A REVIEW OF M-LEARNING MODELS

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Abstract

In the most recent times, mobile visitors form the fastest growing Web community. The ease with which web pages or information is retrieved from the Web using PDAs or cell phones is a result of the rapid development in wireless technologies like GPRS, EDGE, etc. Also the development of educational technologies tends to be more mobile, portable and personalized. This development is quickly changing the traditional classroom learning to the electronic learning (E-learning). Mobile Learning (M-Learning), an extension of e-learning is based on the use of mobile devices such as cell phones, PDAs, smart phones, notebooks, etc over wireless networks to provide interaction between learners and teachers 'anywhere and anytime'. Much of the interest so far in m-learning has been focused on development of tools for teacher administration, classroom management, quizzes and note-taking. This paper presents an evaluation of some M-learning models developed in an attempt to formulate a standard for future m-learning systems.

Key words: m-learning model, m-learning framework, mobile agents.

1. Introduction

Learning is an active process of building knowledge and skills through practice within a supportive community. It comprises not only a process of continual personal development and enrichment, but also the possibility of rapid and radical conceptual change [1]. A first step in postulating the theory of M-learning is to distinguish what is special about mobile learning compared to other types of learning activities. An obvious, yet essential, difference is that it starts from the assumption that learners are continually on the move. We learn across space as we take ideas and learning resources gained in one location and apply or develop them in another. We learn across time, by revisiting knowledge that was gained earlier in different context, and more broadly, through ideas and strategies gained in earlier years providing a framework for a life time of learning. The need to re-conceptualize learning in the mobile age has given rise to intensive research work on Mobile learning. In recent times, this need has also propelled researchers to recognize the essential role of mobility and communication in the process of learning. That is to say, the role communication and interaction play in the learning process is a critical success factor. Within this context M-learning can contribute to the overall quality and accessibility of learning.

The term m-learning is coined to describe the convergence of mobile technologies with e-learning [6].
Unlike the traditional teaching and learning environments, in which learners follow a fixed sequence to instructional resources, such as textbooks in classroom settings, M-learning as an extension of E-learning has the potential to make learning even widely available and more accessible than we are used to in the existing E-learning environments. While mobile devices are approaching ubiquity today, the m-learning industry is still in its infancy [4]. M-learning, like E-learning has no standard model per se; only enhancements of models of learning [13]. Different authors and researchers have made attempts at developing models which are reviewed in this paper. The MOBILearn project [3] is an attempt at developing a framework for M-learning.

Review of Existing Literature

From literatures reviewed there are no previous work done on the review of M-learning models. The existing reviews are based on e-learning models and comparison of M-learning systems [16].

2. Features of Mobile Learning Systems

The mobile learning system described by the following features:
- Allows users to have access to course resources independent of time and place
- Allows authenticated users to have access to the system
- Allows users to have access to the resources in different formats (voice, text, picture and video)
- Allows the reuse of material
- Allows users to carry out the functions defined as an education component.
- Offers flexible environment in which other services and components can be added.

3. M-Learning Models and Frameworks

The following subsections discuss some M-learning models and frameworks.

3.1 Model for m-learning adoption

A proposed model for m-learning adoption, which contains an m-learning environment, which is underpinned by the traditional learning environment and also supported by effective m-learning policies and guidelines, was made by [8]. Within the traditional learning environment, as indicated in the model, learning can still take place through desktop PCs. Within the m-learning environment, there is a communication infrastructure (represented on the diagram as a dashed line) in figure 1 below, 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. This model proposed by [8] 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 m-learning adoption enable learner-to-learner communication, as well as learner-to-teacher communication. The model portrays some of the essential elements of a mobile learning 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. 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 m-learning environment. However, they still have an impact on the m-learning 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 m-learning environment.

