

# Super Alpha: Arabic Alphabet Learning Serious Game for Children with Learning Disabilities

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**Abstract.** Children with learning disabilities need dedicated attention to cope with their peers in class. One way to help is using technological assistive learning means as an extra gate to learn different concepts. This study describes the findings of comparative experimental research that questions the effect of using serious games on these children's learning process. The main focus is the design, implementation, and evaluation of an educational platform with different games that are picked based on existing special teaching strategies. It is created to question whether serious games can facilitate the work of the professionals or not by comparing it with a normal instructional method, in the context of an educational activity, which is learning the Arabic alphabet.

**Keywords:** Learning disabilities · Serious games · Children · Education · Arabic

## 1 Introduction

The usage of technology for educational purpose is a well-established and growing research area, namely educational systems for children with learning disabilities. One of the main aims of exploring this research field is the involvement of these children in the society development, and utilizing their intelligence in a beneficial way. According to the IQ tests held by CDS,<sup>1</sup> students with learning disabilities have average or above average intelligence levels. However, they struggle with coping with the typical learning process. Hence, it is hard for them to accomplish their academic tasks properly. This leads to a wide gap between their intelligence and academic achievement, which could lead to frustration and other problems.

These children receive and process information differently because they have learning disabilities (LDs), which are hard to diagnose [2]. Learning disabilities exist in a huge part of our societies. Statistics of (NIH<sup>2</sup>) show that 60 % of adults with literacy problems had untreated LDs. Moreover, according to (NCES<sup>3</sup>), 41 % of children

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receiving special education services have LDs. Accordingly, the problem of promoting learning for LD children has attracted much of the interest of research. Studies have revealed that LD children are four to five times more likely to use special learning techniques rather than the normal ones [4]. In some cases, they achieve higher test scores provided that they are taught with the approaches that can cope with their disabilities [3].

In our work, we further investigated the teaching techniques for LD children, with the cooperation of experts working in rehabilitation centers in the field. One of the promising approaches is the usage of games as an assistive teaching technique [5]. We utilized the existing teaching strategies specially made for LD children, taking into consideration their psychological background, to build an engaging platform containing different educational games. The platform is called Super Alpha, and it aims at teaching them the Arabic Alphabet. We conducted a study to analyze and evaluate the effect of the developed platform on the learning process and outcomes. The focus of the study is to experiment the effect of serious games on the learning achievement of LD children compared to other normal teaching means that already exist. The developed platform was evaluated with a number of LD children, and its effect on them was compared to the effect of the normal instructional means they receive, namely the regular presentation slides used in classrooms. The tests were held to compare the effect of using serious games on two aspects: the learning achievement of the children, and their level of engagement during the learning process.

## 2 Related Work

Many research studies have investigated the potential of serious games. Education is the top field for gamification research with 26 % of attention [8]. According to [1, 2, 5, 6], the evidence provided about the impact of games is mixed. Some studies found positive effects, some found negative effects and some found no effect of using serious games. The studies supporting the positive effects of educational games reasoned this to the presence of the game elements, as games offer some factors that the regular teaching methods lack [5]. An overview of the existing work in this field is presented in order to highlight the points of strength, extract the research gaps and incorporate such aspects in the proposed design.

LeFCA [5] is a game for children with autism that presents basic skills for them in German. The results of the tests showed that having a game in native language for intellectually disabled children is promising. Accordingly, developing similar educational games for developing countries (see footnote 2) is considered to be effective, Super Alpha aims to achieve for the Arab children. CLES [12]<sup>4</sup> is another project developing serious games addressing the learning process of persons with cognitive disabilities. Although it is effective, it is mainly designed for adolescents, not children. Moreover, it aims at enhancing the daily life processing skills not the academic achievement of the users. Ecriver Medialexie is an offline tool that addresses dysgraphia. Unlike games, this tool is not engaging and therefore is not helpful for children. Also, it supports

