IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 2, February 2016

M-Learning: Effective Framework for Dyslexic Students Based on Mobile Cloud Computing Technology

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Abstract: As mobile technologies and dissemination become more widespread, mobile learning (m-learning) has become a dominant, powerful approach to educate, teach, and train the world. M-learning has a significant effect on how people, especially dyslexic students, learn. Although there is a good amount of research covering m-learning for dyslexia, there are many gaps that still need to be addressed. One considerable issue is the lack ofan effective m-learning framework that meets the real needs of dyslexic students based on their cultural backgrounds. In this paper, the authors develop a cloud-based m-learning framework architecture and highlight the guidelines of the effective solution that should be met in the design phase. The proposed framework architecture enhances students' personal and learning abilities by providing adaptability to meet their learning needs.

Keywords: M-learning; cloud computing; mobile cloud computing; dyslexia.

I. INTRODUCTION

Learning is essential for all students, either with or without disabilities, and it plays an important basic role in the evolution of nations. With the evolution of electronics, learning has relied on traditional learning methods [1]; however, it has developed to take the shape of electronic learning (e-learning).

With the accelerated development of the past decades, an emerging revolution in technology has caused a shift from e-learning to the widespread use of mobile technology [2]. Mobile technology has an extensive influence on people's daily lives, and its effects are not restricted to normal people, but it also has opened broad boundaries for a substantial segment of humanity, including learners with disabilities. Hence, the learning process has shifted from a reliance on traditional learning to include modern forms of learning and mobile technologies, such as mobile learning (m-learning) [3]. M-learning can be defined as "any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies" [4]. M-learning is not bounded by a specific time and a specific location, rather it can be accessed anytime and anywhere [5]. It allows learners to access learning in a convenient flexible way and transforms it from something they have to do to something they like to do.

Cloud computing is a recent technology in the market and has gained significant weight in many different areas, such as the government, industry, education, entertainment, and medicine [6]. Cloud computing is "[a]computing cloud is a set of network enabled services, providing scalable, QoS guaranteed, normally personalized, inexpensive computing infrastructures on demand, which could be accessed in a simple and pervasive way" [7]. In 2009, cloud computing was used as a new computing technology to overlap the limitations in traditional m-learning systems that have limited educational resources, low network transmission rate, and high costs[8][9][10]. Hence, the concept of mobile cloud computing (MCC) emerged[11].

M-learning has become the dominant learning mode, especially for learners with special educational needs [12]. One of the common disabilities under the specific learning difficulties umbrella is dyslexia [13]. Dyslexia is a language-based learning disability of neurological origin, with deficits in spelling, reading, and writing that vary among different language orthographies [14]. About 15–20% of the global population has a linguistic learning disability, and 70–80% of this population have dyslexia [15]. Therefore, appropriate educational support and overall awareness are required to address this category of specific learning difficulties to help the community of dyslexic students.

In this work, the authors consider the lack of an effective m-learning framework based on cloud computing for dyslexia and present new m-learning framework architecture a ilored to the different needs of dyslexic students. This paper presents the guidelines of the proposed framework that should be met in the design phase.

This paper is organized as follows. Section II presents the related work. Section III demonstrates the problem statement in detail. The proposed framework architecture

is illustrated in Section IV. Section V presents the guidelines for designing the proposed framework. Finally, Section VI concludes the paper and presents the future work.

II. RELATED WORK

Khemaja and Taamaallah[16] proposed a mobile Intelligent Tutoring System (ITS) for specific needs students. This proposed system helps with the acquisition of communication skills in different situations by combining OSGi features and semantic web technologies. The system is adaptable, re-configurable, and based on an Android platform. However, the proposed system did not include one important assistive technology for special needs tohelp them in their lives:text-to-speech.
Berninger et al. [17]noticedthat littleresearch had been done in computerized instruction for learning writing skills for students with dyslexia, dysgraphia, and oral and written language learning disabilities. For that, the researchers evaluated a new system for computerized writing instruction by using an iPad for children with dyslexia, dysgraphia, and written and oral language learning disabilities. The system included18 lessons with different learning exercises for enhancing spelling, handwriting, and sentence composition. The results reflected improvements in the following measures: spelling and both oral and written measures of syntax construction. However, a major drawback of this study is that it was done after the school day, when students felt tired,so a lack of student's attention was an important issue here.

