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“Let’s Play a Game!” Serious Games for Arabic Children with Dictation Difficulties

Samaa M. Shohieb¹^[0000-0002-2832-6171], Abd Elghaffar M. Elhady², Abdelrahman Mohsen³, Abdelrahman Elbossaty³, Eiad Rotab³, Hajar Abdelmonem³, Naira Elsaed³, Haidy Mostafa³, Marwa Atef³, Mai Tharwat³, Aya Reda³, Aya M. ³ and Shaibou Abdoulai Haji⁴

¹ Faculty of Computers and Information, Mansoura University, Mansoura, Egypt
sm_shohieb@mans.edu.eg

²Deanship of Scientific Research, Umm Al-Qura University, Saudi Arabia
amemohammed@uqu.edu.sa

³ Students in the Faculty of Computers and Information, Mansoura University, Mansoura, Egypt

⁴ Institute of Educational Research, Korea University, South Korea
haji@korea.ac.kr

Abstract. The purpose of this paper is to present a gaming application (Mega Challenger) dedicated to students with dictation difficulties between seven and nine years old. The user interface of the game will be presented in this paper, as well as, design principles of the game. Also, experiments have been performed to test the effect of the Mega Challenger game on the performance achievement of students with dictation difficulties; a type of dysgraphia. A dictation achievement pre-assessment was held for the students based on learning difficulties standards, and all results were recorded for further analysis. After applying 48 training sessions using the “Mega Challenger” application for 16 weeks, we had a post-assessment, with the assistance of learning difficulties tutors and experts. According to the experiment, pre and post results of the students show a significant difference between the student’s performance in the pre-assessment and post-assessment. Usability evaluation of Mega Challenger based on ISO 25062:2006, for post-user study interviews with students’ teachers concluded that Mega Challenger decreases the assessment loads of teachers and is a promising tool for students who have dictation difficulty. Children with dictation difficulties achieve better academic results when they play the game and that they are more motivated in serious games.

Keywords: Game-based Learning, Dictation Difficulty, Learning Disability, Technology in Learning, Human-Computer Interaction.

1 Introduction and Motivation

Learning difficulties are neurological based processing problems. These processing problems can interfere with learning necessary skills such as reading, writing and mathematics. They can also interfere with higher level skills such as organization,

time planning, long or short-term memory and attention. To handle learning difficulties, students need to practice a combination of their skills; information processing and motor skills.

Some researchers studied the importance of a game-based approach for learning processes aiming at increasing engagement and motivation in general [1-8]. Also, more specifically, attempts were made to handle learners with learning difficulties using game-based rehabilitation approach such as [2] who presented a prototype of a tablet-based game for writing practice. The first evaluation was by adults (about 24 years) reporting a perception of an appreciation and usefulness of the gameplay. Researchers in [3] compared the sensorimotor approach with the effect of a computer-assisted practice on handwriting problems reduction for children with learning difficulties and dictation difficulties. They performed their tests on 42 students divided into three groups; control group, sensorimotor approach group, and computer group. The computer group showed more significant development than the other groups.

Giordano and Maiorana [4] presented a practical web-based software system that can be used on tablets. Their system based on the Dynamic Time Warping algorithm to recognize the hand gestures through writing from merely connecting dots to complete writing a word that is compared with a reference trace that an expert has done. Also, [5] built a responsive web-based game to improve dysgraphia children' handwriting. The game helps students in writing words or letters to get a better score and make them practice in pre-graphism delete simple forms such as circles and straight lines, through many game motivations such as other rewards and more lives to advance in the game. They informally tested with children under the supervision of the developer. The students were engaged; the game has an impact on the students.

