

Recommend Computer Studies Courses for Students Taken based on Supported Mobile Learning Modes

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Abstract—Mobile learning is not a concept anymore, learning and getting education has transcended the traditional physical barriers. Many mobile learning applications are developed based on different theories of learning. Both learner and teachers are excited to adopt this promising technology. Mobile phones and other hand held technologies improved significantly, emerging and evolving rapidly. Modern mobile devices are equipped with advanced features, multiple interfaces and synchronization capabilities. However the technology growth may not necessary complies with what the educational sector needs as it is not the core focus of mobile technology. On other hand new courses and disciplines are also not fully compatible with the mobile functionalities and features. This research is intended to review the existing computer studies Ontario Curriculum for High School students and the mobile functions that devices in the market have to find the relations between learning topics and hand held devices' functionalities. The results analysed and the mobile learning modes found in this research as well as the proposed recommender system, hence, can provide not only users but also course authors great help when the users make decisions of taking courses and purchasing new devices in order to do further learning as well as when the authors take different learning methods into consideration in designing learning activities.

Keywords—Mobile devices, mobile learning, mobile phones, iPad, iPod

I. INTRODUCTION

It is needless to mention about the growth of technology, particularly mobile phones and mobile hand held devices. New devices are more sophisticated and equipped with advanced features, multiple interfaces and synchronization capabilities. Mobility, accessibility, localization and personalization make mobile devices more attractive for day to day usages. The objective may differ, but almost everyone is holding a mobile hand held device.

Wireless, mobile, portable, and handheld devices are very common and many sectors are trying to use this essential human partner. Mobile phone penetration rate has reached more than 92% across the EU in 2005 [2]. By the years 2015 universities are forecasted to be ubiquitous [13]. The advance wireless technology is ideal for mobile learning with improved mobile functions [3].

Using mobile technology is a growing trend of this era. However there are still privacy issues and very little

acceptance from old school thinking, though things have improved in the last decade which is a very positive and encouraging sign. Students in China, Japan, Philippines, and Germany benefit a lot using mobile technologies to learn English and Mathematics. Shanghai Jiao Tong University has thousands of students attending live lectures by live mobile video learning system [12]. Up to 900 teachers and 40,000 students at 72 different universities in Japan are currently using this system [8], and thousands of students are enrolled in hundreds of courses offered by NKI, an institution in Norway [1]. IT students of the University of Technology in Sydney, Australia are using mobile devices as a self study tool [10].

Learning through mobile devices is convenient, as there is no time and space constraint. It is a cost effective learning approach as everyone possess some sort of mobile device [11]. It is also a green solution because it is energy saving due to the fact that it requires less travel which results in the reduction of carbon [1].

Existing mobile technology's features and capabilities are the main consideration when developing any mobile application. Essential framework and interfaces are being developed in order to use the mobile technology. However, it is equally important for the learning community to map their needs with the mobile device's functionalities and characteristics. iPhones, tablets, Palms, Personal Digital Assistants (PDA), Pocket PCs, smart phones and digital cell phones are examples of handheld devices which can be potentially used for learning purposes.

According to the Ontario Curriculum for High School students, prepared, compiled and published by the Ontario Ministry of Education [15], the research goal is to identifying suitable learning topics in computer studies which can be taught using mobile technology. We will further elaborate the learning topics categories as per the mobile devices which can be used for computer studies. Based on mobile device's capabilities, we will categorize and define mobile learning modes. For example, the GPS receiver function can be mapped to the Field Work learning method. The importance of this research is to establish the relationships between the learning methods and mobile device's functions and then to map the mobile learning modes with the learning topics in computer studies.