Staels and Broeck[18]investigated whether orthographic learning enhances the reading process in the Dutch language for dyslexic children. They examined phonological recoding to determine whether it could be enhanced by using text-to-speech software or not. The children were asked to read some words aloud correctly. Half of the participants read different stories on computer screens using text-to-speech software, while the rest of the participants read stories without the help of text-to-speech software. After that, students were assessed with the following: a naming task, a spelling task, and an orthographic choice task. This study showed the ability of dyslexic children to obtain orthographic knowledge through independent reading. However, text-to-speech software did not support the children's ages. Thus, the use of text-to-speech software is not recommended for primary dyslexic children because these students need to participate in active reading to enhance their reading skills.
Hall et al. [19] developed a technology-based system that blends curriculum-based measurement (CBM) anda universal design for learning (UDL) to enhance reading ability for disabled students. The proposed tool has three components: CBM for monitoring students' progress, an online forum for discussion, and an interactive computer-supported reading environment. Based on data analysis, the results reflect the high potential of CBM and the UDL to enhance reading comprehension. The teachers can create interventions for students in an easy way because the flexibility of the proposed tool. However, the main limitations of this tool are that it does not consider the student's background, since backgrounds differ from student to student. Also, CBM assesses only the material, not the teacher's explanation.

Kumar and Karie[20] developed a learning and communication system for children with speech disabilities using a mobile platform. The system consists of agraphical user interface (GUI)that includes categorized pictures and a keyboard. The user clicks on the image and the system sends the image to a phrase library to convert it to a suitable text. Then, the text-to-speech engine processes the text and produces the sound as an output. The system is based on an Android platform with multimodal input–output design. It is a user-friendly system, portable, and maintainable. However, the system has a potential concern of not checking the meaning and correctness of the user's input.

Alsobhi and colleagues [21]noted that e-learning systems are ineffective and cause failing for dyslexic students because these systems are general, whereas a particular application is required for the specific category of dyslexia. The researchers investigated dyslexia types and assistive technologies and proposed a framework. In this framework, the authors identified different pedagogical needs and provided a support to e-learning developers to design their plan. They identified functional–technical requirements that must be met in the design. However, the authors failed to evaluate it.

Fernández-López et al. [22] developed Picaa, a mobile platform based on the iOS tablets, which is tailored to special learning needs. The proposed system covered four learning exercises: sorting, associations, puzzles, and exploration. Educators can personalize the exercises at the interface and content levels to meet students' requirements. The adaptability feature allows the children to perform different activities that previously may not have been available to them. This platform showed the positive impacts on children's development of learning skills; however, it did not consider the development of social and collaborative skills, which are areas of significant shortage in special educational needs. Furthermore, this platform did not support the multimodality function, which enhances the learning process.

Anoual and Abdelhak[14]designed an Arabic game system for dyslexic students. This system included three kinds of activities: linking pictured and written language, visual memory training, and distinguishing similar orthographical and phonological letters. The authors considered what might increase students' attention by using simple graphic pages with light background colors. However, they did not consider the real needs of dyslexic students and did not test the system for efficiency. Furthermore, the system lacked multimodal support and was limited to desktop access only.

DOI 10.17148/IJARCCE.2016.52115

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 2, February 2016

Table I below summarizes the limitations of previous researches.

TABLE I SUMMARYOF RELATED WORK

Paper title and year	**Limitations**
Towards Situation Driven Mobile Tutoring System for Learning Languages and Communication Skills: Application to Users with Specific Needs, 2016.	• Lack of text-to-speech support.
Computer Instruction in Handwriting, Spelling, and Composing for Students with Specific Learning Disabilities in Grades 4–9, 2015.	• Lack of learner's attention.
Orthographic Learning and the Role of Text-to-Speech Software in Dutch Disabled Readers, 2015.	• Range of sample's ages did not support the use of text-to-speech software.
Addressing Learning Disabilities with UDL and Technology StrategicReader, 2014.	• Only assessedthe material, not the teacher's explanation way. • Did notconsider the student's background.
Development of Basic Learning and Communication System for School Children with Speech Disabilities Using Mobile Platform, 2014.	• Did not check data's correction.
Toward Linking Dyslexia Types and Symptoms to the Available Assistive Technologies, 2014	• Not evaluated.
Mobile Learning Technology Based on iOSDevices to Support Students with Special Education Needs, 2013.	• Lack of collaboration and social skills. • Lack of multimodality.
Arabic Games System for Dyslexic Learners, 2013.	• Did not consider the real needs of dyslexic students. • Not tested. • Limited access via desktops only. • Lack of multimodality.

