

Mobile Technologies and its Impact – An Analysis in Higher Education Context

Seibu Mary Jacob¹ and Biju Issac²

¹ School of Engineering, Swinburne University of Technology (Sarawak Campus), Kuching, Malaysia

²School of IT & Multimedia, Swinburne University of Technology (Sarawak Campus), Kuching, Malaysia

Abstract—The technology of internet and wireless networks conceived the revolutionary concept of mobile learning or m-learning. Mobile learning through wireless enabled laptops within a university campus can make use of the learning management system that is already available through internet or intranet. Without restrictions within the four walls of computer labs or library, students can now access the learning resources anywhere in the campus where wireless access points or hotspots are located. We briefly investigate on the mobile learning concepts and also expand briefly on different wireless technologies, eventually emphasizing on a secure 802.11 network. Later an analysis of the student perceptions on mobile learning is presented through a survey and the future trends were discussed in conclusion.

Index Terms—wireless networks, mobile learning, student perceptions, analysis

I. INTRODUCTION

The technological era has gone far in terms of internet technology and thus ushered in e-learning via computers. Online courses in universities as well as courses with online resources became the state-of-the-art technology in e-learning. The immobile computers in the computer labs on-campus offered a digital library at the student's finger tips. But then these online resources subscribed to by the university could be accessed only in campus. Here is where portable PCs came in to the rescue, and then the concept of wireless LANs. A wireless capability gives the institution a straight forward, cost effective solution to maximize all the benefits of the educational network. The availability of laptops which connect to the hotspots in campus removed the restriction from the campus lab PCs [1]. Higher education campuses become fertile ground for wireless LANs fueled by the explosive adoption of mobile devices among students and faculty [2]. Mobile learning or m-learning is ushered in with open arms, as universities and colleges become the most aggressive adopters of Wi-Fi Technology. The recent affordability, power and usability of laptop computers have begun a trend towards portable computing in education to meet this need [3], [4]. Mobile technologies are rapidly being developed and adopted increasingly on a global scale. The highly sounded concept of e-learning is superceded by m-learning. It's clear that m-learning is a subset of e-learning [5]. Keegan in his latest book provides systematically the advantages, disadvantages, recommendations to enhance learning in mobile environments [6]. It is a world of information at the fingertips of the present generation.

Brown J.S. talked of this as information navigation [7]. The constructivist approaches brought in the concept of Communities of Practice (COPs). A Community of Practice perspective sees learning in more informal settings taking place as a by-product of joining a group of practitioners and having a legitimate, peripheral participation in one or more aspects of the practice being carried out by the experts [10]. As COPs begin to play a noteworthy role in teaching and learning environments, the focus is on the COP, not the instructor. The challenge here today is to find proper ways to tap the community mind [7] so that the existing social and natural resources for learning are used effectively and productively. If we as instructors succeed here, there lies amazing ways to accelerate learning and capture knowledge.

This paper is organized as follows. Section 2 contains the basic concepts in electronic and mobile learning, Section 3 discusses briefly on various mobile technologies, section 4 elaborates on mobile learning network architecture, Section 5 briefly states the advantages of mobile learning, Section 6 presents a statistical analysis of a related student survey, Section 7 is the future trends and Section 8 is the conclusion.

II. CONCEPTS IN ONLINE LEARNING AND LMS

Formal Learning can be broadly divided into three categories based on the context of occurrence – Regular Class room learning, Distance Learning and Online Learning. Distance Learning can be within a class room environment or with online access and it can be a combination of both. On the other hand, Online Learning can include E-Learning and Mobile Learning. E- Learning can be done through fixed wireless PCs and laptops, while mobile learning can be through wireless laptops, PDAs, palmtops, tablet PCs etc. This scenario is pictured in Fig. 1. Our focus in this paper would be on mobile learning using wireless laptops, with some mention on other technologies.

When the corporate intranets became common in the 1990s, web-based training arose offering flexibility in the deployment and maintenance of e-learning. With the connection of an intranet, the content of e-learning which could only be stored in CD-ROM previously was made available on a host server. Learners were able to access the training materials through the intranet and even interact with other learners or the instructors in a synchronized environment where they could share and support one another.

