Media Engineering and Technology Faculty
German University in Cairo

Arabic Alphabet Learning Serious Game for Children with Learning Disabilities

Master of Computer Science Engineering Thesis

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Declaration Of Academic Integrity

This is to certify that:

1. The thesis comprises only my original work towards the Master Degree.
2. Due acknowledgment has been made in the text to all other material used.

June, 2016 Jailan Salah ElDin

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Abstract

Children with learning disabilities exist across a wide range of our societies. They have a surprising lack between their intellectual capabilities and academic achievement. Dedicated attention and special teaching techniques are needed to deliver information to them. One way to help is using technological assistive learning means as an extra gate to learn different concepts, and shrink the gap between them and their peers in class. This study describes the findings of comparative experimental research that questions the effect of using educational serious games for children with learning disabilities, and how can they promote their learning process.

The main focus of this thesis is the design, implementation, and evaluation of an educational platform with different serious games that are picked based on concrete and existing special teaching strategies for children with learning disabilities. This platform is created to question whether serious games with special features can facilitate the work of the professionals or not compared to the traditional computer assisted instructional methods, namely the presentation slides mean, in the context of an educational activity which is learning the Arabic alphabet.

Keywords: Learning Disabilities, Serious Games, Children, Education, Arabic Language.

Contents

Chapter 1

Introduction

The usage of technology for educational purposes 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 the need of utilizing their intelligence in a beneficial way.

Learning disabilities exist across a huge part of our societies. According to (NIH[1]), sixty percent of adults with literacy problems had untreated learning disabilities [55]. Moreover, statistics of (NCES[2]) show that forty one percent of children receiving special educational services have learning disabilities [55]. Accordingly, the problem of promoting learning for children with learning disabilities has attracted much of the interest of the theoretical and practical research. Studies have revealed that children with learning disabilities are four to five times more likely to use special learning techniques rather than the normal ones applied in schools [45]. In some cases, research has revealed that children with learning disabilities achieve higher standardized test scores, provided that they are taught with the approaches that can cope with their disabilities [11].

With the cooperation of a group of rehabilitation and teaching centres for children with learning disabilities, further investigations on the techniques applied for the children with learning disabilities were performed.

Since these techniques are applied on children, one suggested way to help them is using assistive learning means inside or outside the class as an extra gate for them to learn and take their time to gain knowledge in different fields. One of the most trending and famous technological assistive learning activities for people of all ages, especially children, is playing computer games. Children are known with their enthusiasm towards games. Accordingly, serious games seems a promising assistive way of learning for them.

Serious games are those games that have a primary purpose other than pure entertainment. Serious games use the different gaming elements such as competition, curiosity,

[1]National Institute of Health, United States
[2]National Center for Education Statistics, United States

collaboration, and challenge, to enhance the incentive of the players to learn a new thing. Serious games are used in many fields like education, training, health, scientific research and industry.

Using serious games in different domains has been the interest of many studies. According to [66], surveys show that education is the top field for gamification research with twenty six percent of attention. Many researchers are beginning to look at the potential that the serious games have as an educational tool. Although the field is still young, there are many games and trials that can show that using serious games in learning might be effective.

Thus, the implementation and the impact of such games is the main focus of this thesis. We have established *Super Hawwaz*. It is a serious gaming platform that was built based on the special teaching strategies applied for children with learning disabilities (LD children) as well as the input of the experts in the field. This platform was implemented, tested, and compared with the normal instructional teaching means used with LD children in their classrooms, namely the presentation slides regular mean. The comparison was done in order to know the effect of using serious games on the learning process of children with learning disabilities.

1.1 Motivation

"I dont have a disability, I have a different-ability." Robert M. Hensel.

Some children struggle with school. They seem unorganised, spoiled, lazy and having difficulties doing their homework. This is due to some troubles they face and can not change, regardless the amount of effort they do. Most of these children are labeled as troublemakers, being unintelligent or spoiled. However, they might be suffering from learning disabilities.

A learning disability is a neurological disorder that results in problems or difficulties in many of the educational tasks like reading, writing, recalling and organizing information [49]. According to the IQ tests held by *CDS*[3], students with learning disabilities have average or above average intelligence levels [36]. However, they struggle with coping with the typical learning process, and it is hard for them to accomplish their academic tasks properly. This leads to a wide gap between their intellectual abilities and academic achievement, which could lead to frustration and other problems. These children receive and process information differently because they have Learning Disabilities (LD), which are hard to diagnose[49].

[3]Center on Disability Studies, University of Hawaii

What is challenging about learning disabilities is the fact that they are hard to recognise or diagnose. That is why LD children are seen as lazy or unmotivated. Accordingly, it is called *"the invisible handicap."* [49].

It is very hard for the parents to see their children suffering and failing in the learning process. In addition, teachers find it difficult to have children with learning disabilities in class, as they may cause a lot of mess in the learning environment. Accordingly, LD children need special treatment and extra dedicated attention. It is tedious for them to cope with their peers, as sometimes their whole problem is to have the piece of information repeated to them more than once. (Loe Feldman, 2007) According to *(Loe Feldman, 2007)*, children who have some symptoms of learning disabilities are more likely to deliver information through special teaching strategies rather than the normal ones [45]. Accordingly, if LD children are well understood and taught in special creative ways, they could reach extreme success and distinguished careers. Examples of famous people with learning disabilities are Albert Einstein, Thomas Edison, Agatha Christie and Walt Disney.

1.2 Approach

In our work, we further investigated the teaching techniques used for LD children, with the cooperation of experts working in rehabilitation and teaching centres in the field. One of the promising approaches is the usage of serious games as an assistive teaching technique [29]. 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. These games aim at teaching them the Arabic alphabet. The platform is called ***Super Hawwaz***. *"Hawwaz"* in an Arabic synonym of the Arabic alphabet.

Additionally, we conducted a study to analyse and evaluate the effect of the developed platform on the learning process and outcomes of LD children. 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. Where 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 knowledge gain of the children, and their level of engagement during the learning process.

Super Hawwaz includes all levels of recognising Arabic letters, their sounds, as well as their shapes in different positions, spelling and composing words following the well known Montessorri[4] syllabus [52]. Montessori is an educational strategy that is used worldwide for children. It is built upon using self-directed activities, collaborative play, and letting the children extract the knowledge themselves [52]. The main feature that was

[4]An educational method based on self-directed activity and collaborative play.

incorporated into our methodology is that the Montesorri method is based on allowing the children to make creative choices during their learning process. Moreover, the Montesorri method in learning languages depends on directing the children to learn the shape of the word as a whole before knowing how to spell or produce it letter by letter [32]. Choosing the Montesorri syllabus was based on an interview that was held with a board of some specialists in the field in an intervention center for intellectually disabled children in Cairo. The reason behind choosing this syllabus is mentioned in Section 3.2.

Different learning methods are included in the platform such as games, instructions and storyboards. The platform reflects the progress of the children in the learning curriculum embedded in the games. The feedback system is designed and implemented based on mixing children's behavior on the platform with the psychological background. Children using *Super Hawwaz* can control what they are being taught. This is important for those who need repetition. Besides, self-esteem can be preserved, as there is no public announcement of results or observations. The platform is designed to work as an extra activity for the LD children to practice on, this can happen inside or outside the classrooms.

1.2.1 Description

The main aim of the platform is to teach LD children the Arabic alphabet letters, shapes, sounds, and the different forms of diacritic signs [5] along with examples for each. This is going to be achieved through implementing a collection of games that the child plays. The child can pass different levels in each game through knowing the letters and their corresponding words. The theme of the platform is a super hero who tries to save a certain city. In order to save the city, the hero has to win seven different battles. A battle is represented by a game. Each game tackles a certain learning skill that helps a certain deficit area in learning disabilities. These deficit areas are: Memory deficit, Organizational deficit, Attention deficit, Visual deficit, Auditory deficit, Language deficit, and Writing deficit.

In order to win a battle (a game), all letters must be accomplished successfully. This means that the child has to pass all stages that contain different questions on a certain group of letters that he/she has chosen by him/herself. The games that are included in the platform are: Hangman, Puzzle, Flipping cards memory game, Shooting game, Painting letters game, Drag and drop game, and Maze game.

1.2.2 Goals and Tasks

The tasks of this work was divided as follows:

1. Studying the related work in areas of serious games, Arabic learning methods, usability of assistive means for children, and applications for users with disabilities.

[5] Short vowel marks used as phonetic guides

2. Designing methods of learning Arabic alphabet, their shapes, sounds and corresponding words according to the Montesorri syllabus.
3. Implementation of the platform.
4. Platform testing and experimentation.
5. Performance analysis and evaluation.

