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A Comparative Review of Mobile Learning Models

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ABSTRACT

The adoption, uptake and diffusion of MMLearning as a new educational paradigm which is more flexible than learning using the desktop computers is on the increase. This trend is further fueled by increased penetration of mobile technologies and adoption of same for seamless communication. In addition to this is the uptake of mobile technology as being witnessed by the unprecedented explosion of mobile devices being produced, particularly mobile phones. However, challenges are also rife as to what model of MLearning best suits particular environments, genre of learners and learning contents. In this paper, we examined learning models with a view to elucidate their peculiarities, identify their strentghts and weaknesses and provide a general overview of these models in the literature as a way of guiding would be adopters.

Keywords: MLearning, Technology, Adoption, Diffusion, Uptake, Mobile Phones

1. INTRODUCTION

Adoption, uptake and diffusion has remained a prominent concept in literature. DeLone & McLean's comprehensive review of different IS success measures concludes with a model of interrelationships between six Information Systems' success variable categories. The categories of the taxonomy are System Quality, Information Quality, IS Use, Users' Satisfaction, Individual Impact and Organization Impact. The study revealed that the success of an IS can be represented by the quality characteristics of the IS itself (system quality); the quality of the output of the IS (information quality); consumption of the output of the IS (use); the IS users' response to the IS (users' satisfaction); the effect of the IS on the behavior of the user (individual impact); and the effect of the IS on organizational performance (organizational impact). The Information System model performed effectively in the traditional data processing environment and cannot be used directly in the m-learning environment in the Delone and McLean's model which is an updated Information System model. Also there is no interoperability between the Information System model and the Delone and MacLean's model despite being an upgrade version. A proposed model for mLearning adoption, which contains a mLearning environment, which is underpinned by the traditional learning environment and also supported by effective mLearning policies and guidelines, was made by (Baker et.al, 2005).

Within the traditional learning environment, as indicated in the model, learning can still take place through desktop PCs. Within the mLearning environment, there is a communication infrastructure (represented on the diagram as a dashed line) in figure2. 5, containing wireless access points which enables communication between the mobile devices. The mobile devices depicted in the model can be mobile phones, PDAs or any other wireless handheld device. The model proposed by (Baker et.al, 2005). Demonstrates that the mobile devices can be used as academic support for learners via online assessment, providing course content and access to the Internet.

The mobile devices in this proposed model for mLearning adoption enable learner-to-learner communication, as well as learner-to-teacher communication. The model portrays some of the essential elements of a mLearning environment, including at least one teacher, learners, learning and instructional mobile devices, and a communication infrastructure. The stakeholders identified in the proposed model (represented as ellipses) include learners, their parents, teachers, system designers, device vendors, and support staff.

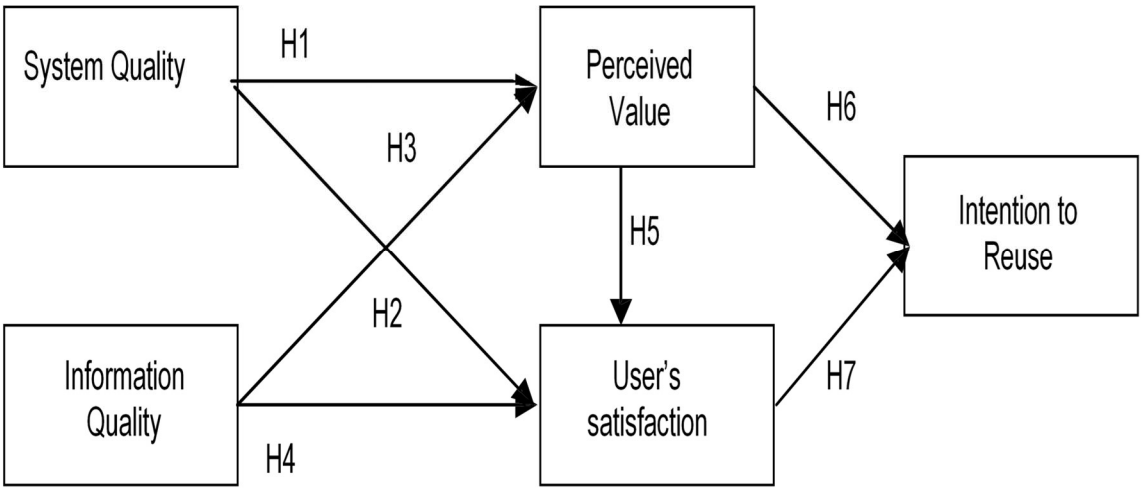

Figure 1: The Research Model of mLearning Systems Success (Chen et al., 2006)

The designers of the systems that execute on the devices, the vendors that sell the devices, and the parents of the learners involved all occur outside the mLearning environment. However, they still have an impact on the mLearning environment. The system designers depicted in the proposed model include both software developers and hardware manufacturers. Teachers, learners and support staff are found in a learning institution within the mLearning environment.

