The basic platform

By David Hildebrandt

Mobile learning is about people learning while being mobile. People are mobile not the devices they carry[1]. While it is true that the devices are untethered, having no wires connecting them to networks, they still must rely on people to carry them. The technology behind mobile learning allows the learner better access to information, resources, and other people when and where he or she needs or desires it[2 3]. Danaher defined a mobile learning community as "a group of people who are mobile for sustained periods of the year or their lives and who recognize in themselves and others a common experience of mobility and a shared commitment to learning for themselves and other group members"[4]. This definition of a mobile learning community does not mention technology; the focus is on people that are mobile that have an interest in learning. The goal of life-long learning is to provide access to learning resources while being mobile—which can take on many forms.

Mobile learning devices

Today there are numerous devices that can be used for mobile learning. Feature phones, smartphones, and tablets can all be used for mobile learning. The features and functions described in this article are common across smartphones and tablets. A subset of the features and functions is found on feature phones. Google and Windows license their respective operating systems to many hardware manufacturers, as such the functions and features enabled on these devices will vary by manufacturer.

Voice calls

The ability to make, or receive, a phone call regardless of location is what started the cell phone revolution. Making and receiving phone calls may not seem like an educational opportunity. However, being able to call an expert for advice could be a form of coaching. The power of a simple phone call is often overlooked. A phone call can connect the caller with his or her learning community—support can be just a phone call away. The learner can also register for a course by dialling a phone number and verbally agreeing to enrol in the course by responding to voice prompts or by entering acceptance via the numbers on the keypad.

Interactive Voice Response (IVR) systems enable a degree of interactivity by playing a pre-recorded message (prompt) and listening for a response either by voice or depressing keys on the phone keypad. The power of IVR systems can be harnessed to create mobile learning applications when the learner may only have access to a mobile phone and an auditory response, such as when learning to speak a foreign language.

Figure 4.1 shows a simplified view of a learner using a basic cell phone to make a call to an IVR system. An IVR system can be programmed to handle numerous learning objectives. The learner makes a phone call to the IVR system. The IVR server answers the call and plays the initial message to the learner. The IVR could recognize the learner's Caller ID and by accessing the Learning Database determine which initial message to play and what options should be made available. The learner would then respond to the voice prompts either by depressing keys on the keypad or speaking his or her response—depending on the sophistication of the IVR system.

Language learners can call in and listen to a mini-lecture, listen to and practice the word of the day, or take a test to determine if they can pronounce the word correctly or to understand it in a sentence. The menu options to support such a system are shown in Figure 4.2. The limitations of using an IVR system with a phone are limited only by the IVR capabilities and the appropriateness of the subject matter to be learned.

When coupled with an IVR system a basic cell phone can become a learning tool. It is the

