Integration of Motion Sensing into Mobile Learning Applications

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***Abstract*—The use of mobile devices in education has greatly increased during the last decade. At the same time, technology advances have opened new spaces and possibilities for the field of mobile-based education in the form of entertainment—where learners can achieve their learning goals whilst having fun. Games on mobile phones have also become an important part of education experienced by young people. With the advancement in technology, utilizing motion-sensors in mobile learning systems have started to evolve. Research indicates that the potential of using motion-sensors in game-based learning could achieve maximum benefits from mobile technology in game-based learning activities, as well as improving this form of e-learning entertainment technology. This paper discusses our ongoing research that aims to improve current learning mobile technologies by integrating a new innovative motion-sensing feature. These advancements are reviewed and evaluated for integration and use in a motion-sensing edutainment mobile application.**

***Index Terms*—Edutainment, Mobile Applications, Motion Sensing**

I. Introduction

In recent years, information technology has been known to provide great solutions for various fields of people errands in social aspects, economics, culture, and education. The field of education is not an exception, and has been revolutionary impacted by information technology. Evidently, there are increasing interests in the use of information technology and new educational methods to promote learning, formally or informally. Educational technologies are used as part of the diverse range of teaching tools to improve student learning activities in educational environments. In the learning environment, children or students could acquire knowledge and learn anything from the various available devices supported for educational materials. These technologies are not limited to computers and software, but to all devices that can be utilized for teaching and learning such as a compact disc (CD), video compact disc (VCD), cameras, mobile phones, personal digital assistants (PDA), global positioning system (GPS) devices, computer-based probes, and electronic tools which have yet to be discovered. With the capability of such technologies there are various types of educational applications readily available in the market, such as educational software CDs, web-based or online learning, electronic learning (e-learning), and most recently, m-learning. Although there are many types of educational applications, the main purpose of the designed technologies is to facilitate effective and efficient learning.

M-learning can be described as a learning technique that takes place across locations or has advantages of learning opportunities offered by mobile technologies such as mobile phones, smart phones, PDAs and handheld devices. Basically, m-learning combines practices, strategies, tools, applications and resources with proven advances in technology to support learning anywhere and anytime [1]. The most outstanding improvement with mobile technology comes down to the fact that students can learn without restrictions to places; in classrooms or outside, with or without teachers' guidance, and during class periods or at any time of day. Many research findings show the potential and effective use of mobile technologies for learning purposes [2-3].

Mobile games used in the m-learning environment offer a rich and interactive learning experience, in which game play strategies are used to enhance learning by promoting learning through motivation. Through mobile games, the activities will engage and stimulate cognitive processes, as well as promote teamwork amongst students, build skills, and interact with problems [4].

One of the possible novelties regarding the methods of m-learning, which is discussed in this study, is the use of games. As a matter of fact, [5] argues that a human being by nature begins to learn through games and playing from early childhood. Consequently, up until now, games were replaced by formal learning at kindergarten. Nowadays, with the new technological advancements in learning, traditional games have been replaced by digital games (computer, console, and mobile games). Hence, digital games are now part of contemporary learning [6]. Furthermore, the method of learning through mobile devices is becoming popular and this is shown by the growing number of available m-learning applications [7-8].

Although there are many types of m-learning applications, this study focuses on the mobile game. A mobile game for learning is a type of game specifically utilized for learning which is able to run on a mobile phone, smart phone, PDA or handheld device [9]. Similar to game-based learning (GBL), the main aim of mobile GBL is to use game play to enhance

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motivation in order to learn, engage in knowledge acquisition, enhance effectiveness of learning content transfer, or benefit from other specific learning outcomes [10].

Mobile phone games are usually designed to be played using the traditional number pads of handsets. This is difficult for user interaction and consequently for the game design. Because of that, one of the most desired features of mobile games is the use of as few buttons as possible. Nowadays, with the evolution of mobile phones, more types of user interaction are appearing, like touch and accelerometer input. To date, we can see touchscreen applied to various devices such as appliances, game consoles, GPS systems, kiosks, ATMs, and especially mobile phones.

Mobile touchscreen user interfaces employ a unique interaction style in relation to the input technique applied. In general, interaction through a touchscreen basically occurs by computer recognition to the location and change in location of input within the display area. Hence, interactivity in touchscreen user interfaces occurs in response to the two dimensional position, path and speed of the input action [11]. This allows six basic finger actions for input: tap, double tap, long tap (hold), drag, flick, and multi-touch (free or rotate).