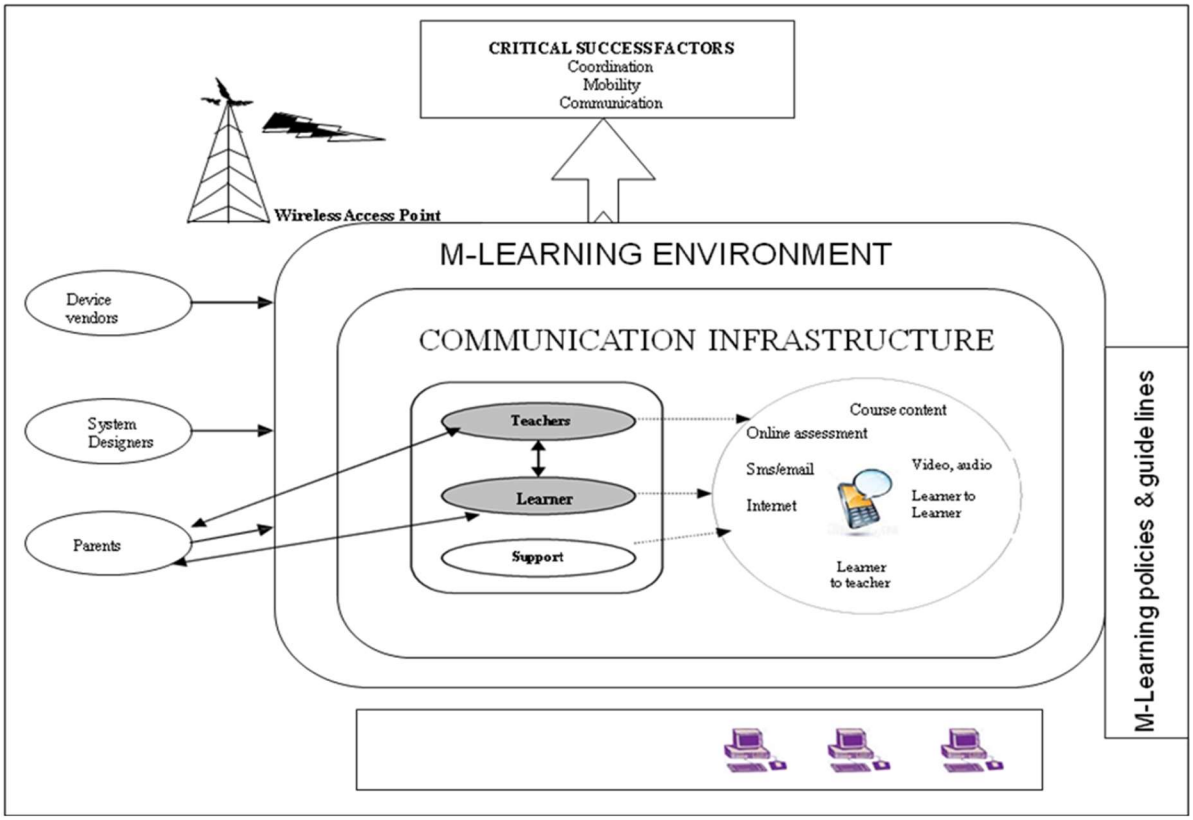

Figure 2: MLearning Adoption Model (Baker et.al., 2005).

Identified gap: In the model for mLearning adoption learning still occurs within the traditional learning environment and on desktop computers, as indicated in the model's diagram in figure 2.5. Within the mLearning environment, there is a communication infrastructure (represented on the diagram as a dashed line) that is not well developed.

2. RELATED WORKS

In this section we chronicled a number of models that has been proposed for MLearning. We identified their unique characteristics as well as gaps.

2.1 DeLone and McLean's model

The DeLone and McLean's model (Chen & Hsu, 2008) is based on an updated information system (IS) success model; the data collected from 350 respondents in Taiwan were tested against the research model using the structural equation modeling approach. The authors observed that as different computing environments require different criteria for quality measures, the previous research work on IS effectiveness performed in the traditional data processing environment cannot be used directly in the newly formed environment, namely m-learning. Built upon previous concepts on Information Quality and System Quality, this study developed information system success on m-learning.

The model includes the following factors that influence users' satisfaction: Information Quality, System Quality, Perceived Value, Users' Satisfaction, and Intention to reuse. The variables have indirect effect: Information Quality, User Satisfaction, System Quality, Perceived Value, and Intention to Reuse. The study reconciled the respecified e-commerce success model with DeLone & McLean's Perceived Usefulness measure. The study is used in the new areas of mLearning and updated IS model. The study also helps the users in the selection of a mLearning system.

Identified gap: The Information System effectiveness performed in the traditional data processing environment cannot be used directly in the m-learning environment in the Delone and McLean's model which is an updated Information System model. In other word there is no interoperability between the Information System model and the Delone and MacLean's model despite being the latter's upgrade version.

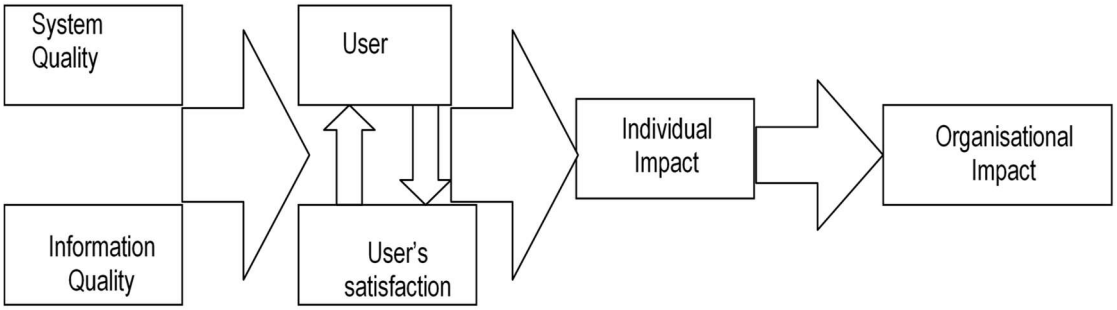

Figure 3: DeLone & McLean's Model (Chen et al., 2006)

2.2 Open learner model

The open learner model was used to promote reflection in combined desktop PC/mobile intelligent learning environments (Bull, et al., 2003). The authors defined an open learner model as, a model that allows the students to see information about their knowledge state held by the tutoring system, which they would not usually obtain through standard system feedback on their input. They said that, because students may automatically compare any such information to their own beliefs about their knowledge, this can be a powerful method of fostering reflection, particularly if the system's beliefs and the student's own beliefs about the student's understanding differ. The authors also stated that one of the ways of using the computer as a tool for learning through reflection is by employing open learner models as a learning resource to promote an individual's reflection on their evolving knowledge and on the learning process.