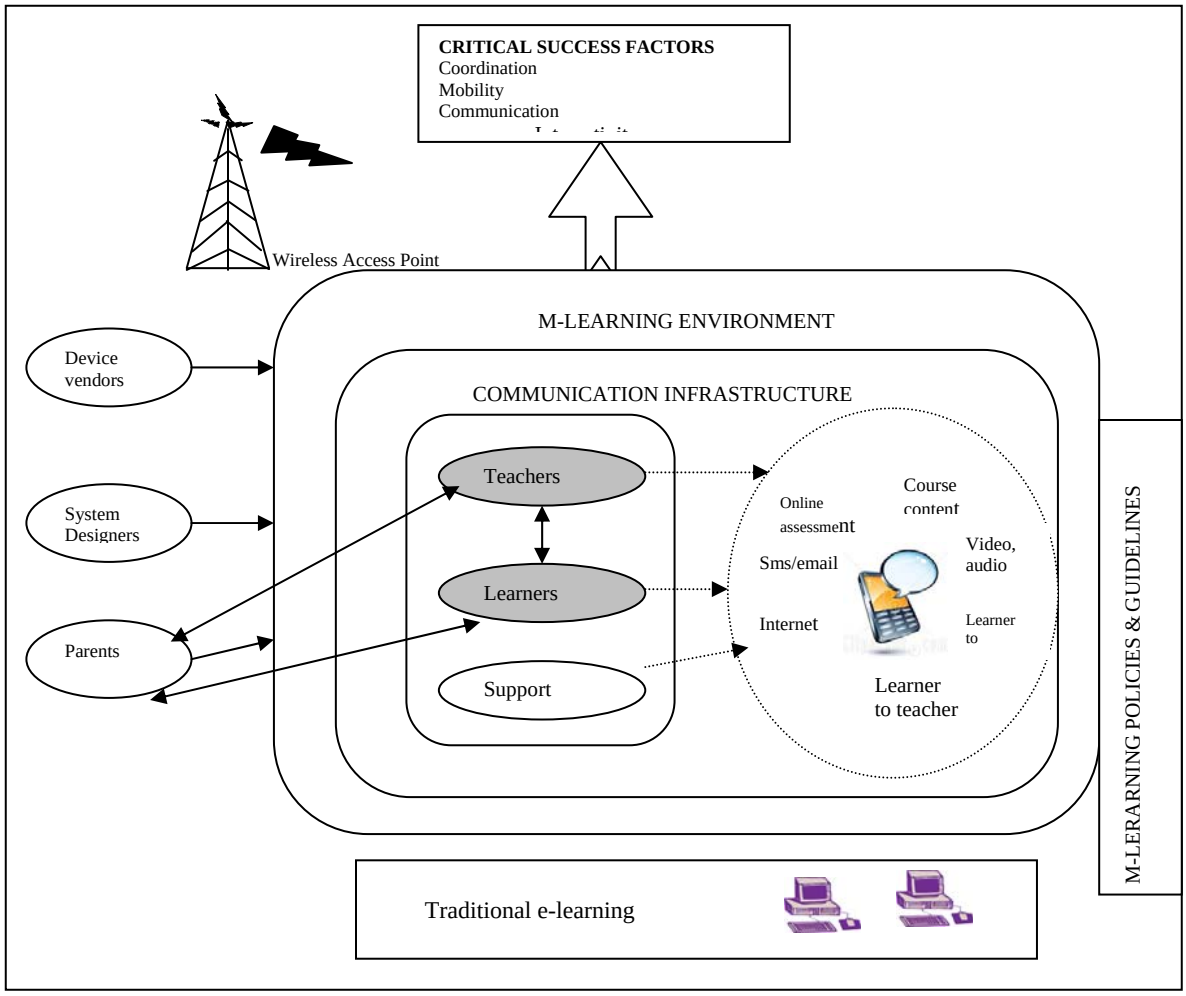

Figure 1: M-learning adoption model

3.2 DeLone and McLean's model

The authors of [6] researched the factors that affect users' intention to use m-learning using the DeLone and McLean's model of Information System (IS) success. 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 m-learning and updated IS model. The study also helps the users in the selection of an M-learning system.

