterate communities. Furthermore, the Talking Book appears to be a cost-effective tool to enable learning and behavior change. ■

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IMPACT OF LOW-COST, ON-DEMAND INFORMATION ACCESS IN A REMOTE GHANAIAN VILLAGE

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