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<sup>4</sup> Cognitive and Linguistic Element Stimulation.

the French language only. [13] is a game that aims at teaching Chinese, it tackles language learning in a good way. However, its mechanics are relatively complicated. There are software tools and recommendation systems that provide activities for LD children like Fast ForWord, Learning Works For Kids, and How Difficult Can This Be? However, they do not drive the incentive of the child to play. Finally, there are some existing games that teach Arabic language to children like ALADDIN [7], Salaam Arabic, and Araboh.com. Although they showed success for children, they do not address the LDs nor the intellectual problems. To sum up, the existing work shows the potential of using educational games for children, as well as some useful factors that were harnessed in our design. Some shortcomings exist, among which: addressing LD children, the rarity of the Arabic content, and the interactivity factor. This raises a need for having a game that utilizes all aspects together (children, learning disabilities and Arabic language) professionally.

### 3 Platform Design

LDs come in many forms, Hogan and Jones defined different deficit areas of LD including memory, organizational, attention, and many other deficits [2]. An LD child might experience one or many of them. Each deficit area has its own teaching strategies and guidelines. Super Alpha aims at tackling seven of the deficit areas and their recommended teaching methods. It includes different games, each targeting one deficit area, aiming to cover most of the common symptoms of LDs among children. This will add a customization and personalization element to the developed platform, to be tailored for the needs of the child.

#### 3.1 Material and Theme

Deciding the curriculum to be taught was based on the input of the experts. An interview was conducted with a board of LD teachers from an early intervention center specialized in promoting the learning process of intellectually disabled children. The curriculum chosen is learning the Arabic Alphabet and words using the Montessori syllabus<sup>5</sup>. Learning through the platform, the LD child should be able to recognize the sound and the shape of each Arabic alphabet letter, along with distinguishing between the three different diacritic signs<sup>6</sup> of each letter. This curriculum was chosen because no prior knowledge is needed from the child. Additionally, it tackles the recognition not production of the language. Production needs extra observation from the teacher. Moreover, this curriculum could be efficiently assessed [7], which enhances the control and correctness of the study. Although LDs come in many forms, they share some symptoms like having difficulties in reading, recalling information, spelling words, and receiving language (known as dyslexia) [2]. That is why the platform built has stressed on the reading goals more than others.

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<sup>5</sup> An educational method based on self-directed activity and collaborative play.

<sup>6</sup> Short vowel marks used as phonetic guides.

The main theme of the platform is a super hero who tries to save a city. In order to achieve that, the hero has to win seven different battles. A battle is represented by a game. Each game targets a certain learning skill that helps a certain deficit area in LDs. In order to win a battle, all the alphabet letters must be accomplished successfully in the game. Accordingly, the child has to pass all stages that contain different questions on the alphabet in order to save the city.

### 3.2 Games Description

Super Alpha contains seven different games, each game addresses a certain deficit area of LDs. The deficit areas are: memory, organizational, attention, visual, auditory, language processing, and writing deficits. Each game was chosen such that its design and mechanics serve the recommended methods of dealing with each deficit. [2] presents the characteristics of the LD deficit areas and their symptoms along with the teaching strategies applied for each deficit area. The game mechanics of our platform are based on these guidelines.

Each game in the platform has different levels that represent the five learning stages needed for the child to learn a certain letter in the alphabet. According to the Montessorri syllabus, and based on the interviews held with the experts in the field, these stages can be translated into five different levels in each of the seven games included in the platform as follows:

- Level 1: matching two identical objects and their names.
- Level 2: recognizing a word of an object given its image.
- Level 3: matching the letter with the words it starts with.
- Level 4: matching the letter with the images of the objects it starts with.
- Level 5: distinguishing between different words starting with the same letter but with different diacritics.

