Utilizing Multimedia Capabilities of Mobile Phones to Support Teaching in Schools in Rural Panama

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ABSTRACT

Providing good education is one of the major challenges for humanity. In many developing regions in the world improving educational standards is seen as a central building block for improving socio-economic situation of society. Based on our research in Panama we report on how mobile phones can be used as educational tools. In contrast to personal computers mobile phones are widely available and in Panama over 80% of the children have access to phones. We report on four different studies building on one another. We conducted surveys, focus groups, and group interviews with several hundred teachers and pupils to assess opportunities, needs, and threads for using phones in teaching and learning. Based on the feedback received we created a set of use cases and finally evaluated these in a field study in a rural multigrade school in Panama. Our findings suggest that current phones with multimedia capabilities provide a valuable resource for teaching and learning across many subjects. In particular recording of audio and video, programs for drawing, and taking photos were used in very creative and constructive ways beyond the use cases envisioned by us and initial skepticism of parents turned into support.

Author Keywords

Developing countries, learning, children, mobile phone

ACM Classification Keywords

H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous; K3.1 Computers and Education: Computer Uses in Education

General Terms

Human Factors

INTRODUCTION

Improving education is a major concern in many countries around the world. From a governmental perspective, improving education is an investment in the country's future that can result in economic growth and increased global competitiveness. For individuals and families in these developing regions, the motivation to participate in education is typically very high, since education is seen as a way to improve personal living conditions and gain in the long term prosperity. Nevertheless, resources for education are limited both on a national level (e.g. budgets available for schools) and on a personal level (e.g. time available for learning).

The use of new technologies to improve education is tempting but very difficult at the same time. New technologies often seem to offer easier and wider access to educational materials and means for improving learning efficiency. At the same time, there is also a very strong cultural influence on how schools are organized and how teaching is conducted. The agreement within a society on what knowledge and

Figure 1. Views of the School El Retiro

Figure 2. A student recording his voice in the English lesson using a multimedia phone

skills are important is deeply rooted and not easily changed. Thus, the approach taken in teaching and the relationship between the teacher and pupil is very much dependent on the culture and must be respected when introducing new technologies. If these technologies impose certain teaching/learning paradigms, even if considered superior to the traditional way of teaching, they are likely to fail.

In contrast to personal computers (PC) mobile phones have become widely adopted around the world, including developing regions. In comparison to PCs mobile phones are easier to administrate and users have a great interest in keeping the devices functional at all times as they use them as communication devices. Additionally there is already an established local infrastructure for buying, maintaining, and repairing phones.

In our research we assess the potential of mobile phones as learning tools. The vision is that in the near future students and pupils would use mobile phones as educational device that offers them much of the functionality traditional PCs offer (as well as additional capabilities for multimedia documentation) and that phones can be used for learning at school. In contrast to previous research, we explore the design space of inherent capabilities of mobile phones, which are only enhanced by some generally useful applications (e.g., drawing application).

In this paper we report on our findings on emergent mobile phone usage and our experience with using mobile phones in the teaching context in schools in Panama. In order to understand how mobile phones are currently used and how widespread access to these devices is, we started our exploration by conducting a survey asking 300 pupils and 85 educators across Panama about current practice. Based on these findings we continued by conducting group interviews and design sessions in two iterations, first with 37 and the second time with 190 teachers in order to understand their needs for support in teaching. In these sessions we especially aimed at uncovering potential use cases, anticipated threats, and expected problems. Our approach was to look at ways in which mobile phones can be useful tools within the current educational system and the current ways of teaching. Based on the rich information that we received we finally designed a field experiment with 40 pupils and 3 teachers in a rural multigrade school (see Figure 1), which is the most common school type in Panama, to explore and evaluate different use cases for mobile phones as teaching aids (Figure 2 as an example use case).

The surveys, interviews, and field study were conducted in Panama and hence the findings apply in the first place there. However in the course of the research we discovered more and more that teachers appropriated the phone as a tool to their personal style of teaching. We see this as an indicator that the approach we describe in this paper could be exemplary for other developing regions and potentially also for developed countries.

The rest of the paper is structured as follows: In the next section we discuss related work in developing countries.

We then give a short overview of the educational situation in Panama and describe in detail the proliferation of computer and mobile phones and their application in rural and urban areas. We then describe the initial concerns and opportunities seen by teachers collected in group interviews. In the main part of the paper we provide a comprehensive description and results of the two weeks field study conducted in a rural school. The paper then wraps up with discussion and conclusion.

RELATED WORK

In the literature we find several learning approaches for using computers and mobile phones for unprivileged.

One approach are low cost laptops specially designed for children, where the most outstanding project is the OLPC [8]. It is equipped with multimedia, collaborative UI (Sugar) and educational software. Authors of OLPC claim that children learn mainly by creating and sharing with their peers using only the laptops. Despite all the efforts, the OLPC have not been received by the developing countries as expected [10]. There have been concerns that this learning model would not fit educational curriculum, requirements and policies of some developing countries [10].