The wide coverage of Internet throughout the world soon allowed a more extensive web-based e-learning

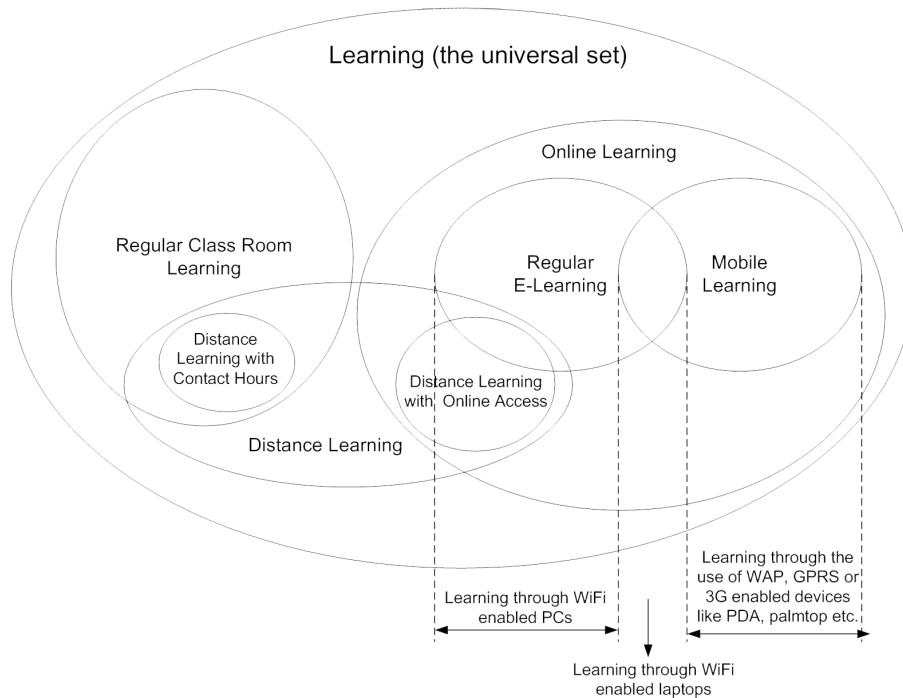


Figure 2. The diagram showing the relationship in different learning approaches

system called the Learning Management System (LMS) to emerge. A learning management system is an online software package that enables the management and delivery of content and learning materials to learners.

The LMS can easily generate the usage statistics of participants and that could help monitor the general progress in accessing learning materials. With the learning management system, it is generally believed that an anytime and anywhere learning environment could be established. However, the number of learners must be substantial for a worthwhile effort to be invested on a learning management system. Selecting the right LMS for the program is a huge undertaking as it simulates the environment where learning will take place. LMS such as Blackboard offers a variety of tools that generally supports content management and collaborative learning. The LMS must create a learning environment which is a place for learner expression and content interaction, a place to connect with other learners and to the thoughts of other learners in a personal and meaningful way. It should be a place to conduct dialogues with the instructors, acts as a repository for learning materials and it should be modularized so that additional functionality and tools can be added based on what learners need, thus supporting collaborative learning and also different modes of learning.

III. VARIOUS MOBILE TECHNOLOGIES

A. The Wi-Fi Technology

A wireless network uses radio waves that communicate in two ways. These networks can operate in two ways – a centralized network with access point, called infrastructure network and a decentralized network without access point, called ad-hoc network. We'll focus on infrastructure WiFi (Wireless Fidelity) network here. A computer's wireless adapter converts the message or data

to be sent into radio signals and transmits them using an antenna. The wireless access point that is already connected to an existing local area network (or directly to Internet) receives the incoming radio signal and decodes it. It forwards that information to the Internet or to any computer on the local network. The process also works backwards, with the access point or router receiving information from the Internet or destination computer, converting it into radio signals and sending it back to the source computer. The radio transmission happens at frequencies of 2.4 GHz or 5GHz, which is considerably higher than the frequencies used for cell phones, televisions etc. The higher frequency allows the signal to carry more data.

The common 802.11 networking standards are noted below. IEEE 802.11b wireless standard was the first version to reach the marketplace. It is the slowest and least expensive standard, and it's becoming less common as faster standards are coming up. 802.11b transmits in the 2.4 GHz frequency band of the radio spectrum and has a speed of 11 Mbps and it uses complimentary code keying (CCK) approach. Another popular standard, IEEE 802.11g also transmits at 2.4 GHz, but it is more faster than 802.11b with a speed of 54 Mbps. 802.11g is faster because it uses orthogonal frequency-division multiplexing (OFDM), a more efficient coding technique. Another standard, 802.11a transmits at 5 GHz and have speeds up to 54 Mbps. It also uses OFDM coding. Newer standards, like 802.11n, can be even faster than 802.11g. 802.11n builds upon previous 802.11 standards by adding MIMO (multiple-input multiple-output). MIMO uses multiple transmitter and receiver antennas to allow for increased data throughput through spatial multiplexing. Because of the support for multiple antennas, multiple streams of communication can be supported. WiFi devices can transmit on any of the supported frequency bands and they can frequency hop between the different bands. This

frequency hopping helps reduce interference and lets multiple devices use the same wireless connection at the same time. If there are too many people trying to use the wireless network at the same time, the users can experience interference or their connections can be ruptured [8].