The next section describes the problem statement of the study, the hypotheses claimed, and the methods followed to support or reject them.

1.3 Problem Statement

1.3.1 Research Question

The research question is to experiment how possibly would applying some exact special strategies and techniques in teaching for children with learning disabilities in an engaging way, like a serious game, affect their learning process. In other words: Can having a gamified system with special features for LD children help them promote their learning process ?.

This question was answered by embedding these learning techniques in a serious game, while focusing on the features of the game itself, then trying to measure how effective this was on their learning process. Two factors were tested in order to answer the research question. The first one is the learning achievement of the LD children, and the second factor is the engagement and motivation experienced by the children during the learning process.

1.3.2 Variables

- **Primary dependent variable:** The learning gain of LD children. (i.e the outcome of the LD children's test scores and results). A specific learning outcome was picked *"Cognitive: Knowledge"*.
- **Secondary dependent variable:** The motivation or engagement level reported during the learning process (enjoyability).
- **Independent variables:** The only independent variable to be examined in this case is the type of learning. Two groups were identified for this variable: Computer assisted instruction using presentation slides, versus the serious games included in the platform.

1.3.3 Hypotheses

Null Hypothesis: There is no statistically significant differences in the learning process outcomes of the LD children when they receive two different instructional treatments: (1) Traditional Computer assisted instructions (Presentation slides); and (2) Serious educational games.

This can be broken down into the following hypotheses:

- **H1:** Children with learning disabilities achieve equivalent academic results when they receive two different instructional means: Regular computer based instructional method and serious games.

- **H2:** Children with learning disabilities experience the same level of engagement during the learning process when they receive two different instructional means: Regular computer based instructional method and serious games.

1.4 Contribution

From one point of view, the field of serious gaming for learning purposes has potential in research. A huge number of studies gives evidence or guidelines about the effectiveness of gamification in learning. However, proofs are rare in this point. Although there are many studies about the merits and shortcomings of serious games, little empirical work was held to approve or disapprove gamification as an effective tool for learning [66].

The focus of this work is to build an educational platform specially made for LD children upon extensive research and examination for the teaching strategies used with them. *Super Hawwaz* is intended to apply specific strategies in digital games, and test them in a professional way. This was done in order to see how effective serious gaming is on promoting learning for LD children.

From another point of view, which is serving the community. This project aims at serving the least privileged LD children whom first language is Arabic by gathering learning disabilities, serious gaming, and teaching Arabic language in one experiment.

There is an obvious lack of such platforms in the field. LD children in developing countries, specially Egypt, need learning assistance. They are rarely diagnosed, and consequently, they are treated the same ways that the non LD children are treated.

1.5 Thesis Outline

The outline of this thesis goes as follows:

Chapter 2 includes a dense review about the areas of focus regarding the study. This includes the past research findings and backgrounds about the key elements of the study like educational game design, learning disabilities symptoms, treatment, and evaluation methods. In addition to the related work, the positive features as well as the shortcomings, and how our platform incorporated this in its design.

Chapter 3 tackles the research methodology followed in the study. It discusses the objectives of the experiment, the approach followed, the implementation methodology, the features embedded in the platform, and the different games included in *Super Hawwaz*, their ideas, levels, and goals.

Chapter 4 explains in details the experimental design approach, elements, and planning. It describes the experimental conditions of the study, the sample selection phase, and other planned methodologies for holding a robust experiment to compare *Super Hawwaz* to the normal instructional mean which is the presentation slides.

Chapter 5 describes the actual procedures of the different experiments held, the testing material and strategies to measure the learning gain, the engagement level, the flow of the different instructional means, and how the tests were designed and structured. Finally, the statistical analysis test types used to analyze the data collected from the experiments are discussed in this chapter.

Chapter 6 includes the detailed analysis of the results of all the tests held during the experiment, as well as a discussion about the insights concluded form these results. Moreover, this chapter includes different extra statistics that were visualized in graphs using the collected data in order to clarify the correlation between the learning gain of the children and their engagement level. Other statistics are also present, they tackle the effect of each game in the platform separately on the children which gives some hints about the overall effect of serious games on LD children.

Finally, **Chapter 7** includes an overall summary about the study, the conclusions drawn from the data analysis, the limitations faced in the study, and the future suggested work to be held and built up on the current study.

Chapter 2

Literature Review

"Anyone who makes a distinction between games and learning doesnt know the first thing about either." Marshall McLuhan

One of the most trending and famous technological activities for people of all ages, especially children, is playing computer games. Statistics show that searching the word *"serious game"* on the internet gets up to ninety seven million results in less than one second [43]. This shows how tempting and effective serious games are. Many previous studies agreed that serious games can be used as educational technology. As many of them can be considered to be targeting edutainment. Edutainment is a term that is used to describe the process of harnessing the entertainment factor in the educational process.

A dense review of the literature in this field was provided in order to be able to answer this question. This section reviews range in focus. It starts from the potential of serious games in learning, to educational games design, to the definition, deficits and symptoms of learning disabilities for children, to the special teaching strategies that are manually applied for them, passing by the techniques used to teach languages for children, and finally investigating the methods of evaluation or assessment used with those children. This review attempts to build some hypotheses based on the past experiences and reviews. The goal of this study is to examine these hypotheses and see whether they are supported or not. This requires exploring what have been done so far in the field.

Finally, this review provides insights regarding the many facets, and challenges of developing an engaging assistive serious game that actively helps in the teaching process for children with learning disabilities.

2.1 Learning through Serious Games

According to *Bouras et al., 2004* [41], computer games have potential in the learning field. They can offer some factors, and competitive activities that the the regular teaching

methods lack. Examples of these factors are having rules, goals, feedback and interactive content in the serious game. Serious games give the children the chance to construct understandings through interactively dealing with information and tools[41], as well as focusing on their areas of strength[49]. Moreover, the enjoyment factor in computer games makes them engaging, and motivating for the children in the classrooms, which is a key factor in the natural learning process *(Bisson and Luckner, 1996)* [10]. This supports the claim that assistive means -especially serious games- can present curriculum in a good way, that demonstrates their abilities and skills.[49]

Some research areas have identified serious games as a good way of education *(Landers and Callan, 2011* [42] *; McGonigal, 2011* [48] *; Muntean, 2011)* [53]), as they help in increasing the motivation of the students to enjoy the learning process [26].

Since serious games are beneficial in general. They can be beneficial for children with learning disabilities as well.

[75] is a study that has reviewed eight studies with empirical data from a learning outcome perspective. All of the reviewed studies aimed -in a way or another- at outlining the effective games, in comparison to other learning approaches. The learning outcomes that were focused on are classified as: cognitive, motor skills, effective (which tackles the attitude of the player), and communicative (which tackles playing in a team). For each outcome, the studies reviewed the effectiveness. However, this study is concerned with the cognitive outcome only.

According to *(OBrien and OHare, 2007)* [75], cognitive learning outcomes can be divided into two aspects: knowledge, and cognitive skills. Knowledge -which is the main focus of this study- refers to the encoded knowledge in both forms : verbal (known as text oriented knowledge), and image based (known as non-text oriented knowledge). The results of this study show that serious games has the potential to improve the acquisition of cognitive skills, especially in the cognitive domain. However, the number of studies is still relatively low to make reliable, and definite conclusions. this requires more research in this area.

Mentioning learning outcomes, students with learning disabilities usually have some problems in the cognitive skills. An engaging, and interactive presentation of knowledge can help them promote learning and benefit from the material being presented.[77]

[69] is a study that aimed at investigating the features of games that can promote the learning process for the players. It describes how well-designed games can provide an environment, in which people are more receptive to learning, compared to traditional environments like the classroom. Reaching this, the study examined two hypotheses. The first hypothesis claims that the learning process is at its best when it is active, goal oriented, contextualized, and interesting *(Bransford, Brown, and Cocking, 2000 [14]; and Quinn, 2005 [59]*. The second hypothesis states that instructional environments should be interactive, provide ongoing feedback, grab and sustain attention, and have appropriate as well as adaptive levels of challenge.

For the first hypothesis, reports showed that games that are designed in an interactive and interesting way can be considered as informative digital learning tools. These tools are used to develop the skills of the students in many educational areas. This means that well designed games have the potential to be a meaningful assistive mean of learning across different domains.