Some approaches to open learner modeling are quite complex, requiring the user to negotiate the contents of their model with the system, providing justifications for changes they wish to make to their model. This not only allows the creation of a more accurate learner model, but discussion and argumentation over the representations in the model also focus the student's attention on their developing knowledge. According to the authors, other approaches to open learner modeling encourage students to contribute information directly to their learner model, or allow them to edit the model, with no argument from the system. As with negotiated learner models, editable models can also serve to encourage reflection, as students must focus on their understanding if they wish to make changes in their learner model. These models have also been implemented in both textual form and structured graphical form.

Identified gap; The Open learning models is still new and much research needs to be carried out to find out the extent of the potential for encouraging reflection through learner modeling in this context.

2.3 Open learner model (C-POLMILE)

An intelligent learning environment for Desktop PC and Handheld computer called C-POLMILE was also developed in (Bull, et al., 2003). It is an open learner model for C programming with two versions; Desktop PC and Handheld versions. These two combined environments use their learner models to help encourage students to reflect on their learning, by making the learner model contents explicit to the user. The interaction types in the model include browsing information; individualized tutoring sessions; multiple choice test questions; interacting with the learner model. The authors stressed that the essential thing in C-POLMILE is the ability of the user to modify its contents by interacting with the learner model. The benefits of such model however, depends on if the learner will ever view his learner model for reflection on how he is being modeled, even though he is aware of the feature, and on how the model is integrated with the aims and interactions of the system.

The two intelligent learning systems in (Bull, et al., 2003) were presented as illustrations. In the first, the same interaction options are available in each version of the system. In the second, the main interaction takes place on the desktop PC, with individualized static revision material offered for synchronization to the handheld computer for later consultation. Each of these systems makes explicit the contents of the learner model to help encourage students to reflect on their learning. The differences in the two environments prescribe the use of different types of open learner model. The authors of (Bull, et al., 2003), however, concluded by saying that "combined intelligent learning systems such as the above are still new, and much research therefore remains to be undertaken to find out the extent of the potential for encouraging reflection through learner modeling in this context."

Identified gap; The combined intelligent learning systems such as the Open learning models are still new and much research therefore remains to be undertaken to find out the extent of the potential for encouraging reflection through learner modeling in this context.

2.4. The Multi-Agent Model - the Bee-gent Framework

Kinshuk (2004) showed how intelligent agents can be used to improve an mLearning system. He stated that the Bee-gent framework can be used to implement the mobile agents in the system. According to him, the Bee gent technology was first released in 1999 by Toshiba, as a new type of pure agent development framework for the advanced network society whose communication framework is based on the multi-agent model. Bee-gent stands for (Bonding and Encapsulation Enhancement Agent). Bee-gent provides applications with autonomous network behavior by "agentifying" them (i.e. Providing an agent interface). Bee-gent then supports agent-based inter-application communication, facilitating co-operation and problem-solving. Bee-gent achieves this in a flexible and open structured manner, making it well suited to providing for co-operative processing in the advanced network society Toshiba (2005)
.

The Bee-gent framework is comprised of two types of agents: agent wrappers and mediation agents.

- ✓ Agent Wrappers are used to 'agentify' existing applications. The agent wrappers manage the states of the applications, which are wrapped around, and invoke the applications when necessary.
- ✓ Mediation Agents support inter-application co-ordination by handling all communications among applications. The mediation agents move from the site of an application to another where they interact with the remote agent wrappers. Figure 2.7 shows how the Bee-gent is used to implement mobile agents in the system.

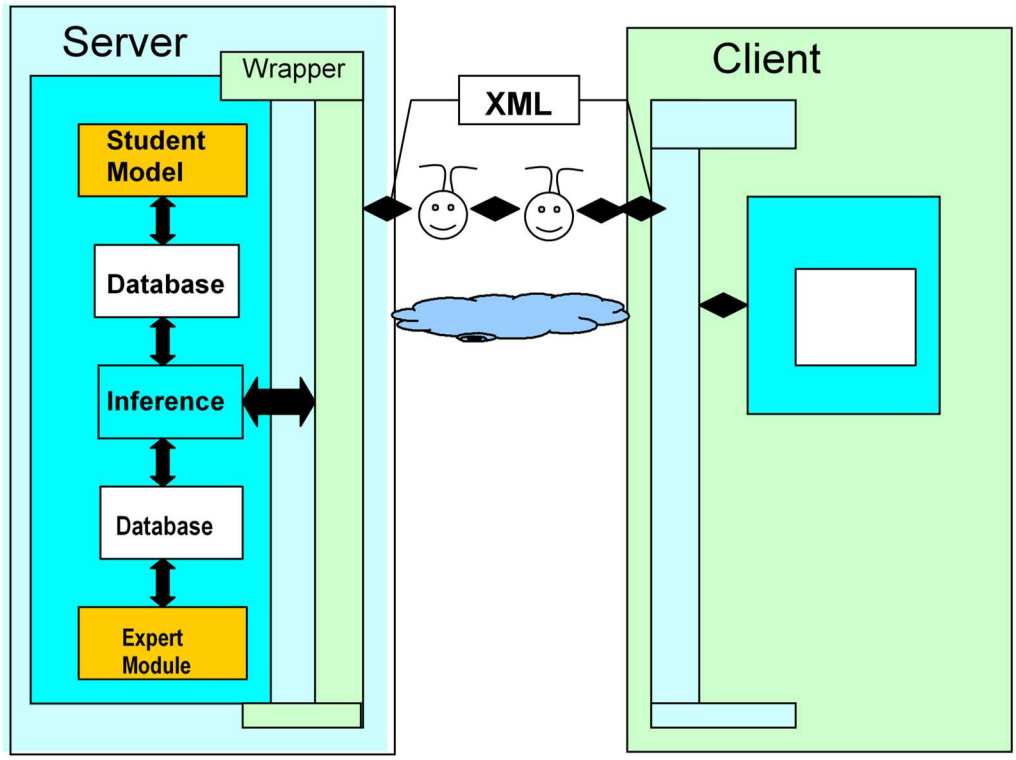

Figure 5: Architecture of Bee-gent (Kinshuk, (2004)

The wrapper agents are used to wrap the client and server side systems, and the mediation agents are used to perform the communication and exchange information with the wrapper agents. The main process scenarios within the system are as follows:

A. The server side: the inference engine interacts with the student model and expert module through the database interface. If something needs to be sent to the clients, the inference engine notifies the wrapper agent with the information that needs to be sent. The wrapper agent creates a mediation agent carrying the information and related program, and launches the mediation agent. If the mediation agent cannot find the target clients, it notifies back the failure and continues the attempts to reach to the target. If the mediation agent reaches the target client, it communicates and exchanges information with the client's wrapper agent and updates the client side.