B. The Bluetooth Technology

Bluetooth is a form of wireless personal area networks (PANs) where it provides a way to connect and communicate information between bluetooth enabled devices such as mobile phones, laptops, PCs, printers, digital cameras etc through an unlicensed short-range radio frequency band. The main advantages of Bluetooth are that it is wireless, inexpensive and automatic. Bluetooth networking transmits data via low-power radio waves. It communicates on a frequency of 2.45 GHz band (between 2.402 GHz and 2.480 GHz), which has been set aside by international agreement for the use of industrial, scientific and medical devices (ISM). The transmission range would be from 1 meter to 10 meters on the average.

Bluetooth can connect up to eight devices simultaneously. Bluetooth uses a technique called spread-spectrum frequency hopping that makes it less likely for two or more devices to be transmitting on the same frequency at the same time. In this technology, a device will use 79 different and randomly chosen frequencies within a designated range, changing from one frequency to another on around 1600 times every second. Thus more devices can make full use of a limited slice of the radio spectrum. Since every bluetooth transmitter uses spread-spectrum transmitting, they don't interfere with each other during transmission. This reduces interference from external devices like mobile phones, microwave ovens or baby monitors, since any external interference on a particular frequency will only last for a short time [8].

C. The WiMax Network or Broadband Wireless Network

WiMAX, the Worldwide Interoperability for Microwave Access, is a wireless broadband technology that supports long distance communication. It is based on the IEEE 802.16 standard, which is also called Wireless MAN (Wireless Metropolitan Area Network). WiMAX could be a potential solution to the suburban and rural blackout areas that currently have no broadband Internet access because phone and cable companies have not yet installed the necessary wires to those remote locations. A WiMAX system consists of two parts – a WiMAX tower and a WiMAX receiver. A WiMAX tower, similar to a cell-phone tower, can provide coverage of around 3000 square miles. A WiMAX receiver and antenna could be within the PCMCIA card, or they could be built into a laptop. A WiMAX tower station can connect directly to the Internet using a high-bandwidth, wired connection and it can also connect to another WiMAX tower using a line-of-sight, microwave link. WiMAX actually can provide two forms of wireless service, namely the non-line-of-sight and line-of sight service. The non-line-of-sight service is where a small antenna on the computer connects to the tower and it uses a lower frequency range – 2 GHz to 11 GHz, similar to that of WiFi. The line-of-sight service uses much higher frequencies (reaching up to 66GHz), where a fixed dish antenna points to the WiMAX tower from the top of a roof or from a high pole, so as to

get the line-of-sight connection. This connection is more stable and is able to send much data with less error. The non-line-of-sight service will be limited to a 4-to-6 mile radius (around 25 square miles of coverage). But for the line-of-sight service through directional line-of-sight antennas, the WiMAX transmitting station can send information to WiMAX-enabled devices or routers installed within the transmitter's 30-mile radius (i.e. around 2,800 square miles coverage) [9].

D. Mobile Phone Network

A mobile phone is a portable and long-range electronic device used for wireless or mobile communication. In addition to the normal function of a telephone to speak to a remote person, current mobile phones can support additional services like SMS (Short Message Service) for text messaging, email messaging, accessing the Internet for lightweight browsing and MMS (Multimedia Messaging Service) for exchanging photos and video. Mobile phones connect to a cellular network of base stations (cell sites), which are in turn connected to the public switched telephone network. Radio signals that 1G networks use are analog, while 2G networks are digital. Note that both systems use digital signaling to connect to the radio towers and more than one user can use a cell. There are three common technologies used by 2G cell-phone networks for transmitting information – Frequency division multiple access (FDMA), Time division multiple access (TDMA) and Code division multiple access (CDMA). FDMA places each call on a different frequency, whereas TDMA assigns each call a certain time slice on an allotted frequency and CDMA allocates a unique code to each call and spreads it over the available frequencies. 3G technology is one of the best available options in mobile communications today. 3G stands for 'third generation' and is targeting the multimedia communication through cell phone or smart-phones. It supports increased bandwidth and high data transfer rates compared to 2 or 2.5G to allow internet browsing and exchange of audio and video files. 3G technology is supported by various cellular access technologies. The three most common ones are CDMA2000, WCDMA and TD-SCDMA. CDMA2000 is based on 2G Code Division Multiple Access, WCDMA (UMTS) is Wideband Code Division Multiple Access and TD-SCDMA is Time-division Synchronous Code-division Multiple Access. 3G networks have potential transfer speeds of up to 3 Mbps. 3G phones are like mini-laptops and can thus accommodate broadband applications, to some extent [8].

4G represents Fourth-Generation communications system that is still under research, which provides an end-to-end integrated IP solution where network convergence of different networking technologies allows voice, data and streaming multimedia to be accessed and sent by users at anytime and anywhere, with higher data rates than the previous versions.