The second hypothesis revealed some of the guidelines of a good educational environment. Some of them can be embedded in serious games. These guidelines show that learning should be goal oriented, which means that the game should have some sort of a main objective or unknown that the player would like to reach. Having an goal oriented game requires the generation of new knowledge *(Jonassen, 2002)* [38]. Learning should also be active, interactive, it should provide adaptive challenge and support, and incorporate feedback. Every action inside the computer game have to result in a form of feedback that is related to the context of the game.[69]

Although the results of the previous studies might be promising, there are currently too few experimental studies examining the range of effects of gamification on learning. This leads to a corresponding lack of theory, practice, and good research in the field.

[43] shows support to using games for learning. This support is based on previous reviews. These reviews reassure that learning is way more effective when the student is enjoying the educational process itself. This comes back to the features that an educational game can provide, these features can be listed as follows:

- Interactivity.
- Having visual and auditory mediums.
- Reproduction, which means that the same condition can be repeated several times.
- Having the ability to be tailored to some individual needs.
- Having effect on more than one sense, specifically for learning disabilities students.
- Providing the engagement and motivation factor (like auditory and visual praising and feedback).

[27] is a study that explored the attitude of children towards serious educational games. The goal of this study was examining whether there is a correlation between the level of enjoyment of the child playing the game and his/her learning gain.

Results showed that more enjoyment of the game leads to an increased level of interest in the subject presented in the game. These results were compatible with the findings of some other studies in the same matter like *(Connolly et al, 2012* [60] *; Ke, 2009* [51] *; Lee and Peng, 2006* [44]. They show that educational games can be suited as a new way of assistive means for learning.

These results were promising. However, some collected data showed that although the level of enjoyment can increase the desire of learning for the child, it can not guarantee that he/she will have a positive learning gain. This clearly means that fun can not be the primary reasons for using learning games, which is a bit depressing.

The study has also shown that the willingness of the students to learn with serious games is related to expectations of usefulness and ease of use rather than enjoyment. In conclusion, the results show that serious games should not only be fun but engaging as well. Thus, when teaching and learning with serious games, the combination of these aspects is one of the keys leading to success.

A comprehensive review of empirical studies of serious games was conducted by *(Hamari, 2014)* [25]. This review identified twenty four studies. Most of them reflected some positive effects of using serious games in learning from the motivational and enjoyability aspects. However, these outcomes depend on so many variables. Examples of these variables are: the individual characteristics of the student, and the context of the game [26]. Thus, the gamification effects are mixed in general and can not be attributed to specific factors. Consequently, an extensive approach might be needed to define the most effective elements of gamification.

To sum up, All the reviews in this section are urging and ring a bell that a lot of research has to be held in order to connect the dots between games and learning.

2.2 Educational Game Design

" Design is not just what it looks like and feels like. Design is how it works."
Steve Jobs.

Game design is a key factor in the effectiveness of a serious game, especially the educational ones. Some guidelines should be taken into consideration in order to make sure that the game is going to be interactive, engaging and motivating enough for the children to be attached to and benefit from it.

According to *(Whalen, et al., 2010)*[74], the key components for successful computer games for children are:

- Multiple exemplars: presenting one concept for the child using different examples. For example, if the goal is to teach the child the concept of a ball, we show him/her examples of red ball, blue ball, large ball , small ball, etc.) Variety in methods used to teach concepts: the concept that the game want to deliver should be presented using different activities (ex: matching, labeling, selecting, sorting,etc.)

- On-repetitive trials: repeating the same trial or activity that the game presents over and over again, especially for learning disabled children as they already have memory deficits. The repetitive trials should start on a single example, and then the game starts to introduce other examples in the same context when the child grasps the concept.

- Customization: the game should customize -as much as possible- the game mechanics to the individual needs of the child.

[29] is a study that was concerned with implementing a serious game for children with autism. Autism have common symptoms with learning disabilities. Accordingly, all the reviews about game design in this study are a matter of interest. The study has defined some components of a successful activity in an educational computer game for children. It mentions that each activity or task inside the game should provide the following:

1. Antecedent: the question or introduction to the activity (either in visual, auditory form or both),this antecedent requires the child's response.
2. Behaviour: the response to the antecedent, which means the action that the child decides to take in order to solve the activity and complete the task. Examples of this could be clicking on the correct answer, and moving an image to its correct place.
3. Consequences : instant, clear and direct feedback for the action of the child, this feedback should inform the child in the case of a correct response, and provide a correction for an incorrect response.[29] A lot of studies have stressed on the importance of the instant feedback in the learning process. Feedback plays a vital role, because it gives the player the chance to know what are the areas or tasks that were not mastered. Additionally, it makes the students feel their success, which can enhance the confidence to keep playing game.[78]

Despite the fact that the target group of this study was children with autism [29]. A lot of the principles and design guidelines can apply for children with learning disabilities. As they share common symptoms, especially when it comes to the learning difficulties.

Also, the study has reassured that the framework that was implemented can be used for other children with and without disabilities. The framework is based on the basic learning interaction. Which can also be applicable in our work.

Inspite of the increasing popularity of the idea of gamification in general. There are many debates around the effectiveness of serious games on education *(McGonigal, 2011)* [48]. One study that addressed such problem has been held to assess the effects of gamification in the classroom. It tackled some specific factors like intrinsic motivation, social comparison, satisfaction, and most importantly academic performance of the students.

The study [26] was based on an experiment of a gamified course using specific motivational game mechanics like leaderboards and badges. They had two groups, one received the gamified curriculum, and the other received the same curriculum without gamified elements. It had six hypotheses, the most important ones were claiming that the increased competition, social comparison, and rewards might have some negative effects on the learning process of the students. This was based on the hypothesis that the effect of

an educational game on the final exam grades can be mediated by the level of intrinsic motivation.

The results of this study found that the group of students in the gamified course showed poorer motivational and academic performance over time, compared to those in the non-gamified course. These results are compatible with the cognitive evaluation theory that suggests that badges and individual rewards might hinder intrinsic motivation, and backfire the level of interest in the learning process *(Deci and Ryan, 1985)* [16]. Also, *(Orosz, Farkas, and RolandLevy, 2013)* [56] have concluded that competition can diminish overall performance, cooperation, and problem solving.

One important remark on these results is that the gamified course was only featuring the effect of having leaderboards and badges in the game. This means that these findings were limited to these mechanics of gaming. Thus, the results can not be an indication of the effectiveness of the educational games, and can not be generalized upon all gamified curricula.

Trying to investigate more about the effective game elements, *(Cunningham and Zichermann 2011)* [79] have provided some design patterns for serious games like feedback, reinforcement, organizing, surprise, unexpected delight or gifting, recognition for achievement, getting attention, and being the hero.[66] is another study that has held a survey about gamification and referred to the same elements to be effective when designing a serious educational game.

[75] is a study that aimed at tackling the effectiveness of different game features on the learning process. Some specific features were investigated. These features are: relevance of information, interactivity, instructional guidelines, level of stress, game task and game type.

The results showed that relevance of information, game task and game type promote the learning process as well as the acquisition of knowledge to a certain extent. While the rest of the features, like level of stress, instructional guidelines, and interactivity; unfortunately; failed to have an impact on learning for the children. Which means that the effectiveness of specific games features is mixed.

Another noticeable thing in the results is that three out of four studies reported that groups that generally played games had a better performance than groups that did not. This gives a hint or evidence about the effectiveness of the new generation of serious games in knowledge acquisition.

Another study concerning the game design was held [43], this study was investigating the design and evaluation of five serious games- specifically speaking their user interfaces- for students with intellectual disabilities. These games were designed in a special manner so that they help students with intellectual disabilities in their daily life routine. All the interfaces were designed with maximum accessibility as well as usability.

To do so, the study has followed some major design principles that works on engaging the students in the games and the learning process itself.

The results of this study were about evaluating those games based on the design principles, and iteratively developing the user interface of these games. Some of these principles can be of a great help for children with learning disabilities like:

- Ensuring presentation at appropriate speed : the game activities have to be presented in a speed that is suitable for the abilities of the children.
- Allowing users to go back : children should be able to go back in steps in any part of the game and repeat when needed. This principle should be followed especially for those who are suffering from learning disabilities deficits.
- Allowing user control : children should have the freedom to choose the activities they play. They should have some preferences in the game context and the ability to customize the activity. (e.g: choosing background sounds, and graphical themes)
- Using text alternatives: it is better to substitute text with other forms or text equivalents like auditory and visual components, because children with LD have problems following text. If the game uses text. It should be clear text for all guidelines, dense blocks of text should be avoided, and plain native language is recommended to use in this case.
- Colours usage : the game designer should not convey information by colour alone, this is done for color blinded children. The game design should also make sure that the visual and auditory components has sufficient contrast so that it is easier to distinguish between them.
- Navigation: the game designer should make navigation in the game clear and easy as much as possible (e.g: use home and back buttons).
- Maintaining organisation: crucial buttons should be clearly displayed and in the same place throughout the different activities in the game.
- Layouts: the simpler the layout the easier it is to draw the attention. Unlike complex designs that makes it harder for children to get familiar with the design.

