A practical look at results from two Mobile Learning pilots in South Africa

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Abstract: MobilED is an Open source project that aims to develop pedagogically-appropriate Mobile technology services to enhance formal and informal learning and teaching environments. A first phase of the platform and services were developed and piloted at two schools in South Africa using only voice and SMS technology. Learners and teachers from both schools gave extensive feedback in the form of questionnaires and interviews. This feedback was evaluated and some of it was interpreted as new technology requirements for future platform development. Other feedback raised new issues that should be investigated. i.e. "What is the influence of mobile voice channels on synthesised voice?". A few practical observations were also made and noted as future recommendations when dealing with similar projects.

Keywords: MobilED, mobile phones, mobile technologies, Text-to-Speech (TTS) engine, Interactive Voice Response (IVR), Short Messaging Service (SMS), Wikipedia, Asterisk, Public Branch Exchange (PBX), Kannel.

1. Introduction

This paper gives a high level overview of the technology used and the results of two pilots of the MobilED project that were hosted at two different schools, one private school and one public school. MobilED is an international research and innovation collaboration partnership to design, develop, pioneer and evaluate pedagogically-appropriate mobile technologies and service for learning and teaching environments. It is supported by evidence-based research outputs to develop sustainable models, processes and practices. The aim is to enable pervasive and equitable access in formal and informal learning contexts.

The project was conceptualised in 2005 and development officially started in early 2006. This is a three year project and the first year was funded by the South African government's Department of Science and Technology. Contribution in terms of mobile phones was received from Nokia, Finland. Meraka's primary project partner, the Media Lab at the University of Art and Design in Helsinki contributed their user design skills to the project, funding their own activities [1] [8]. Three Masters students from the University of Pretoria in South Africa, participated in the project as part of the research for their Masters' dissertations.

The focus of this paper is the feedback received from participants on their experience of the service during the pilots and how that feedback were and will be incorporated in future service and platform development of the MobilED project. It touches on usability and practical issues that should be considered when introducing or developing mobile technology services for school environments. A short overview is given of the technology components that were used. This must be seen purely as background and is not

the emphasis. The project has just completed its first year and the cost associated with widely deploying such a service is not yet established. It is also premature to claim what the economic or societal significance would be, although another paper on the MobilED project discusses these issues partially [2].

The main objective of the MobilED project is to enhance the learning and teaching environments in schools using mobile technology. As South Africa is a developing country, the focus is particularly on those schools that have limited access to information (no library or computers with Internet connectivity) and teaching resources (teachers and text books). Although the project would not be limited to these environments, this objective would always enjoy priority.

It was therefore decided to start with technology that is readily available in the disadvantaged communities of South Africa. There is a very high level of mobile phone penetration in South Africa [3] although the phones may only have very basic functionality. This influenced the decision to base the first phase of the project only on voice and text (SMS) capabilities of mobile phones.

2. Objectives

In order to make an educational mobile application available to the majority of the South African people, it was important to start with very basic mobile applications such as voice and SMS.

The objectives of the MobilED project were to
1. Develop an open Source solution
2. Enable communities with little or no conventional access to the Internet to interact with and gain knowledge from state-of-the-art information sources such as the online encyclopaedia; Wikipedia,
3. Allow knowledge/data contribution to the platform by the learners/community,
4. Pilot the final solution and establish what was effective and what not.
   The technical goals of the first version of the MobilED platform were:
1. Supporting very basic mobile phones as access devices,
2. Interfacing with data sources such as the Wikipedia,
3. Providing an interactive service, using Text-to-Speech engines, IVR applications and messaging technologies such as SMS,
4. Supporting contribution of data to the information source by recording and uploading an audio clip via the mobile phone.

3. Methodology

The project team decided to first develop a basic concept of a possible service and created a video that showed how such a service would typically be used. No formal requirement specification was created or provided. This video was showed to the developers and was the only input that was provided as specification for the platform and service development.