The rest of this paper is organized into six sections. Section 2 reveals the procedure that this research took for finding relations among computer studies components and mobile devices. Section 3 summarizes computer studies learning components (i.e., courses and learning topics) according to Ontario Curriculum for High School students. Section 4 summarizes the functions/features that mobile devices in the market have. Section 5 analyzes the learning methods that each learning topic in the computer studies curriculum use and develops the mobile learning modes which represent the associations between learning methods and mobile device functions. Section 6 maps the learning modes to the learning topics. Section 7 discusses proper mobile devices for mobile learning computer studies according to the discovered mappings among learning topics, learning methods, and mobile device functions.

II. THE PROCEDURE

The whole procedure took by this research to find relations among computer studies learning components (i.e., courses and learning topics) and mobile devices has six steps:

- 1) Most of the universities, colleges, school boards and other educational institutes are preparing and publishing their curriculum. Domain and courses are already interlinked; both need to be mapped with topics as well.
- 2) Similarly, instructional approaches and teaching strategies should be modified more towards formal learning methods, which can be easily identified and can be relate to the subject topics.
- 3) Creating a 'mobile devices functions' list is the next step after the preparation of the domains, courses, topics and learning methods interconnected lists. This requires an in-depth study of existing mobile devices and their functions.
- 4) Identifying mobile learning modes is the next step, in which mobile functions are tied with learning methods. It is a two way mapping, in other words many-to-many type of mapping relations.
- 5) The next step is to map topics (from step 1) with the learning methods (from step 2). There are thousands of learning topics which exists and many more are emerging, hence why the mapping between learning methods and topics will be challenging.
- 6) The final step is to prepare a mobile devices list with their functionalities, as identified in step 3. This collection is updateable in a timely fashion, with the pace of mobile technology advancement.

The mapping procedure proposed here is to find relations among learning components and mobile devices which can be contributes towards computer studies learning courses and topics. The outcomes can be a list of the mobile functions and/or list of actual mobile device(s) which are mapped to the input. Inputs can vary from (1) a learning domain, (2) a course (3) a particular learning topic or (4) group of topics. The

following tables are extracted relations using this methodology (from step 1 to 6).

III. COMPUTER STUDIES TOPIC SELECTION

There are hundreds of course disciplines with many domains and thousands of topics. In addition, there are a number of layers in which these learning domains falls in, for example elementary, secondary and higher education, which is further divided into colleges and university programs. Having said this, we have to limit our scope in order to demonstrate our research results. Our learning domains and topic selection is limited to the high school syllabus, more specifically, senior university courses. We omitted redundant titles and also excluded some topics which are unrelated to our study since our research focus is not to provide in depth educational details. This research's main source is The Ontario Curriculum for High School students, prepared, compiled and published by the Ontario Ministry of Education [15].

Computer studies is teaching students how the computer works, from hardware to software, from defining problem to testing and maintaining programs, and also from algorithm principle to its impact on society. Computer studies is useful and helpful to all Grades 10 to 12 students because its contents sharpening student's problem solving skill, nurturing student's logical thinking and creative design ability, as well as synthesis and evaluation ability [16]. Computer studies category has two courses, computer science and computer programming. Table I lists the learning topics covered by the two computer studies courses.

TABLE I
LEARNING TOPICS COVERED BY THE TWO COMPUTER STUDIES COURSES

Computer Science	Computer Programming
Computer component	Data types and Expressions
Problem-solving strategies	Designing algorithm
Designing software solution	Object-Oriented Programming
The Software Development Life Cycle	Unified Modeling Language
Software development Environment	Prototype complex solutions
Postsecondary opportunities	Design documentation
Computers and society	User documentation
Safe computing	Develop use cases
Cyber bullying	Implement formal testing plan
Identity theft	Linear and binary searches
Environmental Stewardship and Sustainability	Compare the efficiency of sorting algorithms
	Test iterations of a loop
	Identify infinite recursion
	Identify exponential growth in recursive algorithms

IV. MOBILE DEVICE FUNCTION SUMMARIZATION

Any new mobile device that is released has another feature or enhanced existing functionality, which is usually, based on research towards its usage or potential industry needs. The learner picks and chooses the device to utilize for learning, which contains the required functionality for that particular use. For example, if a student wants to study outside of

regular school hours, then a selected mobile device must have either internet connectivity or storage capability to assess knowledge resources.