B. The client side: if a request needs to be sent to the server, the client side will notify the client side agent wrapper, and the agent wrapper will create a mediation agent that is able to carry information to the server. Kassim, (2004) concluded that, the use of mobile agent technologies provide an attractive alternative to implement and improve mLearning environments for devices such as PDAs and mobile phones that have migrate-and- disconnect style of operations. These devices usually have unreliable, low-bandwidth, and high-latency network connections. The use of mobile agents, have a lot of appeal in such situations.

Identified gap: This model implements and improves mLearning environments for devices such as PDAs and mobile phones that have migrate-and- disconnect style of operations. These devices usually have unreliable, low-bandwidth, and high-latency network connections.

2.5 Shih's mLearning model

Shih (2007) developed a mLearning model based on Keller's ARCS Model of motivational design Keller (1987). The learning cycle of the ARCS include: Attention, Relevance, Confidence, and Satisfaction (ARCS). The Shih's MLearning Model is a variation to the ARCS model. It is based on ARCS learning model and mobile technologies' characteristics in promoting and enhancing human interactions, as depicted in Figure 6. The model was created to support instructional design for mobile learning. The learning cycle in the Shih's model, according to the authors includes:

1. Sending a multimedia message to mobile phones to trigger and motivate learners.
2. Searching the Web for related information by using embedded hyperlinks (URLs) in the message received in the phone.
3. Discussing with learning peers by text, voice, picture, or video messaging
4. Producing a digital story telling of what they learn by audio or video diary.
5. Applying what they learn in the simulated environment, such as online educational gaming.

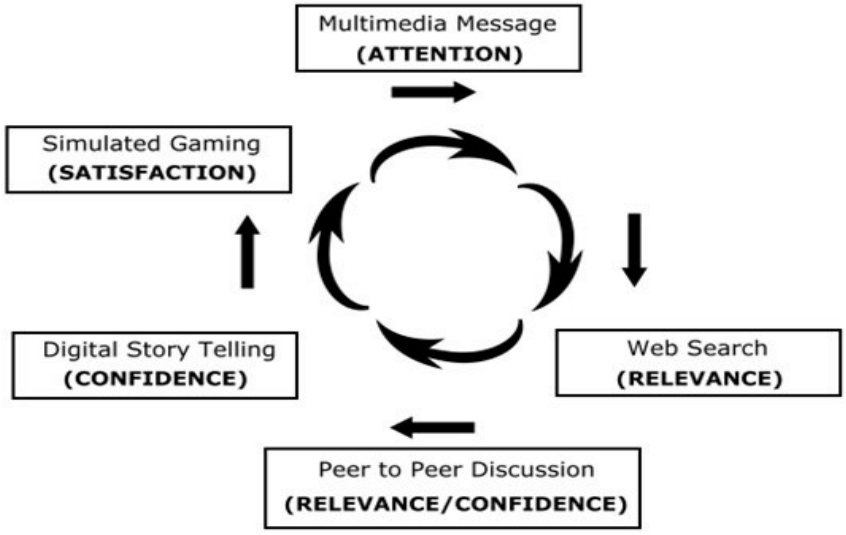

Figure 6: Shih's mLearning model Learning Cycle (Shih et al., 2007)

Identified gap: the Shih's MLearning model draws on the philosophy of social constructivism through the use of collaborative discussion and a learning style theory based on digital story telling. This learning model mainly relies on the mobile computing communication infrastructure, and would be most suitable for applications in blended learning.

2.6 Pedagogical Model Developed For Mobile Tutoring

A theoretical pedagogical model for mLearning called AEFIRIP is developed in (Parsons,et.al, 2007). The model relies on the contemporary models of e-learning and socio-cultural learning theories like Progressive Inquiry, Activating Instruction and Problem Based Learning. The model is focused on the characteristics of mobile learning. AEFIRIP stands for Activation, Externalization, Focusing, Interpretations, Reflection and Information Processing. The following steps of AEFIRIP model, described in Table 1.1, have been created in order to structure the learning process and tutoring activity needed. AEFIRIP is focused on the mobile tutoring practices that facilitate individual learning processes taking place in authentic environments. In addition to the knowledge construction, individual's perception and cognitive processes, like heuristic and logical inference, are heavily emphasized in AEFIRIP.

authors used the AEFIRIP model for developing features of an intelligent tutoring tool called Älykkö ("egg head"). Älykkö consist of intelligent tutoring agents that provides semiautomatic and automatic tutoring as well as indicators based on student's learning process enabling individualized tutoring process for students, even without teacher's virtual presence. In the AEFIRIP model, mobile technology is seen not just as a mediator of the learning activity or collaboration, but also as a trigger and platform that includes guidance and support for learning methods and the learning process. AEFIRIP is an acronym for the phases of the pedagogical model design for facilitating mobile tutoring of learning taking place in an authentic environment.

The model emphasized that the problems being solved during the mLearning process should be as authentic as possible. The same applies to mobile tutoring and learning assignments that must not be tasks done just for the teacher. The authors also stated that the authenticity in this context requires that the culture of professional expertise, i.e., a workplace with authentic tasks, methods, tools, and information sources, should be closely related to tutoring practices. The tutoring and structured learning process makes working in the real environment an intentional and scarf folded learning process needed in order to achieve goals of formal education

Table 1: The AEFIRIP pedagogical model for mLearning and tutoring

Phase	Phase Description of activity
1. Activation	Activating student's prior knowledge and cognitive strategies by context creation or e.g. presenting so called activating questions
2. Externalization	Externalization of student's prior knowledge and thinking models. Students become aware of their prior knowledge by making it visible and exposing it to reflection.
3. Focusing	Focusing students perception and cognitive processing in an authentic learning environment according to the objectives of the learning situation (e.g. by focusing questions or assignments)
4. Interpretations	Explicit interpretations done by student based on perception and prior knowledge/cognitive strategies as well as situational factors.
5. Reflection	Reflection of own interpretations and situational factors.
6. Information Processing	Processing Information Processing consist of sub-learning processes (cognitive processes) such as problem solving, classification, comparison, elaboration among others.