Moreover, Borghese et al. [6] designed an early intervention game in collaboration with clinicians that was called "Exergames" for the dysgraphia disorder. The designed game focused on prewriting exercises. The Exergames were reliably tested on 16 kindergarten children. Berninger et al. [7], as well, used iPad computer-assisted writing instruction to improve skills of students between 4th and 9th grade who suffer from dyslexia, dysgraphia or oral and written language learning disability (OWL LD) (impaired syntax composing). They proved that the customized computerized systems could be used for these grades successfully. O'Halloran [8] designed an android based application based on the genetic algorithm that provides the participant with a series of cues (anagram, grapheme and semantic). The post-treatment attempts after applying their tests on real students showed that spelling moved closer to target words.

Most of the available works in handling students with dysgraphia difficulties target the English language except [9] that presented and investigated the efficiency of an educational application that contained different games to handle some learning difficulties in the Arabic language especially reading difficulty. Therefore, there is a significant shortage of applications that handle students with dictation difficulties, a special type of dysgraphia, in the Arabic language. Consequently, this paper presents a design, implementation, and evaluation of an IOS games application [10] that is dedicated to handling students with dictation difficulties at single word level and uti-

lizes tablet computer or mobile devices as therapy tools. The implemented game focuses on students with dictation difficulties for the Arabic language. Our application helps students to learn how to write Arabic letters and words easily, how to differentiate between pronunciations of Arabic words, how to compare between similar Arabic (letters/word), how to know differences between directions and learning numbers more efficiently, as well. We called the gaming application “Mega Challenger” as it helps the student to challenge his/her difficulties so that he/she can achieve better learning performance.

The software user interface Mega Challenger design principles are presented in sections two and three respectively. Methodology and Experimental Design is discussed and proffered in section four. Section 5 presents the data analysis and results. Sections six and seven conclude and highlight future work respectively

2 Mega Challenger User Interface

Mega Challenger was implemented as ISO /IEC /IEEE 90003:2018 compatible software [11] and evaluated as ISO 25062:2006 (last reviewed and confirmed in 2019) [12]. It consists of three independent games that each game can be played independently from the other games. The games target enhancing a specific problem related to letter recognition and dictation difficulties. The first screen of the entire game is divided into three options; pronunciation of characters, learn how to spell words and write numbers, or the main directions as shown in figure 1, in the same order. The details of each game are described as following.



Fig. 1. The first screen of the entire game is divided into three options from top to down (Pronunciation of Arabic letters, Learn to write words and numbers, and Learning the main directions)

2.1 Pronunciation of Arabic letters

Students were presented with a list of the twenty-eight letters of the Arabic alphabet. When the student touches any letter from the list, he/she hear the pronunciation of the letter. This is considered a training level for the student. This is important to the students with dictation difficulties as it connects the hearing and sight senses with the learning process. Figure 2 shows a screenshot of the entire game. This was an extra feature added by the authors to add the efficiency and effectiveness of the game.

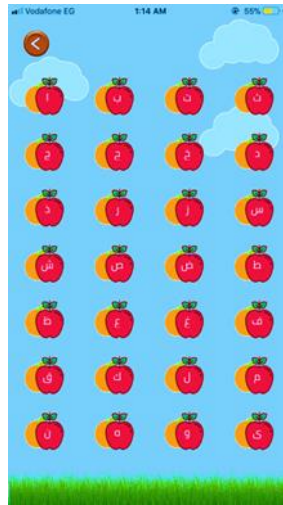


Fig. 2. A list of the twenty-eight letter of the Arabic alphabet embedded in the pronunciation of Arabic letters

2.2 Learn How to Spell Words and Write Numbers

The second game is “Learning How to Spell Words”. This helps the students with dictation difficulties on how to spell an Arabic word correctly. It advances in three subsequent levels. Words presented in the game were chosen sequenced systematically based on the “Nour Elbian” general guidelines to teach Arabic writing for children [13].

The first screen shows the word, picture to this word and a list of Arabic characters. The student must choose the correct letters of the shown word from the list. If the student chose the letter correctly would be shine, else nothing will happen to the letters, after student chooses all letters that included in the shown word and all of it became shine, he/she should write it correctly as shown in the reference word, figure 3.A. Mega Challenger will check the written word if it is true or false. If the written word is false, the student must repeat these steps. If the written word is correct student will go to the next level.