III. PROBLEM STATEMENT

Dyslexia is one of the most common, predominantly hidden learning difficulties in the world. Thosewith dyslexia are creative, but they often areneglected in our society. A person, whetherdyslexic or not, has the right to life, work, and most importantly, learn. For that, it is mandatory to provide supportive, helping hands for dyslexic people in education, and this necessitates specific interventions, as well as understanding and awareness. It is important to adopt an approach that looksnot only at the dyslexic learner's weaknesses and strengths but also at their preferred learning styles. A still open question is which approach may be preferred by the student and will help increase the student's motivation in the learning process.Although dyslexic learners have some common core difficulty; they do not represent an identical separate entity with an identical profile.

Previous studies show that there are many gaps in recent solutions. In this paper, the authors consider the main gaps and lack of an effective m-learning framework in an attempt to meet real needs and backgrounds for dyslexic students and increase their attention and motivation. In this research, the authors develop a novel framework and address the urgent need for guidelines of a creative framework that is more effective than previous solutions and covers the current previous gaps. The major motivation behind this research is to improve dyslexic learners' reading ability, the basic pillar of language, by using today's dominant learning mode and the latest technology, m-learning based on the cloud.

IV. PROPOSED FRAMEWORKARCHITECTURE

The proposed framework architecture, as shown below in Fig. 1, provides an environment to build a mobile application for providing learning materials adequate for dyslexic students.

The architecture includes two parts: one in the mobile device and the other in the remote center (cloud) and the connection between them is via the Internet, as presented in Fig. 1 below.

In the mobile device, there are three layers, as follows:

- **Presentation layer:** This layer includes graphical user interfaces (GUIs) that give the end users access to different services. The GUIs should cover the needs of the end users, who are curricula and teaching methods experts, special education teachers, dyslexic students, and their parents. The interfaces enable the experts to register teachers and evaluate students based on their experiments. The teachers can register students and track their learning status. The dyslexic students can learn the materials and do exercises assigned by experts and teachers anytime and anywhere (i.e., within other groups or a family setting) and their parents can track them while learning and giving them a helping hand when they need it. These interfaces can present the learning materials with different multimedia (e.g., images, texts, and sounds) and enable the students to

IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

International Journal of Advanced Research in Computer and Communication Engineering
Vol. 5, Issue 2, February 2016

interact with them (i.e., pointing on the screen). Hence, the multi-sensory approach (audio and visual) can help develop the cognitive abilities of dyslexic students.