Source (Parsons,et.al, 2007).

2.7 Model Of Web-Based Intelligent Learning Environment

In the works (Sabbir, 2005) and (Kassim, 2004) the author proposed a model of an ideal Intelligent Tutoring System (ITS), a product of Artificial Intelligence (AI) research. The model was based on *Computer Aided Learning* (CAL), which he said has been used in learning and teaching since the 1950s. Traditional CAL resources primarily consisted of tutorials, which are essentially computer-based forms of "programmed instructions". He described the ITS as a new type of CAL system. The Intelligent Tutoring Systems (ITS) typically consist of an internal model of the expert knowledge, the learner's current knowledge and the pedagogical principles. As the learner proceeds, the model of the learner's knowledge and the model of the expert's knowledge are compared, and using AI, the sequence of instructions is dynamically generated to suit the needs of the learner.

Identified gap: The Intelligent Tutoring Systems (ITS) typically consist of an internal model of the expert knowledge, the learner's current knowledge and the pedagogical principles. The model was based on *Computer Aided Learning* (CAL) and a product of Artificial Intelligence (AI) research. There is no innovation just the typical or conventional expert-systems.

2.8. The Tele-education pilot project

This project was demonstrated in Nigeria and implemented in collaboration with the National Open University of Nigeria (NOUN) this is shown diagrammatically in Figure 2.8. It has a pilot scheme comprising 12 study centres located across the nation with a teaching administrative HUB at the NOUN headquarters in Lagos, Nigeria (Odimayomi, 2007) and (Akinyede, et.al., 2008). The tele-education programme provides a flexible environment and interactive learning between teachers and learners regardless of distance bridging the gap in education unevenness among populace using digital opportunity created by the satellite infrastructure with new ICT framework.

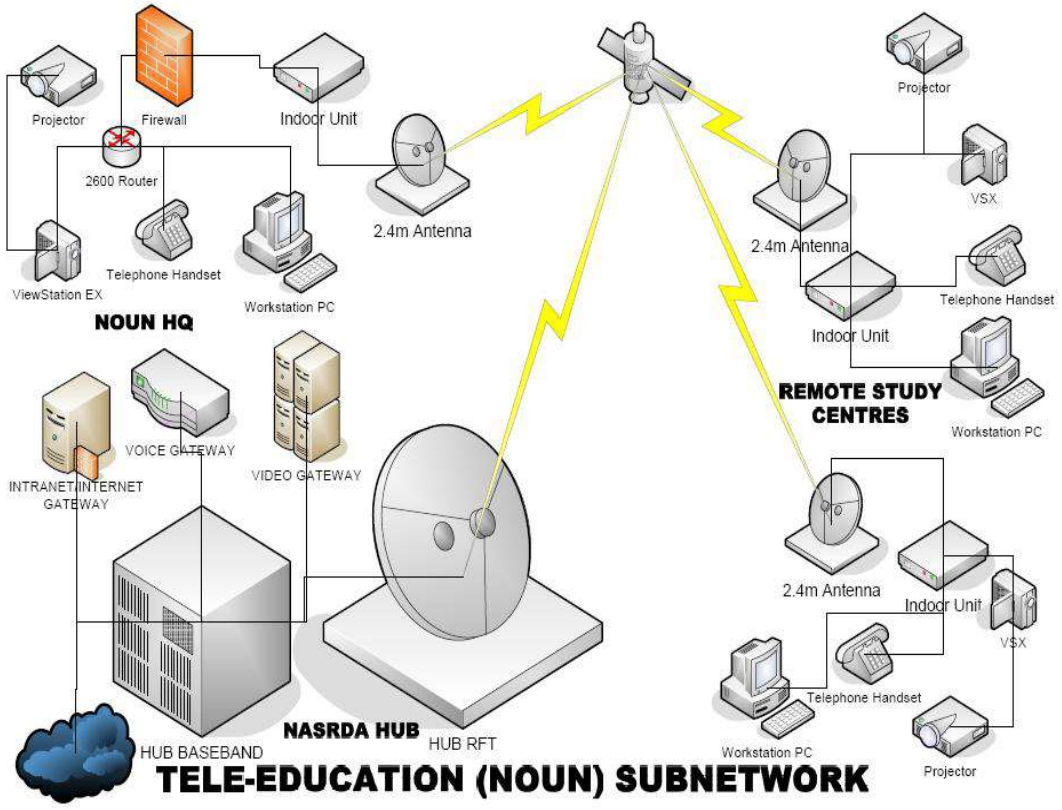

Figure 7: Tele-education Pilot Project for NOUN (Odimayomi, 2007)

Identified gap: It does not incorporate a mobile learning system in its ICT infrastructure. Mobile vans and Hot-spots are not included in its frame work. Also its not connected to a dedicated education satellite consequently more fund is expended in its implementation. The system may also be subjected to bandwidth eruption due to insufficient bandwidth that could result from short changing in bandwidth allocation.

