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"Touch Your Lessons!" Smartphone-based science learning, a solution for deprived areas

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Abstract

Due to computer invention, the distance learning, lifelong learning, and indirect education, all converted to the electronic education and learning. With the advent of smartphones and tablets, direct and indirect education especially mobile learning step towards the use of smartphones. This paper describes how an "Android smartphone" can be replaced with many digital devices, even computers. It has been investigated the main advantages of the smartphone usages in education, and listed their unique characteristics for studying and realizing difficult lessons like mathematics and physics. We have introduced and emphasized some of the applications needed for every successful teacher. Such applications can provide virtual laboratories for experimental sessions when real ones are not accessible, especially in deprived areas. Our study showed that compared to the control group, the smartphone-learned group scored higher. It can be concluded that the level of understanding physics and mathematics concepts were improved using such android applications.

Keywords: Distance education, online learning, Media in education, Mobile learning, Simulations, Teaching/learning strategies.

1. Introduction

20th century was the new era for computation and communication. In 40th decade, mobile car telephones were presented which are very voluminous and massive, and supported only simultaneously limited contacts. At the same time, computers draw new horizons in science and technology.

1.1. Simultaneous growth of the computer and mobile phone technologies

After the invention of vacuum tube computers in 1943, the first IBM commercial computers are manufactured by in 1955, then the first operating systems (OS) was presented which named "Mainframe". "Unix" was another well-known and good-seller OS among diverse primal operating systems, during many years. Before 1995, while PCs was not presented yet, DOS operating systems was dominant, and after that up to date, the Windows operating systems have been lionized [1]. Uppermost of the computer invention, using it in universities and scientific centers was very conventional. Therefore, the science and technology have a good correlation. In 1946 the first mobile phone service was established by AT&T incorporation with a limit coverage. In 70's, computer and technology usage in United States education was instructed in schools and other educational areas. In 1973 the first mobile phone was introduced by Martin Cooper from Bell laboratories. This mobile phone length and weight was about 10.5 inches and 2.5 pounds, respectively; and after each 10 hours charging, could support only for about half an hour communication. Motorola Incorporation succeeded minimize and lighten it as a commercial cellphone. In 1997, the first automatic mobile phone operator was exploited on Japan [2], [3]. Apple computers were used in education during 80's, and several simple simulations are made for personal computers. Educational games and programs developed by various commercial companies. Before the end of 1986 computers was used in about sixty percent of occupations and works of the United States. Conceding the Bush and Soviet leader Mikhail Gorbachev declared an end to the Cold War, laptops or mobile computers were born. Through these years, the first generation of mobile phones, 1G were presented in U.S. which they could only call via analog systems [4]. Ninth decade of the 20th century are the multimedia PCs era. Schools imparted multimedia CDs (Compact Discs of the films, videos, animations, and audio files), and the other kind of Computer Assisted Instruction (CAI) programs, also Goffer servers

aided the U.S. schools in order to reach on the online information. Before the 1995, every American classroom at least had one computer. 2G, the second generation of the mobile phones equipped to Short Message Service (SMS) helping digital communication that had a better quality and speed. Also, the European (GSM) and American (CDMA) communication standards were suggested on 90’s.

Internet global system made jobs, schools and persons to establish personal and popular webpages. Many CAI programs became available for everybody, and diverse contents like multimedia, simulation, and learning softwares or programs were developed on internet websites and databases. Therefore, the schools and other educational centers equipped to internet lines. Along with the Explosive growing of the internet and producing various media and text contents, the volume of the information and data increased. Its outcomes, new powerful servers and databases are provided a new opportunity for teacher and their students. Also, 2G cellphones made it possible to connect to internet and accessibility to multimedia contents [5]. Towards more spreading in routines, the second generation of mobile communication systems could not tackle new demands volume. So, third generation systems in Japan undertook it, on 2001. Using 3G systems the information transfer speeded up to about 2Mbps. High speed of the 3G systems mutated the industry and technology. For example, digital TV showing on cellphones became possible for first time. Associated with market acceptance of the 3G and 4G smartphones, they had technologically made great strides compared to the other cellphones [6].