Information System (IS) model

DeLone & McLean's comprehensive review of different IS success measures concludes with a model of interrelationships between six IS success variable categories. The categories of the taxonomy are System Quality, Information Quality, IS Use, Users' Satisfaction, Individual Impact and Organization Impact (Figure 2). 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)

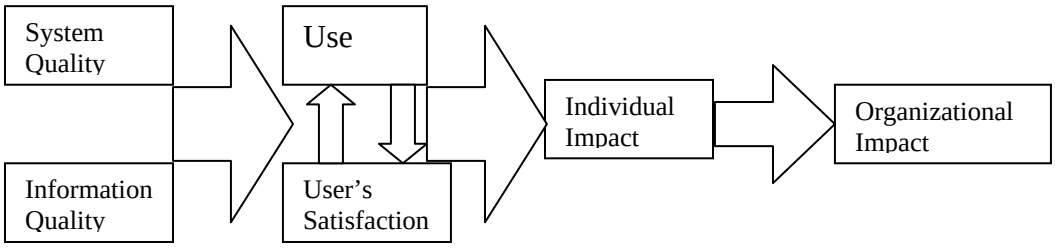

Figure 2: DeLone & McLean's (1992) model (courtesy: [6])

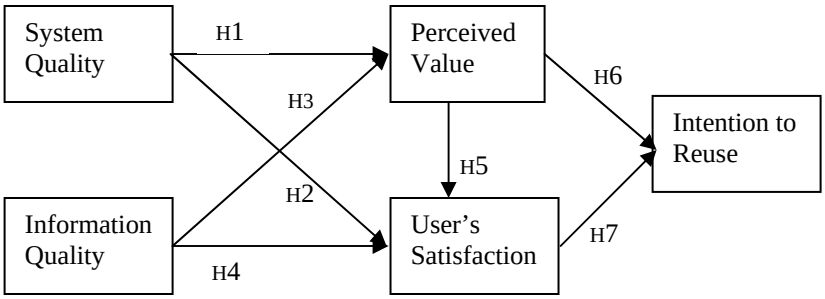

Figure 3: The research model of m-learning systems success (courtesy: [6])

3.3 Open learner model

The open learner model was used to promote reflection in combined desktop PC/mobile intelligent learning environments [9]. 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.

An intelligent learning environment for Desktop PC and Handheld computer called C-POLMILE was also developed in [9]. 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 [9] 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 [9] 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."

3.4 Pedagogical model developed for mobile tutoring

A theoretical pedagogical model for mobile learning called AEFIRIP is developed in [10]. 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, 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. The 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 M-learning 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 scaffolded learning process needed in order to achieve goals of formal education

Phase	Phase Description of activity
1. **A**ctivation	Activating student's prior knowledge and cognitive strategies by context creation or e.g. presenting so called activating questions
2. **E**xternalization	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. **F**ocusing	Focusing students perception and cognitive processing in a authentic learning environment according the objectives of the learning situation (e.g. by focusing questions or assignments)
4. **I**nterpretations	Explicit interpretations done by student based on perception and prior knowledge/cognitive strategies as well as situational factors.
5. **R**eflection	Reflection of own interpretations and situational factors.
6. **I**nformation	Processing Information Processing consist of sub learning processes (cognitive processes) such as problem solving, classification, comparison, elaboration etc.

Table 1. The AEFIRIP pedagogical model for mobile learning and tutoring consists of following phases.

3.5 A model for m-learning in Africa

A model for m-learning in Africa was proposed by [2]. The following summarizes the model developed in 2005. The author stated that learners only have periodic access to the Internet via PCs at learning or community centres and that during these periods of access, the focus is on:

- ICT literacy
- 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:
  - with educational institution
  - with peer learners and study groups

This access, he further stated also provides Administrative and Academic support for learners via SMS, MMS and WAP for:

: administrative information (reminders, notifications, urgent information, etc.)
access to examination and test marks via mobile service number, etc.

3.6 Model of web-based intelligent learning environment

In the works [5], [11] 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. Figure 4 shows the functional model of an ideal ITS.