Most mobile phones also hold accelerometers (a complex motion sensor) which allow the screen to always display the right-way up when users turn it around. With these features, game developers can create new kinds of game play, using new mobile phones which are equipped with 3D accelerometers. These mobile phones use the simple motion of the device to control the game or use complex accelerated gestures which allow the user to move the phone around to accomplish goals in the game. Figure 1.3 shows the suite of sensors found in the Apple iPhone 4. The phone's sensors include a gyroscope, compass, accelerometer, proximity sensor, and an ambient light sensor, as well as other more conventional devices that can be used to sense such as front and back facing cameras, a microphone, GPS and Wi-Fi, and Bluetooth radios. Many of the newer sensors are added to support the user interface (e.g. the accelerometer) or augment location-based services (e.g. the digital compass) [12].

The influence of motion-sensing as a new technology into the game-based mobile learning system is highly significant. In fact, embedding motion-sensing games into learning activities improves current game-based learning mobile technologies. Moreover, it provides learners with a more diversified sensory stimulation and relaxed methods of learning, as well as increased interactivity and a sense of participation through bodily movements [13]. The remainder of the paper details our research to date on developing motion sensing edutainment applications for mobile devices. Section II provides background and related material. Section III explains our conceptual framework and design for a mobile edutainment application, with Section IV detailing the implemented prototype and the results of its testing. A conclusion and future work is provided in Section V followed by a list of references used in the paper.

II. Background and Related Material

Please check Mobile devices containing cellular phones, PDAs and portable media players have played indispensable role in our daily lives. In addition to their original purposes, they include a number of additional functions such as music players, photo galleries and daily planners. The compact physical size of mobile devices, however, imposes inherent limits to intuitive and effective interaction with classic user interfaces such as buttons or a touch pad. Nowadays, mobile phones are evolving into sophisticated tools that incorporate many diverse and powerful sensors. The recent generations of smart phones are advancing with sensors, including GPS sensors, vision sensors (cameras), audio sensors (microphones), light sensors, temperature sensors, direction sensors (compasses) and acceleration sensors [14-15].

New possibilities on mobile devices, especially mobile phones are mobile games which are interactive applications generally created for participatory entertainment aiming. The latest mobile game application have been developed in health, advertising, training, education, science, research, production and work, in which games technologies are used specifically for improving accessibility of simulations, modeling environments, visualization, interfaces, communication, learning, training and productive activities such as authoring , developing or production.

Many researchers have integrated mobile games into learning activities through the development of multi-media and network facilities of computers. The varieties of research results have proved the influence of mobile games on learning achievement. In fact, using digital games in educational instruction positively influences learning achievement, development of cognitive ability, learning motivation and concentration in learning and it is an effective teaching system to improve learning for low academic achievers. Using a game-based mobile learning could increase students' motivation, interest retention and overall learning achievement in comparison with many traditional e-learning systems.

In addition, the influence of a motion-sensing and game-based mobile learning system on learning can be considerable. Embedding motion-sensing games into learning activities provide learners with more diversified sensory stimulation and relaxed methods of learning through games, as well as increased interactivity and sense of participation through bodily movements.

Researchers emphasize on usability in mobile learning applications and it would help to attract attention especially that of students wishing to learn without any obstacles and even improve some application features. Nevertheless mobile technology has been enhanced during this decade. Capability in the case of memory and processing has been increased and screens are much larger. There is faster Internet connection, costs have decreased and young learners are good at text input. These improvements have allowed mobile devices to become

potential useful tools for learning efficiently. The role of information technology has become more important in the realm of learning and teaching as it allows retrieving effective information more easily. Students can find useful information efficiently by computer network, web technology and multimedia technology. Developing attractive learning and education environment has attracted more students. Generating motivation in students to learn and improve the interactive teaching efficiently is an important issue. Various educational learning systems play the role to encouraging and improving students' ability to study. According to educational theories, strong self-motivation produces better pedagogical results and introducing fun into learning further increases its effectiveness. Game-based learning system would be an essential research area of learning. Game-based learning has remained one of the most effective teaching strategies to promote learning. Computer game-based learning possesses a high potential due to its use of multimedia, strong visual stimuli and the use of the virtual electronic environment.