Regarding the game design, reviews were made such that the mechanics of the different games become suitable for the needs of the target group. According to [1, 5, 7] there are key components for successful computer games for children like: multiple exemplars, variety in methods used to teach concepts, on-repetitive trials, and customization. These factors were considered while building Super Alpha, our Arabic learning platform. Based on the previous work and the input of the experts in the field (given the children's preferences and psychological background), the main pillars of the game design in this platform are: using clear auditory material, giving encouraging and extra praise means, avoiding numbers and verbal instructions, using hints, and avoiding score deduction when answering wrongly. The games available in the platform along with the area deficit that each one tackles are listed below:

**Hangman.** This game is a typical Hangman game, where the player is asked to fill in the gaps of the missing letters of a certain word. The deficit area it handles the language deficit. Hangman was picked to handle this deficit because it depends mainly on introducing key vocabulary in context, stressing on the spelling exercises, and modeling slow and easy speech processing [2].

**Maze with MCQs.** In this game the player is asked to go through a maze to reach a final destination. Additionally, we added some obstacles along the way, represented as MCQs. In order to pass an obstacle, the corresponding question has to be answered correctly. The game handles the auditory deficit. This deficit's solving strategy depends on having a lot of auditory components, emphasizing word endings, giving instructions in non-verbal manner (we used arrows to guide the child through the maze), and avoiding spelling activities [2].

**Memory Flipping Cards.** This game asks the player to match two identical cards that are flipped down on the table after seeking the whole board for a short span of time. It handles is the memory deficit because it makes the players practice remembering the letters and their corresponding words, which enhances their short term memory performance. Memory deficit learning methodology depends on having repetitive memory exercises, keeping number of cards of vocab in hands, using simple questions like matching, and providing examples [2].

**Puzzle.** A puzzle game where the player gets to re-organize the scattered parts of the letter's image along with the images of the objects that start with this letter. Exceptionally, the child has first to pick the correct image that will be solved as a puzzle. This will come along with a preview image as an example for the child to imitate. The game handles the organizational deficit. The organizational deficit learning methodology depends on enhancing the structured way of thinking of the child, following clear directions, providing questions with organizational skills (like MCQ), giving examples, and the ability of putting things at their place [2].

**Painting Letters.** This game targets the writing skills of the player by having the Arabic letter on the screen, and asking the players to trace it with their fingers, without going outside the letter nor filling a small part of it. This game handles the writing deficit. It only aims at teaching the letter's shape to the player, unlike the rest of the games that teach three different words per letter. Hence, the difficulty levels of this game are different from the those of the remaining games included in the platform. The levels depend on making the task harder for the child. This is achieved by making the letter thinner for the child to paint and requiring a higher percentage of accuracy. It is designed for the writing deficit because it depends on providing practice in writing, following directions, knowing the shapes of the letters, using activities of visual aids, along with avoiding complicated hand tasks [2].

**Drag and Drop.** The classical matching game using the drag and drop gesture. It includes a set of empty cards with Arabic words or letters, and below them a collection of images that the child is required to drag and drop in the correct slot. The deficit area it targets is the visual deficit. Since children with visual deficits are highly recommended to avoid tasks or activities that include complicated visual components, this game (including empty cards that need to be filled) is considered to be suitable for them [2].

**Shooting.** The idea of this game is to shoot the correct components out of a group of moving objects on a board (e.g.: shoot all the words that start with a certain letter). The

deficit area it handles is the attention deficit. This deficit needs introducing tasks that use signals to draw the attention of the child (the moving objects that the child is asked to shoot will be these signals), along with providing visual examples and steps, and giving extra praise to the child [2].

There are common guidelines to follow in all games like giving extra time for the child to finish the task (in the range of one and a half amount of time of the regular timings made for normal children) [2]. Moreover, giving constant hints to the children while playing, and providing them with detailed instant feedback in any game. Figure 1 represents all the games in Super Alpha along with the home and the choosing letter pages.