IV. MOBILE LEARNING NETWORK ARCHITECTURE

In an educational context as of the wireless network implementations to date, WiFi technology is widely used in comparison to others. Even though WiMax offers a higher bandwidth and speed, it is not widely used in a university context as of now. Bluetooth has transmission problems with distance and cell phones or PDAs are not popular learning tools because of their small screen size,

even though they can complement WiFi technology. The network architecture that can be used in a mobile learning environment should inspire confidence in the users with respect to security. We outline a secure WiFi network design that could help achieve security to the maximum as per the currently available technology.

A. The WiFi Network Architecture

The wireless technology has brought along with it mobile and seamless access to digital information, giving rise to a new paradigm called mobile learning or m-learning. Access to a host of digital information is good enough. But when that is added with mobility, learning style could be improved again. Generally, many universities have 802.11 wireless networks that help the students to access e-learning tools like Black Board Learning System and other digital libraries. Various wireless access points can be placed in common areas like cafeteria, library, reading rooms etc to facilitate online data access in a wireless fashion.

A sample university network with wireless access is shown in Fig. 2. A university wireless network is shown with some basic security features. Students can opt for laptops and could be in the access range of wireless radio communication to get connected to University network and access their student files and other E-learning resources. This liberates them from the need of being stationed within a lab or library set up, where things can be rigid and mobility may not be that possible. For basic security, the wireless nodes which are Wi-Fi Protected Access (WPA) enabled needs to get authenticated with a RADIUS authentication server.

Security is a major concern in any wireless network implementation. In the much more secure network design shown in Fig. 3, the firewall between Internet cloud and enterprise network blocks any unauthorized access. Firewall between Wireless Local Area Network (WLAN) and enterprise network stops or filters network attack from the WLAN side. Virtual Private Network (VPN) provides secure tunneling through the use of IPSec protocol with the use of a separate VPN server. RADIUS authentication server provides the 802.1x mutual authentication and Wi-Fi Protected Access (WPA) with its advanced encryption

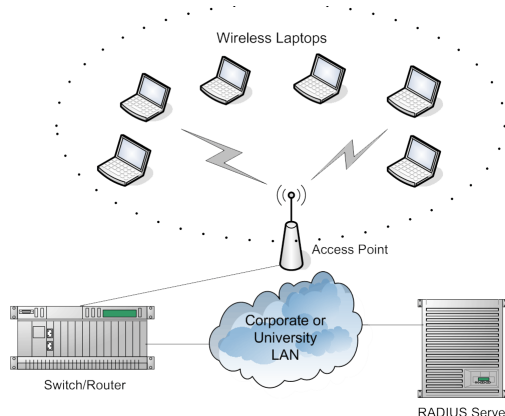


Figure 2. The wireless network in a university showing mobile laptops

protocol (Temporal Key Integrity protocol, TKIP) can be used for secure WLAN communications.

The advantages of using IPSec-based VPN for WLAN are that it allows to use strong authentication mechanisms and it allows operators to provide wireless access without requiring vendor-specific hardware (for both client and AP). When all the security options are tied together, the wireless network requires explicit authentication to allow a device and the user on the wireless network. Also the traffic on the wireless network is highly encrypted, and traffic directed to internal network resources is controlled per user or group by an access policy at the firewall or in the VPN [11].

Mobile learning (m-learning) can also use hardware like personal digital assistants (PDAs), tablet PCs and Bluetooth devices. Instead of planned and purpose-built computer labs, multifunction rooms are being used to support a range of learning goals. These rooms make use of mobile chairs and desks, wireless projectors and interactive whiteboards to create an interactive learning environment. The decision to move to a wireless environment rests on a number of factors like cost effectiveness in building the system, security aspects and reliable bandwidth servicing as wide as possible an area. As per some estimates, the cost of developing or expanding a wired network is around twice as expensive as for wireless systems [12], [13]. In our paper, we are primarily concerned about mobile learning through the use of Wi-Fi technology using laptops, though other technologies and devices are not fully ignored in our discussion.

V. BENEFITS OF MOBILE LEARNING IN HIGHER EDUCATION

The benefits of mobile learning can be felt at the distinct levels as given below. They have some commonalities with benefits of e-learning approaches, as m-learning is indeed a subset of e-learning.

A. Easy Access

Knowledge is delivered on-demand, with updated information within the precincts of the m-learning campus. In a university or academic environment, the use of Black Board Learning System (BBLS) or related technology can augment class room learning and teaching as explained before with instant access to learning materials, as the users can be on the move.