Learning through playing games is considered a very important activity especially in early childhood. The advantage of game playing is that it can encourage players' internal motivation, something many traditional e-learning systems seems to lack. Strong motivation produces better pedagogical results and introducing fun into learning further increases its effectiveness according to educational theories. Game based learning has remained one of the most effective teaching systems to improve learning.

Mobile Game-Based Learning (mGBL) utilizes mobile technologies such as mobile phone, PDA and handheld devices as the playing platform. The concerning issues of mGBL are mobility, restrictions on mobile technologies, pedagogical theory that can be adjusted to the technical capabilities of current standard mobile phones. mGBL applications are developed for a broad variety of learning contexts [17-18]. Games are known as effective platforms to motivate people to play, interact, communicate and learn. Game and learning can be successfully developed and implemented in learning environments by combining both game design and instructional design approaches. They also can be improved by considering various issues such as learning theories, theory of play, mobile platform and technologies (for mobile games), game design, instructional design and others.

Computer game-based learning possesses a high potential due to its use of multimedia and strong visual stimuli and the use of the virtual electronic environment. Researches show [19] that educational computer games can improve on students' motivation, interest retention and overall concentration. Computer games are software applications present unique characteristics; they have a shorter learning curve in comparison with other business soft wares where the user has to read the application manual before being able to learn the program.

Many researchers have integrated computer game into learning activities through the development of multi-media and network in computers [20-24]. A range of research results have proved the influence of computer games on the learning achievement. It is proposed that using digital games in educational instruction positively influences learning achievement, development of cognitive ability, learning motivation and concentration in learning [25]. Some researchers indicated that for low academic achievers, using a game-based learning environment could increase immersion levels and learning achievement [26].

New possibilities on the mobile learning (m-learning) have been opened by recent computer devices to improve learning opportunities but regarding the special characteristic of those (such as their reduced computing power or the size of the display) so some design considerations must be taken into account when creating the games. In recent years, the academic and private sectors have been focusing on the new possibilities offered by the new portable devices. Some companies consider that these devices, which include PDAs (Personal Digital Assistants), Smartphones, Tablet PCs, iPods or even low costs laptops will play a key role in the future of the of information distribution. The new features and mobility give student's opportunities to go one step closer the original e-learning motto, learning anytime and anywhere as there is no availability limitations to connect desktop computer.

One of the advantages of mobile learning is supporting Just-in-time learning (JIT-Learning) scenarios. The knowledge can be accessible by the user at the particular time that is required in contrast with the classical way in which the concepts are acquired with the expectancy of eventually being used. Highly specialized tasks can benefit from this approach (a typical example often heard is installing a specific part in an airplane and learning the procedure right when it comes to the installation)[27].

Another view is the distribution of educational contents in third world countries. The use of mobile devices is useful to access these contents in places where no internet connection (or maybe even electricity) is available.

On the other hand, the rapidly increasing importance of game-based learning [28] can benefit from the advantages of mobility. M-learning systems can be an ideal platform for the distribution of educational videogames and simulations, obtaining more versatile educational systems, and improving the opportunities for long life learning. However, the mobile field is still young and evolving very fast. This means that integrating games in m-learning scenarios is a significant technological challenge that needs to be studied [29] and the motivation for our research.

III. Conceptual Design

The popularity of mobile game-based learning has grown dramatically over the last few years. It can provide learners with maximum learning autonomy, and provide the instructors and education administrators with more flexible teaching and managing methods. Mobile game-based learning can also decrease learning costs and provide an effective way of

combating the lack of learning resources with more learners in developing countries. Some researches indicate that mobile game technologies can be used for educational purposes with their potential mobility and flexibility for learners. However, according to some studies, there is lack of comprehensive development technologies to hold learners' attention in the mobile learning area along with a number of deficiencies within current game-based mobile learning systems. In fact, many game-based learning systems do not utilize new technologies that interact with the system properly. As a result, the applications do not meet learners' expectations and frequently could fail.

