A Multilevel Systematic Approach for Identification of Mobile Learning Multimedia in Low Bandwidth Environment

Nazir Ahmad Suhail
Kampala University
School of Computer Science & Information Technology,
Kampala, Uganda

ABSTRACT

The widespread availability and ubiquity of mobile technology to enhance accessibility and communication has resulted into its usage in different educational contexts in developing countries. On the other hand, the mobile devices are facing some critical challenges such as low bandwidth environment, in particular, among others that significantly impede the quality of service, giving a way forward to designing the appropriate learning material. In this work, we propose a multilevel systematic approach for analysis and identification of mobile learning multimedia in the context of low bandwidth environment. The criteria used in the multilevel framework was based on four phases: visual media database, very commonly used visual media, in depth analysis of selected media, and finally identification of mobile learning low bandwidth visual media. The investigation results concluded with MP4 (video), MP3 (audio), and JPEG (graphic) as mobile learning visual media formats, respectively, compatible with the challenges of low bandwidth environment, a peculiar state associated with many developing countries.

General Terms

Mobile Communication Multimedia

Keywords

Multilevel Research Approach, Mobile Learning, Multimedia, Visual media, Low Bandwidth Environment

1. INTRODUCTION

Rapid advances in Information and Communication Technology (ICT) have continued to drive economic change, restructure businesses, and affect education. In the recent years technological innovations have transformed the way in which information is processed into knowledge. Mobile phones have become essential part of life in this modern society with tremendous growth in wireless communication technologies market. Research shows that mobile technology is one of the fastest growing innovation in the history of mankind with more than six billion connections in use in different parts of the world [2]. In addition to that there is a growing trend of using mobile devices in education, particularly in developing countries [7].

Mobile learning (m-learning), a form of e-learning that uses portable devices such as personal digital assistants (PDAs), handheld computers, and cell phones to support educational processes, is regarded as a powerful tool that may bring new innovative practices in places with inadequate academic resources [11].

The adoption of mobile learning in education sector can help to overcome several barriers and challenges universities in developing countries are facing. The sustenance of this paradigm shift is supported by several favorable factors that include:

- The technology is affordable by majority of people
- The portability characteristic of mobile devices can enable learners to use it anywhere any time even when at home or work place
- Moreover, a larger percentage of students already own this technology. Therefore, they will not incur extra costs when using mobile learning, and
- Mobile learning has the potential to meet the growing demand of higher education by diverse population of adults in Least Developed Countries (LDCs).

The term mobile technology refers to portable equipments that include smart phones (mobile phones with computing capabilities), laptops with wireless connections, and Personal Digital Assistants (PDAs) [3]. The widespread availability and ubiquity of mobile technology to enhance accessibility and communication has resulted into its usage in different educational contexts, more particularly in developing countries. Mobile learning (M-Learning) is designed based on mobility and e-learning [6] that employs wireless technologies to deliver educational content to learners [4] at flexible time, as per need.

On the other hand, the mobile devices are facing some critical challenges, low bandwidth environment in particular, among others that significantly impedes the quality of service, giving a way forward to designing the appropriate learning material [5]. At the same time, the use of mobile phones in Higher Education Institutions (HEI) as a learning tool is an emerging area of research that warrants further investigation to tap the vast opportunity of reaching to billions of people in emerging economies and enriching the learning content with multimedia technology to be easily accessible at their locations [7].

Frehywot et al. [12] carried out the research on e-learning in medical education in resource constrained countries and found that low quality of videos or visual outputs was one of the major challenge users were facing, due to bandwidth limitations that often contributed to low speed network. Therefore, designers of learning content must follow good learning theories and appropriate instructional design for the learning to be effective.

This paper aims at contributing to the relevance of multimedia, in an effort to design the learning content that enhances user satisfaction in mobile learning at higher education in developing countries where limited bandwidth is

available and designing the educational material is costly. The contributions can be summarized as follows. First, we introduce a novel Multi-Level Systematic Framework for investigating the mobile learning multimedia in low bandwidth environment. This framework includes Level I that identifies the multimedia database and Level II research leads to the most commonly used multimedia. Critical investigation of identified multimedia is done at Level III and finally Level IV investigation results into mobile learning low bandwidth multimedia. The paper concludes with the summary of findings.