The idea with this approach was to allow developers the freedom to interpret and decide on the finer details as they see fit. Whatever is developed would be tested during a pilot and the feedback that is received from the learners, teachers and project team, would then be used to influence the specifications of the future platform versions.

In order to use this approach, adequate data had to be gathered from the users during each intervention in order to capture the feedback, evaluate it, and interpret it into future requirements or adjustments. Questionnaires were handed out to the learners after each intervention and interviews were conveyed with the teachers, some of the learners and the

observers to capture additional information. These interviews also assisted to interpret the answers provided in the questionnaires.

4. Technology/Service Description

The MobilED platform has a modular, plug-in-based architecture. It consists of a central core, responsible for session management, threading, global configuration and global process management.

On top of the core are three types of plug-ins:
- Request input plug-ins,
- Data source plug-ins and
- Channel plug-ins.

These are responsible for providing all input to and output from the system. All the components internal to the MobilED platform are developed in the Python programming language [4]; this enables the system to be used on multiple operating systems without the need to recompile.

4.1 Request input plug-ins

Request input plug-ins are responsible for triggering transactions within the MobilED platform; they form the entry point of any incoming request to the platform.

For the first phase there was only one request input plug-in. This plug-in provides connectivity to the Kannel [5] WAP/SMS Gateway, and is used to respond to incoming SMSs received by the gateway.

4.2 Data Source plug-ins

Data Source plug-ins connect the MobilED platform to potentially any electronic information source. They are responsible for translating their source of information's "native" data into a standard access interface defined by the Core; this interface is then used by the Channel plug-ins to present the information to the end-user in a channel specific form.

The *Media-Wiki* [6] *data source plug-in* is a data source plug-in that allows the MobilED platform to access information from Wikipedia, but it also allows any custom Media-Wiki installation to be used with the platform. This makes it fairly easy to set up a communications platform for a localised community.

The *String Message plug-in* is a data source plug-in that is intended to be used to send out short, predefined text messages, and does not provide any form of multimedia content, nor does it allow uploading of information. The MobilED Core uses this plug-in to send out its "welcome", "help" and "error" messages.

4.3 Channel plug-ins

A channel plug-in provides a transmission channel from the MobilED platform to the user; it is primarily an output channel, but some channels may allow input back to the data source during transmission as well.

The *Asterisk channel plug-in* is the only channel plug-in that was developed for phase 1 of MobilED. It provides an audio telephony interface to the MobilED platform by making use of the Asterisk Open Source PBX [7]. This plug-in functions by placing an outgoing call to the destination number, and then reading the requested data to the user using a TTS (text-to-speech) engine inside of an IVR (independent voice response) program. The user has the ability to control the audio playback, by skipping

forward/backward between sections, rewinding/forwarding inside of the current section, pausing, etc., using the keypad of his/her phone.

5. Developments

The platform as described in section 4 above was used during two pilots that were conveyed at two schools in the Pretoria area in South Africa. The two schools that were selected for the pilots were Cornwall Hill College and Irene Middle School. Cornwall Hill College is a private school and Irene Middle School is a public school that is mainly comprised of children that represent the previously disadvantaged communities. The first pilot took place at Cornwall Hill College in March 2006 over a two week period where grade 11 learners (approximately 16 years old) participated in two sessions of two hours each. The second pilot took place at Irene Middle School in July 2006 over a two week period where grade 9 learners (approximately 14 years old) participated in three sessions of approximately three hours each. The mobile phones were supplied to the learners during these sessions and they had to share the phones amongst team members. At Cornwall Hill College there were four learners per team and in Irene Middle School there were six learners per team.