Figure 4.1: Learner using cell phone to communicate with IVR server

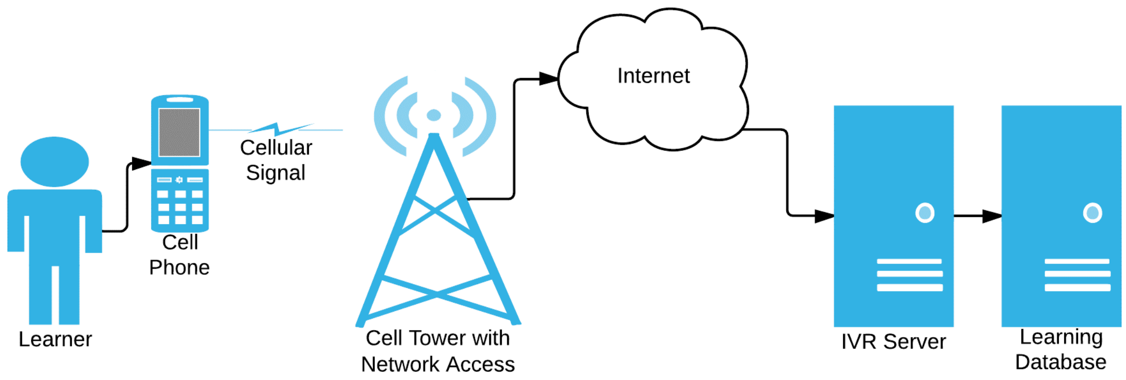
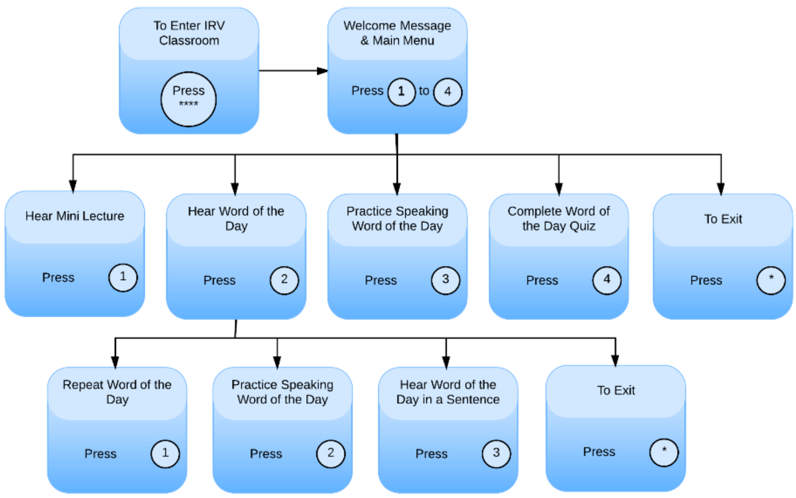


Figure 4.2: Example flow of IVR call for foreign language learning



inherent capabilities of the cell phone coupled with other learning technology that creates a powerful learning platform. In addition, the IVR provides visually impaired learners with an opportunity to engage in mobile learning. There is also the ability to use this approach to reach nomadic populations that are illiterate—being able to hear instructions provides a starting point for their learning.

Text messaging

Short Message Service (SMS), often referred to as *text messaging* or just *messaging*, was designed to allow brief messages to be sent over the cellular network using the phone number of the recipient as the destination identifier. SMS is limited to 160[5] characters though some popular services such as Twitter limit the message length to 140 characters. There is also the Multimedia Messaging Service (MMS) that allows text messages of unlimited length as well as rich media attachments. MMS can be used to share images, video, audio and other multimedia with other cell phone users. Text messaging has become a ubiquitous form of communications found on even the most basic cell phones.

Text messaging can be enabled on a Learning Management System (LMS). The learner, via SMS, can respond to the LMS initiated text message. Returning to the IVR example from the previous section on voice calls, the learner with the help of text messages, could enrol in a class simply by sending a text message. The learner could receive the word of the day along with the definition via text message, and then practice using the word of the day in a sentence by sending and receiving text messages. Text messages could also be used for learning assessment via true/false, multiple choice, or short answer quizzes. The SEMA project, mentioned elsewhere, used all these formats as well as creating groups for message-based discussion, calendar alerts, administrative reminders and study guide support.

The simplicity of text messaging makes it an attractive option for mobile learning. Text messaging as a learning platform is also simpler and less expensive to implement than an IVR system. The constraint of text messaging is that there are still cellular service providers that charge for each text message. There are also cellular service providers that charge for text messages that exceed a monthly quota. Refer to the discussion in the Tariffs section below for more information on monthly charges. Variable charges based on monthly usage can result in hidden costs for the learner that they may be unable to pay.

Consider the cost of text messaging to learners when looking to implement a text messaging based mobile learning application.

A powerful example of using text messaging is found in Edmonton, Canada's Centre to End All Sexual Exploitation (CEASE) that build a program to use mobile text messaging as an outreach strategy (Box 4.1).