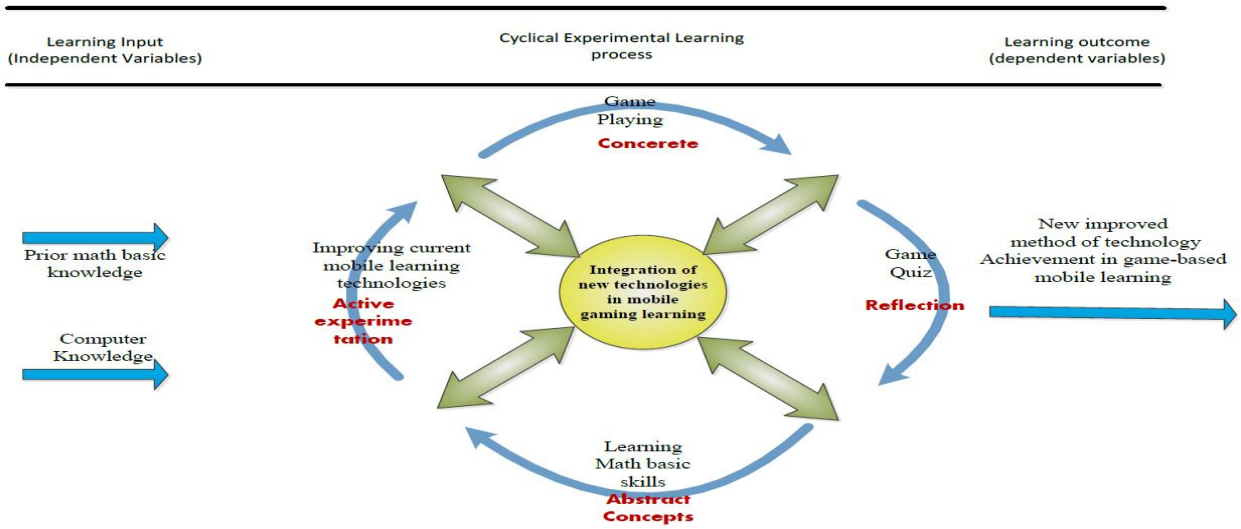

Fig. 1. Conceptual Framework of Motion Sensing Edutainment Mobile Application

Embedding motion-sensing games into mobile game-based learning can be a new innovative method to develop this form of mobile learning system. Based on the latest studies and advanced technologies, motion-sensing games can achieve maximum benefits from mobile technologies in game-based learning activities as well as improving this form of e-learning technology. This section provides a conceptual framework based on the problem statement which is finding an innovative way to develop motion-sensing game-based mobile learning. The conceptual design has been provided through reviewing knowledge in relation to motion sensing mobile learning concepts and discussing requirements. That is, the first phase defines the conceptual design followed by the second phase of associated knowledge and requirements of the proposed prototype, and the third phase presents the process of designing and implementing the proposed prototype.

In this work, the framework expands upon the research problem as it associates to the related literature review [30]. The graphical conceptual framework is formulated based on identifying variables, pointing out the dependent and intervening variables, and finally showing the direction of the study by a diagram. Figure 1 illustrates the conceptual framework and the relationships among the variables and adapted theories in this study. This framework consists of three main stages of learning input, game learning process, and learning outcome [30].

In the second phase a prototype must designed using current technologies. Therefore, there are two mechanisms for delivering mobile experiences [31]—web applications and native applications. Our prototype was chosen to be a web application. A web application is an application in which all or some parts of the software are downloaded from the Web each time it is run. It can usually be accessed from all web-capable mobile devices. Mobile web apps are accessed via the browsers. For a web app, the majority of the download occurs on the initial visit and is stored locally.While some changes are needed to optimize the experience across platforms, web apps generally work on all new smartphones. This means that the cost to build and maintain experiences on multiple platforms is typically lower than a native approach that requires separate designs and builds per platform. As a result, updates are easy for users and publishers, with no need for submissions or approvals from app stores [32-33].

Further, for the design we have decided to use modern client side scripting technologies. Client-side scripting refers to a language that is interpreted by the browser itself, usually in JavaScript. The Client-side scripting languages we have used in our prototype design include HTML5 [34], CSS3 [35] and JavaScript [36]. The advantages of these modern languages include their ability to leverage the new interactive features od modern mobile device hardware. This includes touch screens and motion sensing capabilities. Touch screen phone devices has the characteristics of having very few buttons and most of its users' input interfaces are made through touch by finger or pen [37]. Additionally, many kinds of devices now contain small sensors such as an accelerometer - which is basically a device built into the phone that "tells" the phone which way it is being held up, down, left, right, moving, etc. It also activates auto screen rotation on mobile devices when the user changes their orientation from portrait to landscape or vice-versa. The

accelerometer is designed to track the direction and speed of the movement along an X-, Y-, and Z-axis when a mobile device's user moves the mobile device. The X-axis is parallel to the width, the Y-axis is parallel to the length and the Z-axis is parallel to the depth (front to back) of a mobile device [8]. The advances in accelerometer technology have enabled motion detection to be implemented in many applications for various usages. This capability can be utilized in games and other programs and is the primary objective of our research work.