The second screen will show the same picture shown in the previous screen, but this time the picture is without a word. Instead, there are many choices of the related

word but with wrong spelling. Only one of these words is correct, and the student must select the correct word from them. If the student's selection is correct, he/she will proceed to the third level, as shown in figure 3.B.

The third screen has a picture only, and the student writes the word that the picture represents without any help or reference word. If the student writes the correct word, he will proceed to another word. There are many words, and he must repeat these steps on each word, as shown in figure 3.C.

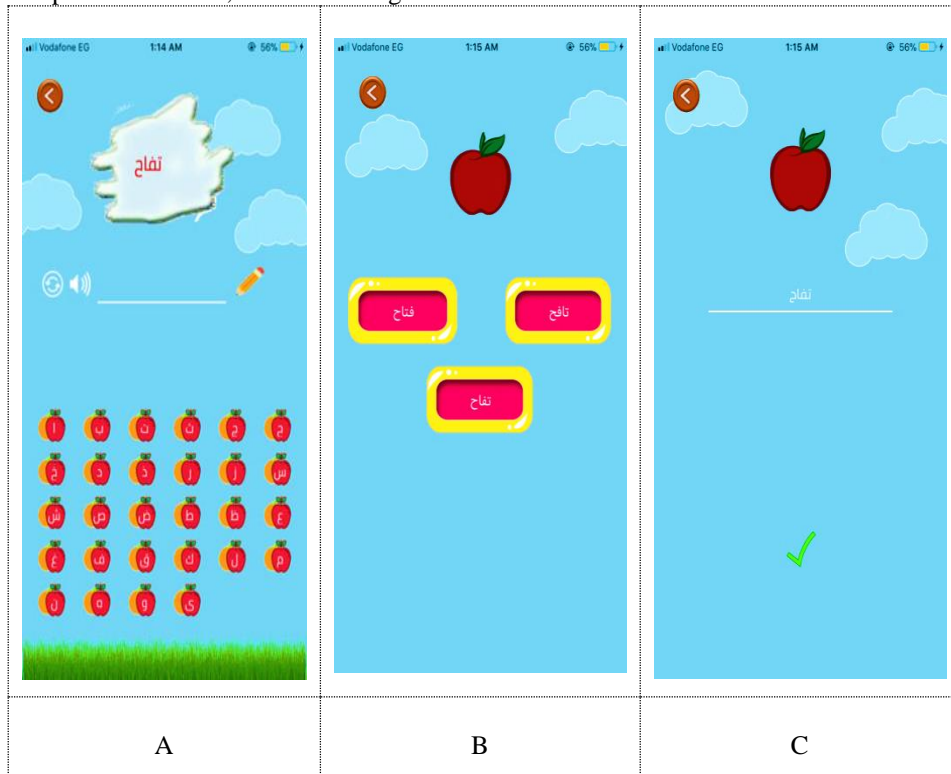


Fig. 3. Learning how to write a specific word beginning from the easier to the harder

Besides helping students in learning letters writing, they also learn in writing Indian numbers (the numbers technique used in the Arab world) correctly. Many levels from one to nine in which each screen has some fruits. The student is asked to count the number of appeared fruits and choose the correct number from the numbers given the list. If the selection is correct, the number will be put in the space and then disappear. The student repeats this step until he chooses the correct number. By this method, the student learns the correct way of writing numbers and the correct direction of numbers as shown in figures 4.

This game can handle children with dictation difficulties such as; change the word spelling, using a wrong letter or use similar characters, or even ignore writing some letters.