Mischief [13] is a project that investigates the use of multiple mice connected to a large display. This approach allows children to work simultaneously on the screen and supports cooperative work and learning. This approach is very economic but is difficult to use in common multigrade school environments, where children from different grades and learning backgrounds share the same classroom. In addition, in a large audience [14], it seems to be difficult to visualize all mice on screen.

Since mobile phones are popular in developing countries [9], this motivated several researchers to explore their usage for learning, with encouraging results. Kam et al. [1, 3, 6] implemented games on mobile phones for learning English as a second language based on traditional game practices in India. Kumar et al. [1] explored the unsupervised learning with mobile phones in the everyday life of rural children in India, while Kam et al. [6] do this in school settings. Results indicate introduced software and technology motivated children in learning [1] and that mobile games can be useful for learning in unprivileged areas only if the local game practices are well understood and considered [3,6]. In MobilED [2] Ford and Leinonen created an alternative approach to the Wikipedia where users can search and edit content through the use of audio and SMS.

M4Girls [11] and Mobi [12] looked at supporting Mathematics learning for students in South Africa. Both approaches considered the educational curriculum, the cultural-social context of the country, and the available technologies. Frohlich et al. [4] and Reitmaieer et al. [5] explored usage of the phone camera plus audio to support storytelling practices in underprivileged areas in India an Africa respectively. The study was focused on adults.

Besides, Hollow and Masperi [7] explored the use of a video-audio player customized handheld device in primary schools in Malawi. Here, children had access to different lessons installed on the mobile devices. The audio-visual lessons were explained by cartoons and were interactive by means of multiple-choice tests. Children could not pass to the next lesson until they answered the tests correctly.

In most of the learning approaches for developing countries presented here [1,6,7,8,11,12,13], researchers have implemented their own applications integrating multimedia features. At least in rural school environments there has not been any exploration in the use of multiple, default mobile phone features without installing any additional learning software. Different from [1] we found (1) an opportunity to use mobile phones to support other subjects besides language learning, (2) particular benefits of mobile phones for multigrade classroom environments, and (3) different, naturally evolved scenarios for mobile phone usage in class.

EDUCATIONAL SITUATION IN PANAMA
Panama has a very young population and a large portion of the population is at school age: 39% of Panamanians are between 0-19 years. Hence, maintaining schools, providing sufficient educational material and having enough qualified teachers is a great challenge. A large portion of multigrade schools (74%) – where pupils of different school-grades share the same classroom – is found in rural areas. This highlights the efforts to maximize the utilization of resources. All children are required to attend school from ages 5 to 17 (13 years of school). Panamanian laws also guarantee them free access to public education. The major subjects taught in schools are Spanish (the native language for most pupils), Mathematics, Science, Social Sciences (Geography and History) and English (as a foreign language). Topics are based on the National Educational Curriculum [15]. The vast majority of children attend public schools. Schools are classified in urban, rural and difficult access area schools according to where they are located.

Government and Teachers Perspective on Technological Challenges in Education
We met with the Secretary of State for Education, the Head of National Education, and Head of Primary Education of Panama. During these meetings, they explained to us the situation and their opinions on implementing new technologies in the schools, i.e. computers in Panamanian schools. With the high number of students and a lack of human resources and infrastructure, their limited budget is often used to fulfill other priorities. In difficult access area schools, the existence of computer labs is almost zero. Overpopulation of children in classrooms and the multigrade system both limit the children's access to computers. Another concern is the security of the equipment. In some areas, computers have been "lost". A further worry is allowing children access to the Internet. They do not want children to visit unsuitable sites. Another problem is computer maintenance.

RESEARCH METHODOLOGY
We realized four studies that can be grouped in three stages. In stage (1) we used surveys to analyze the access and use of technology by teachers and children and to get initial clues where and how mobile phones could support the learning-teaching process. In stage (2) we used focus groups, interviews, and paper prototyping, in two different studies to validate findings from stage 1, discuss about benefits and concerns of using mobile phones in class and extract teachers' ideas and opinions for using mobile phones as educational tools. Finally, we conducted a field study in stage (3), to explore how pupils and teachers make use of multimedia phones in a classroom setting and to validate the results from previous stages.

STAGE 1: ACCESS AND USE OF TECHNOLOGY BY TEACHERS AND CHILDREN
In Panama, as in Latin America in general and in other developing regions, there exists a digital division between urban and rural schools, which we wanted to capture in the survey. We realized the survey in May 2009.

The survey was conducted in three typical public schools in Panama, where two were urban schools located in Panama City and the other a rural school located in Panama East. The interviews were conducted during a 12-day period in May 2009. In total, 300 children were interviewed − 148 from urban schools and 152 from rural schools. The children were between 9 and 17 years of age. The average age was 12.4 years. 52.2% of the students were male. Additionally, 85 teachers were interviewed, of whom 65% were female. These initial findings have been reported in detail in [16], here we summarize the most important findings.