5.1 School selection

The project team wanted to investigate the two extremes found in South African schools for several reasons. These reasons as well as the schools that were selected were:
- Two of the external MobilED researchers are teachers at Cornwall Hill College and the team wanted to test the technology in an environment where people are already able to use the basic mobile functionalities. The learners could also be closely observed by the particular two teachers that understands the objectives of MobilED. The idea was to iron out any practical or purely technical problems that are not necessarily dependent on user capabilities.
- Irene Middle School was a natural choice of a school that represents the developing world as it is Cornwall Hill College's outreach school.
- We wanted to see what the influence of the service language has on learners. In both schools, the language of instruction is English. However, there is a much larger percentage of learners in Cornwall Hill College who has English as a first or second language, compared to learners in Irene Middle School, where English is often a third language. Cornwall Hill College also starts with English as instruction language from grade one, compared to grade 4 in Irene Middle School.
- It was important to establish whether technology literacy and frequent exposure to technology plays a big role on service adoption, as the target user group would typically not be exposed to technology on a frequent basis. Cornwall Hill College has several computer labs and the learners use these labs on a daily basis. The majority of the grade 10 learners (that participated in the pilots) if not all, have their own personal mobile phones. Irene Middle School did not have any computers at the time of the pilot and very few of these learners have their own mobile phones. In the majority of the cases where these learners have access to mobile phones, it belongs to their parents or is the "family phone".
- From a platform progression and future development point of view, it was important to get a wide range of feedback from learners with different needs, environments and backgrounds.

5.2 System functionality used during the pilots of phase 1

Stage 1
During the pilots, the learners did a lesson on HIV AIDS and had different sources of information:
• Pamphlets,
• Books and
• The Audio Wikipedia via MobilED [8].

When using the Audio Wikipedia via MobilED, the learner uses the standard text messaging capability of the mobile phone (SMS) to request an article from the MobilED platform, by entering a key word relating to the topic of interest, and sending the message to the phone number assigned to the MobilED platform. The service calls the user, and starts reading the Wikipedia article from the top, using interactive voice response (IVR) and text-to-speech (TTS) technologies. It reads the article to the user using a synthesised (computer-generated) voice in combination with pre-recorded voice prompts, and accepts input from the user via DTMF (Dual Tone Multi Frequency)/Touchtone key presses.

Each article is broken up into sections (it uses the sections as they appear in the Wikipedia article). Initially the system greets the user with the message stating the article name, after which it starts reading the first section of the article. During the reading process, the following DTMF/Touchtone key commands are available and a print-out of these was provided to the learners:
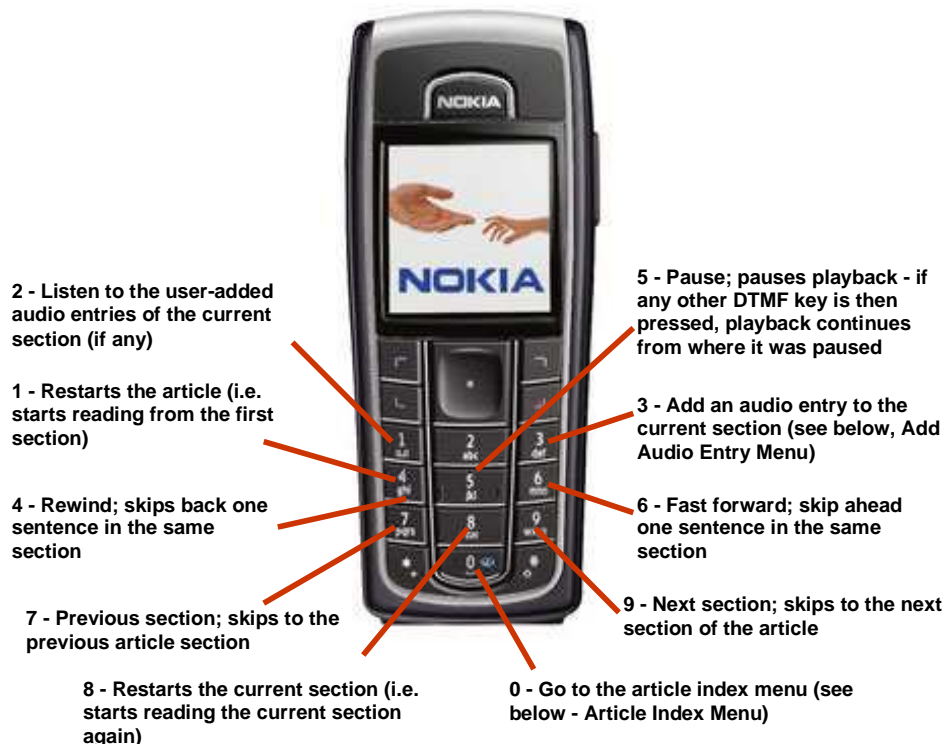
2 - Listen to the user-added audio entries of the current section (if any)