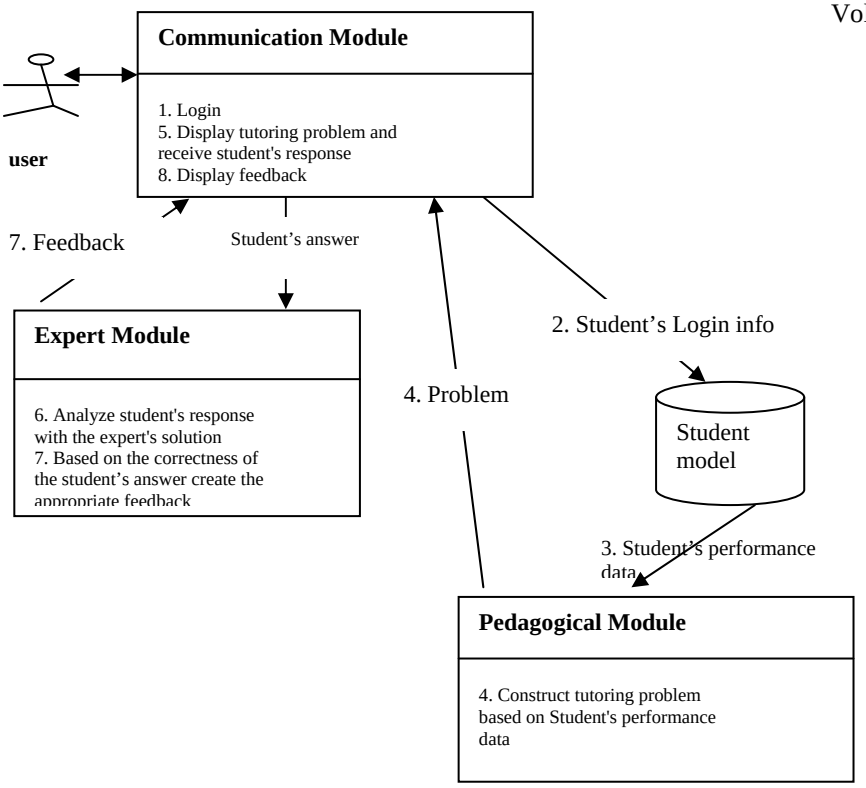

Figure 4 Functional Model of an Ideal ITS

3.7 The multi-agent model - the Bee-gent framework

Kinshuk in the work [4] showed how intelligent agents can be used to improve an m-learning 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 [7]. 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 5 shows how the Bee-gent is used to implement mobile agents in the system.

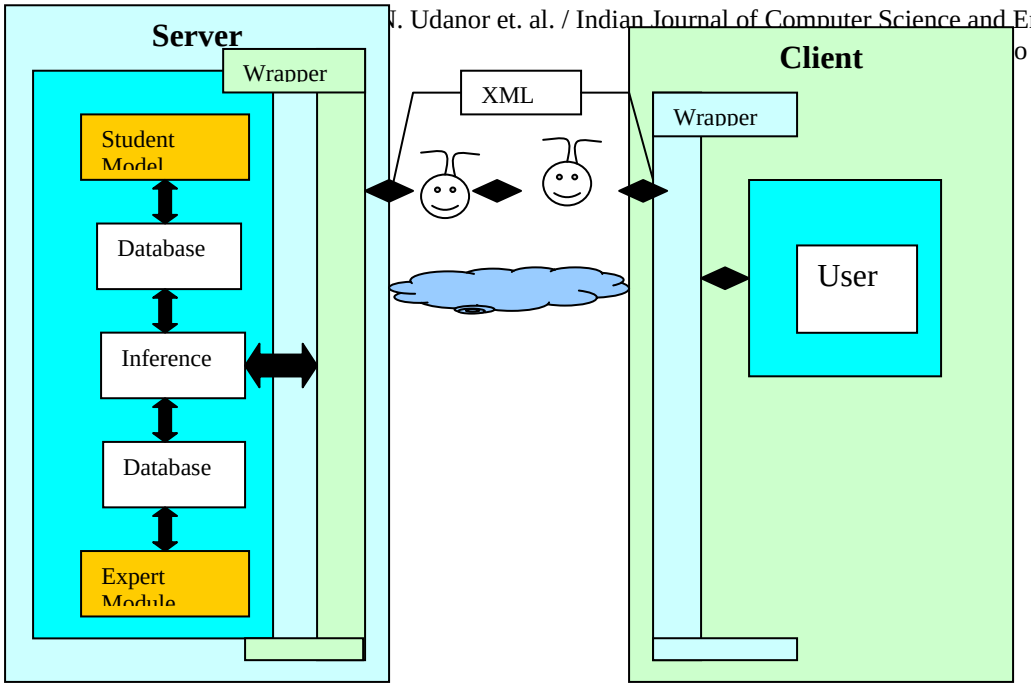

Figure 5: Architecture of Bee-gent (courtesy [4])

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.