Access to Technology
Although we expected a higher penetration of mobile phones than access to computers, the actual numbers were still surprising: 97.6% of teachers and 80.3% of schoolchildren had access to a mobile phone. This is in accordance with the worldwide trend [9] of mobile phone penetration in developed as well as developing countries. Children have limited access to computers and Internet at home: in fact, in the case of children in urban areas 11.9% have computers without Internet and 49.3% with Internet access at home; from children in rural areas, 14,6% have computers with Internet and 11,4% without Internet. A considerable number of teachers and pupils have modern mobile phones. About 60% of the educators and 77% of children have access to mobile phones with Internet access and/or an integrated camera.

Potential Usage of Mobile Phones for Learning
In order to see where mobile phones could be best used as learning platforms, the children were asked about subjects where they have the most difficulties in learning and where they might want help with (e.g., through learning games). Additionally, we asked them how they get to and from school to get a better picture of possible user scenarios where children might be able to learn with mobile phones. Answers indicate many children (44.2%) would appreciate help in Mathematics, especially multiplication.

Some children felt that they "*cannot learn the multiplication table*" or do "*not [have] much time to practice*". Although most children saw their main problems in Mathematics, the overall responses differed greatly between rural and urban areas. Students in rural areas wanted support in a more diverse set of subjects, whereas students in urban areas were largely concerned with Mathematics.

We also asked teachers which subjects they thought children struggled with and could benefit from the use of technology (computer and/or mobile phones). The majority of teachers considered Mathematics (94.8%), English (35.1%), and Spanish (25.6%) as the most difficult subjects. Teachers stated that children in primary schools "*do not know the multiplication table*" and those in middle schools exhibit a "*lack of [basic mathematical principles]*" and "*do not know the four basic arithmetic operations*".

When we asked teachers about their opinions on educational applications on mobile phones, in particular for mathematical exercise (e.g basic Arithmetic) and English learning, 75% supported the idea of reinforced Mathematic learning and 54.1% supported the idea of English language learning.

STAGE 2: TEACHERS OPINION OF USING MOBILE PHONES IN CLASSROOM

Based on findings from our previous survey we wanted to explore some concrete ideas how teachers think mobile phones can be used in class. So we conducted focus groups and a large interview with a paper prototype.

Focus Group

In December 2009, we realized three focus groups with a total of 37 teachers in 3 different schools, two urban and one rural school. There were 28 male and 9 females with an average of 42,9 years old. We asked the participants regarding their expertise using PCs and mobile phones. The rating scale was from 1 to 5, where 1 meant no experience and 5 meant expert user. Participants have had an average expertise of 2.94 using a computer and an expertise of 3.6 in the use of mobile phones. This implies that 82% of participants were more experts using mobile phones than computers.

Most teachers liked very much the idea of using mobile phones for supporting teaching: "*they (children) really like this thing and are more expert than me*"; "*I think with mobile phones children will be very enthusiastic*". But two teachers were strongly against using mobile phones in classroom, "*I do not agree using mobile phones for learning in special Mathematics because (they) lead children to be more dump and dependent… computers do everything*".

According to the teachers, main concerns with the use of mobile phones are the security, distraction, and behavior problem among students, as one commented to us: "*Imagine large classes of 30 and even 40 students with mobile phone, how I control that (they) use it properly.*"

Two teachers had already used mobile phones in class with their pupils "*I was tired that my students filming me all the time and put me in the Internet… I am cabinetmaking teacher and because of the limited class time I have not enough time to review their works, … so one day I tell them open your (mobile phone) camera and take a picture of your work … they were so enthusiastic and concentrated taking the pictures… next day everyone wanted to show me and explain their works… since then I do not experience such bad behavior and I continue time to time using the phone in my class.*"

Many teachers agreed upon the key being the multimodal usage, especially combining audio, pictures and text. As well as to design applications as games to prevent children from becoming bored. All teachers considered the SMS exchange as strong problem for learning Spanish. The shortness and incorrect writing of the words are their main concerns. In general, they welcomed the help of mobile phones for Math, Spanish and English and perhaps also other subjects.

Paper Prototype

During three weeks of February we had the chance to interview around 190 teachers, which represented 1% of the teacher population in Panama. The teachers interviewed were representative of urban, rural and difficult access areas and we met them in groups of 30-40. We presented them a big paper prototype with an example of a mobile learning platform, where teachers would be able to create tasks and send to their pupils. The paper prototype was informed from our results of our previous focus groups. In total, we presented four (2x2) paper prototypes: one pair that would allow creation of mathematics tasks and another pair for science tasks, each pair consisting of one prototype representing a child's phone and the other a teacher's phone. The majority of the teachers (80%) liked the idea of using mobile phones easily in class. Teachers stated that students are very good with new technologies and are able to work with it. However, they think "*if we ever work with such phones… we have to receive good training on how to use it or otherwise children will know more than us*".