1.2. Smartphone as a pocket computer

While the smartphones were developed, the computers were improved to more powerful and smaller machines, but they were larger than cellphones, yet. In the other hand, scientific researches and computational methods flattened using computers. Increasing the speed and accuracy of computers, caused to employing them in advanced theoretical and experimental researches, therefore the computer usage for many disciplines and fields rose up and became an evaluating tool for decreasing errors, and costs, more and more. Nowadays, imagine of computer deletion from many disciplines looks impossible. In addition to scientific and engineering applications, computers have been employed on the industry, marketing and commerce. Gradually the relationship between computers and peoples either professional or non-professional, grew in a way that they felt more dependence and need to them, so people tend to carry personal computers with a smaller size and more possibilities. Advent of mobile smartphones, which they have accessible memories and operating systems, made it possible that smartphones fulfill many requirements of the computer users. For example, it seems that using cellphones as an important device to surf the internet, is one of the main reasons for smartphone demands versus tablets and laptops. “Pew Institute” reports shows that, 21 percent of smartphone owners uses their devices as the main gadget for connecting to internet [7]. According to “Global Web Index”, about 65 percent of internet users, get online using the cellphone and 19 percent use tablets. The master of the “Tehran computer technologist trade union”, in an interview with the Iranian "World of Economics" claimed that people presumption about cellphones as a necessary thing, is the reason of cellphones presence in household basket. “Mirmehdi” said that Iranians pay for cellphones, whereas laptops, computers and tablets aren’t so [8].

Cellphones were brought in Iran after 1994, todays after about two decades, there are more than a hundred million of registered SIM cards, and short messages more than Iranian population are exchanged per day. In 2012, “Asriran” agency had been claimed that 94 percent of Iranian students uses SMS every day. 90 percent of them on classrooms and 10 percent on exams, send or receive messages. 75 percent take their cellphones on the bed, into bath or WC [9], [10]. Reviews show that the application softwares or Apps, which have abilities to send and receive messages, pictures, and films, are wide-spreading replaced with traditional inexpensive communication methods such as SMS, so that the possibility of the installation of such messenger applications is one of the important criteria for many of the smartphone customers [11], [12]. A glance to statistics of such mobile application users shows that there are many smartphones in Iran. According to local observations more than 50 percent of Iranians use the smartphones and more than 50 million mobile Internet users are reporting by Iranian news agencies and famous websites [13], but Pew Institute estimates this figure to be around 42 percent [14]. The authors claim that such differences can be concerned to the existence of smuggling phones in the Iranian market [15].

1.3. Which Operating System?!

After 2008, total sales of smartphones increased from 11 percent to 60 percent of all sold out cellphones. In 2014, about 500 million cellphones had been sold yearly, which 300 million of them were 3G or upper smartphones. One of the predominant differences between smartphones are their operating systems where the application softwares are installed on them. About 85 percent of smartphones on 2014 were “android” OS, 12 percent of them were “Windows phone” OSs, 0.5 percent were “Blackberry” ones, and the remains had less enthusiasts [16].

Nowadays, after about four years, it seems that more than 85% of worldwide smartphones are android OS and less than 15% of them are iOS, and the other operating systems are almost omitted [17] (also, see this statistic prediction [18]). Also, there are many both amateur and professional programmers for smartphone operating systems who produce and make programs and applications, then publish them on Internet.

In the other hand, the use of cellphones and their provision, looks more than users needed; For example, Iranian cellphone costumers wait for the new models and versions of the most famous brands to accommodate themselves with the last technologies. A census report that produced by “cafebazaar” and conceded to “Weblogina” shows that averagely, Iranian using of the latest versions of androids are more than international average [19], [21]. In spite of the disadvantages of the cellphones, it has been provided a potential to use the personal cellphones for informal and formal instruction/Learning, including cookery, housekeeping, and spreading out many cultural and commercial publicizing announces; another issue is that cellphones can be used to learn or teach foreign languages, astronomy, pharmacology, and even the **mathematics and physics concepts.**

2.Cellphone applications in Mobile-Learning

Cellphone applications in video and visual instructions have been begun in U.S. army from many years ago. About the mid-decade of 1990s, using technological and digital mobile devices -such as digital book readers, classroom answering systems, portable computers and laptops, and the record-player devices- were seriously prepended as learning tools. The first fully-described report about cellphone using in learning or "mobile learning" were published on 2007 [22].