The final conceptual design can be summarized as having the following key features: web based mobile application; written using HTML5, CSS3, and JavaScript; will integrate the desired motion sensing capabilities; and navigated by a touch screen input mechanism

IV. Implementation and Evaluation

For the actual implementation the conceptual model designed was put into development. That is, a Web app mechanism was chosen as the most suitable way to implement the motion-sensing mobile game-based learning prototype as it can be accessed from all web-capable mobile devices. Moreover, HTML5, CSS and JavaScript were chosen as client-side scripting as they are able to be interpreted by the various leading browsers, as well as using the accelerometer and touch screen technologies as the sensing device for user interface control. A math based game was selected as the educational subject on this mobile motion prototype. Based on previous studies, there is an identified gap in the current mobile math learning systems which integrate the motion sensing capabilities of accelerometers. In addition, other research has indicated that many learners find the subject of mathematics difficult and math e-learning could improve their math skills as well as encourage their strategic thinking. Another positive aspect of choosing math based content is its ease of preparation. In fact, developing a math learning application is much easier than other content such as geography or science e-learning in terms of coding, graphic design and time constraints.

The game prototype involves four math screens, one each for the operations of addition, subtraction, multiplication and division. The main page provides the learners with the opportunity to commence the game by tapping on the start button.

By tapping on the start button on the main page the user is taken to the first math operator interaction page. On this page a simple addition math question is asked. That is, the learner has to add single-digit numbers together. To select the correct answer the user has to navigate a 'bouncing' orange ball over one of two of the provided solutions and tap the screen where the ball is located. The ball is moved by tilting the hand held device in the appropriate directions. The application interfaces with the accelerometer in the device, translating hand movements to movement of the orange ball on the screen. If the correct or incorrect solution is selected an appropriate information pop-up window will appear. In the case of a correct answer the user is taken to the next math operator screen to continue the game. In the case of a wrong answer, the learner has to answer the question once again until they get the correct answer.

There are three more screens after the math screen, one each for subtraction, multiplication, and division. All math questions are composed of single integer numbers, with the solutions all being integers also. As the math operations in the prototype are generally classed as fundamental the game is specifically targeted for children is the age range of 5-9 years old, or those beginning their math education. However, there are no issues in extending the complexity of the math questions or even diversifying the game to other areas such as spelling and simple trivia questions of a multiple choice nature. For simulation and testing of the prototype the aim was for a simple game to be used in order to easily verify the correct functioning of the technology and the conceptual design it was implemented from.

The prototype was extensively tested on numerous mobile devices that include accelerometer devices and included BlackBerry PlayBook tablets, Apple iPad's and iPhone's, and some Android based OS mobile devices. In 100% of all cases tested the technology worked and the prototype simulation testing was successful. A small set of real world testing was conducted by the author's children also. The small sample size was a result of the time frame constraints of the initial testing phase and the complexity and time involved in getting ethics approval to get a larger real world testing environment. It is planned that such classroom real world testing will be done in Phase 2 along with enhanced versions of the edutainment mobile motion sensing game.

V. Conclusion and Future Work

The literature has shown that there are a number of deficiencies with current game-based mobile learning systems. For instance, advanced mobile technologies are being integrated into many new game-based mobile learning systems. As a result, they cannot meet learners' expectations and ultimately will fail. Consequently, there is a need to enhance current game-based learning mobile technologies. Our research has found a new way to enhance this form of mobile learning system based on the latest studies and advanced technologies. In particular, motion-sensing technology has been embedded in game-based learning activities to achieve maximum benefits from mobile technologies as well as enhance this form of e-learning technology.

In this research we have used a web-application for delivery, developed in HTML5, JavaScript, and CSS3 that has facilitated the integration of the accelerometer into the math based edutainment mobile application. Testing results showed that a successful motion sensing edutainment game can be easily developed that functions on a diverse range of mobile devices. As such going forward our research plans to expand the scope of the edutainment games and conduct real world

testing in the class room to gather user feedback on game engagement and usefulness.

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