STAGE 3: FIELD STUDY IN THE CLASSROOM

Motivated by the findings from previous stages, including the high accessibility of mobile phones and teachers and children welcoming mobile phone usage, we decided to conduct a field study in a school. Our goal with the field study was to explore the design space of using mobile phones inside the classroom that fit with the local educational curriculum and teachers' needs. This goal splits into the following research questions: (1) how can multimedia capable mobile phones be used for learning in real classroom settings?; (2) how do teachers and pupils embrace the use of mobile phones to support common learning tasks in-situ?; (3) how will teachers integrate mobile phones in their daily teaching plan?

The findings from stage 1 stated that (1) pupils living in rural areas have much lower access to computers at home than their urban peers, (2) children in rural areas seem to welcome the support of the mobile phone in all the core

subjects, including Maths and (3) teachers agree on expecting benefits of using mobile phones in multigrade schools. Thus we decided to start our field study with rural multigrade schools and then extend it to urban schools.

User Study Settings

The user study was realized with students and teachers from 4th, 5th and 6th grade of the school El Retiro (see Figure 1). The school is located in the province of Coclé, around 120 kilometers from Panama City. The school El Retiro is classified as rural multigrade school. The school-grades are organized as follows: 1st and 2nd grade are together in one classroom; likewise 4th and 5th grade are together. Kindergarten, third, and sixth grade have their own classroom. Most of the habitants of El Retiro live from the agricultural activities, and as workers of the two main luxury hotels located in Coclé. The families there have low income. Although it is located in the rural area, the school is one of the few schools privileged with a computer lab with (very slow) Internet access.

In order to avoid any bias a mobile phone was given to each participant. The model used was a Nokia 5530 XpressMusic, which was provided by Nokia for the duration of the study. This model was selected because it includes robust and rich multimedia and communication features. In addition it provides touch screen interaction (with fingers and stylus), thereby enables, e.g. drawing apps.

Since a modern mobile phone is in Panama, similarly to most places around the world, a status symbol and also the monetary value (retail price in the US in 2010 about 150U$) of these mid-range phones is in this region significant (a phone represents 60% of a typical monthly salary in this community) we decided that the phones were only used by the pupils in school and were not taken home in order to minimize the risk of theft or mugging. The teachers received the phones first, and they were encouraged to use the phone during the time of the field study also as their regular phone.

For the pupils we decided to start with the highest grade and introduce the mobile phone there first. The rational for this was that this reduces the potential for bullying and at the same time allowed a step-by-step introduction. We then continued to introduce the phones to the next lower grade and so on. We anticipated an effect (1) that the younger children would then be eager to try it out if the older children had it first and (2) that older children could help explaining how the phones work and provide additional support. Both expectations were well met and the introduction went without difficulties. Every child used the same unique phone during the whole field study. The mobile phones were delivered daily at the beginning and returned at end of each class that the teacher planned to involve cell phones. In order to introduce the use of mobile phone to pupils, to help when required and to observe the development of the field study, the first author of this paper stayed in the classroom.

On all children's mobile phones a logger application had been installed which ran transparently in background, auto-starting on system boot, and cross-monitored with another watchdog application. The logger records every few seconds which applications are actively used by the participants. The data is logged with timestamp to a text file per day. Additionally, every 20 seconds the logger takes a screenshot of the active application of the pupil while the phone is in use (i.e. not in sleep mode). The application was written in Python (logging, picture taking) and Symbian C++ (access to system APIs). The data was logged to hidden folders on a 4GB SD card. The data could only be accessed by inserting the SD card directly into a computer. Hidden files and folders prohibited images from being erased by children as well as from appearing in the picture gallery.

The user study was realized from September 6th to 17th, 2010. The schedule in the school was from 8 a.m. to 1:30 p.m., thus five and a half hours. The school-hour in multigrade schools is 60 minutes. On average, children used the mobile phone around three to four hours daily, which represents between 54% and 72% of daily school time.

Besides the information we got from the logger file we realized two surveys (one before and one after the study), a final group interview, and a daily observation of pupils' interaction with the mobile phone. In the first survey, we asked children and teachers about their expectations on how to use a multimedia mobile phone for learning. At the end of the study, all participants filled in a post study questionnaire about their feedback and opinion of the study. Additionally we interviewed all the children to discuss about their learning experience during the study. We also met some parents to get their opinion about the use of mobile phones to support learning.

Participants

In total 40 children and 3 teachers participated in the user study. The mean age of the pupils was 10.5 years and 20 were girls. In the sixth grade and fifth grade there were 13 pupils each, and in fourth grade there were 14 pupils. The participating teachers were the teacher of sixth grade, fourth-fifth grade, and the English teacher. From the 40 children, only 4 children said they had a computer at home, but 39 children stated that someone in the family had a mobile phone at home. Even 10% of the children participants owned a personal mobile phone. There were 7 children that had never used a mobile phone before. Children have had no experience with touch screens before.