1 - Restarts the article (i.e. starts reading from the first section)

4 - Rewind; skips back one sentence in the same section

7 - Previous section; skips to the previous article section

8 - Restarts the current section (i.e. starts reading the current section again)

5 - Pause; pauses playback - if any other DTMF key is then pressed, playback continues from where it was paused

3 - Add an audio entry to the current section (see below, Add Audio Entry Menu)

6 - Fast forward; skip ahead one sentence in the same section

9 - Next section; skips to the next section of the article

0 - Go to the article index menu (see below - Article Index Menu)

Figure 1: Navigation instructions

The "article index menu", enables the user to listen to the topics of the different subsections of the article and provides the opportunity to jump straight to that section to listen to that part of the article. This accessing of information on the Wikipedia formed the first part of each pilot.

Stage 2
After the learners gathered all the necessary information, they also had the opportunity to contribute information to the information source (local Media-Wiki server) by recording his/her voice over the telephone. By pressing the appropriate key on the phone, it causes the system to enter the "audio-entry menu"; this instructs the user to begin recording. The entry had a maximum time limit of 5 minutes; this can be changed if desired. During such a recording session, the learner can:
- Listen to the recording that was just performed
- Re-record the recording
- Save the recording and add it to the article
- Cancel the entry; this will delete the recorded audio clip, and return the user to the "end-of-section menu".

6. Results

As mentioned in previous sections, learners had to complete questionnaires after every intervention. This section gives a summary of the aspects that were questioned during each pilot. The data displayed in this section does not always add up to the results of all the learners, as some of them did not complete all of the questions and therefore slight variations can be expected between the noted and the actual responses. Percentages are expressed as a total of the answers received.

6.1 Interaction with the service

The learners were asked several questions around their personal interaction with the service. The final question was whether they believed they would be able to use the service by themselves in future. In a question relating to this issue, learners were asked whether somebody helped them or not.

Table 1: Service interaction

	Cornwall Hill College	Irene Middle School
I will be able to use it in future	93,2%	91,0%
Somebody helped me	86,4%	37,3%
Even with the help of someone else, I will not be able to use the service by myself in future	6,7%	1,5%

It seems that an overwhelming majority of learners in both schools are confident that they would be able to use the service in future. There are however learners (only a small percentage (6,7% and 1,5%) that feel that even after somebody helped them, they will still not be able to use the service independently in future.

6.2 System response

The system response were measured in terms of the time the service takes to call you back after submitting your key-word for an article and how fast the system responded when the navigation options of the menu were used.

Table 2: System response

	Cornwall Hill College	Irene Middle School
The service took too long to call me back	40,1%	28,6%
The service did not react prompt enough during a session	34,1%	15,9%

By looking at the results, the opposite is also true that about 60% of Cornwall learners and 71% of Irene learners were happy with the time it took the system to call them back. In addition about 65% and 84% respectively were satisfied with the system response during a session. Overall it seems like the Irene learners were more satisfied with the system response than the Cornwall learners. During the pilot at Cornwall, we experienced technical problems with the system. This might explain the higher dissatisfaction with the system response reported by Cornwall compared to Irene. It is also interesting to note that the time for the service to call a student back is perceived to be worse than the service reaction time during navigation.

6.3 Navigation

We wanted to establish how the learners experienced the navigation options while listening to an article. This is very important, as it forms the main part of the user's interaction with the service. The following table is a summary of the feedback.