Using these constantly reviewed design principles we can develop more effective serious games for children with learning disabilities. The previous game design guidelines were harnessed in *Super Hawwaz* in order to help the LD children achieve better results in their learning process.

According to [29], some basic learning concepts for mouse or touch-screen games can be followed in the game design, these concepts can be easily applied if the activities in the game covered these modes of learning:

- Matching
- Pointing out and Selecting
- Sorting and Categorizing.
- Production responding.

Along with the design principles and guidelines for educational games that have been investigated previously, there exists some concrete and concisely structured models for educational game design. One of them is the Effective learning environment, Flow, and Motivation (EFM) model. It is a user centered game design. It gives some game design criteria in each of the three fields (environment, flow, and motivation) [78]. We will introduce these three factors in brief.

According to the EFM model , the successful learning environment requirements include:

- Having highly interactive tasks and feedback.
- Defining specific goal and scheduled programs.
- Providing incentive mechanisms and continuous challenges.
- Having appropriate tools for the students and users.

For the flow in the EFM model, it is the factor that achieves the balance between the challenge and ability. The flow factor is the one that makes the users of the educational game feel involved, and enjoy the game. According to the flow theory, producing a good flow in the game requires:

- Having clear objectives of the game.
- Giving the player the chance to concentrate on one task.
- Giving the impression of not worrying about failure.
- Distorting the sense of time and experiencing new concepts.

Finally, the last factor to be discussed in the EFM model is motivation. The importance of motivation come from the role it plays in promoting learning, specially for children. According to *Yi Zhang, Liming Shan, and Shixiang Li, 2014)*, there are four important components of motivational design, these components are : attention, relevance, confidence and satisfaction. It is clear that the requirements of learning environment, flow, and motivation are consistent with each other, as well as other models [78].

To sum up, the ideal scenario for implementing effective educational games is having the best of both worlds, which is a mixture between game design and learning strategies. As easy as it may seem, determining the perfect balance between learning outcome and engagement, usability and fun is very challenging. Thus, this is the main concern of a lot of research areas nowadays in the field of serious games.[41]

This section tackled the design requirements in educational games. The upcoming sections discusses the other controlling factors for a successful educational game like: symptoms and deficits of children with learning disabilities, the learning strategies used for the evaluation methods used to asses their work.

2.3 LDs: Definition and Symptoms

There are several definitions of learning disabilities. Most of them agree that it means having learning difficulties or problems that does not have to be associated with physical disability.

According to [49] *"Learning disabilities is a general term that refers to a group of disorders which are due to identifiable or inferred central nervous system dysfunction, which may be manifested by delays in early development and/or difficulties in any of the following areas: attention, memory, reasoning, coordination, communicating, spelling, calculation, social competence, and emotional maturation "*. Learning disabilities come in many degrees of severeness.

Children with learning disabilities possess average ability, and they have a surprising lack of compatibility between their intellectual ability and academic achievement[49]. This means that having a learning disability does not give any indication about a low IQ for the child. According to *Learning Disabilities Association of Canada*. The causes of learning disabilities are not visual, motor, hearing or even cognitive impairments. They are neurological impairments that result from genetic or biochemical factors. Experts claim that most of the students with learning problems receive their educational means in regular classrooms, and they are not even diagnosed. This might be the reason behind having below average academic performance for many of them [11].

[49] presents in a detailed manner the characteristics of the learning disabilities deficit areas as well as the teaching strategies and evaluation methods to overcome them. Common learning disabilities deficit areas that our study is interested in aling with their symptoms are listed below:

- **Attention Deficit :** having problem in maintaining attention towards auditory or visual components, along with the inability to focus on the task at hand.

  Symptoms of this deficit might include: being disorganized, having bad results with sustained focus requiring activities, along with being easily distracted and forgetful.

- **Auditory-Processing Deficit :** having problems analyzing and interpreting the auditory content, this happens with the absence of formal hearing impairment.

  Symptoms of this deficit might include: frequently asking for repetition of the information being processed, having difficulties in learning sounds and phonics, having language and vocabulary development problems, hearing the auditory material inaccurately or out of sequence, inability of filtering out background noises, and preferring visual games to those that include listening or speaking.

- **Visual-Processing Deficit:** having difficulties in analysing visual messages without being diagnosed with visual impairment.

  Symptoms of this deficit might include: having below-average reading level, forgetting what has been read silently, having tremendous spelling errors, performing badly in visual activities, and being easily distracted by too much visual components like brightly colored ones.

- **Visual-Spatial Deficit :** having difficulties in analysing the spatial components of visual material or messages, visual impairment is also absent in this deficit. Symptoms of this deficit are slightly like the visual processing deficit ones and might include: poor tracking (e.g using finger to follow moving objects), problems with estimating the passage of time, and weak graphing abilities.

- **Language-processing deficit :** the inability to express and receive language without having any sensory impairments. Symptoms of this deficit might include: having limited vocabulary, poor word retrieval skills (so they substitute words of similar meaning), problems following directions, and difficulties in linking themes and verbal concepts.

- **Organizational deficit :** having general difficulties in structuring the purposes of planning, monitoring, and evaluating information. Symptoms of this deficit might include: forgetting a lot of stuff, having difficulties managing highly structured tasks (they tend to procrastinate), poor choice and decision making, and being distracted from the topic quickly.

- **Memory Deficit:** one of the most common deficits in learning disabilities children. It is resembled in difficulties in retaining and recalling information. Symptoms of this deficit might include: the inability to recall information over long periods of time (can only remember over a day or two), forgetting words, details, and sequences of auditory components, and difficulties passing timed oral/written tests, as well as 'fill-in-the-blank' questions.

- **Writing Deficit :** having difficulties in writing and following direction with hands during writing a letter or a word.

  Symptoms of this deficit might include: the inability to copy the letters or the words properly, and having difficulties answering the hardcopied exams that needs writing.

There is also Mathematics deficit, but it is not of much interest in this study, as the platform is only tackling the ability of the LD children to learn Arabic words.

Many studies and reviews confirm the previously stated deficits as the symptoms of learning disabilities. According to [43] these deficits can be categorized as memory, problem-solving, conceptualizing, and perception problems. This study has also classified memory deficit to include problems regarding recognizing, obtaining, and recalling information from short-term storage memory, and consequently long-term and remote memory.

In support to the checklist of learning disabilities symptoms, [11] have also summarized the behaviors that the LD children manifest like: poor language abilities, memory problems, hyperactivity (e.g having problems completing an assigned task), attention problems, and ;most importantly; poor academic performance.

Moreover, a study has been made concerning helping students with learning disabilities succeed in higher education [77]. To achieve that, the study had a detailed description of the categories of learning disabilities like : problems in visual, spatial, time and auditory perception, memory and sequencing difficulties, and inabilities regarding sensory integration and communication. This is compatible with the studies mentioned above [11],[43],[75], and [49].

In conclusion, learning disabilities are real, they have well defined deficit areas, and these different areas have plenty of common symptoms, which made it better while implementing *Super Hawwaz*, as the individual needs will not be varying from one student to another in an annoying manner. Accordingly, a large subset of LD children can be exposed to it equally. The next section discusses the learning strategies that has been established for the children with learning disabilities. And, the reviews made about these strategies.

2.4 LDs: Teaching Strategies

Since children with learning disabilities have special needs, they also have to learn in special ways. There are many learning methods and strategies that are applied for learning disabilities students. The aim of this study is to explore these strategies and apply them in a context of a serious game so that it becomes an engaging mean of education for them.

A study [13] that was conducted about learning styles of Attention Deficit Hyperactivity Disorder (ADHD) children. ADHD is a different from learning disabilities. However, they share some of the symptoms (e.g memory deficit, attention deficit, poor language processing, etc.). The findings in this study showed that these children need special educational methods and techniques through identification of their individual needs and learning styles. The study has managed to reject the null hypothesis claiming that it is very hard to find a common learning styles and strategies among ADHD children [13], which is promising. Such results show some evidence that exposing the LD children to a common learning methodology that includes special learning techniques might be effective. These techniques can be applied in a computer game and hopefully be beneficial on the academic achievement level of the students.