2.1. Learning theories and Smartphones

The mobile learning idea were developed with digital devices especially mobile computers on 70s. Thereafter, learning theories try to expand mobile learning as a flourishing theory. Nowadays, smartphones as a device with high and multiple abilities, are suitable choices to support various mobile learning theories [23]. For instances, using short message services and multimedia technologies would be analyzed using "Behaviorist Learning" theories. Utilizing multimedia facilities and e-mails, games, simulations, and ask-answer softwares, artificial museums and galleries, virtual travels, using GPS and google map services, respectively are referred to various concepts such as "cognitivist learning", "constructivist learning", "problem-based learning, "activity theory", and "location-based" learning. The possibility of using e-mail services, social networks, and like them for learning are related to "socio-cultural" theory, "collaborative learning", "conversational learning", "life-long learning", "informal learning", and Connection-Oriented concepts [24]. Many potentials of mobile technology for learning will be unheard, because the teachers and parents are not familiar to them. Authors of present paper believe that informing and awareness about the smartphone importance in learning are of necessities, especially for Iranian educational system. "Marc Prensky", who was introduced "digital native" and "immigrant native" terms firstly at 2001, believes that the present educational systems are not designed for modern students. He attributes the "digital native" term to people who are grown with digital devices like cellphones and tablets from childhood, so they have a different cognition about digital world relative to others, even comparing to digital immigrants. He describes these ideas in his second book, "Don't Bother Me Mom - I'm learning". This book claims that the computer and video games which seems as a counter cultural phenomenon, can help breeds for 21st century successes. On the other hands, these methods describe parents how to help children for exchanging their threats to vantages [25]. Knowing the digital learning virtues is the first step to encountering with modern students and using their tablets and smartphones as new learning potentials.

2.2. Smartphones for science education

One of the main aims of this paper is to introduce several abilities of smartphones for education of sciences, especially in teaching mathematics and physics contents. Using this feasibility contains general benefits and defects which are listed on the areas about "mobile learning" and "smartphone-based learning"; but it has special abilities which made it to an important and unavoidable choice in learning. Referring to certain references, main advantages of mobile learning have been listed underneath [26], [28].

2.2.1. Decreasing the restrictions of time and place for learning

There are remarkable benefits such as:

- Existence of Portable memory, software packages, evaluating projects and tests.
- Using the social networks facilities for out-of-school education and lifelong learning.
- Databases, online exams, forums, and internet, Bluetooth, and Wi-Fi sharing.
- Possibility of setting up the virtual experiments out of the laboratory using videos and simulation softwares.

2.2.2. Compensating some discriminations and learning facilities shortages

- Cost reduction via setting up some experiments by experiment simulator softwares.
- Possibility of learning many of the empirical concepts without need to advanced experimental devices.
- Employing the sensors and hardware of a smartphone to describe how a measurement gadget works. Some measurement applications are available on smarts phones to use instead of some expensive gadgets like Lux-meter, voice-meter, compass, vibration-meter, tesla-meter, and so on.

2.2.3. Increasing tendencies of students for learning in schools

- Reducing mathematics and physics anxiety.
- Motivate stimulating the sense of cooperation and interaction between learners.
- Stimulating students' curiosity and filling their leisure times with making educational programs and mathematical-physics-based games.

2.2.4. Supporting the lifelong learning and self-learning programs

- Internet facilities such as online learning and testing, forums, etc.
- Applications, softwares, e-books, etc.