The author [11] concluded that, the use of mobile agent technologies provide an attractive alternative to implement and improve mobile learning 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.

3.8 Shih's mobile learning model

The author [14] developed an M-learning model based on Keller's ARCS Model of motivational design [15]. The learning cycle of the ARCS include: Attention, Relevance, Confidence, and Satisfaction (ARCS). The Shih's Mobile Learning 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.

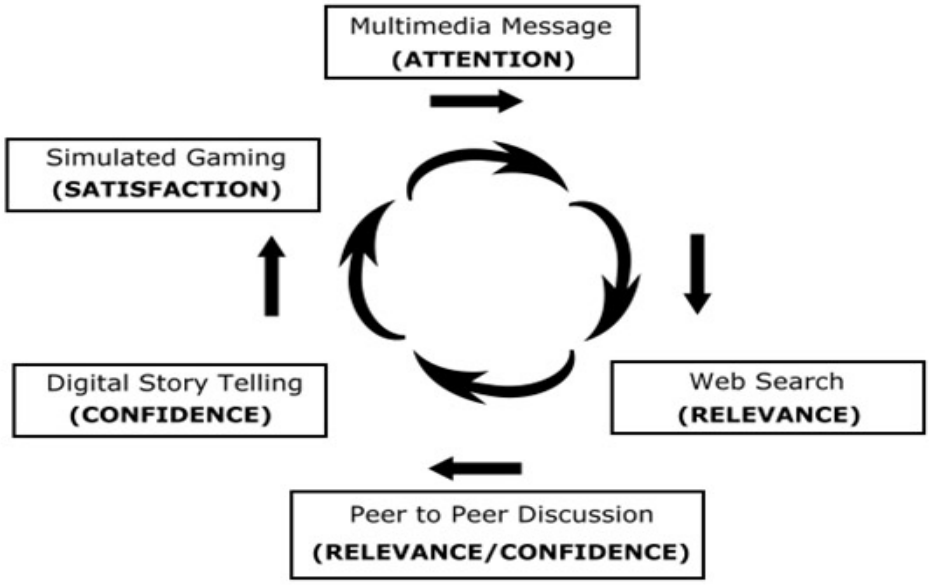

Figure 6. Shih's M-learning Model Learning Cycle (courtesy: [14])

The authors stated that the Shih's M-learning 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 and/ or pure mobile learning environments.

3.9 Framework for mobile learning based on education component Systems

Ali in [12] presented a framework on the process of developing mobile learning services based on education components. According to them, mobile learning system development is based on three main domains: mobile usability, wireless technology and e-learning system.

Mobile usability: the mobile usability refers to validating the services in each mobile device that is involved in the mobile learning system. This includes the type of mobile device, the features of the mobile and the mobile content design and evaluation method. They said that it is essential to consider the following issues in developing the mobile learning system:

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

Wireless network: wireless network infrastructures, capabilities and the 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

E-learning system: The needs of virtual learning and e-learning components and system. From the E-learning system point of view the following are important issues in the development process:"

Conclusion and Future Work

From the review of existing m-learning models studied so far, it is obvious that m-learning is still at its infancy, and researches done in this field is still at individual or group basis. There is not yet, a clear standard model. The MOBILearn project is the only major effort made up to date on a global scale at developing a standard model and framework for future m-learning systems. In future work, an enhanced model for m-learning for low bandwidth networks that uses intelligent mobile agents would be appropriate.

REFERENCES

[1] Mike Sharples, Josie Taylor, Giasemi Vavoula (2005). *Towards a Theory of Mobile Learning. International Journal of Continuing Engineering Education and Life Long Learning*, 12(5/6), 504-520.