[45] is a study that is tackling the different academic and educational outcomes of children with disabilities like ADHD and others. It specifies some useful academic intervention strategies. These strategies can be listed as follows:

- Choice making strategies : the child should have the freedom to select the activity to do. A study about choice making was made and showed significant increase in academic achievement when the students selected their work from a teacher developed menu.
- Project-based learning : it is a concept that focuses individual interests, skills, and characteristics of the children. It provides a tailored, interactive, and dynamic way of learning.
- Computer-aided instruction : digital assistive means -specially computer games- has a potential to be a universal design feature for students and children. Digital means are interactive, and have multi-sensory material. Additionally, computer based activities can provide clear instructional objectives and immediate constructive feedback.

This can be useful in supporting the idea of building up a computer-based platform that attracts LD children to learn a certain concept [45]. The study also suggests some other of the guidelines that should be taken into consideration while implementing an educational game for LD children. Examples of theses guidelines are: being proactive, providing specific goals and objectives of the activities in the game, preventing unwanted or depressing challenges, supporting an adaptive behavior, having an interactive and engaging format, and giving immediate feedback.

A study has been made about a serious game for teaching Arabic language for children in Qatar [57]. It has revealed some of the strategies they have applied in the digital teaching process. Their main objective was to engage the students in the narrative game and help them recognize and produce the Arabic letters. The goal of this study is extremely close to *Super Hawwaz*'s objectives. This was achieved by exposing the children to a lot of auditory and visual Arabic material in the game, giving them the chance to

have many trials in the exercises, and using straightforward and concise learning tasks. The game also gave attention to the individual needs of the children. It used to capture their interests, and choose the suitable learning activity accordingly.

According to [28], a three pronged strategy has proved to be promising in teaching children with cognitive and intellectual disabilities. The strategy presents three steps to teachers who would like to promote learning for their intellectually special students :

1. Evaluating the individual needs, skills, strengths and weaknesses of the child.
2. Selecting the best instructional techniques that will fit with the childs academic needs. They should be compatible with the content, attention grabbing, and age appropriate.
3. Combining these different techniques in an individualised educational program.

After analyzing the results of this study, an important finding was concluded. This finding clarifies that no two children are alike when it comes to learning. It means that there is no single educational technique that is considered to be the best for all children. This is contradicting with the results mentioned previously about the previously mentioned study [13]. This study has rejected the hypothesis that said that there is no common learning style between ADHD children.

Accordingly, the platform implemented in our study *(Super Hawwaz)* was built to combine the existing teaching strategies for LD children. This was done through having general guidelines of teaching techniques, while having a variety of activities and games that can suit different needs at the same time.

Another study that can be categorized under the umbrella of the studies that investigate how to help LD children succeed in higher education was reviewed. This study has discussed some strategies and teaching techniques that have a positive effect on students with learning disabilities [77]. By analyzing these techniques, it has been found that they share four common themes or guidelines, these themes are:

- Giving the children enough time to digest the represented material and respond to tasks.
- Organizing and scheduling the objectives and the content of the material to be presented to the children.
- Presenting course contents and materials using multi-sensory means.
- Attracting students toward the tasks and capturing their attention.

According to *(Lerner 1997; Lowry 1990; Rose and Meyer 2000; Sandock 2000)*, these previously mentioned teaching strategies can help promote learning for LD children in many ways. These methods provide an inclusive and interactive learning environment, in

addition to the fact that they offer them the opportunity to control their learning process [77].

One of the main features that were planned in *Super Hawwaz* is the feature of user profiling. The platform was designed to have different games targeting different learning skills, and the experts in the field would choose the most suitable activity for the child. Also, the levels of the games in the platform adapt automatically to the progress of the and learning curve of the child. According to [57], educational games for children shall not include textual instructions. Instead, short animations, signs and explanatory image are to be used for the ease of the use of the children.

A great number of studies has presented teaching related practices to children with learning disabilities. [28] has found useful practices in this field, these practices can be more of tips for the teachers in the classrooms to follow while conducting lessons. Accordingly, it is recommended that these tips be taken into consideration while building computer educational games for LD children. The highlights of these tips are :

- Providing a review of the previous lesson before starting the current lesson. Summarizing helps children with memory deficit link information.
- Letting the children correct their own mistakes. This is achieved through giving hints and instructions.
- Setting learning objectives, and letting the children know what is expected from them to do in the lesson -or the game in the case of the assistive technology means-, in addition to showing examples.
- Highlighting keywords in vocabulary to help the child focus more.
- Reducing the frequency of timed tests, and giving the children their time to solve the questions.
- Simplifying instructions, choices, and scheduling. If the task is presented in a simple manner, the children dealing with the disability will comprehend the activity in a productive way.
- Using auditory and visual components to present lessons and concepts.
- Dividing assignments and tasks into small segments.
- Using assistive technology that makes the instructions more interactive. Which is compatible with many reviews that emphasized on the fact that using technology in education helps a lot.
- Keeping a vocabulary bank for the hard or remarkable words if the material includes language learning. This point was taken into consideration while implementing *Super Hawwaz*.

- Giving instant feedback upon interacting with the different activities. Giving immediate praise helps the child repeat the correct action again when assigned the same task, specially if this child has a learning disability.

Going back to the review of the study [49], the review discussed in details the learning disabilities deficit areas, along with their symptoms (Section 2.3). In this section, the teaching strategies and evaluation methods for each area are presented so that they give guidance in constructing the educational games mechanics.

- **Attention Deficit:** removing time limits from activities to prevent negative energy and loss of interest, giving positive feedback when possible, and preparing for the upcoming tasks. Additionally, drawing the child's attention every now and then, using visual examples and guiding steps, and using calming background music if possible might be helpful.

  Possible evaluation methods could be: avoiding lengthy tests, measuring knowledge not endurance, giving extra chance for assessments, building evaluations on basic concepts digestion not only grades, and giving hints when possible.

- **Auditory Processing Deficit:** using a lot of auditory materials, making the auditory components as slow as possible, using simple vocabulary, emphasizing word endings when speaking, and avoiding spelling in tasks. These guidelines are valuable for using serious games for LD children because it will help in deciding which audio technology to use in the game (e.g use a low voice pitch when using text to speech).

  Possible assessment methods could be: breaking the test into small segments, using verbal directions in questions, giving only one task at a time, providing extra time if needed (the original duration times one and a half is sufficient).

- **Visual Processing Deficit :** reducing the amount of visually distracting components, assigning fewer questions with maintaining the same level of difficulty, and avoiding hard visual tasks like matching.

  Possible assessment methods could be: assessing the LD children differently when it comes to visual tests (e.g giving them tolerance in visual mistakes).

- **Visual Processing Deficit :** the same guidelines of visual processing deficit, in addition to using colored components when teaching.

  Possible assessment methods could be: using oral tests.

- **Language Processing Deficit :** slow vocabulary modeling, giving the chance for the child to process syntax of the language, placing the alphabets in front of the child always while working on tasks, and introducing key vocabulary in context.

Possible assessment methods could be: providing a quiet space for testing, in addition to the assessments methods for the attention deficit.

- **Organizational Deficit :** providing structure for the tasks, avoiding wandering off topic while teaching a new concept, and clearly stating the instructions in points.

  Possible assessment methods could be: using question types that do not require a lot of organization such as *"fill in the blanks" , "true or false", or "multiple choice"*, and providing examples on how to solve questions before exposing the children to tests.

- **Memory Deficit:** using repetitive practices on the same task, as well as varying multi-sensory approaches, presenting new concepts in short steps, and using index cards for the vocabulary words.

  Possible assessment methods could be: Using **Multiple Choice Questions (MCQs)**, providing the word bank when exposing them to fill in the blanks questions, and providing examples on regular basis before asking the student to solve a test.

- **Writing Deficit:** Making clear directions for the child to follow, using big figures to trace at the beginning, in addition to avoiding detailed letters or shapes to write.

2.5 Linguistics: Arabic Language

Since the children are interested in playing games, it will be very beneficial to make use of the games they play to help them improve their skills. There are several games and websites specifically designed to be accessible for people with learning disabilities. Nevertheless, in most of the schools -especially in Egypt- few children hear or know about such applications or games. In addition, few games are dedicated for teaching the Arabic language. It is extremely rare to find a platform that is tailored to fit special LDs in the aim of teaching the Arabic language. There is a big need to have educational games teaching the Arabic language, and at the same time targeting the children with learning disabilities. Also, these games can be used by children with no **LDs!** (**LDs!**), and consequently will make learning more fun and easier.