Description of the tasks

The first day we gave a general overview of the multimedia capabilities of the mobile phones to all teachers of the school. Then we asked teachers to design practicing tasks that utilize mobile phones and are according to the learning goals and content they had planned to teach in the near future. Additionally, based on previous findings, we asked teachers to focus on Mathematics, Spanish, English, and

Nature Science. However, teachers were free to add additional subjects in which to use the phones in the field study.

With respect to phone capabilities, we studied four main multimedia features, which are: 1) taking a picture and recording a video, 2) watching a video, 3) recording voice and listen to it and 4) painting and writing with the stylus.

For camera, video, and audio functions only those integrated with the mobile phone have been used. For evaluating the use of the stylus with the touch screen, third-party software was used, namely PaintPad (www.zensis.com) and Sticky Notes Touch (www.offscr.com). The former allows drawing and painting from blank as well as painting on saved images. StickyNotes simulates a post-it pinboard where users can pin hand-written messages.

The description of the activities realized during the field study including tasks, multimedia features used, and learning content is presented in Table 1.

Watching Video

The activity of watching video was realized in Mathematics, Spanish and Nature Sciences, as described in Table 1. All teachers used this feature to introduce a new topic, following the same pattern: pupils observed the video several times; after that teachers reinforced the concept with explanations and discussion with the pupils; then pupils saw the video one more time. In the end, the teacher realized other activities to extend and reinforce the topic either with or without mobile phone. The videos lasted between 1:10 and 9:38 minutes. Because of the considerable size of the videos (between 3 and 142 MB) they were installed on pupils' phones before the class.

The videos that children observed were either watched online (table 1, e), downloaded and saved on children phones (table 1, a), or own home-made videos. In the first case, the Internet connection was so slow that this form of watching video was tried only once and later replaced by the option of download, save and install on children's phones the day before the lesson. The third case is interesting to clarify: some videos were made by the grade teacher (see table 1: c) but also one teacher requested an external Math pedagogue to create the video to introduce the concept of measuring an area using the International System of Units (Table 1: a). This topic seems to be complex in rural areas, both to teach and to learn. Multigrade teachers in Panama have no specialization in any specific subject, but have a general background. In the video the Math teacher recreates the size of the square meter and its submultiples with the real measure.

During the observation of videos pupils were fully concentrated and most of them played the videos longer and more often than required while waiting for peers to finish. In standard class situations, children are often distracted and miss part or all of teachers' explanations and the lesson. It carries out that children are often too shy to ask the teacher to clarify on open questions. When watching lessons from video, pupils can easily repeat parts of the video they missed or did not understand.

Children and teachers stated that watching videos helped pupils in understanding the class. One teacher said "*it (video) can help the student to learn easier through repeating*", another said "*when students see the video three or four times, they have almost learned the lesson*". Children also welcome the use of watching videos, as one pupil commented to us *"(videos) explained me better (the lesson)".*

Educational Goal	Learning activities using the mobile phone
Mathematics: History of the longitude measures (6th)	(a) **Watching** a **video** about the history of the measure and the International System of Units as introduction of the topic; pupils in group of 2-3 **film** using part of their own body to measure e.g.: blackboard, books, walls, etc.
Measures of Area using the International Systems of units: square meters(6th)	(b) Children **watched a** customize **video** introducing the concept of square meter, its multiples and submultiples, then in the yard, children represent the size of a square decameter and **take a picture** of it
Addition of homogeneous fractions (4th) and multiplication - division of fractions (5th)	(c) Children **watched a video** introducing the concept of addition with homogeneous fractions. (d) **Watching video** about the concept of multiplication and division of fractions respectively.
Multiplication table (4th)	Children **listen an audio** file and with the multiplication tables recorded by the teacher
Spanish: Graphemes of questionable writing in building homophones words in the context of a sentence (6th)	(e) Children opened Youtube, search and **watched a video online** (use of B-V). (h) Either **teachers take picture** of orthographical tasks (use of S-C-Z) from the Spanish book and **send via Bluetooth** to the children. Or **children take picture** directly from the Spanish books task. (use of B-V) (i) Children solve the tasks with **paint pad** (figure 3), then they **save and sent the filled task** to the teacher **via Bluetooth**
English Practicing future tense (6th); Practicing reading and pronunciation (6th)	(j) Teacher **recorded herself (audio)** reading an English letter using future tense in their phone; the file was installed on the children´s phones; pupils **listened to it** while reading the letter from the book (figure 2), then children **recorded themselves reading** aloud the letter; finally teacher and children listened to all recorded audio
Months of the year and days of the week(6th)	Children individually prepared a speech about it**, filmed** in groups of two with children switching roles (speaker/cameraman).
Listening (5th and 4th)	Teacher **recorded English nursery rhymes**, then pupil **listened** and extracted known words
Nature Sciences: Biology Human reproduction and sexuality(4th, 5th),	(k) Teacher **took a picture** of an exercise about the human reproductive system, sent it **via Bluetooth** to pupils, then children solved the exercise using **PaintPad**, saved it and sent it back to the teacher, who evaluated it using **PaintPad**. (figure 3)
Sexual reproduction of the plants (5th)	(l) Children were asked to go the garden and to **make a video** about the part of the flowers
Nature Sciences: Ecology Fossil fuel energy sources (6th)	(m) Teacher set pupils a questionnaire for pupils to **look up answers in Google**; then they **created a video** in groups of 3 where the pupils act as interviewee, interviewer and cameraman. (n) Building of a conceptual map about petrol using the **stylus** and the **StickyNotes Application**
Social Sciences: Privatization and globalization (6th)	(p) Children prepared for a debate where in groups of 3 pupils recreated a talk-show using the **video camera** of the phone.
Religion: Love and respect your father and mother (6th)	(q) Pupils painted (using **paintPad**) the history of the Bible; then **sent it via Bluetooth** to the teacher (figure 3).