Mobile devices are not yet in mainstream learning; instead it is being used as supplement of the traditional education [1]. Combining both mobile and traditional learning approaches is a better solution for specific courses [7]. Almost all available mobile devices can be used for this purpose such as; Blackberry smart phone, iPod, PDA Windows, PDA Palm, Tablet PC, Wireless, Notebook, iPad, Samsung Galaxy Tab, Dell Inspiron Duo, RIM, BlackBerry tablet, iPad with front-facing camera, HP Palm WebOS tablet and many more [1][6].

Mobiles equipped with camera can be used for many educational purposes, if Augmented Learning Contents (ALC) techniques are used for online and offline multimedia contents [3]. The techniques proposed an image retrieval method, which is used for rapid access of large repository of multimedia contents. Similarly many experiments were done to use the audio feature of mobile technology for learning English [9].

Mobile Plant Learning System (MPLS) [4], MobileMath and MathX projects are examples of mobile device usage in elementary schools. GPS is a context aware feature of mobile devices, which is used for formal Math and Geometry courses. The GPS functionality was used successfully for Geography course field work [5].

Some other obvious mobile functions which can also be used for learning purposes, for example a mobile can act as piano, guitar or drum set for music study and can be used as a level and ruler for many other learning tasks. In the library, built-in camera can be used as a barcode scanner or a comic-strip viewer to find reading materials. Art can also be taught by a camera equipped mobile. A few more exciting features have emerged recently, such as color matching by phone technology which was launched by Hewlett-Packard to find the right colors and face recognition utility by Carnegie Mellon. Table II lists partial mobile device functions which are available and patiently can be used by educators and learners.

TABLE II
MOBILE DEVICE FUNCTIONS (MFS)

Mobile Device Functions	MF Code	Mobile Device Functions	MF Code
Making call	MF1	Object recognising	MF20
Chatting	MF2	Microphone	MF21
Instant messaging	MF3	External MIC input	MF22
Email	MF3	Digital Compass	MF23
Key Pad	MF4	Maps	MF24
Color Display	MF5	GPS	MF25
HD display	MF5	built-in Wi-Fi	MF26
Landscape display	MF5	Internet connectivity	MF26
Camera	MF7	SSL VPN support	MF26
Two cameras	MF7	Calculator	MF27
Audio playing	MF9	Bluetooth support	MF28
Background audio	MF9	Fingerprint Reader	MF29
Stereo Phone Jack	MF9	USB connectivity	MF30
Integrated Speaker	MF9	Clock	MF31
MP3 support	MF9	Bump/Tapping tech	MF33

Speakerphone	MF9	Multi Language	MF34
Wireless headsets	MF9	Charge Port	MF35
Hearing Aid	MF10	Word Phone	MF36
Audio recording	MF11	Security	MF37
Magnetic Stripe (MSR)	MF12	Touch Panel	MF38
Bar code scanning	MF13	Touch vibration	MF39
MS Word/PDF reader	MF14	Silent mode	MF40
Video playing	MF15	Vibration option	MF41
Video recording	MF16	Extended Battery	MF42
Video Conference	MF17	Drop Specification	MF43
Snap Shots, Picturing	MF18	Water proof	MF44
Image retrieval	MF19	Extended Storage	MF45

V. IDENTIFY MOBILE LEARNING MODES

Teaching strategies and learning methods are based on course objectives, learning audiences and the learning environment. These are usually published parts of course curriculum and are used as guidelines for educators.

Learning methods are identified as per course ingredients, so that the course theme can be delivered and received smoothly. The other core component of learning methods is the available educational media. Textbooks and blackboards are examples of the traditional educational media. Modern media can be listed as, slide projector, sound recordings, computer-based information, audio-visual media and sensory learner's media [14]. Table III lists common learning methods and codes for computer studies drawn from the Ontario School board [15].