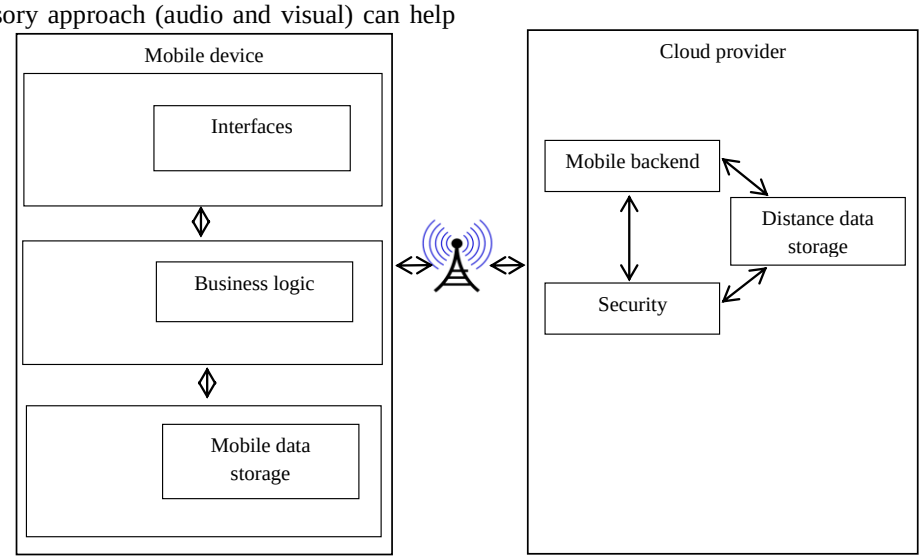

Fig1 The proposed framework architecture

- **Operation layer:** This layer represents the business logic of the framework by determining howdata is created, stored, displayed, and changed. To enhance the performance, the operations should be divided between the mobile device and the cloud. For example, displaying the learning materials can be carried out in the mobile device rather than in the remote data center,which will enhance the performance and decrease the network load. In other words, authentication and authorization operations should be carried out in the data centersince these data are stored in the remote database. There is a communication between the mobile device and the cloud in order to synchronize data.
- **Data storage layer:** This is where the local persistent data are stored (i.e., the learning materials, including images and sounds). Storing the mobile data in the mobile local storage enhances network performance because there is no need to communicate with thecloud for each fetch instance. Also, this layer uses a cache technique to provide better performance by storing data temporarilyand then sends the data to the cloud to store. Moreover, synchronization is important to maintain each student's profile using remote data to maintain consistency.

The cloud provider side includes the following subcomponents:

- **Mobile backend:** It allows the environment to run the mobile application logic by providing runtime services to the application. Also, it implements the business logic of the remote server, maintaining and synchronizing device data that is stored in the backend. In sum, it provides application security.
- **Security:** This subcomponent manages access to the application by allowing authorized users access and providingapplication and data protection between the mobile device and the cloud.
- **Distance data storage:** Enables the remote mobile data to be stored and accessed. This includes storing the mobile app data in a form suitable for rapid accessing by the application. This subcomponent also includes a cache for faster access by the application.

V. GUIDELINES FOR DYSLEXIA FRAMEWORK DESIGN

After presenting the framework architecture for dyslexia, different sets of guidelines are identified as the basic stages of building the effective, required framework for dyslexia. These standards includeaddressing the basic pedagogy strategy,addressing each educational goal as an independent lesson, dividing the scientific content into parts that contain the linked lessons, and limiting exercises and linking them to the lesson.Standards should make the content richer than that in textbooks by displaying content by audio, texts, and images, and matching reality [23] by using well-known vocabulary from school curricula based on student age and local culture. Another problem to address isteaching language decoding[13] based on the targeted language since dyslexia differs from one language to another, for example, recognizing the Arabic language as gender-specific, enhancing students' recognition using repetition strategy[24], and addressing self-advocacy [13]by considering the learners' different backgrounds. Furthermore, the framework should achieve consistency [25] by maintaining consistent data displays and keeping the locations of the main icons and information consistent on all screens, and it should enhance flexibility by considering student preferences [13].The pictures should be understandable, clear, and from the current culture of dyslexic students[26], and the framework should support interface features[27] (e.g., enhancing visibility [25] by using light background colors), and audio features [28](e.g., voice clarity and understandability for the students).

DOI 10.17148/IJARCCE.2016.52115

VI. CONCLUSION AND FUTURE WORK

Cloud computing with mobile technologies opens avenues for dyslexic students to learn anytime and anywhere. However, there is much work that needs to be done in this area. To improve learning process performance and personal abilities for dyslexic students, the authors have developedan effective m-learning frameworkarchitecture based on cloud computing technology. This proposed frameworkenables experts and teachers to teach and assess dyslexic students. Moreover, dyslexic students can learn material and carry out exercises. The most considerable feature of the proposed framework is adaptation to fit each student's profile and preferred learning style by implementing content in different formats (images, audio, and texts) and by allowing students to interact with the content through pointing on the screen.

As a future work, the proposed frameworkarchitecture can be customized and developed as a fully mobile platform that can be deployed on Android or iOS platforms. The solution should be adaptable for dyslexic students' needs andtheir cultural backgrounds.

ACKNOWLEDGMENT

I express my deep sense of gratitude to **Dr. Reda Mohamed Salama and Dr. Abdulrahman Altalhi,** associate professors in the Information Technology department, who advised me during writing this paper. Also, my warm thanks to **Dr. Mohammed O. Abu Al Rub**, associate professor in methods of teaching students with learning disabilities, who provided me with comprehensive information about dyslexia during the preparation of this research.

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