2.9 MLearning Models' Strengths and Weaknesses

We have discussed and diagrammatically represent various mLearning Models in the previous section. What follows next is a table summarizing the mLearning models' strengths and weaknesses

Table 2: Summary Of Mlearning Models' Strengths and Weaknesses

Model Name	Strength	Weakness	Remarks/Gap
Model for m-learning adoption.	It contains a wireless access point which enables communication between the mobile devices. Learning can also occur through desktop PCs. Mobile devices can be used as academic support for learners via online assessment, providing course content and access to the Internet.	This model operates as in traditional learning environment	This limits the operational mode or range of the mLearning model
Information System (IS) model	The success of an IS can be represented by the quality characteristics of the IS itself (system quality) the quality of the output of the IS (information quality); consumption of the output of the IS (use); the IS users' response to the IS (users' satisfaction); the effect of the IS on the behavior of the user (individual impact); and the effect of the IS on organizational performance (organizational impact)	The IS effectiveness performed in the traditional data processing environment cannot be used directly in the m-learning environment in the Delone and McLean's model which is an updated IS model.	There is no interoperability between the IS model and the Delone and MacLean's model. (which is an updated version of the IS model)
DeLone and McLean's model	An updated information system (IS) success model. Built upon previous concepts (IS) on Information Quality and System Quality, this study developed information system success on m-learning model includes the following factors that influence users' satisfaction: Information Quality, System Quality, Perceived Value, Users' Satisfaction, and Intention to reuse.	In the Delone and McLean's model which is an updated IS model the IS effectiveness performed in the traditional data processing environment cannot be used directly in the m-learning environment of the Delone and McLean's model.	There is no interoperability between the IS model and the Delone and MacLean's model. (which is an updated version of the IS model)
Open learner model	Promotes reflection in combined desktop PC/mobile intelligent learning environments. The model allows students to see	The same interaction options are available in each version of the system (desktop PC and hand held devices).	Students can edit the model, with no argument from the system.

	information about their knowledge state held by the tutoring system. Students can contribute information directly to their learner model, or edit the model, with no argument from the system. Models have also been implemented in both textual form and structured graphical form.		
Open Learner model (C-POLMILE)	An open learner model for C programming with two versions; Desktop PC and Handheld versions. Help encourage students to reflect on their learning. Makes contents explicit to the users. The interaction aspect of the model include browsing information; individualized tutoring sessions; multiple choice test questions; interacting with the learner model. The essential thing in C-POLMILE is the ability of the user to modify its contents by interacting with the learner model.	The main interaction takes place on the desktop PC.	The main interaction takes place on the desktop PC.
The multi-agent model - the Bee-gent framework	Intelligent agents are used to improve a mLearning system. Used to implement the mobile agents in the system. The Bee-gent framework is comprised of two types of agents: agent wrappers and mediation agents. The use of mobile agent technologies provide an attractive alternative to implement and improve mLearning environments for devices such as PDAs and mobile phones that have migrate-and- disconnect style of operations. The use of mobile agents, have a lot of appeal in such situations.	These devices usually have unreliable, low-bandwidth, and high-latency network connections.	Low-bandwidth and high-latency network connections.
Shih's mobile learning model	The model was created to support instructional design for mobile learning. The learning cycle of the ARCS include: Attention, Relevance, Confidence, and Satisfaction (ARCS).	This learning model mainly relies on the mobile computing communication infrastructure, and would be most suitable for applications in blended learning environments	The model is mainly suitable for applications in blended learning environments.

	1. Sending a multimedia message to mobile phones to trigger and motivate learners. 2. Searching the Web for related information by using embedded hyperlinks (URLs) in the message received in the phone. 3. Discussing with learning peers by text, voice, picture, or video messaging 4. Producing a digital story telling of what they learn by audio or video diary. 5. Applying what they learn in the simulated environment, such as online educational gaming.		
A model for mLearning in Africa	Downloading of content access to articles/study materials/other resources e-mail/bulletin board/chat room (communication and interaction) Learners use mobile phones on a regular basis. Academic support for learners via SMS communication and interaction. Administrative Information (reminders, notifications, urgent information, etc) access to examination and test marks via mobile service number, etc.	Learners only have periodic access to the Internet via PCs at learning or community centers.	Learners are not truly mobile since they are restricted to periodic access to the internet at community centers.
Model of web-based intelligent learning environment	The model was based on Computer Aided Learning (CAL). The Intelligent Tutoring Systems (ITS) typically consist of an internal model of the expert knowledge, the learner's current knowledge and the pedagogical principles. As the learner proceeds, the model of the learner's knowledge and the model of the expert's knowledge are compared, and using AI, the sequence of instructions is dynamically generated to suit the	The model was based mainly on Computer Aided Learning (CAL).	The Intelligent Tutoring Systems (ITS) typically consist of an internal model of the expert knowledge, the learner's current knowledge and the pedagogical principles. There is no innovation just

	needs of the learner.		the typical or conventional systems.
Tele-education pilot project for NOUN	The tele-education programme provides a flexible environment and interactive learning between teachers and learners regardless of distance bridging the gap in education unevenness among populace using digital opportunity created by the satellite infrastructure with new ICT framework.	It incurs excessive charges from ISP in purchase of Bandwidth for Internet access. It incurs bandwidth eruption due to not having enough bandwidth.	It does not incorporate a mobile learning system in its ICT infrastructure. Mobile vans and Hot-spots are not included in its frame work. Also its not connected to a dedicated education satellite consequently more fund is expended in its implementation. The system may also be subjected to bandwidth eruption due to insufficient bandwidth that could result from short changing in bandwidth allocation.

3. EXISTING SATELLITE BASED EDUCATIONAL PROGRAMS

This section presents an overview of some existing satellite based educational programs, namely, the Italian satellite (ItalSat), the Indian national satellite (InSat) system, and the Indian educational satellite (EduSat).

3.1 Italian Experience In Italsat

The concept of multiple spot beam communications was successfully demonstrated in 1991 with the launch of Italsat, which is a satellite-based education program developed by the Italian research council (IRC). With six spot beams operating at 30 Ghz (uplink) and 20 Ghz (downlink), the satellite interconnects TDMA transmissions between ground stations in all the major economic centers of italy. It does this by demodulating uplink signals, routing them between up and downlink beams, and combining and remodulating them for downlink transmission. In ItalSat, laser beams can also be used to transmit signals between a satellite and the earth, but the rate of transmission is limited because of absorption and scattering by the atmosphere. Lasers operating in the blue-green wavelength, which penetrates water,

have been used for communication between satellites and submarines.