Tabla 1. Learning activities realized during the field study

Figure 3. Different usage of photo annotation as used by students. Left: Filling a Spanish orthographic task 6th grade; middle: writing the parts of the human sexual reproductive organs 5th grade, right: painted pictures of a bible story

Recording Video by Pupils

In contrast to watching video, this feature was used by teachers to extend, review and reinforce a topic. Debate, dramatization, speech, and dialog were common activities which teacher used to help pupils learn the concept. Teachers stated that using the video camera enhances the motivation and involvement of pupils to do these tasks. Pupils showed their motivation with filming in that they did not stop before every group member was content with the result. Repeating the film-takes could as well help pupils indirectly in learning the lesson.

Pupils filmed individually as well as in small groups. Teachers later reviewed recorded footage. Filming videos was one of the most preferred activities and pupils found it simple to use "*for me it is very easy... only I press a button and I am filming*".

Recording and Playing Audio

Teachers used this activity especially in English (see Figure 2), but also in Mathematics (see Table 1). Pupils found this feature to be very practical for improving the pronunciation in English and welcomed it more than we expected: "*I can hear me and correct pronunciation errors*". Teachers stated that when children record their own voice when reading, and later play it, it supports (1) the self- evaluation and self-critical spirit of the pupils, both important aspects for the teaching-learning process, (2) the improvement for pronunciation and listening to English.

In our pre-study questionnaire half of the 5th grade children answered they imagine mobile phones helpful for learning multiplication tables; not with pictures, games or text as we imagined, but with voice. They stated that with the cell phone they have the opportunity to record the multiplication table talking or singing, and listen repetitively. From our observation and talks with teachers, we think the reason of this preference can be: (1) the usual technique in this classroom for learning the multiplication table being iterative listening and <u>repeating</u> in choir (auditive memory) and (2) different from lower grades where pupils learn the concept

of multiplication, on fifth grade pupils already knowing the concept of multiplication, with the requirement for visualizing the concept being lower.

Take a photo, Writing and Painting

One activity proposed from teachers was to take a picture of a task in the book, then let children fill it in, and finally send it back to the teacher. Books are only lent to the children, thus they are not allowed to write into them. So either children have to handwrite the exercise or pay to receive a copy of the practice. Teachers commented "*they manage that pencil (stylus) just as it (was) a real one*". For several examples see Figure 3, a) in Spanish, b) Biology, and c) in Religion. Painting and drawing still plays a role in upper levels of primary schools and not only in arts. In subjects like Nature Science and Religion, painting is among the main activities done in class. In sixth grade a teacher asked pupils to paint and illustrate a reading from the Bible, which can be seen in Figure 3. PaintPad was more successful than we expected, as one pupil said "*I love it... I can erase, change color and repaint again ... in the paper I cannot erase or change colors after I started*". *I feel phone*

Figure 4 Conceptual map done by pupils of 6th grade using Sticky Notes Touch®.

was helpful for learning about female and male reproductive system and was very funny to write on the phone"

Finally in the class of Nature Science, children once used StickyNotes to create a conceptual map (see Table 1: n and Figure 4). From our observation and conversation with children they missed from this a mechanism to erase letters and not to "trash" the whole note away. It is important to note that the creation of conceptual maps is the most common practice in Panamanian schools to summarize what children have learned.

Interaction and behavior of the children in class

Although children had no experience with such phones, they learned very fast how to use them. After the second use of any multimedia function, most of the children had no more questions regarding the use of the mobile phone. Even more, sending a file via Bluetooth was explored only three times with sixth grade and two students were able to do it alone the second time. According to our observation children who had not used a mobile phone before, at the end of the study, were similarly skilled as others. The most difficult task was writing with the virtual keyboard, especially for those not familiar with mobile phones. During the 2nd week, there was no question how to use a function of a mobile phone in 6th grade. Fourth and fifth grade still had some questions because they started with the study two days later than 6th grade.

According to the teachers, pupils were much more involved and participative in the class, and more enthusiastic and concentrated in the realization of the tasks with the cell phones.