**Fig. 1.** Super alpha games: overview for the seven games in the platform in addition to the home and choosing letter pages

## 4 Methodology and Experimental Design

This work experiments the effect of specially designed serious games for LD children on their learning process, compared to other normal teaching means that already exist. This was achieved through implementing Super Alpha, and testing it with a sample of LD children. The null hypothesis states that there is no statistically significant difference in LD children's achievement when they receive two different instructional treatments: traditional computer assisted instructions (presentation slides); and serious games. The first hypothesis(H1) claims that LD children achieve worse academic results when they play a serious game rather than a computer based instructional methods. The second hypothesis(H2) claims that LD children are less engaged in the serious games rather than computer instructional methods. The Methodology presented by [9] to evaluate the gamification effect was used as follows:

#### 4.1 Model Planning

It is a between-group design that has a control and treatment group, they resembled the computer assisted instruction and the gamified version users respectively. Participants were divided into two independent sub-groups of the same number of LD children. The first subgroup used the presentation slides teaching approach, while the second used Super Alpha.

In order to make sure that that the computer assisted mean had an equivalent content comparing to the one presented by the platform, the presentation slides were designed to be identical to the games' structure, following the Montessori syllabus as well. The platform consists of six content-identical games presenting three words with different diacritic signs for each letter, in addition to a writing game (each game has 5 levels). Accordingly, the presentation slides for each letter contain five different slides representing the stages of learning the Montessori way. The slides are repeated six times in order to make sure the children in different groups get the same amount of material repetition, to make the only changing factor the gamification one. As for the writing game, it was equated by including a slide with the shape of the letter and asking the child to trace it in order to learn how to write the letter.

#### 4.2 Material Preparation

This phase includes defining the facilitators, environment, and task scenarios. There were two facilitators. A tester who sits at the back of the classroom observing and helping with any technical details, and a teacher who is right next to the child helping him/her if needed. The experiments were held in the children's classrooms. The device used was a touch-pad (9.7-inch iPad Pro). Paper-based tests for the evaluation as well as consent forms for the parents were used.

#### 4.3 Sample Selection

Participants reflecting the characteristics of the target audience were selected from different early intervention centers specialized in the field. The selection was based on the academic level reached in the curriculum, as they were required to have minor background about the Arabic alphabet. Their age ranged from 6–9 years old. However, age did not matter as much as the academic phase of the child, as different levels of severity can be found across LD children [4].

### 5 Test Conduction

A target population of 36 officially diagnosed LD children were randomly assigned into two groups (control group:  $n = 18$ , and experimental group:  $n = 18$ ). Most of them shared the same LD symptoms of having problems in reading, recalling information and distinguishing between words. Each group was exposed to its respective learning mean during the experimental sessions. Participants in the experimental group played the 5 levels of

the seven games consecutively, while participants of the control group were left with the equivalently designed presentation slides for the same amount of time. A session's duration of both groups ranged between 25 to 30 min, with arranged breaks in between.

In order to perform the comparison of the learning process between the two groups, learning gain as well as the engagement level of both were measured after using the corresponding learning instructional mean.

### **5.1 Learning Gain Test**

Before using their respective version of educational software, each participant had a pre-test in the material embedded in the game or slides. An identical copy of the same test was given after using the perspective instructional mean. Participants were asked to answer the test with no help from the teacher unless there was a problem understanding the question itself. To ensure the homogeneity level of the experiment, the structure of the test was compatible with the material embedded in both means. It is a paper-based MCQ exam on a single letter of the Arabic alphabet (the letter to be presented either on the game or on the slides). It consists of five sections, each section examines one of the five stages of the Montessorri syllabus mentioned previously. Learning gain was calculated by subtracting the number of correct answers that the participant got in the pre-test from the number of correct answers received in the post-test. By comparing the learning gain of both groups, conclusions were drawn about the educational effectiveness of the serious game versus the presentation slides.