Text-to-speech/speech-to-text

With the introduction of Siri[6] and Google's Speech Recognition for Android devices it is now possible to give voice commands to a smartphone. It may be as simple as the smartphone reminding its owner about a scheduled meeting, setting an appointment for next Tuesday at 2PM, or converting an incoming text message or email to speech and reading it aloud. This ability to convert natural speech into text for a message

Box 4.1: Reaching the sexually exploited in Edmonton, Canada via text messaging

Recognizing the ability to send a text message that had sufficient information to be actionable by the recipient, Edmonton's Centre to End All Sexual Exploitation (CEASE) decided to send text messages to a mobile phone list culled from an adult advertising site about the services offered by CEASE. The phone numbers were entered into FrontlineSMS, a free SMS management tool, and CEASE crafted the text message. FrontlineSMS sent the text message to the mobile phones informing the recipient that he or she could contact CEASE for counselling, training, income support, victim advocate, and peer coaching. The goal was to augment the work CEASE does in person as many sex workers are no longer working on the streets and a new way to access sex workers was needed.

CEASE found that the work to gather the numbers using automated tools and to import the phone list into FrontlineSMS was about an hour. This gave them the potential to access hundreds of potentially exploited persons with ease. Though this was a pilot program the number of recipients that responded positively was encouraging. They did have a few individuals respond asking to be removed from further notifications. The positive responses either thanked them for the good work, or asked for more information.

FrontlineSMS required a laptop running their software, and a GSM modem plugged into the laptop to send and receive SMS messages. The cost for sending the SMS messages was considered negligible, as it was part of the monthly service plan. FrontlineSMS is free.

This case study shows that text messaging can be used to communicate with a group of at risk men and women that could not be reached easily any other way.

Source: Gow, G., Quinn, K. and Barlott, T. (2014). *Sexual Exploitation Outreach with Text Messaging: Introducing Project Backpage*. Frontline SMS Case Study. Available at: http://static1.squarespace.com/static/56e1a99907eaa0941d037b0a/56e1aa9e06dcb7bbf42a70ce/56e1aaf306dcb7bbf42a7a35/1457629939677/frontlinesms_casestudy_Sexual-Exploitation-Outreach-with-Text-Messaging.pdf?format=original. Accessed 6 Nov. 2016.

or email, or to issue voice commands by speaking to the smartphone are powerful tools when developing training for visually impaired learners. While powerful, the technology is not perfect and users may find it difficult to be understood by the smartphone. This can be mitigated somewhat when the smartphone can be trained to understand the owner. There may also be higher monthly costs due to increased data consumption.

eMail

Many mobile devices provide access to email. While this may not be thought of as a learning solution, sending email messages to an automated system can engage the learner in educational activities. By responding to an email message and performing the task as directed a new email can be sent furthering the exploration of the subject being studied. Email should not be discounted as a learning tool. Email can be used for performance support, sharing or exchanging resources, and keeping in touch with a community of practice. However, email will require the learner to have a data plan on their mobile device so that they can manage the monthly cost. Designing an interactive learning environment without consideration of the potential to increase the monthly cost is disingenuous to the learner.

Internet

Internet over a cellular device provides the learner with access to the vast information on the World Wide Web. This also means that a Universal Resource Locator, or URL, can be used to direct the learner to specific resources. By tagging specific resources with a URL the learning system can send a message to the learner and include the URL to a resource to further the learner's knowledge. URLs are the backbone of the Internet and they are used to link to audio files, video files, documents, graphics, HTML pages, and websites. It is the URLs that provide the connection to the plethora of social media sites and the Internet based tools.

Leveraging the Internet for learning requires a change of focus from content author to content curator. Rather than spending time developing content from scratch for use in courses, the focus becomes that of locating high quality content on the Internet that can be repurposed to further the learner's knowledge. It is also important to ensure that selected content remains available as websites can disappear without warning or the URL of a selected site changes due to a website redesign.