After the field study we asked children if they perceived a change in the interaction and behavior of the pupils in the classroom using a mobile phone. Most of the children, 84%, stated that they feel to learn more using a mobile phone, 54% stated that they participated more actively in the tasks, and around 65% of children stated that classes were more interesting and funny using a mobile phone. 63% of children stated that with mobile phones they were more collaborative with their peers. Only 3 students stated that class interaction was equal to that without cell phones.

Use of mobile phone by gender and age

At the beginning, boys seemed to be more comfortable and learn faster using the phone than their girl peers. During the first day of the user study in 6th grade, four of the first five children that finished the activity were boys. Consequently we got more questions from girls the first day.

Our recorded screenshots indicate that boys were more curious than girls and explored the phone more eagerly than girls – though this gap decreased a little by the second week. The most explored and used applications by boys were games, filming and taking pictures. Possible explanations for this are 1) that according to teachers the female pupils behaved and are better students than their male peers, and 2) boys at the beginning finished many of the tasks

quicker than girls and therefore had more free time while waiting for girls to finish.

Another interesting aspect was the carefulness. Girls have been more careful in completing the tasks with the mobile phone, especially when painting with PaintPad. E.g., girls painted slowly and if the painting did not satisfy them, they repeatedly started over. In contrast most boys did not, which can also explain why girls took longer to finish.

Children learned by doing, they were not intensively trained in any of the features used. Further, age played a significant role as well. Comparing children of 6th, 5th, and 4th grade, higher grades learned faster to use the functions of the mobile phones. However we think with more training children of 4th grade could compete with their higher peers.

Teachers and children alone

Can children and teachers get along integrating the mobile phones in the learning activities without our supporting attendance? This was the question raised at the end of the study. So we decided to conduct a last day trial with 6th grade without us, where teacher and children worked completely alone. The teacher advised two activities: first children had to look up information about nature gas (Nature Sciences) in the mobile Internet (in teamwork) and then they should create a video with the information found. The second task was to take a photo of a learning task in the Spanish book, fill it out and send it to the teacher via Bluetooth.

According to the film we captured, screenshots and the teacher's opinion, the activity worked very well; she commented to us "*there were no questions on how to do they just knew how to do everything (on the phone)*" "*they were concentrated…*". The only problem was that phone memory was full and she could not receive all works.

Multigrade classroom

In our study we also observed that integrating mobile phones in class helps to free some time for teachers, especially valuable in multigrade classrooms. One example of the field study: While pupils of fifth grade were making a video about the parts of flowers in the garden (Table 1: l), the teacher gave a Math lecture to the pupils of 4th grade. When fifth grade pupils returned, the teacher reviewed their videos while children of 4th grade were solving a Mathematic practice related to the lecture before.

Feedback from the participants

Children and teachers reported positive feedback from the features used. We asked teachers to evaluate the usefulness of the multimedia functions used during the study on a 1-5 scale, where 5 meant strong agreement that it was useful. All the functions were considered between useful and highly useful: Play a video 4.5; Record a video 4.9; Take a picture plus Paintpad 5.0; Record voice and play audio 5.0. Table 2 shows a summary of pupils' opinions. We asked pupils from 6th grade about their opinion on using sticky notes: 85% of pupils considered it easy to use and liked it,

77% considered it interesting, 69% of them considered it was funny and 85% think it supported them in learning.

Item	Watch Video		Record Video		Voice		Paint Pad®	
	Y	N	Y	N	Y	N	Y	N
It was easy to use	89	11	89	11	89	8	92	8
I like it	95	5	97	3	92	8	97	3
It was funny to use	89	11	86	14	95	5	92	8
It was interesting	89	11	89	11	84	16	92	8
I feel it help me to learn better and more	86	14	89	11	86	14	89	11

Table 2. Opinion of the students about the use of some multimedia functions in percentage.

Parents feedback

At the end of the user study we met five mothers and three fathers of the participants from 6th grade in order to know their opinion about the study. From the 8 participants, only one male had never used a mobile phone before, the others owned a mobile phone. We presented some of the works done by the children with the mobile phones.

Parents were very astonished when seeing the works realized by the children with the mobile phone since they did not expect such outcomes. As one father commented *"at the beginning when my child told (me) about this (study) I was very skeptical of using (mobile) phones in the class…but now I am surprised and really see (it) would be very useful in class"*. At last, one mother commented at the same respect *"I did not know all the things that are possible to do with a cellphone."*"

Similarly to teachers' concerns in our surveys, the main concern of parents was bad use of the cell phone, for example playing or accessing/recording inadequate material. Nevertheless, parents saw more benefits than risks using the mobile phone and were conscious of their role as supervisor of their children: *"it is important that (we) control that the children use them correctly"* and *"having the right supervision from us at home and teachers at school, I see no problem of using them (mobile phones) for learning"*.