Accordingly, this study has chosen the content of the games embedded in the platform to be learning a language. Languages are the vehicles for communicating our ideas, beliefs and needs, especially for children. They are used in order to maintain contact with each other, gain and give information, and last but not least, persuade and accomplish goals.[11]

Observing children having progress in a language , automatically developing over the course of their first few years of life is one of the greatest wonders. Although languages develop naturally, reading does not, it must be explicitly taught[71]. Achieving this for

intellectually disabled children needs a lot of work.

Moreover, statistics show that approximately twenty percent of children have some form of language learning impairment [55]. Unfortunately, these children who face difficulties in language learning are not diagnosed until they have gone through school failures, which leads to bad academic achievements.*(Shay- witz, Shaywitz, Fletcher, and Escobar, 1990).* [67]

[71] is a study that used one of the well-known approaches in exploring the linguistic aspects as well as problems for children struggling with language learning impairments. This approach depends on looking cross-linguistically at children who have difficulties learning their native languages in their own countries. This approach has proven to be fruitful because different languages have different structures, which means that the properties of one language might be useful for testing hypotheses based on another language.

The findings of this study were interesting. It confirmed that there is variability in the rate as well as the quality of language learning, and that there exists a larger than expected number of children who suffer from language learning difficulties. Most importantly, the results showed that one of the effective techniques to drive measurable improvements in language development is to combine explicit training in some factors. These factors include phonological, morphological, and language comprehension skills all together. Moreover, the study assured that using assistive technologies and computer based strategies can offer potential to solve the language learning impairment issue .

The previous part discussed the reason behind choosing the the content of the platform's games to be learning a language. The following part explains why we chose the Arabic language specifically.

The reason behind choosing the Arabic language to be taught through *Super Hawwaz* lies in the review done about what has been done so far in this field. It is extremely rare to find a platform that addresses both learning disabilities children and learning Arabic language at the same time. Moreover, Arabic is the second most widely used script in the world. It is widely spoken with an estimated two hundred million native speakers [3]. Unfortunately, very few studies have tackled the Arab children's vocabulary in the pre educational phase.[57]. Finally, the Arab world lacks awareness about language learning difficulties in general. Despite the integral role the technology plays in their lives recently, we can hardly find available online Arabic educational softwares to help in the classrooms [57]. Consequently, inquiry and research in technology-based language instruction is required. Since *Super Hawwaz* aims at teaching Arabic language alphabet and some primary words in it, the area of the techniques of teaching the Arabic language for children had to be furtherly investigated.

The components of any language are content, form, and syntax [11]. This study has stressed on these components for the Arabic language. According to [49], general language

usage are concentrated on language production. Which means that children with language learning difficulties suffer from word finding, and very limited oral vocabulary. Shedding some light on the nature of the Arabic alphabet teaching methods is a step towards achieving the platform's goal.

A paper under the title *"Web Design for Dyslexics: Accessibility of Arabic Content"* [3] has focused on the design of digital content for users with specific learning disabilities, especially Arabic dyslexics. This paper has highlighted some of the linguistic Arabic problems like: word recognition, letter recognition (especially for the orthographically or phonetically similar letters), memory problems, letter reversals, word omissions, word additions (especially in diacritics), and difficulties in audio and visual processing. Naturally, these problems vary in the severeness between the individuals.

One challenge of the Arabic language is having diacritics that change the whole meaning of the word, these diacritics are for sure helpful. However, they add complexity in reading, specially for readers with learning disabilities. This happens because they need a high level of processing skills, memory, and visual discrimination. For this reason, *Super Hawwaz* is only interested in presenting Arabic words with differences in the diacritics of the first letter only, because the base goal of the game is to teach the children Arabic alphabet and some basic related words [3].

Investigating more about the Arabic language teaching methods. ***"Abjad"*** [2] is a system that overcomes key teaching challenges associated with the Arabic language. It achieves this objective by identifying the underlying patterns and relationships in the Arabic alphabet. This system categorizes Arabic learning into different categories or areas (organized from the easiest to the hardest):

1. Letters of the Alphabet : this includes the recognition of the sound and shape of each letter, in addition to knowing the name of the letter itself.
2. Word formation: this includes selecting out a specific letter in a word.
3. Writing: this includes writing letters with guidance of direction.
4. Short Vowels : learning phonetics of letters in different words.
5. New Vocabulary: having some sort of a bank of words for each letter with different diacritics.

These previously mentioned areas are the same areas that *Super Hawwaz* tackles trying to teach LD children the Arabic Alphabet and its related words.

The Arabic language is very challenging, especially when it comes to teaching it to children. It is even more challenging when it comes to teaching it to children with learning disabilities. The most remarkable areas of challenges according to [2] are :

- Arabic is a language with high complexity : it contains twenty eight letters, each letter has three different instances or forms (e.g at the beginning, middle, and end of the word) [18]. It is hard for the children to distinguish between them. Also, the number and positioning of dots is considered to be challenging for children too.
- Semi cursive script : Arabic is not a fully cursive language. Some letters do not attach to the next ones. And, the challenging mission in this part is to convince the children why is this the case for these letters in an engaging way.
- Various letter forms: unlike English (which has two forms only: uppercase and lowercase), the Arabic language has many forms associated with each letter distinguished as follows:
  - Three letters have four character forms.
  - Nineteen letters have two essential forms.
  - Two letters have only one essential form.

[57] is a study that aimed at implementing an Arabic learning games for K students. Its main concern was to help them recognize and produce the Arabic alphabet. By recognition of a letter we mean knowing the sound and the shape of the Arabic letter (mastering pronunciation and identification the form of the letter by the end of the curriculum). For the production, it means that the child should be able to write the letter or pronounce it correctly in a word. In *Super Hawwaz*, we are only concerned with the recognition of the Arabic letters and words, as production is not feasible for LD children. It needs extensive monitoring and observations from the teachers.

This study has also investigated some of the obstacles and differences between the Arabic language and its European counterparts [57]:

- The Arabic language is read and written from right to left.
- The majority of the letters of the alphabet are connected together when constructing words (unlike English or many other languages).
- Each letter has many different forms depending on the position in the word (i.e. isolated, initial, medial and final)
- Pronunciation wise, it is a one-to-one correspondence language, which means that each letter has a unique sound, and words can be written as they are pronounced (phonetically).

The question now is what possibly could the solutions to these challenges be. There is a teaching technique called *" The Alphabet Families"*. The twenty eight letters are categorized according to their forms and natures into seven groups. Each group has a color code, and they are all collected in a triangular shape as shown in Figure 2.1.

They are collected this way because when the letters are arranged according to their characteristics, they form a symmetrical seven by seven triangle. This pyramid shape makes the Alphabet easier to remember and relate to for LD children. This way gives the students a sense of order and familiarity with the alphabet. Another presented solution is to introduce the forms of the letters in an engaging ways like the *"Hands and Tails"* teaching method. These solutions were taken into consideration while designing the different games in *Super Hawwaz*.

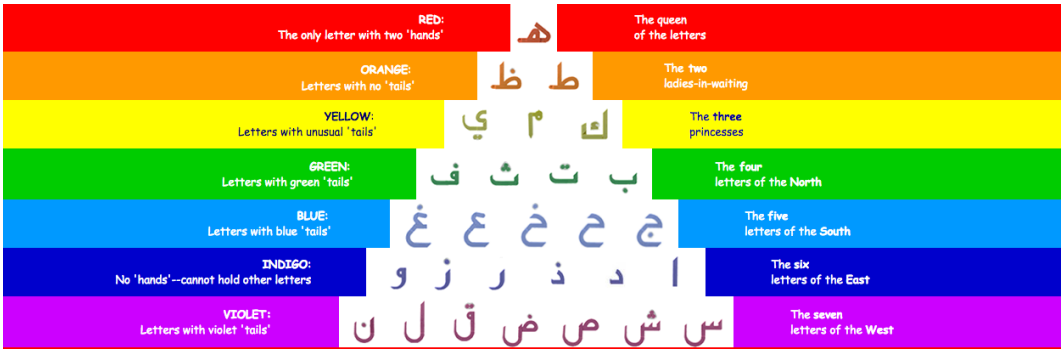

Figure 2.1: The pyramid of letters methodology (By Abjad [2]).

The next section describes in details the evaluation methods used to assess the performance of the children learning the Arabic alphabet.

2.6 Evaluation and Assessment Methods

One last, yet very important aspect that had to be tackled for this study is the methods and techniques used for assessing LD children. This was useful in the evaluation and testing the platform phase. The methodology is to asses the students in the special ways they used to be evaluated with in order to determine the effectiveness of the game designed for them.