2.3 Learning Directions

Most of the students with dictation difficulties are not able to differentiate between directions. This game helps the student to learn the name of each direction and match with a suitable arrow. The student is asked to choose a suitable arrow for every direction. These levels are shown in figure 5

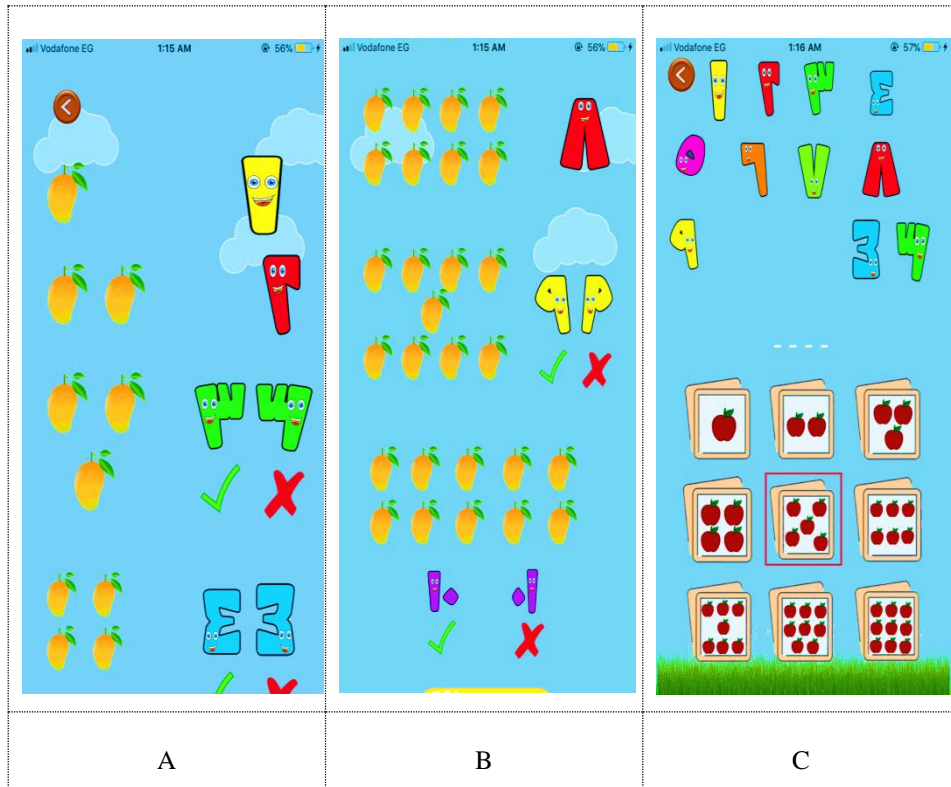


Fig. 4. A game to help students in recognition and writing of the Indian numbers

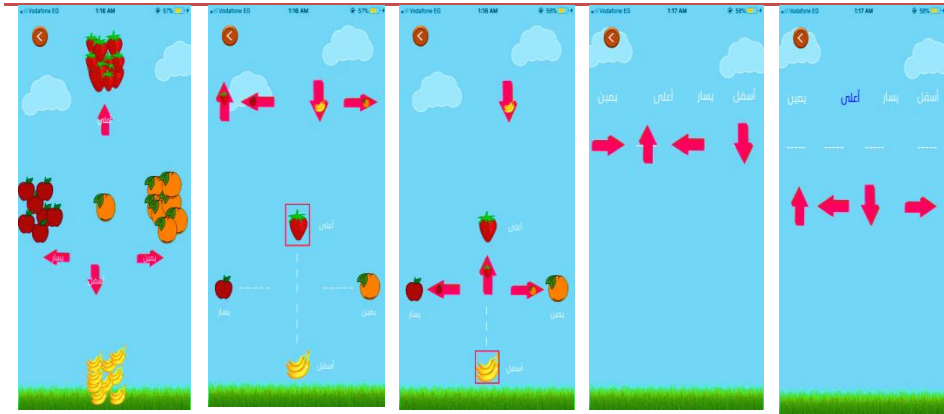


Fig. 5. A game to help students in recognition the directions

3 “Mega Challenger” Game Design Principles

The user interface of Mega Challenger is designed in a manner to fit children who start reading and writing (between 7-9 years old). The design principles are stratified with the guidelines of game design [14] which are to:

1. Provide informative and immediate feedback. The feedback is visualized through making a comparison with a reference trace and combined with written text.
2. Reduce short-term memory load. This is gained, for instance, by clearly visible record and score for playing the game.
3. Presentation based on a feedforward technique. For example, we used bright colors for objects, and light colors for backgrounds, so that the student can easily concentrate on the targeted task.
4. The game is accessible, free, and easy to reach on the Apple store. It can easily be installed on an iPad or iPhone device.
5. Tracking of student performance should be allowed in the game by storing his/her advancement and score.

A set of writing exercises are hidden inside the game dynamics that are presented to the children in a way to avoid boredom. Also, the game motivates the writing process of the players with offering immediate encouraging audible feedback reward to go ahead in the game.

4 Methodology and Experimental Design

This experiment tests the effect of playing the game on students with dictation difficulties motivation and learning performance achievement. The work has been accomplished through implementing a mobile-based application and testing it with a sample

of students with dictation difficulties. The null hypothesis states that there is no statistically significant difference in student's achievement when they receive a learning game. The first hypothesis (H1) claims that students with dictation difficulties achieve better academic results when they play the game. The second hypothesis (H2) claims that students with dictation difficulties are more motivated in serious games.

4.1 Sampling Procedure

Students with dictation difficulty who are between seven and nine years old in Mansoura city primary schools, in Egypt, in the academic year 2018-2019 were the targeted statistical population of our experiments. The selected population (including 42 students from 3 different primary schools) is selected with utilising volunteering sampling technique after obtaining consent from their parents and an approval of the children to participate. An ethical approval was obtained from the ethics committee of the faculty of Computers and Information, Mansoura University_ Egypt. The students differ in their demographic data. Fifteen of them were girls and twenty seven were boys. Twenty of students were 7 years, ten of them were 8 years, and eight of them were 9 years.

4.2 Clinical Interview

Three psychological and behavioral experts have clinically interviewed the selected students. They analyzed the students by criteria of the 4th edition of Diagnostic and Statistical Manual of Mental Disorders (DSM-V MD) [15] to detect any mental, visual or auditory disability. Therefore, the dictation difficulties could be specified whether they are generated because of mental disabilities or learning disabilities.

4.3 Dictation Achievement Assessment

A dictation test from the academic books of the first grade is performed for the students to detect ones who have dictation disabilities. The test was performed according to standard dictation tests regulation; the dictation achievement test consists of 60 words [16]. For more reliability and accuracy of the test, psychological and behavioral experts were scrutinizing the students' performance during the assessment. After performing the pre- assessment, students without dictation difficulties are given 0, and students with learning difficulties are given 1. Also, students with dictation difficulties were assigned a score between 1 and 10 to detect the achievement record and consequently the severity of their problem based on the dictation pre-assessment.

4.4 Test Conduction and Evaluation (Data Collection)

Mega Challenger was offered to learning difficulties specialists for evaluation and the software was modified based on their comments. Then the final version of the software was used with the students over 16 weeks with 48 sessions (3 sessions every

week). Each session was about 10-15 minutes; this time is recommended by learning difficulties specialists who helped us. Sessions were conducted under the supervision of both the tutors of the difficulties specialists and the researchers. Mega Challenger was presented on a touch-tablets and touching phones. In order to maximize the benefit from Mega Challenger, students were asked to play the game in its sequence that was designed based on the “Nour Elbian” general guidelines to teach Arabic writing for children [13]. Finally, we administered a post to the students with dictation difficulties assessment and compared the results with the pre-assessment to determine how the computer-based game improves the performance of the students with dictation difficulties.