TABLE III
COMMON LEARNING METHODS FOR COMPUTER STUDIES (LMS)

Learning Methods	LM Code	Learning Methods	LM Code
Lecture	LM1	Preparing Jot notes	LM14
Listening	LM2	Case study, investigation	LM15
Observing / Visual media	LM3	Writing Reports	LM16
Multimedia Presentations	LM4	Research Work / Projects	LM17
Computer Based Learning (CBL)	LM5	Pictorial, graphic, images help	LM18
Reading	LM6	Trying (Simulations)	LM19
Surveys and interviews activities	LM7	Pattern Matching, comparison	LM20
Data collection	LM8	Tutorial Support	LM21
Data manipulation	LM9	Online contents	LM22
Group discussion	LM10	Offline contents	LM23
Literature Circles	LM11	Parental involvement	LM24
Cooperative Learning	LM12	Problem Solving Activities	LM25
Field Work	LM13	Slideshows	LM26

The terminology Mobile Learning Mode in this context is different terminology than the traditional definition. Mobile learning mode is a basic unit which identifies the best fit between learning methods and mobile device functions. Learning modes are formed based on mobile functionalities with learning methods in mind.

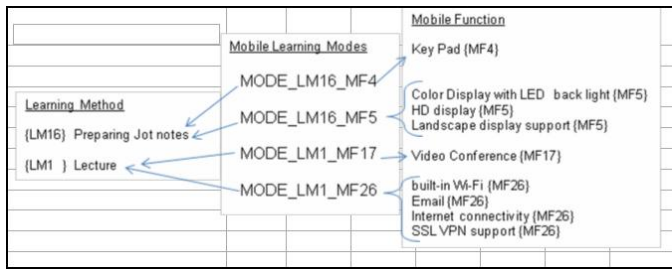


Fig. 1 Examples of mobile learning modes

As one of the previous study suggested [5], "Educators should consider the learning requirements and then build fruitful learning settings out of simple and accessible mobile technologies." Forming mobile learning modes means to achieve similar objectives. Mobile learning modes are established based on mobile device functions (Table II) and learning methods (Table III). Fig. 1 demonstrates the mapping details for a couple of methods listed in Table 4. Due to the length limit, Table IV only lists partial mobile learning modes for computer studies.

TABLE IV
MOBILE LEARNING MODES FOR COMPUTER STUDIES (PARTIAL)

Learning Methods	Mobile Learning Modes
Lecture	MODE_LM01_MF17, MODE_LM01_MF26
Listening	MODE_LM02_MF9, MODE_LM02_MF10,
Observing / Visual media	MODE_LM03_MF5, ...
Multimedia Presentations	MODE_LM03_MF19 MODE_LM04_MF4, ...
Reading	MODE_LM04_MF33, MODE_LM06_MF5, ...
Data collection	MODE_LM06_MF34 MODE_LM08_MF11, ...
Group discussion	MODE_LM08_MF45 MODE_LM10_MF1, ...
Cooperative Learning	MODE_LM10_MF28 MODE_LM12_MF1, ...
Field Work	MODE_LM12_MF28 MODE_LM13_MF20, ...
	MODE_LM13_MF44

VI. RELATION FINDINGS FOR LEARNING TOPICS AND MOBILE LEARNING MODES

As topics, learning methods, and mobile device functions are already identified in the previous sections, Table V illustrates those computer studies topics and their mappings with the learning methods. The relationship building is continued in Table VI, which shows the topic relations with the mobile learning modes formed in Table IV. Again, due to

the length limit, Table V and Table VI only list partial mapping relations.