B. Options for Self-study

The flexibility of m-learning enables participants to learn at their own time and pace even more compared to the fixed PC access, hence the amount of information retained from the training is often greater, which results in increased information retention. By making academic courses more accessible, this will generate a more skilled workforce that can contribute to the economic growth of a country. In a university scenario, it depends on which course the student gets enrolled in.

C. Evaluation and Feedback

Assessment tools can be included into the m-learning or e-learning packages to monitor student's progress, and produce detailed usage reports. This can be given as feedbacks to students or learners. With the ability to create electronic assessments, it is trivial to find what users have learned, when they have completed courses, how they

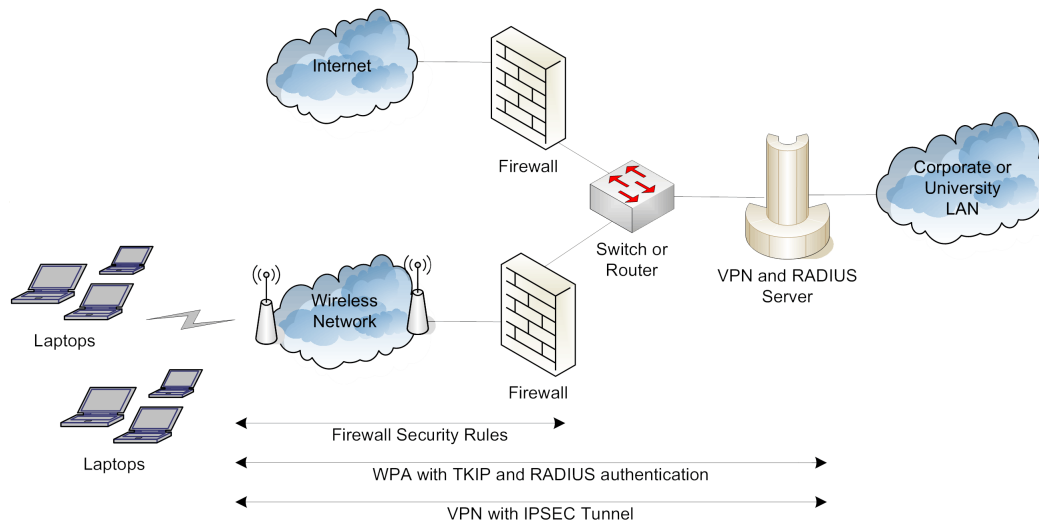


Figure 3. A secure university network design for wireless nodes in mobile learning environment [10]

performed, and their levels of improvement. Automated reporting and statistical analysis of the learning process can be produced in order to quantify the e-learning benefits to the organizations.

D. Access of Online Repository

The online materials accessed through m-learning system offers a place for the lecturers and students to interact frequently. Learners have access to a stored repository of knowledge and information like the digital course materials and a host of other online digital libraries for assignments and exams. The digital library access can be of two types – Subscribed Digital Library access and Free Digital Library access. The subscribed access can be through an organization's or university's subscription to these sites or through personal subscription. M-learning accentuates this process and brings it to the advantage of the learner, thus boosting student learning.

E. Communities of Practice

The three elements of a COP are a domain, a community and a practice and the theory behind is that learning involves participation in a COP. This involves 'a more encompassing process of being active participants in the practices of social communities and constructing identities in relation to these communities' [14]. Most COPs meet online and m-learning makes this click well. The increasing participation in the COPs enlarges the individual's learning domain and ensures the process of learning [15].

VI. ANALYSIS OF STUDENT PERCEPTIONS ON MOBILE LEARNING

The particular study was aimed to explore and analyze factors crucial to overcome the possible hindrances of implementation of m-learning in university education. Student perceptions of m-learning may be influenced by specific individual variables. The variables taken into consideration in this study were gender, course of study

and attitudes to new technologies. Research has indicated that men are strongly influenced by perceptions of usefulness in technology usage decisions. But women are more attracted to the ease of use. Men and women focus on different aspects of using computers [16]. The authors felt it's worthy that the theories of technology acceptance be considered in studies of this sort. Rogers speaks of five different adopter categories in his description of a general framework of technology acceptance within the theory of diffusion of innovations. The five adopter categories—innovators, early adopters, early majority, late majority and laggards are regarded in this study [17],[18]. The three specific objectives of the survey were: (1) to explore students' general attitudes to e-learning through wireless networking (or mobile learning) on campus; (2) to analyze the relationship between the attitudes in (1) and specific background factors like gender, course of study, attitudes to new technologies; (3) to explore the most important advantages and disadvantages that the students anticipate in the context of mobile learning. The scope of the study conducted in 2006, included students who have been exposed to wireless networks in the university environment during one semester. The questionnaire was distributed to a large sample of 250 students across Business and Engineering streams in a Malaysian university. The response rate was 76%, and thus the analysis was based on the 190 responses received.