### **5.2 Engagement Test**

Another test was held for the participants in order to draw conclusions about the difference between the engagement level of the two different means of learning.

It is a 5-likert scale standardized questionnaire inherited from [10], it consists of 9 items that measure the overall flow of any activity through measuring two factors: control, and enjoyment. A hard copy of the questionnaire with the 9 questions and 5 possible likert scale answers for each question was handed to the tutors right after the session. They were asked to fill it according to their observations for the children while interacting with the respective learning means. By comparing the results of both groups, conclusions were drawn about the engagement level of the platform versus the presentation slides.

### **5.3 Flow Test**

According to [11], flow is defined as "The holistic sensation that people feel when they can act with total involvement". Csikszentmihalyi's model represents flow as a channel between the skill and the challenge the user finds in any activity. Flow is present in an activity where there exists a balance between skill and challenge levels. If the challenge is higher than the skill, the user will experience anxiety. If the skill is higher than the challenge, the user will suffer from boredom. According to [10], flow is considered to be more of a continuous process rather than a final state. Thus, another test was held for



the group exposed to Super Alpha. This test's aim was measuring the flow of the different games in the platform according to the participants' skill and challenge measurements in each different level. Two five likert scale questions were presented to the tutor of the child to answer during the session. They rate the challenge level and the skill level the child felt going through the same activity, respectively. This was done after each of the five levels in each game of the seven games. This gives a total of thirty five items to answer per participant.

## 6 Results

Data was collected to be analysed on SPSS (Statistical Package for the Social Sciences) in order to have an understanding about the effectiveness of the platform. An independent t-test was held between the two groups in order to compare between the learning gain as well as the engagement level for the different instructional means.

### 6.1 Learning Gain Results

The results of the test between the two groups revealed that the learning gain was normally distributed for both groups and that there was homogeneity of variance as assessed by Levene's test for equality of variances ( $p = 0.67$ ). It was found that after the two interventions, the learning gain resulting from using the game as the educational mean ( $M = 3.00$ ,  $SD = 1.36$ ) was significantly higher than the gain of the other group which used the presentation slides ( $M = 0.67$ ,  $SD = 1.28$ ) ( $t(18) = 6.077$ ,  $p = 0.00$ ) with a difference of 1.977, standard error difference of 0.4673 and 95 % confidence interval from 1.95 to 3.92. This rejects the hypothesis stating that LD Children achieve worse academic results when they play a serious game rather than normal instructional methods (H1).

### 6.2 Engagement Test Results

The results of the independent t-test between the two groups revealed that the ratings representing the engagement level of the group of children who used the game as an educational mean ( $M = 4.28$ ,  $SD = 0.47$ ) were significantly higher than the ratings of the engagement level of the other group that used the presentation slides ( $M = 2.35$ ,  $SD = 0.66$ ) ( $t(18) = 9.95$ ,  $p = 0.00$ ). This was reported with a difference of 1.92, standard error difference of 0.192 and 95 % confidence interval from 1.51 to 2.31. This rejects the hypothesis stating that LD Children are less engaged in the serious games rather than normal instructional methods when it comes to carrying out an educational activity (H2).

### 6.3 Flow Test Results

For the flow test, Fig. 2 shows the skill versus challenge rates for each game separately, while Fig. 3 shows how far each game was from the desired flow level. This distance was inherited from [10] and calculated using the form:

$$\text{FromFlowDistance} = 0.25 \times (\text{Skill} - \text{Challenge})$$

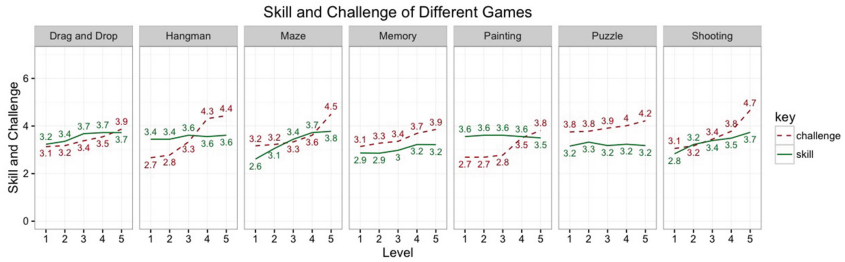


Fig. 2. Skill-challenge results for each game in the platform

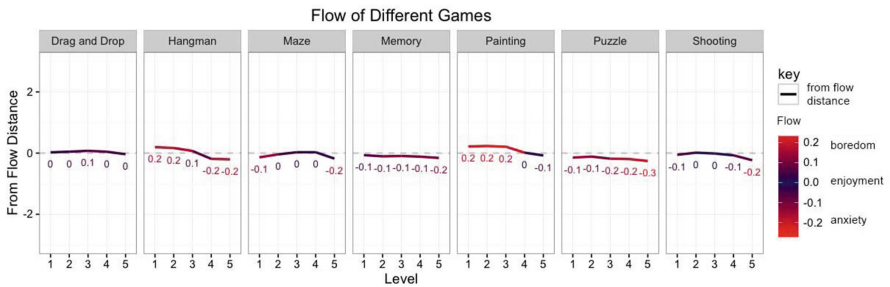


Fig. 3. Far from flow distance for each game in the platform

Some games reflected good flow rate and enjoyability throughout the sessions like Shooting, Maze, and Drag and Drop games. Other games were easier than the expected, where the children passed the earlier levels easily and did not suffer from the challenge like Hangman and Painting Letters games (skill > challenge). The rest were more challenging for the children where they experienced some anxiety trying to pass their different levels successfully like the Puzzle and the Memory Flipping Card games(skill < challenge). Another common observation is that all the games have ascending challenge level as designed by the Montessorri syllabus. Additionally, level 5 in all games had the highest challenge ratings, as it represents the hardest stage which is distinguishing between the three different diacritic signs of each letter. This indicates consistency in the design of the five levels for each game. To sum up, the overall flow of Super Alpha is acceptable, the results show that the participants had an enjoyable experience going through the different levels of the different games in the platform.

## 7 Discussion

The results show a statistically significant difference between the two instructional means used to teach the Arabic alphabet for LD children (presentation slides and serious games). This difference exists in both aspects: the learning gains and the engagement level, rejecting the null hypothesis stating that there is no difference in the children’s achievement when they receive different instructional treatments.

The statistical analysis shows that using the educational gaming platform Super Alpha is more effective than using the presentation slides for the learning achievement as well as the engagement and enjoyment levels of the participants. This might get back to the presence of the different game elements in Super Alpha. These factors offer a more amusing teaching fashion compared to that of conventional computer assisted mean they are used to.

## 8 Conclusion and Future Work

Promoting learning for LD children is a growing research area. In addition to trying to hold an experiment that claims that serious games are beneficial for LD children, this study tries to describe the properties of a successful game design that is suitable for their needs. Super Alpha; an educational platform that was built based on the strategies applied for LD children; was implemented, tested, and compared with a normal instructional teaching mean. Data analysis showed significant differences in the learning achievement as well as the engagement level of the participants between the two instructional methods. Participants who played the game achieved higher scores and showed more motivation compared to those who were exposed to the presentation slides on the same content. This might be due to the existence of the game elements that affect the enjoyment level of the children, and accordingly their learning gain.

Further investigations need to be done on each game element in the platform in order to know which one affects the learning achievement the most for the LD children. Moreover, we can test the game with the non LD children to see the difference between them and their LD peers receiving the same games for learning. Super Alpha can be tested to support deeper curriculum (i.e. production not only recognizing of the Arabic language). Finally, a concrete test of the correlation between the usability and the learning achievement of the children, and an experiment that examines the effect of the different age ranges on the gaming preferences are needed.

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