Table 3: Navigation

	Cornwall Hill College			Irene Middle School		
I did use the navigation	86,7%			75%		
The navigation was	**Difficult**		**Easy**	**Difficult**		**Easy**
	35,9%		64,1%	17,5%		82,5%
The navigation options were	**Right**	**Too little**	**Too many**	**Right**	**Too little**	**Too many**
	35,6%	34,4%	40%	62,5%	26,6%	10,9%

The majority of the learners reported to have used the navigation. It was interesting to note that almost all the students with the exception of a few (none at Cornwall and 5 out of 67 at Irene) answered all the questions on this section. Even though they have not used the navigation, they still had an opinion regarding it. Not one of those that did not use the navigation left out any questions regarding this topic and there was only one learner that left the navigation part of the questionnaire out completely. One would also assume that the learners that did not use the navigation may have perceived it to be too difficult and therefore did not even try. Upon closer inspection of the answers, the majority of the learners that believed the navigation was difficult did use it.

6.4 The time aspect when listening to the information

Learners were asked whether they had enough time to listen to the article and whether more time would have made a difference.

Table 4: Response time

	Cornwall Hill College	Irene Middle School
There was enough time to listen to the article	33,3%	70,3%
More time would have made a difference.	66,7%	83,3%

The Irene learners were much more satisfied with the time they had available to listen to the article and it is surprising that even so, a much greater percentage of learners indicated that more time would have made a difference. Unfortunately the two schools did not allow equal amount of time during the class to complete the assignment and the Irene learners had far more time allocated in the class for this activity. It is therefore difficult to say whether the actual speed of service interaction and reading of the article is perceived to be the time issue or whether it is the time allocated to complete the assignment.

What did come out in some of the remarks of quite a few questionnaires, were that students would prefer the article to be read slower and have more time to make decisions around navigating to the different sections.

6.5 Listening to information versus reading

Learners were asked whether listening to information is effective or whether only reading is effective.

Table 5: Listening versus reading

	Cornwall Hill College	Irene Middle School
Listening is effective	11,1	39,1%
ONLY reading is effective	88,9	60,9%

It is obvious from the results that the majority of learners prefer information in a text format. Irene learners seems to be more comfortable than Cornwall learners to listen to information.

6.6 The synthesised voice

As human language technologies (HLT) and in specific, text to speech (TTS) engines is one of our institute's research areas, it was important for us to gather information around learners' perception of the synthesised voice and what their preferences are.

Table 6: The synthesised voice

	Cornwall Hill College	Irene Middle School
I could hear the voice clearly	4,4%	9,1%
I feel comfortable listening to a synthesised voice	24,4%	6,2%
I would use a service with such a voice in future	22,2%	7,8%
I would prefer the service in another language	31,8%	87,5%
I can understand the synthesised voice most of the time	20%	20%
I prefer the gender of the voice to be	Male – 4,4% Female – 40% Don't care – 55,6%	Male – 3,1% Female – 78,1% Don't care – 18,8%
I prefer the voice to sound	Young – 17,8% Adult – 35,6% Don't care – 46,7%	Young – 71,9% Adult – 9,4% Don't care –18,8%

It is obvious that the learners did not like the synthesised voice at all and this might also explain why the majority feels that it is not effective to listen to information (see previous section). A lot of the learners complained about the volume and clarity.

The voice used for the Cornwall pilot is and American English voice and might have had an influence. The voice used during the Irene pilot is a completely synthesised voice and does not sound human at all.

A substantial amount of learners in Cornwall (31,8%) indicated that they would prefer another language and suggested mainly Afrikaans and Sepedi that are South African local languages. The majority of learners at Irene (87,5%) indicated that they would prefer another language and suggested mainly Sepedi and Xhosa that are also South African local languages. It seems therefore that learners prefer to receive information and learn in their home languages as one would assume the languages suggested are their first language.

6.7 Gender profile

At Cornwall Hill College, the percentage of boys compared to girls was approximately 8% less to that of Irene Middle School.