Apps

Apps allow developers to create applications that run on mobile devices and access the hardware subject to the device manufacturer's security policies (see Hardware section below). In June 2016, Apple had 2 million applications and Google had over 2.2 million applications available for download in their online stores[7]. With this volume of Apps there is a high probability that there is an App for just about anything a mobile device user wishes to do. There are even Apps that extend the functionality found in learning management systems to mobile devices.

With the introduction of HTML5, it is becoming possible to develop applications that are browser based. HTML5 implementation improves video, audio, and offline capabilities for browser based applications. HTML5 is growing in popularity; however, the implementation of HTML5 is still inconsistent and not all mobile devices implement all the HTML5 features. Therefore, cross platform testing is still required for HTML5 based applications. HTML5 should not be confused with the Apps being described here however. Apps in this article refer to software development where the App's source code is compiled to run natively on the targeted smartphone. As the power of mobile devices grow and network speeds improve, this distinction may become irrelevant.

The benefit of Apps is how they enable the extensibility of mobile devices. If a need can be identified an application can be written. The challenge of Apps is that they are device specific. An App that is written for an iPhone will not run on an Android device and Apps written for iPhone or Android will not run on the Microsoft mobile devices. This lack of portability means that Apps need to be developed for each platform that will be supported. There are tools emerging that allow developers to write code that is portable—but device specific refinement is still required. Overtime the portability of Apps will increase, but for now it requires additional effort to support multiple smartphone operating systems.

Hardware

This section will discuss the hardware that is included on mobile devices and use with mobile learning. Not every mobile device will have everything described in this section. It is difficult to talk about hardware and not mention software—as software is what allows the mobile device's hardware to be utilized by applications. For the sake of simplicity, only the hardware is discussed below. The modern mobile device can be thought of as a handheld computer—complete with internal storage for data, programs, temporary storage, and an operating system that controls the basic functions. Of course basic functions of a mobile device are extensive—as they do much more than make and receive phone calls.

Accelerometer

The accelerometer is a sensor that lets the mobile device know up from down. An example of this is when the accelerometer provides the device orientation so that the screen can rotate as the device is rotated. The accelerometer can detect small changes in the orientation of the mobile device—an example is the game Temple Run that allows the player to navigate a maze just by tipping the mobile device side-to-side or up and down. The accelerometer provides data on the learner's movements allowing an application to respond accordingly. Simulations that require hand-eye coordination are more realistic when the accelerometer is used to track learner actions. The accelerometer is shared by other applications as well as the mobile device itself—and critical movements could be lost due to other applications accessing the sensor.

Battery

It is important to remember that a mobile device relies on its battery and can only operate while the battery contains sufficient power. Individuals that do not have direct access to power to recharge their mobile devices must seek alternative ways to recharge their mobile device. With an estimated 1.6 billion people (Box 4.2) that do not have easy access to electrical power, individuals having to travel to recharge their devices should be taken into consideration.

When developing mobile learning strategies, consideration needs to be given to learners that

Box 4.2: Community power from mobile-charging services

GSMA published a report on the high cost of charging mobile devices in locations that are off the power-grid (off-grid) in July 2011. It estimates that 1.6 billion people do not have access to electricity. Yet the number of individuals who live off-grid and own mobile devices is increasing each year. These individuals need to use alternative ways to charge mobile devices such as solar-chargers, car batteries, hand-crank chargers, or finding a small power generator. However, these all require purchasing additional equipment that may break, become inoperative, or be costly to access. For example, the cost for charging a mobile device in Kenya is around the same price they pay per minute of airtime (USD 0.18 – USD 0.25)[a].

GSMA noted that many of the cellular base stations in these remote areas operate off the power grid. In such locations the cellular providers have developed methods of generating power onsite either from a generator or from renewable "green" sources. Many of the cellular base stations generate more power than they need. This excess power could be made available to the local people. An example of this is Safaricom that had developed a mobile handset charging dock that is affixed near their cellular base station.