A. Methodology

The first objective, namely the students' attitudes to m-learning was measured using seven closed questions. The statements hypothesized in the questions were:

1. Wireless networks offer seamless access to digital information, and hence is a boost to this information age.
2. The use of the wireless network can increase flexibility of access to resources (like Black Board website, slides, notes, library journal access etc.) in my studies.

3. The wireless networks are not generally very secure and so I wouldn't want to use it when I can use desktop PCs.
4. The use of the wireless network can improve communication with teachers and tutors.
5. The use of the wireless network can improve the learning (pedagogic) value of the courses and the courses are more recommendable to others.
6. With wireless network I do not need to depend on library PCs or lab PCs. Accessing of internet for working on assignments within University is a lot easier.
7. Do you prefer mobile phone to be used for mobile learning (since it can access web pages)?

It was noted that statement 3 was a negative statement unlike the others which were all positive statements. Statements 1-6 were given alternatives based on the Likert scaling on a scale of 1-5, where 5 represents 'I agree totally' and 1 represents 'I disagree totally'. The statement 7 offered the alternatives: 'Yes' and 'No'. The percentages of the responses to statements 1-6 were calculated separately for the Engineering and Business students and differences noted as shown in Table 1. The lower limits of the 95% confidence intervals were calculated. If the lower limits covered zero, it was decided that there was no statistically significant difference present.

As the second objective, a factor analysis was performed on the closed ended questions to show the inter-relationship between the questions. Then a multiple regression analysis was attempted using the variable 'Attitude'. This was an index formed by summing the responses to the statements 1-6 for each individual. The response 'I agree totally' was given the index value 5 and the response 'I disagree totally' was given the index value 1. The total index for each individual could vary between 6 and 30. The three independent variables used were gender, area of specialization (Engineering/Business), attitudes to new technology (measured in five levels: innovator, early adopter, early majority, late majority and laggards). Here graphical comparisons were also done between engineering and business students in the matter of attitude to new technology and preference of mobile phone to be used for mobile learning.

As the third objective, through two closed ended questions and one open ended question information was gathered on the most important advantages and disadvantages, from the students' experience with the m-learning system in place in the university.

B. Survey Results

As shown in the Fig. 4, the majority of the responses for the questions on the use of the wireless networks for learning have shown a mean close to 4 (I agree to a large extent). The best mean was 4.2 in response to the statement "wireless networks increases flexibility of access to resources in learning" and the worst mean 3.4 in response to the statement "wireless networks can improve communication with teachers and tutors". The implication was that the students agreed to a large extent to the easiness, flexibility, assistance, improved communication offered by the mobile learning platform.

The survey revealed only marginal differences concerning the attitudes to the usage of the wireless

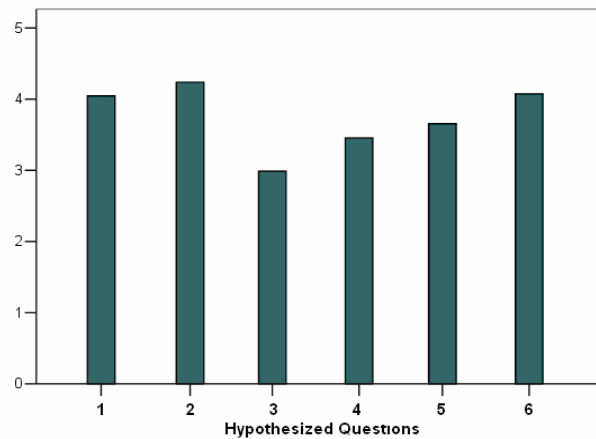


Figure 4. The mean Likert scale score for the student attitude towards mobile learning.

networks between the two streams of the University, namely Engineering and Business, as is seen from table 2.

Regarding the second objective, a factor analysis performed on the closed ended questions showed a close inter-relationship (factor score more than 0.5) between the questions. From the multiple regression analysis attempted using the variable 'Attitude' and the three independent variables gender, area of specialization (Engineering/Business), attitudes to new technology (measured in five levels: innovator, early adopter, early majority, late majority and laggards), there was seen a significant statistical relationship between the attitude index and attitudes to new technology ($p < 0.05$, $R^2 = 3\%$) at 5% significance level. But there was seen no significant relationship ($p > 0.1$) between attitude and gender or attitude and area of specialization at even 10% significance level. Fig. 5 reveals the distribution of the attitude index in each of the five categories showing attitude to technology. Clearly the innovators show a closer distribution of the attitude scores between roughly 17 and 27 with the highest minimum and an outlier which is not so far compared to the other four categories.

Through two closed ended questions, information was gathered on the most important advantages and disadvantages, from their experience with the m-learning system in place in the university. As shown in table 2, the main advantages highlighted were: There was easy access to learning materials/resources, and there being no need to

TABLE I.
THE ADVANTAGES WITH M-LEARNING WITHIN A UNIVERSITY CAMPUS.