[49] defines the assessment process as *"An ongoing process involving the collection of data for the purpose of evaluating the performance of a student "*. The assessment process is very tricky in the sense that it has to be fair and reliable for all students. That is why the teacher should be aware of the philosophies, learning strategies and styles, and preference-based learning theories.

Accordingly, the teachers of the LD children should refine their presentation methods, activities, and assessments in order to be compatible with the skills and needs of the students. This is hard to implement in the classroom on so many levels. This is where the focal point of educational games lies. It is the fact that a serious game can offer some factors that are not available in the classroom, like having different activities that fit a variety of skills of the LD children.

[11] has introduced some evaluation measures that are used for children with learning difficulties in the classroom, these measures are:

- Progress graphs and charts: this means quantifying the grades or the gradual performance of the child on a graph or chart to see where his/her learning curve go. It helps the teachers monitor the child's progress. The knowledge to be measured does not have to be in a form of grades, it might be represented in the manner of the time that the child took to recognise the answer or the number of correct occurrences of the answer. This was one of the applicable methods suggested to use in our study. It is achieved through evaluating the child by counting the number of words he/she mastered knowing the Alphabet.

- Performance records: this method is based on monitoring the performance of a kid regarding a group of skills over a long period of time, (Example: week 1 : 2/10 , week 2 : 5/10 , etc.). It is usually used in evaluating the behaviour changes as well as the academic ones.

- Portfolios, learning logs and dialogue journals : these are ways of documenting the student's work or filing it in a professional way, this technique is mostly used in writing and comprehension activities.

According to [49], there are some methods that can also be appropriate for assessing and evaluating the children, but it specifically tackles evaluating the vocabulary learning curve. These methods are completely related to what *Super Hawwaz* offers and presents, some of these methods are listed below:

- Having a graded wording list where the words are listed, and the teachers puts a certain symbol in front of the word resembling the performance of the child recognizing this word (e.g recognized correctly, after many trials, or not at all).

- Creating a running record reflecting the number of mastered words throughout a long period of time, and the evaluation method used here is dividing the number of correct words by the total number of words and multiplying by hundred. Which gives the knowledge percentage at each checkpoint. This method is the one used in our study. It is adapted from *(Teachers Manual for Early Success Program by Houghton Mifflin)* [30].

- Using the *"Standardized Tests of Educational Achievement"*: these tests give detailed information about the student's academic improvement level comparing him/her to a normal control group of students. This was a suitable testing method for the

platform, as the experiment held compares LD children's knowledge to their previous records. Primary results of this method show that LD children already have significant lag on the academic level. This approach is adapted from *(Kaufman Test of Educational Achievement, Woodcock Reading Mastery Test)* [22].

2.7 Related Work

After reviewing the key areas regarding the topic. Related work been revised in order to know what has been done so far in the field, highlight the strength points to be incorporated in our proposed design. And extract the research gaps as well as the shortcomings of this work and how would our suggested platform *(Super Hawwaz)* solve these shortcomings.

2.7.1 LeFCA

One of the most related games to the field of computer assistive games for children with intellectual disabilities is the 'LeFCA' framework.[29] This game is made especially for children with Autism, as they share some common symptoms with LD children. The main objective of the game was to teach those children some basic skills and concepts (learning shapes). The platform consisted of four games tackling different deficit areas in Autism. Figure 2.2 shows an example of a game in LeFCA.

It was tested with a pilot study, and the results showed that the idea of having a software platform in native language (in this case German) for these children is promising. They liked the interface and thought it was friendly. The teachers also assured that its appropriately sequenced for learning. The study was conducted on four kids, and all of them mastered all games easily. Also, they have been interested in it post the study.

The reasons behind the success of the game is that it was the first software that the children could encounter in their native language. As a result, developing similar educational games specially for economically disadvantaged countries is considered to be effective. And, that is exactly what our Arabic learning platform is aiming at. In review to this game, it has been found that *(Bosseler and Massaro, 2003)* [12] have implemented an animation program for autism children also. Two experiments were conducted and have proven that those children are capable of learning new language using a software agent can be effective.

shortcomings: LeFCA was implemented in German language, thus it can not help Arab children, this is in addition to the fact that it only tackled learning shapes and nothing else.

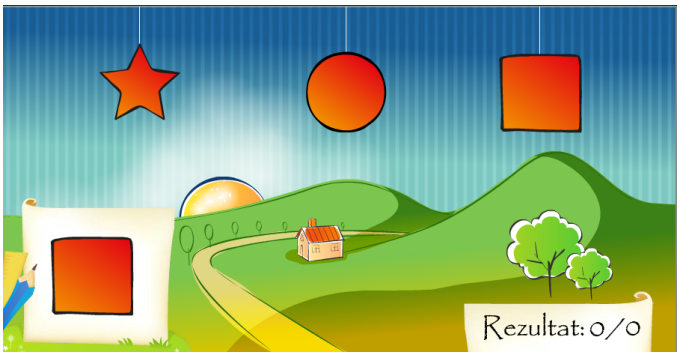

Figure 2.2: LeFCA: Autism Game.

2.7.2 CLES

Cognitive and Linguistic Element Stimulation (CLES) is a project that aims at developing an adaptive serious game addressing the learning process of persons with various cognitive disabilities. The system's main task was to generate learning scenarios for the player according to their individual needs. This has been done by taking into consideration the player's strengths and weaknesses (e.g profiling). It has focused on cognitive and intellectual disabilities like logical reasoning, as well as perception, attention, and memory problems.[30]

Shortcomings: The game is effective, yet its mainly designed for adolescents (not children). Moreover, it has tackled cognitive disabilities in general which are different from learning disabilities. It aimed at enhancing the daily life processing skills of the users, but not the academic level.

2.7.3 ALADDIN

Aladdin is a framework that re-conceptualized the Arabic language learning curriculum in Qatar. The main theme of the platform is an adapted version of the famous Arabic story ***"Aladdin and the magic lamp"***. It is well known and loved by children because it is a folklore based game that never gets old. And, it was originally implemented to test the group learning techniques in the classrooms using certain tabletop devices [26].

It is consisted of two main parts: storytelling and learning activities. The storytelling part depends on listening sessions (Aladdin story is presented in twenty two episodes), and each episode starts from where the previous part finishes, and each lesson is finalized with a context related activity assessing the child's understanding of this lesson. The learning activities included many group educational games like Bingo and some drag and drop tasks. The platform is actually very engaging and appealing. It uses visual aids, music, interesting narrating voices, reviewing lessons, and fun educational games.

Figure 2.3: Rosetta Stone Game.

Concerning the results, it was successful, the learning curve of the students in Qatar was steep, even those who didn't have any backgrounds about the curriculum. But, the older kids showed more interest than their younger peers.

Shortcomings: Although the game was successful on so many levels (it is one of the closest trials to what was intended to be done in *Super Hawwaz*), it did not address the disabilities, and it has another shortcoming which is depending on the interactive device used to encourage group work (the tabletop) which is expensive on one hand, and not feasible to use with LD children on another.

2.7.4 Rosetta Stone

Rosetta Stone is an educational game that aims at teaching the users different languages the way they used to learn their first (Figure **??**). It depends on giving lessons with ascending difficulty levels teaching the user to think in his/her new language. Rosetta Stone provides up to 24 languages to learn including Arabic. It also uses assisting pronunciation activities for some languages, namely the speech recognition technology. [63]

Shortcomings: Rosetta Stone is considered to be one of the closest games to this study's goal. As it aims at teaching the languages using the self directed goal method held in this study using the Montesorri syllabus. However, it is not mainly designed for children, and it lacks the fun interactivity factors. Moreover, it is not available for everyone as it is not a free open source game.

2.7.5 The Chinese Game

Another game was made to teach the Chinese language in an interactive way. It is an educational RPG game that aims at experiencing the Chinese culture and heritage. The main theme was having an avatar that tries to explore the Beijing's cultural characteristics in an interactive story. It puts the player in different situations where he/she has to interact in Chinese with different characters along their way [78].

Shortcomings: It tackles the language learning part in a good way. Yet, it is designed for adults, and its mechanics are a bit complicated.

2.7.6 How Difficult Can This Be?

It is a guiding video of the **F.A.T workshop (Frustration, Anxiety and Tension)**. It gives direct instructions and activities for the children with learning disabilities. The video is mainly conducted using the help of experts, special teachers, parents, and students. [76] It gives a real life simulation of the daily life situations of a child with learning disabilities, the whole experience is good because it gives a chance for the people who do not suffer from **LDs!** to experience the LD children's feelings. It gives some tasks and lets them handle it the way the LD child.

Shortcomings: It only represents how the LD children feel, and does not offer actual, interactive solutions to them.