All the parents welcomed the idea of using a mobile phone for learning. They mainly think that children will be much more motivated and involved in class; as one mother said *"my son was extraordinary motivated (during) this two weeks to go to the school"*; another mother commented *"for children learning using a mobile phone is amusing"*.

DISCUSSION

More than expected, in Panama access to mobile phones is much higher than to traditional computers. We were surprised how many of currently used phones had cameras and multimedia capabilities, suggesting that many people have mid-range phones. In our study we chose a phone model that is currently at the upper end of mid-range phones and has many features of a simple smart phone. We expect that these capabilities will be available also in the low-end phones over the next years. Many of the functions used rely on a touch screen with a stylus. However, our studies re-

vealed that teachers are able and willing to create tasks that fit the phones available. Moreover, based on our good experience in the field study, we think that providing Internet access via the phones is manageable. Letting children know that using the device is not an uncontrolled space (as their interactions are logged) helps to ensure responsible behavior.

In the surveys and focus groups we asked children and teachers to speculate about potential uses of the mobile phone as educational device and got valuable responses on how to create successful learning environments in a developing country context. Though major parts of the field study were inspired by these comments, over the course of the study we got interesting findings that validated, but also contrasted, contradicted, and extended the suggestions made. Hence we argue that the use of surveys and focus groups only is not sufficient to understand requirements and to design deployments. In the surveys, using phones as educational devices was often seen as using the phone instead of a computer. In the field study we realized that standard video and audio capabilities, comparable limited on traditional PCs, were considered among the most useful functions for supporting learning because both allow children to create and to replay content.

Primed by having computer labs in schools, teachers were concerned about managing the phones and the infrastructure and teaching children how to use them. With traditional PCs this is in many schools the central issue. Here we see an interesting advantage of mobile phones. In the field study we could observe that children learned very fast using the new device after a short introduction. As the children used the phones as a personal device (each child had one phone) while in school they felt ownership and also had the opportunity to explore on their own pace. We observed that some children gained skill very fast and then were able and willing to help their peers. Though, we observed a gender difference in the approach of exploring devices. Further, our positive expectations on introducing phones top down (starting from highest grade) were met.

To our surprise we could witness how teachers embraced the new technology. Teachers learned within days to make use of the phone as a teaching resource and discovered new opportunities for using it in class. Several of the ideas, especially with taking photos and annotating them, were mainly developed and refined by the teachers. Having the simple usage model of a phone and in some cases the paint application enabled a versatile use without requiring a complex learning platform. For teachers it was a great value to tailor the content in an easy way to their current teaching plan. Here the multimedia recording turned out to be a very valuable resource. We learned that providing pre-fabricated digital content might be very difficult, as it would need to fit the teacher's plan and style of teaching. By providing tools where teachers can move their content easily into the digital domain we expect that many teachers can be won over as it eases their effort for preparation.

Before the field study, teachers and especially parents were worried that mobile phones might not be useful and distract the children from learning. Furthermore they did not see a link between a PC and a mobile phone and most of them could not imagine how a mobile phone could be used in a sensible way in school and for teaching. However, after the field study parents saw a clear benefit in using mobile phones in the school context, even though they were initially skeptical. They were surprised of the activities done with the phones and proud of the products their children created with these devices.

CONCLUSION

In this paper we presented our research on how multimedia rich phones can aid or support the school education in rural areas in developing countries. We conducted our research with children living in urban as well as rural areas, which had low access to computers but high access to mobile phones Besides, a considerable percentage of teachers and pupils reported to have access to modern mobile phones that include multimedia and networking features, i.e. integrated audio player, integrated camera and Internet access.

The findings we gained from surveys, interviews, and discussions with several hundred teachers and pupils show that pupils and teachers seemingly welcome edutainment applications on their handsets, in special for Mathematics and languages. Besides, standard multimedia phones showed to be a versatile and resourceful tool and our findings in the field study suggest that multimedia phones are ready to be used in class as they are, even without external learning applications installed. Phone manufacturers and service providers can take this as advice to equip their phones with some applications (drawing, multimedia annotation, easy import of traditional media) that are generally useful in the educational context when targeting developing markets.

The results of our final field study can be summed up to the following two key findings: (1) Rather than preparing mobile phones with pre-edited content, teachers were creative to fit features of the mobile phones into their teaching plan and (2) recording video and painting on the phone were the activities that children liked most to do.

Similar to earlier reports, we also observed a higher degree of concentration, involvement, motivation, and participation in the realization of the tasks given when pupils learned with mobile phones. However, this finding is not fully conclusive because of the limited duration of the field study and because pupils might have been influenced by the technology novelty effect. In the same direction we cannot conclude that pupils learn more effective using mobile phones. This would require a long-term study evaluating pupil progress over time. We are planning on conducting such a study in the near future.

Besides, we are going to evaluate in more detail the large amounts of application data we logged to see how the data supports our qualitative findings and provides us even deeper insights. Further we want to extend our field study to children in urban areas.

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