Advantages with m-learning	Percentage in favour
Easy access to learning resources	74%
Learning is easier as I can chat with online friends to clarify doubts	43%
No need for lab or library PCs to be free	79%
Less virus attack as we can use our own wireless laptop to connect to network	30%
Communication is a lot easier with teachers and friends	33%

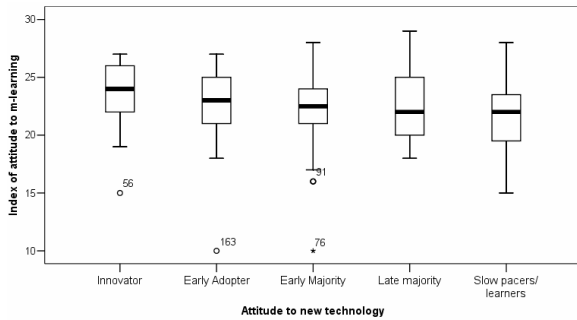


Figure 5. The Box plot showing the Attitude Index to m-learning on the Attitude to new technology categories.

wait for lab or library PCs to be free. The disadvantages highlighted included that the laptop needed to be carried by the student to the school from home; Also the non availability of a laptop caused some to have no access to the wireless network at all. They also expressed concern about bandwidth and speed when many users were connected to the access points. The students did not seem to be much aware of the security issues with wireless networks.

The student responses were invited through another closed question regarding how they would like to see mobile learning in the future. Majority of students voiced that they wanted laptops, PDAs and hand phones to be used together for communication and learning.

The open ended question was aimed at getting at least two points on mobile learning from the student’s point of view in the campus. The qualitative information was content-analyzed and classified into main categories. Students responded that wireless networks are a must for university campuses as it is not possible to offer PCs to all the students. The system was praised as a tool which made the university life less time consuming since students could download necessary information for assignments during anytime they are free. Some voiced that carrying a mobile phone is handy compared to laptops; hence it is convenient to use high end mobile phones for accessing wireless networks. A minority commented that not many could afford to buy a laptop or high end mobile phones to connect to the wireless networks. In general students felt that the wireless network boosts efficiency and effectiveness on both sides (the student and the lecturer)

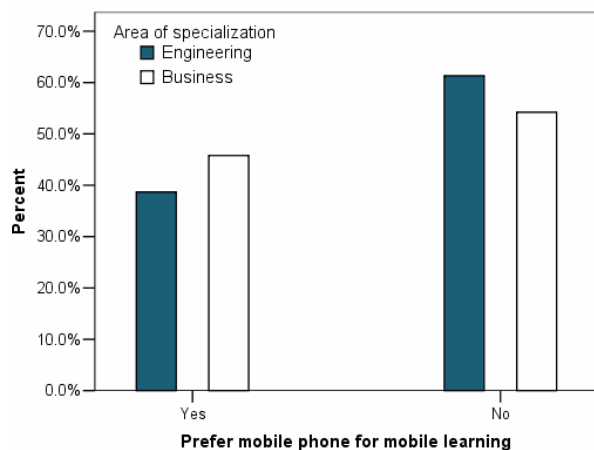


Figure 6. The preference of mobile phone for mobile learning

TABLE II.
THE DIFFERENCES IN NEGATIVE RESPONSES RELATED TO THE ENGINEERING AND BUSINESS STREAMS.

I disagree totally / I disagree to a large extent	Engg. Deg.	Bus. Deg.	Diff.	Lower limits of the 95% Confidence Interval
Wireless networks offer seamless access to digital information, and hence is a boost to this information age.	5%	2%	3%	0.1%
The use of the wireless network can increase flexibility of access to resources (like Black Board website, slides, notes, library journal access etc) in my studies.	3%	2%	1%	64%
The wireless networks are not generally very secure and so I wouldn't want to use it when I can use desktop PCs.	32%	27%	5%	69%
The use of the wireless network can improve communication with teachers and tutors.	12%	11%	1%	8%
The use of the wireless network can improve the learning (pedagogic) value of the courses and the courses are more recommendable to others.	6%	6%	0%	51%
With wireless network I do not need to depend on library PCs or lab PCs. Accessing of internet for working on assignments within University is a lot easier.	12%	6%	6%	22%

of the learning endeavour.