3.2. Indian Experience in INSat

The Indian National Satellite System (INSat) is a series of multipurpose geo-stationary satellites launched by the Indian Space Research Organization (ISRO) to satisfy the telecommunications, broadcasting, meteorology, education and search and rescue needs of India. Commissioned in 1983, INSat is the largest domestic communication system in the Asia Pacific region. It is a joint venture of the Department of Space, Department of Telecommunications, India Meteorological Department, and India Radio and Doordarshan. The overall coordination and management of INSat system rests with the secretary-level INSat Coordination Committee. InSAT satellites provide 199 transponders in various bands (C, S, Extended C and Ku) to serve the television and communication needs of India. Some of the satellites also have the Very High Resolution Radiometer (VHRR), CCD cameras for metrological imaging. The satellites also incorporate transponder(s) for receiving distress alert signals for search and rescue missions in the South Asian and Indian Ocean Region, as ISRO is a member of the Cospas-Sarsat program.

3.3 Indian Experience in EduSat

With the success of the InSat-based educational services, a need was felt to launch a satellite dedicated for educational service and ISRO conceived the EduSat project in October 2002 EduSat is the first exclusive satellite for serving the educational sector. It is specially configured to meet the growing demand for an interactive satellite-based distance education system for the country through audio-visual medium, employing Direct-To-Home (DTH) quality broadcast. The 1950 kg EduSat is launched from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota, into a Geosynchronous Transfer Orbit (GTO) by ISRO's Geosynchronous Satellite Launch Vehicle (GSLV). From GTO, EduSat reaches the 36,000 Km high Geo-Stationary Orbit (GSO) by firing, in stages; it's on board Liquid Apogee Motor (LAM). In GSO, the satellite is co-located with KALPANA-1 and INSat-3C satellites at 74° east longitude. EduSat carries five Ku-band transponders providing spot beams, one Ku-band transponder providing a national beam and six extended C-band transponders with national coverage beam. It joins the InSat system that already has more than 130 transponders in C-band, extended C-band and Ku-band providing a variety of telecommunication and television services.

4. NIGERIA COMMUNICATION SATELLITE -1R (NIGCOMSAT-1R)

NigComSat-1R is a replacement satellite for NigComSat-1 satellite. It is a critical ICT backbone infrastructure to drive the National ICT revolution in providing revenue diversification for the Nation and offering cost effective solution and affordable access to meet Nigeria's Educational, telecommunication, broadcast, aviation, maritime, defense and security needs. NigComSat-1R has the same features as NigComSat-1 with modifications of the payload aimed at addressing domestic and international market needs. It is a super hybrid, high power, quad band Geo-stationary satellite which provides optimal and cost effective voice, data, videos and internet, and application services solutions. NigComSat-1R was launched on 19th December, 2011 from Xichange satellite launch center located in south west China. The space craft entered the predefined orbit of perigee being 200km and apogee 41991km. It is built on Dong Fang Hong 4 (DFH-4) satellite bus developed by China Academy of Space Technology (CAST) and launched by LM-3B launch vehicle developed by China.

4.1 The Design Features of NigComSat-1R

NigComSat-1R is built on DFH-4 bus platform having its launch mass as 5150kg. It is the largest domestic communication system in the West African region. Its orbital location is 42.5º East longitudes and has a 15 year service life span. The communication satellite provides 40 transponders; 28 active and 12 redundant transponders as shown below:

- ✓ C-band: 4 active Transponders
- ✓ Ku-band: 14 active Transponders
- ✓ Ka-band: 8 active Transponders
- ✓ L-band: 2 active Transponders and 7 service antennas.
- ✓ The footprints and coverage areas for NigComSat-1R are:
- ✓ Ku – band ECIWAS 1 REAM EIRP 53dBW/49dBW
- ✓ Ku – band ECIWAS 2 REAM 48dBW
- ✓ New Ku-band (Oriental) with content
- ✓ C-band BEAM 43.44/38dBW
- ✓ Ka-band BEAM
- ✓ L-band navigation beam, global coverage, provides navigation overlay service (NOS) based on the European Geostationary Navigation Overlay Service (EGNOS) and 2 L – band signals transmitted L1 and L5.

4.2 Benefits of NigComSat-1R

NigComSat-1R is a hybrid satellite with radiation hardened technology, high reliability, onboard software, reprogrammable ability, fault tolerance, redundant components and high efficiency. Below are some of its benefits:

- ❖ Stronger footprints and center beams over the African continent.
- ❖ Better look angles and shorter latency for intra-Africa communication.
- ❖ More powerful signal strength.
- ❖ Increased reliability and availability of Ku-band due to adequate fade margin compensation for attenuation losses by rain.
- ❖ Reduced cost of deployment of VSAT installations through acquisition of smaller equipment.
- ❖ Availability of Ka-band broadband services at lower cost arising from the frequency re-use techniques, competitively priced transmission capacity, small antennas and reduced terminal prices.

4.3 Advances in Satellite Technology

Through the last decade, there has been tremendous advancement in satellite communication technologies in the world. Satellite communication started with the use of multiple access based mainly on time division multiple access (TDMA), moving to bandwidth reuse through the use of spot beams, then the extraordinary hopping technology and finally now the low orbit system technology.

4.4 Time Division Multiple Access

Communication satellite system has entered a period of transition from point-to-point high capacity trunk communication between large, costly ground terminals to multipoint-to-multipoint communication between small and low-cost stations. The development of multiple access methods has both hastened and facilitated this transition. Satellite communication technology was based on using TDMA technique for user allocation on the communication channel. In Time Division Multiple Access (TDMA), a number of earth stations take turns transmitting burst through a common transponder. Since all practical TDMA systems are digital, TDMA has all of the advantages over FDM/ FM/ FDMA that digital transmission usually has over analog.