Note: [a] GSMA. (n.d.). *Green Power for Mobile: Charging Choices*. [pdf] Available at: http://www.globaltelecomsbusiness.com/pdf/charging_choices.pdf Accessed 6 Nov. 2016.

Source: GSMA. (2011). *Community Power from Mobile-Charging Services*. [pdf] Available at: http://www.gsma.com/mobilefordevelopment/wp-content/uploads/2012/07/charging_services.pdf Accessed 6 Nov. 2016.

do not have easy access to electrical power. Deploying mobile devices to learners when the learners will not have ready means for charging the devices will lead to a failed program. In rural areas, learners may only access a generator, and network coverage at a weekly market.

Bluetooth

Bluetooth is a low-power personal network that is designed to allow electronic devices to communicate over short distances, normally around 10 meters (30 feet). The most common use of Bluetooth is pairing an earpiece to a person's smartphone so that they can use the smartphone without having to hold the smartphone to their ear. There is no reason why other uses of this capability cannot be developed. The auto industry has been adding Bluetooth capability to automobiles for several years to allow the vehicle owner's smartphone to connect with the automobile. Recently the sports industry has begun to make wearable devices, such as the Nike Fuelband, to monitor heart rate, steps taken, and calories burned and share the data with applications running on a smartphone.

Bluetooth provides a means for classroom equipment to communicate with the learner or the teacher. Bluetooth capability can be built into field equipment allowing learners to connect once they are within range of the equipment and complete pairing (gaining access). Once paired with a Bluetooth equipped piece of equipment the learner would be able to send commands and receive data for later analysis. Bluetooth also allows learners to share data amongst themselves—creating a collaborative micro-network.

Camera and video

Mobile device manufacturers have continued to improve the quality and capabilities of the built-in camera and video recorder. With the built-in flash and improvements to low light conditions, it is possible to take pictures or video without having to worry about the level of ambient light. This has led to a rise in picture and video sharing using Apps/platforms like Instagram[8] (picture) and Snapchat[9] (photo & video).

A mobile device can even geotag the picture or video using the GPS (see below) coordinates. The *geotag* adds metadata to the picture/video that provides timestamp, geographical coordinates of where the camera was when the picture was taken, type of camera, and a plethora of other data relevant to the image. The geotag, in an academic context, provides validation that the learners were where they were supposed to be. On the other hand, if the learner is performing fieldwork, accurate documentation where the pictures were taken is recorded automatically.

Care should be used with geotagging. Pictures or video that are taken at the learner's home that are geotagged and then shared publicly provide the GPS coordinates of where the learner lives. This may not be in the best interest of the learner. It is best to have learners turn off geotagging unless it is needed for a specific assignment and never geotag from their home or any place that they wish to keep private. It should also be mentioned that video, and high definition images, result in large files—and large files being sent over cellular networks may result in higher data usage fees.

QR Codes are an example of leveraging the built in camera with an App that also communicates with the browser on a mobile device. The QR code shown here contains the URL to the ITU Publications page. The ability to scan a QR Code provides a convenient method of providing links to additional learning resources without requiring the typing of long URLs. QR Codes can be affixed to buildings, signs, and printed on paper or clothing. QR Codes can contain far more than a URL. QR Codes can encode about 4200 alphanumeric characters.

Global Positioning System

The use of the Global Positioning System (GPS) has changed forever the way people navigate in countries where roads have been mapped in sufficient detail. The GPS signals can be received by smartphones as long as there are unobstructed views of the sky.

A smartphone can be turned into an orienteering compass by installing one of the many compass applications. There are also Apps that let you enter the GPS coordinates of a location and then use the built-in GPS on the smartphone to aid the learner in navigating to the target location. By using a GPS recorder a person can engage in geocaching or other forms of exploration of his or her environment and capture the exact location of observations or phenomena.

Microphone

A microphone is required for voice conversations on a cell phone. There is an additional advantage with smartphones—being able to record voice or ambient sounds. The only limit to the recording length is the available memory for storing the recording.