As per Fig. 6, the responses to statement 7 mentioned in section 6.A, showed the majority of students responded ‘No (as the screen size is small)’ to the usage of mobile phones for mobile learning against the alternative ‘Yes (as I can at least access some information)’. Here it was noted that the Engineering students have been on the negative side than their Business counterparts. It could be indirectly inferred that the response is an indication of the technical know how that the Engineering students have over Business students, since they preferred a laptop based network communication over mobile phone

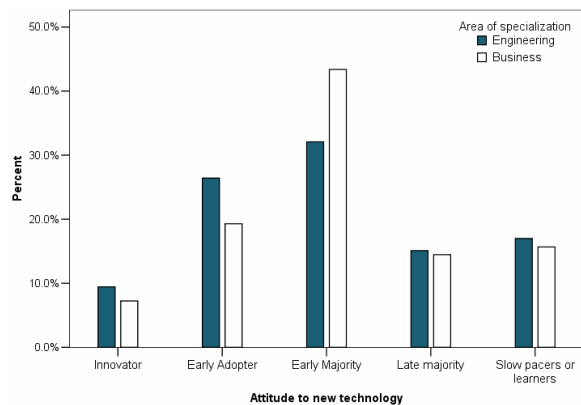


Figure 7. Graph showing the Attitude to new technology in Engineering and Business Students.

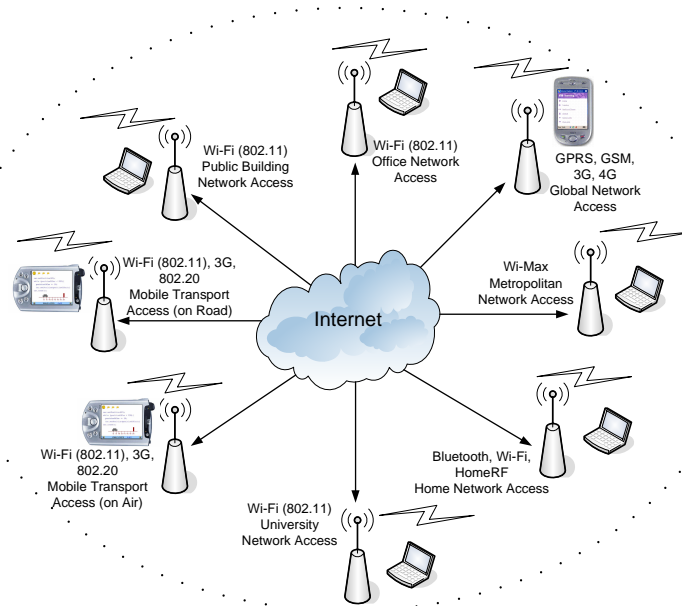


Figure 8. Future convergence network where different technologies co-exist and seamless mobility and ubiquitous computing emerge.

communication for full fledged web-based mobile learning that has heavy learning contents.

Fig. 7 shows another graph that indicates that the Engineering students were more daring with respect to adopting and using new technologies, while the Business students were topping in early majority.

VII. CURRENT AND FUTURE TRENDS

The future of mobile learning looks very challenging and the authors are quite dogmatic about its wide acceptance in future, especially with more research on the mobility management in Wireless LAN (WLAN), research on increasing bandwidth for 3G/4G or related technologies and greater research on co-existence technologies like Wi-Fi, Wi-Max (for Broadband) and 3G/4G devices communicating to each other. For example, a scenario like the one shown in Fig. 8 can be anticipated – where ubiquitous, anytime, anywhere networking for mobile learning can become a reality. The 4G (fourth generation) system that is under research and development will be a fully IP-based integrated system achieved after the convergence of wired and wireless networks, where computers, mobile phones, PDAs and consumer electronics etc will be offered end-to-end quality of service, and services anytime, anywhere, at affordable cost and one billing.

VIII. CONCLUSION

The study on mobile learning paradigm that is getting popular in many universities and higher education institutions was a pleasant experience to the authors. Different wireless technologies were discussed and the use of WiFi network was highlighted. The WiFi secure design was discussed briefly as any security incident can make the approach unpopular. The analysis of student perceptions on m-learning points to the fact that mobile learning is widely embraced by the student community. The students also were keen to use all available sources of m-learning through laptops, palmtops, mobile phones and PDAs so that access to knowledge and information would

be anytime and anywhere. They did express dissatisfaction with small screen size of PDAs and mobile phones, when used in mobile learning context. Though 3G and related technologies suffer in terms of a wide bandwidth suitable for e-learning, mobile learning on 3G/4G devices can be on the rise and can eventually get integrated with other technologies like Wi-Fi, Wi-Max (broad band) etc to form a global network through internet.

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AUTHORS

Seibu Mary Jacob is with the Swinburne University of Technology (Sarawak Campus), Kuching, Sarawak, Malaysia and is a part-time PhD student with UNIMAS, Malaysia. (e-mail: sjacob@swinburne.edu.my).

Biju Issac is with the Swinburne University of Technology (Sarawak Campus), Kuching, Sarawak, Malaysia. (e-mail: bissac@swinburne.edu.my).

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