We presented a questionnaire to teachers of children with dictation difficulties. There were six teachers for 42 students in 3 primary schools. Questions were asked to the teachers after the user study (Table 1 that in turn concerned the perceptions of the teachers about utilizing Mega Challenger. All the presented questions were created based on usability measurements for game development standards [17] and ISO 25062:2006 (last reviewed and confirmed in 2019) [12]. Questions were in Arabic language and translated into English after conducting the study for readability reasons. Authors conducted quantitative analyses on the collected interview content.

5 Results and Discussion

5.1 Usability test analysis

It was performed on questions that were asked to the teachers after the user study, which are formulated as seen in Table 1. This analysis was based on ISO 25062:2006 [12], which is a standard method for reporting the usability evaluation of an application.

Table 1. Questions Asked In the Interview after the User Study.

Q#	Interview Questions
1.	Did your frequency of administering teaching sessions to your students increase after using Mega Challenger? Also, describe the time and place of using it most frequently.
2.	Describe any specific issues experienced while using Mega Challenger, and any notes you may have in that regard.
3.	Describe any noteworthy responses shown by your students while using Mega Challenger, and upon which feature/instance that response was given.
4.	Do you feel that Mega Challenger presented instructions and verbal communication clearly, i.e., was Mega Challenger clear enough to teach dictation through its instructions?
5.	Which one do you consider is the most suitable device size to utilize Mega Challenger: tablet or smartphone?
6.	Was your student able to use Mega Challenger alone (without assistance)?
7.	What would you recommend adding to Mega Challenger, and why?
8.	What do you consider the positive and negative aspects of “Mega Challenger” to be, and why?

These questions investigated teachers' experience with and feedback about using Mega Challenge. The usability measurements with each metric response are shown in Table 2.

Table 2. Usability Objective and Subjective Measurements.

Usability Attribute	The Question Number and the corresponding Metric	Number of positive
Effectiveness	Q5: Device performance with the game	6/6
	Q7: Increase student's concentration	4/6
	Q8: Lessons go smoothly	6/6
Efficiency	Q4: Grading the action of the child	6/6
	Q6: Needs a little help from the teachers	6/6
	Q7: Willing to write short words after using MegaChallenger	6/6
	Q7: Willing to make written exercise after MegaChallenger	5/6
	Q7: Willing to be dictated after MegaChallenger	5/6
User	Q1: Ease of teaching	6/6
Satisfaction	Q2: Ease of calibrating difficulty levels of vocabulary	6/6
	Q3: Fits the students needs	5/6
	Q8: Willing to continue learning using MegaChallenger	4/6

5.2 Data analysis of student's performance in the pre-assessment and post-assessment

The results show a significant difference between the student's performance in the pre-assessment and post-assessment . Consequently, the students were greatly motivated by playing a game. Base on the experiments we rejected the null hypothesis stating that there is no development in the student's performance when they receive a learning game. Results of each student for the pre and post-assessments are shown in figure 6.