2. BASIC CONCEPTS
Definition 1: Mobile Learning
In literature, mobile learning is defined differently by different authors. The mobile learning definition used in this paper is the acquisition of any knowledge and skills acquired anywhere, anytime, using handheld devices such as common cellular phones, smart phones and tablet PCs, iPods, personal digital assistance devices (PDAs), digital cameras, and flash discs etc. However, in the university setting mobile learning refers to learning environment which is "based on mobility of technology, mobility of learners and mobility of learning" [1].

Definition 2: Low bandwidth
Low bandwidth refers to insufficient bandwidth as compared to needs. Bandwidth which is the rate of data communication of any channel is scarce in developing countries. Moreover, low bandwidth is always coupled with other bottle necks such high cost of technology, misuse and mismanagement of available little bandwidth due to ineffective or non existence of any bandwidth management policy in the organization.

Definition 3: Multimedia
Multimedia can be defined as multi–media (e.g., text, graphics, audio, video etc.) or combination of these various media types, whereas visual media includes only graphics, audio, and video.

3. METHODOLOGY
This research reviewed literature using terms related to mobile learning, multimedia, visual media, low bandwidth environment and higher education in developing countries. Boolean Operators "AND" and "OR" were used to connect search terms aimed to study all relevant article suggestions [12].

4. MULTILEVEL SYSTEMATIC FRAMEWORK
Multilevel research has the potential to investigate and validate the theoretical concepts [15]. Literature shows that over the years researchers have used the multilevel research approach to explore several theoretical concepts [14]. This paper used the Multilevel Systematic Approach [8] shown in Fig.1 for the identification of mobile learning low bandwidth visual media (graphics, audio, and video) aiming to overcome the critical barriers to mobile learning in developing countries.

At the heart of analysis of the Multilevel Framework are criteria based on four phases: visual media database, very commonly used visual media, in depth analysis of selected media, and finally identification of mobile learning low bandwidth visual media.
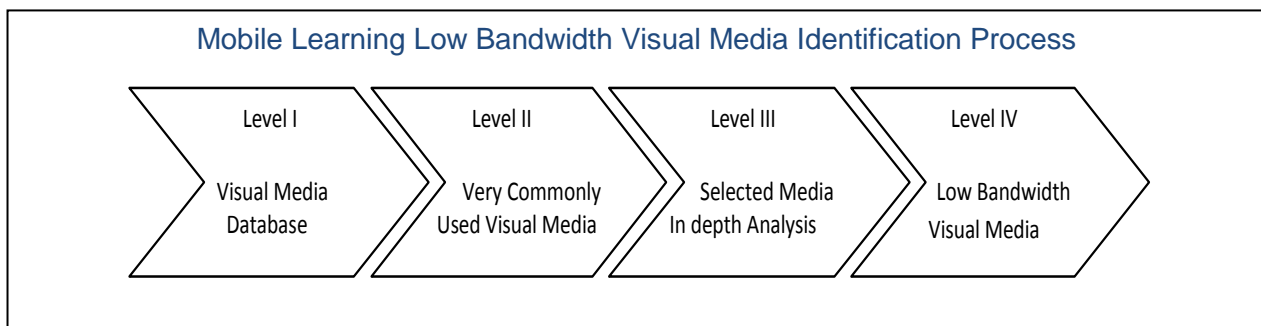

Fig1: Multilevel Systematic Framework

A. Visual Media Database
At first phase of analysis, we identified a database [13] for existing visual media, clustered into four classes; Very Commonly Used (VCU), Commonly Used (CU), Average, and Rarely used multimedia formats.

The phase two analysis of the multilevel systematic approach led to selecting the most commonly used visual media based upon the usability characteristic of various media types (graphics, audio, and video). Table 1 summarizes the media formats and their corresponding characteristics.