TABLE V
COMPUTER STUDIES TOPICS AND LEARNING METHODS MAPPING (PARTIAL)

Learning Topics	Learning Methods
Computer component	LM01, LM05, LM06, LM18, LM21, LM26
Problem-solving Strategies	LM06, LM19, LM21, LM25
Computers And society	LM01, LM03, LM04, LM07, LM16, LM21
Data types and Expressions	LM03, LM04, LM06, LM21
Designing Algorithm	LM03, LM04, LM06, LM21, LM25
Object-oriented Programming	LM01, LM03, LM04, LM19, LM21, LM25
User documentation	LM16, LM18, LM21

TABLE VI
COMPUTER STUDIES TOPICS AND MOBILE LEARNING MODES MAPPING (PARTIAL)

Learning Topics	Learning Methods
User documentation	
Associate Learning Methods	
LM16 (Preparing Jot notes)	MODE_LM14_MF4, MODE_LM14_MF5
LM18 (Pictorial, graphic, images help)	MODE_LM18_MF5, MODE_LM18_MF30, MODE_LM18_MF33
LM21 (Tutorial Support)	MODE_LM21_MF5, MODE_LM21_MF9, MODE_LM21_MF15, MODE_LM21_MF26

VII. DISCUSSIONS

There are a lot mobile devices in the market and we have heard new one announced almost every month. So due to the rapidly changes of mobile devices as well as the paper length limitation, here we only consider 7 of 23 surveyed mobile devices, they are Apple 64GB iPad, Apple iPod Touch, Apple iPhone 4, HTC HD2, Motorola ES400, Nokia C7, and Sony Ericsson W910i.

Any individual course can be mapped to any mobile device using the procedure described in Section 2. Courses have related topics; each topic can be taught by using different learning methods. Each learning method is tied with the mobile functions by mobile learning modes. Mobile device functions can lead to the mobile device. Each and every device has some functionality which can be used for learning, so it can be mapped to the course activity.

With the procedure and analysis results, a recommender system is built. Two kinds of clients can use the service, mobile phone users and web browser users. For the mobile phone users, they can either get recommend list of courses that they can use their mobile phone to learn or checking if they need to purchase other mobile phones for the courses they prefer to take. In the latter case, the users may choose

similar courses in which the required mobile learning modes (i.e., the mobile device functions required by some learning methods that the course author used in the learning activity design) are supported by their current mobile phones.

The system's approach is to manage it by:

1) Grouping the functions; for example MF26 is not one function but instead a group of functions (built-in Wi-Fi, Internet connectivity, SSL VPN support). Similarly MF5 donated to Color Display with LED back light, HD display and Landscape display support.

2) Counting the existing related functions in an individual device.

Using this approach, the best fit can be found based on available data: Apple 64GB iPad (4, amount of supported Mobile Learning Modes can be used for learning CS) < Apple iPod Touch (7) < Motorola ES400 (10) < Sony Ericsson W910i (11) < HTC HD2 (15) = Nokia C7 (15) = Apple iPhone 4 (15).

With these data, we can tell that three of the seven mobile devices support more mobile learning modes than computer studies learning topics and courses required than others. They are Apple iPhone 4, HTC HD2, and Nokia C7. As we all know by now that HTC HD2 actually is a product of HTC couple of years ago, but we can see that it can still support many mobile learning modes as Apple iPhone 4 for students learning computer studies relevant contents. Students who own HTC HD2 do not need to purchase a newer mobile device for their learning. It is good to both educators who want to adopt mobile learning in computer studies for high school students in Ontario but also saving students and parents a lot of money, moreover, this result shows students - "you don't have to always pursue latest mobile devices, yours is good enough still!"

Although the curriculum may be changed in years later, the summarized mobile device functions, the learning topics and the learning methods associated with the topics can also be expended to the pre-built dataset at anytime easily. In fact, not all of curriculum changes often [17], some of them have their revision every eight to ten years. For others which have shorter revision period (which is still more than four years), actually the revisions are always enhancement rather than completely replace the old curriculum with all brand new courses and learning topics. The results analysed and the mobile learning modes found in this research as well as the proposed recommender system, hence, can still provide not only users but also course authors great help when the users make decisions of taking courses and purchasing new devices in order to do further learning as well as when the authors take different learning methods into consideration in designing learning activities.

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