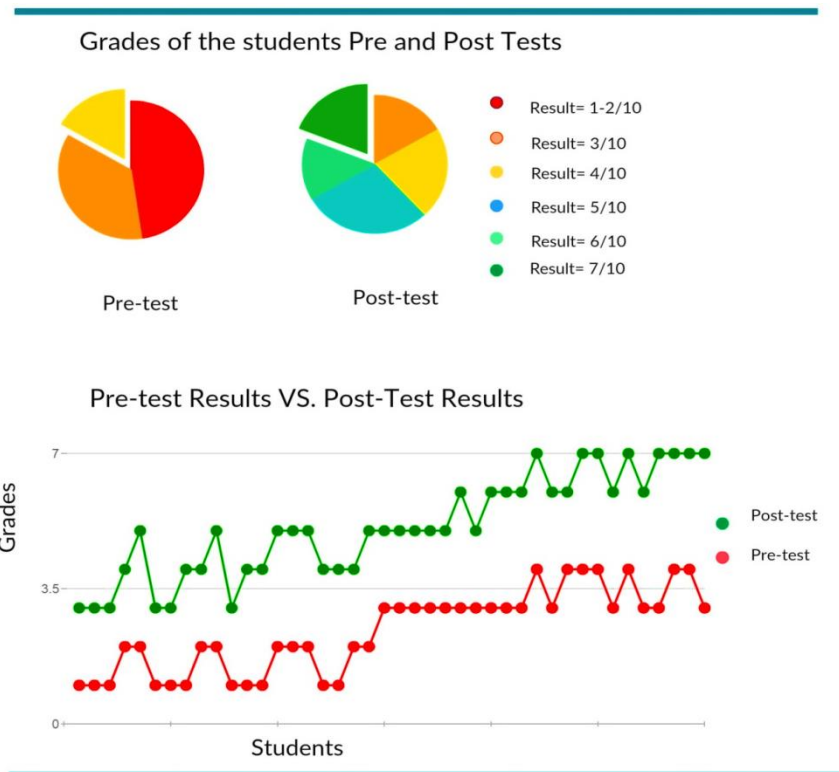


Fig. 6. Results of each student in the pre and post-assessment

A paired-samples t-test was conducted to compare students' academic performance before and after using Mega Challenger. There was a significant difference in the scores of the students before ($M=2.43$, $SD=1.06$) and after ($M=5.10$, $SD=1.32$) using Mega Challenger; $t(41) = -30.31$, $p = 0.000$. These results suggest that the use of Mega Challenger does help students with dictation difficulties to perform better academically. Specifically, our results suggest that when academic games are incorporated into the teaching and learning process, it helps students with dictation difficulties.

Data were collected and analyzed to have an understanding of the effectiveness of the Mega Challenger. Post-assessment in combination with teacher's reports revealed that the Mega Challenge application was attractive to student. Also, the students were engaged by both the voiced pronunciation of the word. Teachers, additionally, mentioned that the application sounds provided uniformity in teaching dictation to students, which better accommodated the children's learning.

The majority of the participants gave positive responses to the questions, which revealed satisfactory user experience with the game. Figures 6 reveals that parents believed the application to fit students' needs, they can use the game almost every day at home. Teachers found it easy to use to calibrate the difficulty levels of teaching mate-

rials, and to teach dictation via Mega Challenger. Teachers indicated that the application ran well on mobile phones, though they added that they may prefer tablets. They appreciated the accessibility of the application as it could be used anywhere, how it could be used semi-independently or with simple guiding, and how smoothly the lessons went. They, consequently, recommended the inclusion of more vocabulary and ability to train of writing sentences.

6 Conclusions

Mega Challenger is a gaming application that has been built based on the teaching strategies applied for children with dictation difficulties. It was designed, implemented tested on 42 children who have different demographic data but all have dictation difficulties. According to the experimental results of the students, show a significant difference between the student's performance in the pre-assessment and post-assessment. Usability evaluation of Mega Challenger, based on ISO 25062:2006 [12], on post-user study interviews with students' teachers concluded that Mega Challenger decreases the assessment loads of teachers. Mega Challenger is a promising tool for students who have dictation difficulty.

We concluded that children with dictation difficulties achieve better academic results when they play the game and that children with dictation difficulties are more motivated in serious games.

7 Future Work

7.1 Improving the Interaction

Authors have observed that some children have weak finger muscle coordination or weak arms. Ex. While they try to touch the screen of the iPad, their touch finger sometimes crashed the surface, that the application incorrectly recognized that action as scrolling instead of touching. Therefore, the sensitivity of the application should be increased. Also, the author hopes to extend Mega Challenger to be feasible for much more learning difficulties, such as dyscalculia and dyslexia.

7.2 Enhancing the Interface

The next goal of this research is to enhance the Mega Challenger to teach complete sentences to the learning difficulty in the Arabic language. We can add acting verbs and the other sentence parts to the Mega Challenger.

7.3 Enhancing the User Centered Design

Enhancing the user-centred design by recruiting more volunteers as users is one of the most important issues in the future work. Mega Challenger needs to be tested on more

children with dictation difficulties to take more feedbacks, consequently improving the game.

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