B. Very Commonly Used Visual Media

Table1. Very Commonly Used Visual Media Formats

Visual media Type	Format and Extension	Characteristics
Graphics	Bitmap Image File (.bmp)	Very Common
	Graphical Interchange Format File (.gif)	
	Joint Picture Expert Group/ JPEG(.jpg)	
	Portable Network Graphic (.png)	
	Tagged Image File (.tiff)	
Audio	Window Media Audio (.wma)	Very Common
	Wave Audio File (.wav)	
	Real Audio File (.ra)	
	Moving Pictures Expert Group Layer / MP3 (.mp3)	
Video	Apple Quick Time Movie (.mov)	Very Common
	Advanced System Format (.asf)	
	Audio Video Interleave (.avi)	
	Moving Pictures Expert Group-4/ MPEG-4 (.mp4)	
	Moving Pictures Expert Group 1,2 (.mpg)	
	Real Video (.rv)	
	Shock Wave Format (.swf)	
	Real Media (.rm)	
	Window Media Video (.wmv)	

C. In- depth Analysis of Common Visual Media Formats

The criteria used for the critical investigation of the common visual formats discussed under the themes Graphics, Audio, and Video was based on qualitative parameters which is appropriate to serve the objectives of the study.

Graphics:

The in–depth analysis of commonly used graphic formats was based on the following qualitative parameters:
- Developer (owner),
- Platform (operating system required to open),
  - ISO approval (approved by International Standard Organization),and
  - Proprietary (whether open source or proprietary product) presented in Table 2.

Table2. In-depth Analysis of Commonly Used Graphic Formats

Graphic Format	Characteristics				
	Extension	Ownership (developer)	Platform compatibility	Non proprietary	ISO approval
Bitmap Image File	.bmp	Microsoft and IBM	Windows	X	X
Graphic Interleave Format	.gif	Compuserv	Cross platform	X	X
Joint Pictures Expert Group (JPEG)	.jpg	ISO	Cross platform	✓	✓
Potable Network Graphic (PNG)	.png	W3C	Cross platform	✓	✓
Tagged Image File	.tiff	Adobe	Windows, Mac	X	TIFF/IT

Audio:

The study used the same parameters as used for graphics for in-depth analysis of audio formats presented in Table 3 that included : Developer (owner),ISO approval (approved by

International Standard Organization), and Proprietary status (whether proprietary or non- proprietary product).

Table3. In-depth Analysis of Commonly Used Audio Formats

Audio Format	Characteristics				
	Extension	**Ownership (developer)**	**Platform compatibility**	**Non proprietary**	**ISO approval**
Windows Media Audio	.wma	Microsoft	Windows	X	X
Wave Audio Format	.wav	Microsoft and IBM	Windows, Mac	X	X
Moving Pictures Expert Group layer 3 (MP3)	.mp3	ISO	Cross Platform	✓	✓
Real Audio	.ra	Real Networks	✓	X	X

Video:

The in-depth critical analysis of very commonly used video formats as shown in Table 4 was based upon the following qualitative parameters:

- Developer (Publisher/Owner)
- Platform Compatibility (Operating system required to open)

- Non-proprietary
  - International standards/ISO approval (Recognition by International Standard Organization)
  - Packet data dependency (Packet dependency upon the previous packet in terms of delay or loss) and
  - Mix media encoding capability (Ability to encode various media types; video, audio, graphics, and text).