2.2.5. Help to think coherently and understanding the concepts

- Receiving, organizing, and exploring more information and Data.
- Possibility of setting up certain hypothetical and subjective experiments.
- Understanding immaterial concepts and making connections between mathematics and physics.
- Possibility of investigations on complicated systems such as the system of equations with ranks more than three,

difficult integrals, drawing intricate functions, many-particles systems in physics, and etc.
- Support the teachers to create mathematics or physics intuition in themselves and their student's minds, for example using smartphone applications to learn some boundary, popularization and extension conditions such as limit, definite integrals, or the first newton's law in a frictionless motion.
- Availability and portability of necessary handbooks, encyclopedias, diagrams, and tables.

3.A survey about basic science "Applications" for Android smartphones

In spite of cellphone presence in family basket of goods, due to financial difficulties to purchase by some families, we suggest using smartphones in universities as a proper solution and suitable digital device for mobile learning programs or other training. Employing Smartphones on the graduate educational centers, can be associated with a better consciousness, intelligence, planning, and management. On the other hand, in an era where all students are "digital natives", proficiency in their language namely digital language, looks inevitable, so familiarity with smartphone applications, not only is a good choice but also is a teaching necessity. Considering to the high population of android users and the user's satisfaction, our survey was based on the applications of the Android smartphones. However, many of the understudy (Android) applications have other versions for the other well-known operating systems (such as IOS). For this survey, we installed some of the best, famous store applications such as "Bazaar Android", "blackmart Alpha", "Google Play", and "Samsung apps" on our devices (Samsung notes 2, 3, 4, 8, Galaxy S3 neo, S5, and similar smartphones and tablets), then some of the best well-known basic science applications were downloaded and installed from these stores. Searching the websites and user's review notes and comments helped us to find some of the best applications which they are beneficial for teaching, learning and retention of the basic science concepts, in high schools and universities [29], [33]. Some of the most useful applications are listed underneath.

- **"Physics Reference"** is an application that contains teaching and testing about physics subjects such as motion, thermodynamics and temperature, dynamics, relativity, chemical kinetics, mass, gravity, physics constants, radioactivity, and etc. The special advantages of this software are its flash cards and exams. Some of its users believe that if Isaac Newton had an android smartphone, he would install this application!
- **"Physics One Apps"** would be perhaps one of the best android applications with a very beautiful structure, and it can be found as a very good reference for everybody who need to a complete physics handbook. The "Physics Cheat Sheets Free" is a similar software, too.
- **"Mobile Observatory astronomy"** is an astronomical software that contains all seasons' constellations, and it has search tools and zooming features to show and describe the characteristics of celestial objects.
- **"LHSee"** is a very fascinating software for simulating the CERN-Particle-accelerator. Both amateur and professional advocates of science can be had professional observations. Using the facilities of this application, the particles collisions in Geneva detectors can be seen.
- **"Wolfram Alpha"** is more than a mathematics application. Solving complicated integrals, function derivatives, graph theory calculations, drawing various functions in a desired interval, solving a system of equations, and optimizations, are just some of its susceptibilities.
- **"Math Ref"** is another offline mathematics application where contains more than 1400 formulas, figures, points and useful examples about math concepts and equations. Even, it has many questions about various math fields with their answers.
- **"CrossS"** allows to draw 3D shapes. Also, it allows to intersect them into smaller partitions. This software is appropriate for teaching geometry in high schools and for certain courses in universities that need to 3D drawings and imaginations.
- **"Periodic Droid"** is both a periodic table and an encyclopedia. It has information about both chemical and physical properties of elements such as their electronic and crystal structure, color and atomic mass, electronegativity, melting and boiling points, and so on. Also, it contains a list of isotopes, their half-life, and tools for searching the names and symbols of the elements. One of the advantages of this application from the learning point of view is existing exams to test the users' familiarity with elements. "Chemdoodle mobile" is a similar software, with the advantage of drawing chemical structures and simulating their NMR spectrums.
- **"Science Challenge"** is just like "Periodic Droid" namely presents exams about elements; furthermore, it brings up different questions about scientific concepts such as physics, chemistry, and biology. It tries to raise up the knowledge level of the students and their teachers and parents. Presenting the mixed tests with a beautiful and funny menu increases the brain ability for transferring and switching among different subjects.
- **"Science Facts"** contains a vast broad scientific information and census like this: "Do you know that 7% of cats and 21% of dogs snoozes while sleeping?!"