The ability for learners to record themselves, to record others, or to record specific sounds enables the learner to add another dimension to their mobile learning. The ability to create an audio diary, interview a subject matter expert, or record the amazing sounds of the Australian Superb Lyrebird while researching in the field are all powerful ways that the built-in recording feature could be used to extend learning. Incidentally, some apps can exploit the microphone for measuring wind speed.

Near Field Communications

Near Field Communications (NFC) differs from the other forms of communication, as NFC does not rely on active radio transmission as the other communication services (cellular signal, Bluetooth, & Wi-Fi). NFC uses radio-electromagnetic fields to exchange data with a radio-frequency identification device (RFID). NFC devices must be in extremely close proximity—within 20cm (7.86 in) of each other.

NFC technology can be found in credit cards and mass transit payment cards such as Oyster in the UK and CLIPPER in the San Francisco Bay Area. These cards with their embedded RFID tag allow instant payment, or account debit, with just a quick pass over the NFC card reader. NFC devices are not limited to read-only operation; it is possible to update the content of certain NFC devices.

While this may not seem like an innovation for mobile learning, imagine a scavenger hunt where the learner must navigate to the correct location using GPS and then scan the RFID tag that is located there—retrieving the next clue all at the same time. Another use could be for self-guided campus tours or orientation to a school or university. An advantage of RFID tags is that they can be embedded in any material that allow radio waves to penetrate, thus creating semi-permanent and weather-proof installations.

Universal Serial Bus

The Universal Serial Bus (USB) allows peripheral devices to be connected to a smartphone or tablet, which allows device functionality to be extended. External storage devices, LCD projectors, or connecting to a computer are all common uses for the USB port found on many smartphones and tablets. However, the USB port can also connect instrumentation packages such as signal analysers. This extensibility means that environments can be instrumented and the learner simply provides the smartphone to read data from the devices. The use of USB enabled devices is another example of how the smartphone or tablet can be turned into handheld field equipment that is modified to meet the needs of a particular study.

Wi-Fi

The Wi-Fi capability on mobile devices makes it possible to connect to the Internet over local networks providing faster and cheaper access than using the cellular network for Internet access. Wi-Fi only devices are also available; they do not have the capability to access the cellular network monthly cellular contracts are not required. As Wi-Fi hotspots grow the need for cellular access diminishes. Unfortunately, the growth of Wi-Fi hotspots is occurring at a far faster pace in the Northern Hemisphere, which only exacerbates the digital divide with the Southern Hemisphere.

Security

A mobile device that has access to sensitive information creates a security risk when that device is lost or misplaced. Knowing a mobile device that has confidential information is no longer under the control of a trusted person is cause for concern. While it is possible to have the mobile phone provider turn off the phone's ability to make calls, they cannot easily remove access to Wi-Fi networks or remove files and data that are stored on the mobile device.

Modern mobile devices can access the Internet. Without proper network filters, it is possible for an adolescent to access Internet sites promoting pornography, hate, violence, and many other websites that are inappropriate. Relying on network filtering is insufficient as the filtering only works while the mobile device is connected to the organizations network via Wi-Fi. All that is required to bypass the local network content filters is turning off the Wi-Fi and allowing the smartphone to connect via the cellular network.

While there are some free apps that can be downloaded to mitigate this, they require the phone to be rooted—gaining full control over the device. This is not something that cellular companies want subscribers doing and rooting a device may void the cellular contract. Furthermore, an app that a learner is directed to download and install can just as easily be uninstalled. Thus, security and content control that is in the hands of the learner is only an illusion—as the learner can circumvent the security and content settings easily.

There is also the challenge of knowing that a website can be trusted. Individuals that are unfamiliar with the Internet may mistakenly believe that everything they read on the Internet is true. For individuals that are engaging in informal learning activities, the lack of critical thinking skills could create misconceptions about the topic under study—thus interfering with the knowledge acquisition they are undertaking.