Table 7: Gender profile

	Cornwall Hill College		Irene Middle School	
Total # of learners	45		67	
# of Boys	19	42,2%	30	50,8%
# of Girls	26	57,8%	29	49,2%

It is interesting that the observers remarked that boys were obviously dominating the use of the equipment in Cornwall Hill, even though they were the minority. This was however not the case at Irene Middle School, where there was approximately an equal amount of boys and girls in the classroom and the observers did not note any dominance.

What was however observed at Irene Middle School was that the girls generally shared the equipment freely and encouraged everyone in the group to participate, even if it meant that it slowed them down.

In both schools a higher percentage of boys (Cornwall-94,7%, Irene-93,1%) interacted with the service compared to girls (Cornwall-84,6%, Irene-88,9%). The girls (Cornwall-44,4%, Irene-50%) also found the navigation more difficult than the boys (Cornwall-13,3%, Irene-21,1%). One gets the impression that the boys were more comfortable to use the technology.

7. Conclusions

Due to the fact that a vast majority of learners (93,3% at Cornwall and 91% at Irene) feel confident that they will be able to use the service in future and the majority (64,1% at Cornwall and 82,5% at Irene) found the navigation easy, one assumes that the technology tested during this pilot is fairly easy to use. The learners from Irene had an opportunity to play with the equipment the day before they participated in the pilot. This might explain why they found the navigation that easy compared to Cornwall. *It is recommended that learners and teachers have adequate time to familiarise themselves with the equipment, before it is used for learning.*

The system response time is highly dependent on the mobile networks and the service provider has very little control over that. *It is therefore recommended that teachers have other learning material available when possible in order for the learners to continue with their assignments while waiting for the service to call them back.*

The fact that a substantial amount of learners (34,1% at Cornwall and 15,9% at Irene) felt that the system responded too slow during navigation, should be balanced with other remarks from learners; "They need to navigate slower". We believe that this is not really a problem but did make some changes to the MobilED platform after these pilots that should increase the system response during navigation. However, we again *emphasize the dependence on the mobile network for prompt system response.*

Many learners suggested that the navigation must be made simpler and suggested that there should be fewer options. One learner even suggested using voice commands from the user instead of using the keys on the mobile phone. *At Meraka we are working on speech recognition systems and as soon as this is ready for deployment, we will consider incorporating that into the MobilED solution.* One should involve learners in your service testing before you pilot the system. This might assist in defining a more suited navigation system which might mean fewer options, but be more practical. *For future services and pilots, we will consider involving learners and teachers in the requirements and testing phases of the project.*

Some changes were made to the navigation after these two pilots, but have not been piloted yet. In the new version, the server also sends an informative SMS containing the requested article/section title, the index of that section/article, and the first few words of the article (as much as can be fit into a 160 character SMS). The user is now able to specify an exact subsection of an article as a request, thereby allowing him/her to only receive the specific information he/she is interested in. Furthermore, the server keeps a user's usage history, and is therefore capable of receiving requests relative to the previous request by the user, e.g. if the user requests a subsection of the section he/she previously visited. This is done by merely sending a request that starts with a forward slash ('/' character). At any

point, the user can SMS the word "help?" (with question mark) to the system, in which case the server will respond by sending an SMS outlining the usage principles.

An example of this new functionality would be:

1. The user sends an SMS containing the word DOG to MobilEd

2. MobilEd downloads the Wikipedia article named "Dog", and parses it.

3. MobilEd sends an SMS containing the requested article title, first few words of the article's first section, and an abridged index of the top level sections available in the article (see figure 2).

4. MobilEd calls the user, and starts reading the article from the top, using interactive voice response (IVR) and text-to-speech (TTS) technologies. The "index menu" option available to the user (as in the previous version of MobilEd) now corresponds to the index that was sent in the SMS in step 3 above.