Table4. In-depth analysis of Commonly Used Video Formats

Video Format	Characteristics						
	Extension	Ownership (developer)	Platform compatibility	Non-proprietary	ISO approval	No Packet dependency	Mix media encoding ability
Apple Quick Time Movie	.mov	Apple	Windows and Mac	X	X	X	X
Advanced System Format	.asf	Microsoft	Windows	X	X	X	X
Audio Video Interleave (AVI)	.avi	Microsoft	Mostly Windows	X	X	X	X
Moving Pictures Expert Group - 4 (MPEG-4)	.mp4	ISO/MPEG	Cross Platform	✓	✓	✓	✓
Moving Pictures Expert Group 1,2	.mpg	ISO/MPEG	Cross Platform	✓	✓	✓	X
Real Video	.rv	Real Networks	Windows and Mac	X	X	✓	X
Shock Wave Format	.swf	Mac	Mac	✓	X	✓	X
Real Media	.rm	Real Networks	Windows and Mac	X	X	✓	X
Windows Media Video	.wmv	Microsoft	Windows	X	X	X	X

D. Identification of Mobile Learning Low Bandwidth Visual Media

This section draws the results from previous section C presented in Table 5.

Table5. Mobile Learning Low Bandwidth Visual media

Visual Media Type	Format	Characteristics						
		Extension	Ownership (Developer)	Platform compatibility	Non proprietary	ISO approval	No Packet dependency	Mix media encoding ability
Graphics	Joint Pictures Expert Group (JPEG)	.jpg	ISO	Cross Platform	✓	✓	N/A	N/A
	Potable Network	.png	W3C	Cross Platform	✓	✓	N/A	N/A

	Graphic (PNG)							
Audio	Moving Pictures Expert Group layer 3 (MP3)	.mp3	ISO	Cross Platform	✓	✓	N/A	N/A
Video	Moving Pictures Expert Group - 4 (MPEG4)	.mp4	ISO	Cross Platform	✓	✓	✓	✓

The phase 4 analysis concluded with the mobile learning visual media compatible with low bandwidth environment as discussed below.

Graphics:

Our investigation results found that JPEG and PNG are the only two types that can operate in any platform, are open source, and has attained approval of International Standard Organization (ISO).

The Joint Photographic Experts Group (JPEG) format is the most popular graphic format among others in this category designed to store images on the web, has some distinct and unique characteristics. User can make "trade off" between size and quality of image. JPEG can reduce the image file size up to 1/5 of the original. Using that technique a 300 kb file can be compressed to 60kb without degrading the quality of image increasing the perceived level of mobile user satisfaction in low bandwidth environment.

The Portable Network Graphics (PNG) developed with an intention to replace GIF is the newest graphic formats [9] As shown in Table 5, PNG is cross-platform, widely used, open source file format (non-proprietary) and is recommended by W3C as well as ISO International standards [10]. Furthermore, PNG can reduce the size of image up to 1/50 of the original uncompressed image file. For example, a 200kb graphic file can be reduced to 4kb size using PNG algorithm. However, some extra techniques are required for that conversion.

Audio:

The phase 4 investigation results for audio format suggested that Moving Pictures Expert Group layer 3 (MP3) is non proprietary, cross platform, and has attained the recognition from International Standards Organization (ISO) as shown in Table 5, whereby all other audio formats do not possess these characteristics. Therefore, MP3 is identified as low bandwidth environment audio format to be used in mobile learning to support the academic processes in developing countries

*Video***:**

Based on the investigation results of phase III, we found that Moving Pictures Expert Group 4 (MPEG-4) has the following characteristics: Cross platform, Non-proprietary, International standards/ISO approved, No packet data dependency upon the previous packet and has Mix media ability.

In addition, MP4 has some exciting attributes that include:

-MP4 is aimed to serve mobile devices and broadcasting other professional applications
-Mp4 can operate over lossy networks such as mobile 3G or Wifi

-Mp4 incorporates scalability, error recovery techniques to preserve quality when changes in bandwidth occur in low bandwidth environment
-MP4 provides for lower bit rates (10Kb/s to 1Mb/s) with a good quality
-MPEG-4 standard is wider than the previous standards of MPEG family
-MPEG-4 video compression supports lower bandwidth consuming applications such as cell phones.

From above we conclude that MPEG-4 is most appropriate video format to be used for mobile learning in developing countries to address challenges of low bandwidth environment.