Recognizing the need to provide security and content filtering that is under the control of a trusted administrator has given rise to several companies that are offering solutions while not being overly intrusive. These companies provide either full device control or create a walled off storage space for sensitive data. While this does require the installation of an App, or family of Apps, once installed the Apps are locked and can only be deleted by the trusted administrator.

Tariffs

The data in Table 4.1 shows that the features that are included in a plan vary greatly by country. Many of the countries are offering unlimited plans, yet there are still countries applying the pricing methods from last century when the price per call was based on distance called and the duration of the call. The same archaic pricing model is also found with text message and data plans. As competition increases in these countries it is hoped that unlimited plans will be rolled out. The importance of unlimited plans is that they remove the financial risk from learners as they enrol in a learning program or engage in informal learning activities. While unlimited plans may appear to cost more, they allow the learner to treat the cost of the mobile device as a fixed cost.

Depending on the design of a learning program the learner may need to access voice, text messaging, and data. Data access may be the biggest cost the learner will face on a monthly basis if the learning program uses rich media—be it downloaded or streamed to the mobile device. This variability in the costs borne by the learner needs to be understood and must be included as an indirect cost the learner will face when enrolling in a mobile learning course.

Creating rich video content may seem to be an ideal delivery method. However, it may put the cost of completing a course consumed by the learner on his or her mobile device out of reach financially. If a course is designed knowing the cost that will be incurred by the learner then the course price could be adjusted. Learners in urban areas may have access to Wi-Fi in cafes or business centres.

Conclusion

This article has covered many features and functions of a feature phone, smartphone, and tablet. At this time the only difference between a tablet and smartphone is that a tablet does not have phone capabilities—everything else is possible. There are some tablets that can use Skype for 2-way voice conversations using voice over Internet protocol (VoIP). As competition in the tablet market continues to grow it is only a matter of time before the smartphone and tablet merge into a single powerful device.

Table 4.1: Selected country tariffs for monthly mobile service for 2016

Monthly Cellular Plans						
Country	**Monthly Fee (Euros)**	**Included Voice Minutes**	**Overage/Minute Voice**	**Text Messages**	**Monthly Data**	**Data Overage Charges**
Brazil	€ 28.19	1,000	n/a	unlimited	2GB	unknown
Canada	€ 61.27	unlimited	n/a	unlimited	1GB	€ 3.40/100MB
China	€ 18.62	500	€ 0.03	10,000/Month	1GB	€ 0.04/MB
France	€ 19.99	unlimited	n/a	unlimited	2GB	speed reduction
Germany	€ 34.99	unlimited	n/a	unlimited	2GB	speed reduction
India	€ 16.51	unlimited	n/a	100/day	1GB	unknown
Indonesia	€ 8.71	75	€ 0.10	150	5GB	unknown
Italy	€ 35	1000	n/a	500	2GB	speed reduction
Japan	€ 60.05	unlimited	€ 0.22	unlimited	7GB	speed reduction
Mexico	€ 54.95	unlimited	unlimited	unlimited	unlimited	n/a
Nigeria	€ 5.81	2,560	Monthly fee charged to reset voice usage	unknown	2GB	Monthly fee charged to reset data usage
Russia	€ 38.79	5,000	€ 1.01	5,000	15GB	unknown
South Africa	€ 142.64	unlimited	n/a	unlimited	10GB	€ 0.07/MB
Turkey	€ 13.94	1000	€ 2.84/250 Minutes	1000	2GB	€ 2.84/GB
United Kingdom	€ 39.00	unlimited	n/a	unlimited	12GB	unknown
United States	€ 91.50	unlimited	n/a	unlimited	10GB	Speed reduction