TDMA is easy to reconfigure for changing traffic demands, resists noise and interference, mixes voice and data traffic. With TDMA, each ground station is assigned a time slot on the same channel for use in transmitting its communications. Each TDMA station has to know when to transmit and it must be able to recover the carrier and clock for each received burst in time to sort out all unwanted baseband channels. While one TDMA is transmitting, all other stations monitor these slots and select the communications directed to them. By amplifying a single carrier frequency in each satellite repeater, TDMA ensures the most efficient use of the satellite's onboard power supply.

4.5 Bandwidth Reuse through the Spot Beam Technology

A spot beam is a satellite that is specially concentrated in power, normally sent by a high-gain antenna so that it will cover only a limited geographical area on earth. Spot beams take satellites communication to the next level. On a spot beam, frequencies are reused and downlinked to different locations. Bandwidth can be adjusted to cover areas as large as the entire Nigeria States and as small as a university campus.

In addition, satellite antennas have been designed to transmit several beams in different directions using the same reflector. The satellite transponders receive signals from the earth on one frequency, amplify and transmit back to earth on a different frequency. Spot beams are used so that only earth stations in a particular intended reception area can properly receive the satellite signal. It allows satellites to transmit different data signals using the same frequency. Because satellites have a limited number of frequencies to use, the ability to reuse a frequency for different geographical locations without data interfering with each other at the receiver allows for more local channels to be carried, since the same frequency can be used in several locations.

4.6 Frequency Hopping Technology

Frequency hopping is a method by which we move communication satellite signals from transmitter to receiver. It is a method for interconnecting many ground stations spread over great distances. This was demonstrated in 1993 with the launch of NASA's Advanced Communications Technology Satellite (ACTS). These satellites use what is known as the hopping spot beam technique to combine the advantage of frequency reuse, spot beams and TDMA. By concentrating the energy of the satellite's transmitted signal, ACTS can use ground stations that have smaller antennas and reduced power requirements.

4.7 Low Orbit Technology

The latest development in satellite technology is the use of network of small satellites in low earth orbit (200km or less) to provide global telephone communication. The Iridium system, for example; uses 66 satellites in low earth orbit (LEO) while other groups have or are developing similar systems. Special telephones that communicate with these satellites allow users to access the regular telephone network and place calls from anywhere on the globe. Anticipated customers of these systems include international business travelers and people living or working in remote areas.

4.8 The Menos Hub

Menos is a revolutionary networking concept used to exchange multimedia content over satellite. It is intended for professional broadcasters, allowing them to share video and audio materials among several sites scattered across a large geographical area. It has been designed to provide these broadcasters not only with the fastest and most cost effective technologies to perform the media exchange, but also with a complete range of tools to facilitate the related coordination tasks and improve people collaboration across the network. In traditional satellite communication systems, television and radio materials are exchanged as real time transmissions from one ground station to another. This requires the reservation of a satellite segment for fixed time duration, a manual line up procedure and expensive uplink equipment. At the receiving site, the transferred material needs to be used on the fly or recorded.

The coordination between the two stations and the network operating center must typically be done via terrestrial or mobile telephony. MENOS is fundamentally different with IP as the core protocol; all exchanged material transmits through a central hub station, which also provides permanent two-way satellite IP connectivity among all remote stations. It can also be retained in the central hub station for archiving and later accessed by other stations. The reservation of bandwidth and the lineup procedure are automatic and the uplink stations are smaller and much less expensive than traditional systems. In general, the two-way IP connectivity is ideal for Voice over IP (VoIP) coordination channels, e-mail exchange, intranet and internet access and other collaboration tools.

4.9 Menos System Architecture

A MENOS system consists of a redundant central platform (hub) connected to a number of remote sites, each equipped with a satellite interactive terminal (SIT). The terminal is able to transmit or receive data to and from the hub. The data can be exchanged between the hub and the terminal or between two terminals via the hub. From the terminal to the hub, the data is transmitted either on a dedicated single channel per carrier (SCPC)or in a return channel shared dynamically in time and frequency with other terminals. Low rate data, such as internet and intranet exchange, VoIP, radio exchange and low bit rate file transfers are typically sent using the multiple frequency time division multiple access (MFTDMA) channels, while real time television transmission and fast file transfers are operated in single channel per carrier. All transmissions are first received by the central hub. If necessary, the transferred material can be automatically archived in the central hub for later use by the remote stations. Data is transferred from the hub to the stations on one of the two MFTDMA multiplex carriers, i.e. multiple channels per carrier (MCPC). The first one regroups all the video transfers and the second one regroups the internet data, the file transfers and the VoIP calls.

Different types of MENOS remote stations are available depending on the type of applications performed at the remote site.

- Data SITs only provide data and VoIP connectivity and can be used for intranet, internet, virtual private networks (VPNs) and interactive collaboration tools.
- Radio SITs provide all the services of a Data SIT in addition to radio exchange services.
- Television SITs provide all the service of a Data SIT in addition to television exchange services.

MENOS terminals can also be integrated into mobile units, in the form of digital satellite news gathering (DSNG) trucks or flyaway kits.

5. CONCLUDING REMARKS

We have x-rayed various mLearning models, their strengths and gaps in this discourse as a way of establishing what is needed to be done for design, development, adoption, uptake and diffusion. Also, various country-specific developments and models were examined. Ali Mostakhedenin-Hosseini (2003) presented a framework for developing mLearning services based on education components. He opined that mLearning systems development is based on three main domains: Mobile Usability, Wireless Technology and e-learning System. Mobile Usability: refers to validating the services in each mobile device that is involved in the mLearning system. This includes the type of mobile device, the features of the mobile device and the mobile content design and evaluation method. As we conclude this paper, it is essential to consider the following issues in developing the mLearning system:

(1) The nature of the services (long/short content)
(2) The type of offered services (Voice, text, pictures and moving pictures)
(3) The services features and characteristics (long text require bigger screen size)

Wireless Network refers to wireless network infrastructures, capabilities and cost of services. This include also the operator rolls, such as the data rate, QoS security etc. The wireless network requires the consideration of the following issues in the development process:

(1) The existing network service will influence the types of the services.
(2) The cost of the service plays an important role.

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