Although this functionality has not been piloted with learners, we expect this enhanced functionality to make navigation easier.
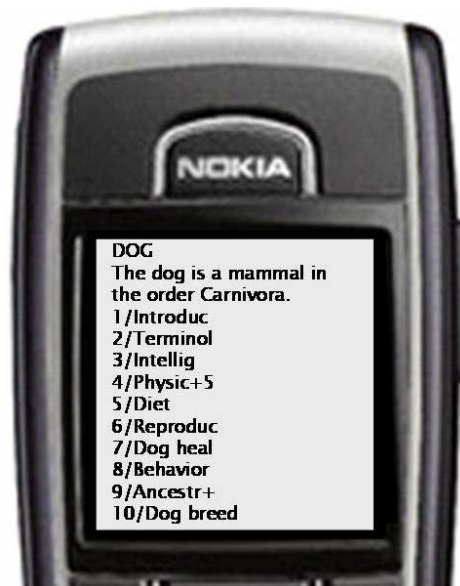

Figure 2: Example of article request response

Quite a lot of students complained about the time that was available to listen to the articles and there could be several reasons fort his; from the time allocated in the class, the fact that groups of learners had to share a device to the fact that the article was read too fast. The one clear need that was picked up from comments in their questionnaires is that *there is a definite need to be able to control the speed at which the article is read.* This functionality will be considered for future platform development.

Very few learners reported that they could hear the voice clearly and would feel comfortable to listen to such a voice. Learners also found it very difficult to hear and understand the articles that were read. The quality of the voices used in the two pilots might not have been that good and sounds very different to South African English. Classrooms are also very noisy environments and when learners have to listen to articles being read and played on a microphone, it can become a challenge to hear. Quite a few learners commented that the voice should be louder and clearer. The voice quality is also influenced by line clarity and switching between mobile and fixed-line networks. *One needs to test the quality of synthesised voice over a mobile telephone voice channel in order to establish whether this is an effective solution and how it might be improved. At Meraka, we are also busy developing a South African English voice for a Text-to-Speech engine and that will be*

used in future projects. Once this voice is available, we will investigate the influence of all the other factors on the voice quality over the telephone line. It might also be useful to provide learners with individual headsets to mask the classroom noise.

The vast majority of learners (88,9% at Cornwall and 60,9% at Irene) reported that only reading is effective when one receives information. This perception might be due to bad experience with the synthesised voice. It is interesting though that the Irene learners were more comfortable with listening to information compared to Cornwall learners even though they disliked the voice far more. This might be due to the fact that Irene is only comprised of black learners and Cornwall is mainly comprised of white learners. Verbal transfer of information is very common in the black communities and might contribute to developing good listening skills. *In the meantime additional SMS functionality for content delivery was developed and incorporated in the MobilED platform. This can be used for short bits of information. In future, when more advanced phones with data capabilities become more available in developing communities, one can send Wikipedia articles in text.*

In general, learners either preferred a female voice or did not care about the gender. It is interesting to note that the majority of Cornwall learners prefer an adult voice as opposed to the majority of Irene learners that prefer a young voice (excluding the learners that did not care).

Whenever students use this kind of technology, the group dynamics are important. Care should be taken that students don't take complete ownership of the equipment and don't allow others to use it as well. It will be worthwhile to establish why the girls seemed to struggle more with using the technology than the boys. *Ideally, every student should have access to his/her own mobile phone. "Both personal and group learning are most effectively supported when each student has access to a device. The ownership of the devices is thus a key consideration"* [9].

Different cultures share and contribute information in different ways. It was interesting that the Cornwall learners (mainly white) contributed factual information in a very formal way to the MobilED-Wikipedia. The Irene learners all prepared a little play with a lot of singing and acting. This is very common in African cultures and the MobilED team immediately realised the potential of incorporating Multi-media capabilities in the MobilED platform. The first stage of Multi-media capability was developed after these pilots and integrated in the MobilED platform.

Since it seems like the girls are less confident to use the technology and struggles a bit more than the boys, it would be important to *look at the group dynamics to try and assess whether the girls get equal opportunity to use the technology, whether there are any acts of intimidation between the boys and the girls and whether there is really a difference in skills.*

"This platform enables communities with little or no conventional access to the Internet to interact with and gain knowledge from state-of-the-art information sources. It also allows conventional Internet-based information providers to reach a wider audience, for instance in cases where SMS-style communication is more suited to the information at hand" [10].

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