Source: Data from: Liberty Web. [online] Available at: http://pos.tim.com.br/?franquia=2gb&trk_source=tim&trk_medium=button&trk_campaign=pos.2gb&uf=sp; for Brazil. Smartphone Plans. [online]. Available at: http://www.rogers.com/consumer/wireless/smartphone-plans?ipn=1; for Canada. China Mobile. [online]. Available at: http://www.10086.cn/bj/index_100_100.html; for China. Zen Package with unlimited calls and SMS. [online]. Available at: https://boutique.orange.fr/mobile/forfaits-origami-zen; for France. o2 Free. [online]. Available at: https://www.o2online.de/tarife/smartphone-tarife/; for Germany. airtel Infinity. [online]. Available at: http://www.airtel.in/myplan-infinity; for India. Telkomsel Samsung Galaxy Note 7. [online]. Available at http://www.telkomsel.com/galaxynote7; for Indonesia. TIM Special Start. [online]. Available at: https://www.tim.it/offerte/mobile/voce-e-internet/tim-special/tim-special-start; for Indonesia. For Softbank Smartphone. [online]. Available at: http://www.softbank.jp/en/mobile/price_plan/smartphone/; for Japan. Prepaid Talk, Text & Data. [online]. Available at: https://us.telcel.com/secure/ServicePlans; for Mexico. MTN Xtravalue. [online]. Available at: http://www.mtnonline.com/xtravalue; for Nigeria. Ultra. [online]. Available at: http://en.mts.ru/tariffs/ultra/; for Russia. RED VIP Plus. [online]. Available at: http://www.vodacom.co.za/vodacom/shopping/plans/red-vip-plus; for South Africa. Speaking Packages. [online]. Available at: http://www.turkcell.com.tr/paket-ve-tarifeler/tumu/faturali-hat; for Turkey. Mobile Phones. [online]. Available at: http://www.three.co.uk/Store/mobile-phones; for United Kingdom. Family Plans. [online]. Available at: https://www.att.com/shop/wireless/data-plans.html; for United States. All accessed 9 Nov. 2016.

In developing countries it would be beneficial to see partnerships between the MNOs and the national education providers so that citizens could gain access to mobile device at a reduced monthly subscription rate. By providing another means to access learning the citizens can gain valuable knowledge and increased income—raising the quality of life for everyone.

The development of mobile devices is still in its infancy and continuous innovation is expected. While devices are far more powerful today than the devices from three years ago, what they will be like three years from now can only be imagined. With the powerful capabilities and extensibility of mobile devices with Apps, there is a large unchartered territory that is ripe for mobile learning research.

Finally, to revisit recommendations from earlier in the article:

- Tariffs based on number of voice minutes used and the number of text message sent creates a variable component to subscribers' monthly bill. This may create a financial hardship for individuals accessing learning through their mobile device. Cellular providers should consider a flat tariff structure with unlimited text and voice minutes.

- NGOs that deploy learning solutions need to consider the financial burden they are creating for those accessing learning via mobile devices. Designing content to reduce the bandwidth required will save learners considerable money. If images and graphics are being sent to the mobile device, ensure the files are as small as possible to reduce data consumption.

- Educational providers should partner with mobile network operators (MNO) when rolling out a mobile learning program. Establishing a partnership between the MNO and the educational provider would allow for a negotiated subscription rate.

- Mobile phones are full of toxic chemicals and contain many small parts. Improper disposal can lead to polluted drinking water and choking hazards to small children and wildlife. To ensure the environment is protected, subscribers should be given incentives to recycle old and broken handsets. This is necessary to keep the devices out of landfills and waterways.

- Mobile Network Operators (MNOs) must protect the youth from content that is inappropriate. Today it is more of a hands-off "not our problem" approach. Yet they do nothing to enable content filtering by 3rd parties. The little content filtering that there is can be easily bypassed. An improvement would be exposing the DNS settings to that they could be set by parents or network administrators to a trusted DNS level content filter such as OpenDNS.

- Understand that devices deployed in areas that are off grid need to be recharged. Bundling devices with heavy duty batteries and self-contained charging devices (solar, hand crank, etc.) could increase safety for women and children that must travel to charging stations in dangerous and hostile regions of the world.

Endnotes

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