5. CONCLUSION

In this paper, we highlighted the benefits of mobile learning through which distance learning could be imparted to billions of adults in resource constrained economies in an efficient manner. We emphasized that use of mobile technology in higher education in developing countries is viable, sustainable and affordable media. More importantly, the paper proposed a multilevel framework for understanding and analyzing visual media for comparing their parameters. We used the framework for identification of mobile learning low bandwidth visual media formats to be used in the context of developing countries. The research concluded that MP4, MP3, and JPEG are the only mobile learning video, audio and graphic formats, respectively that are compatible with challenges of low bandwidth environment to address the critical issue of low quality multimedia contents facing the users, among others, impeding the integration of mobile learning in developing countries in the university settings. Future work may include investigating the multimedia for use in mobile learning in developing countries to increase further the perceived level of user satisfaction using the same framework with more parameters added.

6. REFERENCES

[1] El-Hussein,M. O. M., & Cronje, J. C. 2010. Defining Mobile Learning in the Higher Education Landscape, Educational Technology & Society, vol.13, no.3, 12–21.

[2] Rajput,A., and Thakur, V. 2014. M-Learning: Innovative E-Learning, Strategic Model for Adoption, International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), vol. 3, no.1, January –February, 307-310.

[3] Sarrab,M., Elgamel, L., Aldabbas, H. 2012. Mobile Learning (m-learning) and Educational Environments, International Journal of Distributed and Parallel Systems (IJDPS), vol.3, no.4, July, 31-38.

[4] Brown, H. T. 2005.Towards a model for M Learning International Journal on E-Learning, vol.4. no.3, 299–315.

[5] Sirkemaa, S. J. 2014. Analyzing e-Learning and Modern Learning Environments, International Journal of Information and Education Technology, vol.4, no.2, April, 176-179.

[6] Ravindranath, K., Rao, K.R.S. 2013. A Survey on Energy aware offloading Techniques for Mobile Cloud Computing, International Journal of Computer Trends and Technology(IJCTT), vol.4, no.7, July, 2081-2086.

[7] Deb, S. 2011. Effective Distance Learning in Developing Countries Using Mobile and Multimedia Technology, International Journal of Multimedia and Ubiquitous Engineering,vol6, no.2, April, 33-40.

[8] Suhail, N. A., Lubega, J., and Maiga, G. 2012. Multimedia to Enhance Blended Learning Experience in Constraine Low Bandwidth Environment, Lecture Notes in Computer Science, Springer-Verlag Berlin Heidelberg, vol. 7411, 362-372.

[9] Thyssen, A, "Common Image Formats. Image Magick v6 Examples"–2011.
http://www.imagemagick.org/Usage/formats/

[10] Hoe, N.S.2006. "Free/Open Source Software Open Standards",Asia-Pacific Development Information Programme (UNDP-APDIP), e-Primers on Free/Open Source Software.

[11] Chambo, F. F., Laizer,L.S., Nkansah-Gyekye,Y. and Ndume,V. 2013. Mobile Learning Model for TanzanSecondary Schools: Case Study of Kilimanjaro Region, Emerging Trends in Computing and Information Sciences, 4(9), September. 698-701.

[12] Frehywot, S., Talib,Y.V.Z. , Mikhail,N., Ross,H., Hanna Wohltjen, H., Bedada, S.,Korhumel,K., Koumare, A.K., and Scott. J. 2013. E-learning in medical education in resource constrained low and middle-income countries, Human Resources for Health, vol.11, no.4, 1-15.

[13] The file extensions resource. File info.com 2003-2005. http://www.fileinfo.com/filetypes/video

[14] Rousseau D. M. 2011. Reinforcing the micro/macro bridge: Organizational thinking and pluralistic vehicles, Journal of Management, 37, 429-442. doi:10.1177/0149206310372414

[15] Costa1, P.L.,Graça1, A.M., Marques-Quinteiro1, P., Santos1, C. M., Caetano1,A., and Passos, A.M. 2013. Multilevel research in the field of organizational behavior: An empirical look at10 years of theory and research, SAGE Open, July-September,1–17. DOI: 10.1177/2158244013498244, sgo.sagepub.com