4.Using android smartphones in optics and acoustics learning

The impact of virtual laboratory-based, computer-based or simulation-based learning in physics have been investigated several times [34], [38], but we have practiced a similar version by android smartphones on our physics students. In order to study the impact of educational android software for teaching physics and mathematics concepts, we have always chosen one or two classes as the control classes and explained the concepts in a traditional way, with the help of the textbooks.

We then interviewed five to seven students of each class. We explained the subject of the research to them and asked them to answer our questions honestly. These students had high grades and were considered to be active students in the classroom; therefore, they were relatively skilled in the studying and learning methods and had a higher level of education than others. So, the investigation on improving the level of understanding of concepts could be studied at the

highest possible level. Considering to that some of these students are referenced for their classmates and help them learn the lessons, they were given some information about their approach to this method and its efficacy on them.

In one of the architecture courses, we employed the optics and acoustics applications like “pocket optics” [39] or “Tone Generator” [40], during certain theoretical courses. In comparison with similar courses which we did not use them, it was realized that the implication of such softwares lead to better perception. Furthermore, some students claimed that understanding the related concepts is very hard or impossible without the simulations of such Apps. Even, many of students believed that the effect of such applications in learning is the same as the effect of similar real experiments in labs. Also, during the courses which we did not use such applications or simulation programs, and the text book with their pictures was just described, many students had basic difficulties with the related concepts. The investigation in the test sheets shows that answering questions related to the concepts simulated by the Apps is known better than the control class; the benchmark for such a comparison has been the mean scores of each class were only for the research questions.

Interviews and surveys also suggested that in most cases introducing and implementing Apps and providing related explanations in the classroom is more successful and effective than only introducing them. Because, firstly, many students do not force themselves to install and run the Apps outside the class and they think the introduced textbook is enough for them. Secondly, it seems that the presented descriptions in the classroom can better develop the relationships between the underlying concepts in the students' minds with the software simulations. In this way, the student will be encouraged to install the software in order to remember the concepts presented in the class.

A similar comparison is done for more complex concepts such as the interference of waves. According to the students’ claims, understanding the practical concepts are hard or even impossible without the empirical experiments or App simulations. The tests’ marks showed that almost no clear or right imagination about more complicated issues such as “optical wave interference” and “electron wave function” was formed in their minds. Only after the presentation of the relevant Apps, such imaginations would be improved, more than two times better than measured for simpler concepts. Certain applications like “Wave Interference Patterns for High School Physics” [41], “Slits_Interference Film” [42], “PhotoElectric Effect Simulator” [43], “light Diffraction” [44], “quantum Harmonic Oscillator” [45], “Quantum Physics Simulator” [46], and “electron orbitals” [47] have great helps in shaping and improving such imaginations.

5.Concluding remarks

Investigation on history of education and electronic learning shows that using the facilities of an android smartphone can be support many purposes of mobile learning, and suitable alternative for almost all of the digital teaching aids such as computers, laptops, video-audio players, and so on. Using cellphones are gradually expanded among students and colleagues, and since many of them are “digital natives”, the application of this technology is a requirement for the future of teaching and learning. It seems that the current learning policy especially in Iran, does not predict any good place for smartphones. Using these abilities in nowadays education not only is a fantastic thing or a choice for getting better but also is a vital and inevitable issue. We have introduced some of the best application softwares for mathematics and physics which shows the possibility of using the “android smartphones” in learning the confusing concepts of sciences. Therefore, such applications are not only an outlook for the future but also is a provided background for modern education which should be recommended and developed.

By studying the students' examinations and interviewing them, we found that an improvement about 5% (for simple concepts) to 30% (for complicated concepts) was achieved in the level of students’ understanding. This improvement can fill the shortages of labs, maquettes, and other simulation tools in the presentation of mathematics and physics concepts especially at deprived universities and centers.

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