[2] Brown, T.H. (2005). *Towards a model for* m-learning *in* Africa. **International Journal on E-Learning** ISSN 1537-2456 Volume 4, Issue 3, 2005

[3] Taylor, J., Sharples, M., O'Malley, C., Vavoula, G. & Waycott, J. (2006). *Towards a task model for mobile learning: a dialectical approach.* Available on: http://kn.open.ac.uk/public/document.cfm?docid=5374, last accessed 27th March 2006. Guidelines for learning/teaching/tutoring in mobile environment. Available on: http://www.mobilearn.org/download/results/public_deliverables/MOBIlearn_D4.1_Final.pdf

[4] Kinshuk, Taiyu Lin (2004). *Improving mobile learning environments by applying mobile agent technology.* Massey University, Palmerstone North, New Zealand. Available on: http://www.col.org/pcf3/papers/pdfs/kinshuk_lin_2.pdf. viewed 12th March, 2010.

[5] Sabbir Ahmed Kazi (2005) *VocaTest: An Intelligent Tutoring System for Vocabulary Learning using the "mLearning" Approach.* Centre for Research in Pedagogy and Practice National Institute of Education. Available on: http://conference.nie.edu.sg/paper/Converted%20Pdf/ab00283.pdf. Viewed on 20th March, 2010.

[6] Chen, C.-M., & Hsu, S.-H. (2008). *Personalized Intelligent Mobile Learning System for Supporting Effective English Learning. Educational Technology & Society*, *11* (3), 153-180.

[7] Toshiba (2005) *Multi-Agent Framework for 100% Pure Agent System* .Corporate Research & Development Center TOSHIBA Corporation. Available on: http://www.toshiba.co.jp/rdc/beegent/index.htm. Viewed on 21st April. 2010.

[8] Andrea Barker, Greig Krull and Brenda Mallinson (2005) A Proposed Theoretical Model for M-Learning Adoption in Developing Countries. Available on: http://www.mlearn.org.za/CD/BOA_p.14.pdf viewed on 15th April, 2010.

[9] Susan BULL, Adam Thomas McEVOY (2003) *An Intelligent Learning Environment with an Open Learner Model for the Desktop PC and Pocket PC,* to appear in Proceedings of International Conference on Artificial Intelligence in Education, IOS Press, Amsterdam.

[10] Pasi Silander , Anni Rytkönen (2007) *An Intelligent Mobile Tutoring Tool Enabling Individualisation of Students' Learning Processes Häme Polytechnic University of Applied Sciences and University of Joensuu, Finland (pasi.silander@hamk.fi) Department of Computer Science, University of Helsinki, Finland (anni.rytkonen@cs.helsinki.fi)*

[11] Kassim, A. A., Kazi, S. A. and Ranganath, S (2004)., *"A Webbased Intelligent Learning Environment for Digital Systems"*. International Journal for Engineering Education, Vol 20, No 1, pp 13-23, 2004.

[12] Ali Mostakhdemin-Hosseini, Jari Mustajärvi (2003) Framework For Mobile Learning System Based On Education Component. *Proceedings of the International Conference on Theory and Applications of Mathematics and Informatics – ICTAMI 2003, Alba Iulia*

[13] *Terry Mayes & Sara de Freitas* JISC e-Learning Models Desk Study Stage 2: Review of e-learning theories, frameworks and models *Available on: http://www.jisc.ac.uk/uploaded_documents/Stage%202%20Learning%20Models%20(Version%201).pdf viewed 0n 4th March, 2010.*

[14] *Yuhsun Edward Shih and Dennis Mills (2007). Setting the New Standard with Mobile Computing in Online Learning. International Review of Research in Open and Distance Learning Volume 8, Number 2. ISSN: 1492-3831* June – 2007

[15] *Keller, J. M. (1987).* Development and use of the ARCS model of motivational design. *Journal of Instructional Development, 10*(3), 2-10.

[16] Georgieva, E., A. Smrikarov, T. Georgiev (2004), *A General Classification of Mobile Learning Systems*, Proceedings of the ComSysTech'2004, June 16-17, 2004, Varna, Bulgaria, pp.IV.14-1-IV.14-6,