2.7.7 Fast ForWord

Fast ForWord is a wide training program intended to enhance cognitive skills of children like attention, processing, and cognitive skills. It is a collection of software tools that include various activities for the children [23].

Shortcomings: It stresses more on the phonological aspect of the disability rather than academic skills.

2.7.8 Learning Works For Kids

It is a tailored website that addresses different learning disabilities and suggests existing tools and games according to the profile of the child, as shown in Figure 2.4. It has a positive effect that it depends on the recommendations of experts in the LD field [9].

Shortcomings: It is only a recommendation system, which means that it doesn't provide a software solution to LD problems. Also, it is only provided in English.

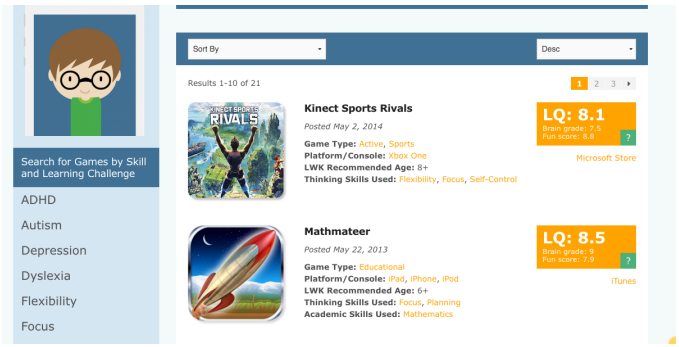

Figure 2.4: Learning Works: Games recommendation website.

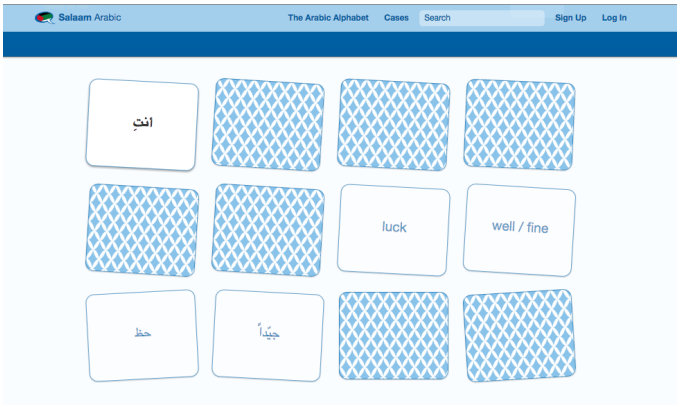

Figure 2.5: Salaam Arabic: Arabic learning website.

2.7.9 Salaam Arabic

Salaam Arabic is one of very few websites that aim at teaching the Arabic language. It is very entertaining and friendly (see Figure 2.5. It also includes some hard linguistics presented in an engaging way [65].

Shortcomings: It only suits adults, and it doesn't address learning disabilities by any means.

2.7.10 Islamic Playground

An online platform that is specialized in Arabic Alphabet learning games, it is very good for beginners, and gives instant feedback [34]. Figure 2.6 shows a game in the platform that teaches following the directions of the letter's shape.

Shortcomings: It does not also tackle any type of intellectual disabilities. No scientific methodology in presented in the games. Also, the content is to an extent restricted on certain cultures and backgrounds.

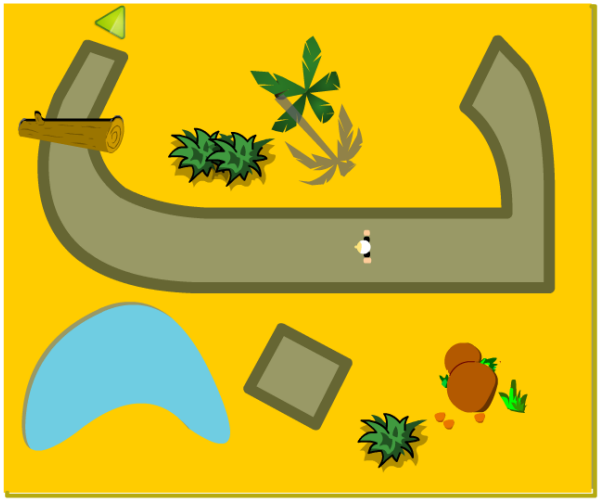

Figure 2.6: Islamic Playground: Arabic Alphabet Game.

Figure 2.7: Ecriver Medialexie: Dysgraphia Game.

2.7.11 Ecriver Medialexie

It is an offline tool that addresses dysgraphia, the good thing about it is that it addresses disabilities. It is very helpful in the sense that it checks text that the writer types on spot and gives feedback immediately [50].

shortcomings: it is not engaging because it is a tool not a game, so it is not helpful for children. Also, it only supports French language.

There are lots and lots of other games in the same context like **BridgingApps** [15], **Sheppard Games** [68], **Araboh** [8], and **My Arabic Website** [6]. But the common feature between them all is that there is always something missing in the puzzle. This raises a need for having a game that collects all aspects together: children, learning disabilities, and Arabic language in a professional way. And this is where the contribution lies.

2.8 Review Summary

From the literature review, it can be concluded that there are many different effects of serious games in education. Which means that the evidence provided about the impact of games was mixed. Some found positive effects, some found negative effects and some found no difference in performance between the gaming and the normal teaching methods on the students. Most of the studies reflecting the positive effects show that using technological assistive means can be an engaging and motivating mean of learning specially for children. Most of the studies show that the students have a generally positive attitude towards games for learning. Additionally, more enjoyment of the game led to an increased level of interest in the subject being introduced through the game.

For the negative effects, some studies showed that some factors such as explicit learning tasks, instruction and support supplemented by teachers, may be more decisive than the experience of fun during playing the game, which means that those studies have concluded that serious games can be an assistive mean of learning and can not replace the normal means of learning like the school teachers. Other studies showed that increasing the fun or motivating factor might backfire the good effects of the educational game, as it makes the students focus more on the game mechanics not the educational content. Others show that using leader boards and badges might be harmful because they increase the competition between the students, thus they never perform better in their final exams regarding the gamified subject, they only get high scores in the game.

2.8.1 Shortcomings of Existing Work

After reviewing the key topics regarding the topic. Related work was revised in order to know what has been done so far in the field, as well as the shortcomings of the existing solutions and how would the suggested platform (*Super Hawwaz*) solve these shortcomings.

The first and the most problematic shortcoming is that most of the educational games in the field are not based on specific learning strategies or methodologies. Another common shortcoming of them is that they lack the input of the experts in the disabilities field. Moreover, the field still needs some research in the aspect of effectiveness of serious

games. The current studies suggest solutions, but a only a few number supported these solutions with data analysis or quantitative evidence .

There are lots of games in the same context. However, the common feature between them is that there is always a missing feature whenever we try to address the LD children teaching problem. This raises a need for having a game that collects all aspects together (Children, learning disabilities and Arabic language) in a professional way.

The main focus of the study is to overcome these shortcomings by building a platform that introduces the Arabic alphabet to LD children based on the existing special teaching methods that are applied in their classrooms. The platform is designed to be engaging, motivating, self tailored, and beneficial on the academic level as well. This was done through extensively investigating the teaching methods for LD children, along with the important game mechanics for any educational games.

2.8.2 Strength Points of Existing Work

Some studies built the game design and content on some concrete and existing scientific methodologies like depending on the meta-cognitive strategies, others depended on learning outcomes, investigating some disabilities symptoms and computer-based design, and dependeding on the user interface design.

What we wanted to do is to embed the related and specific teaching strategies for LD children along with the effective game designs into our platform just the way they did. A very good example of that was the platform made for Autism children which is one of the closest experiments to our work. The main differences are the type of the disability, game content, and the language.

Another focal point found in the related work is tackling the fun and motivation aspect in the games, most of the platforms out there have built the games in a user friendly and usable way so that they guarantee that the motivation factor is present in the serious game.

One last factor is the customization of the individual skills and needs of the target group (Like CLES). We wanted to have the platform tailored for the variety of deficit areas that can be found for the LD children.

Instant Feedback is one of the most reliable factors in the success of any serious game. *Super Hawwaz* took this into consideration during the design process.

The next chapter explains how was this dense review harnessed in the methodology of planning, designing, and implementing *Super Hawwaz*, in order to be built upon professional bases.

Chapter 3

Methodology

This chapter describes the methodology followed to answer the research question. It starts by discussing the main objective of the study, followed by the details of the design, planning, and implementation phases of the system. Finally, it shows an overview of the features embedded in the platform, the different games included in *Super Hawwaz*, their idea, levels, and goals.

3.1 Objectives

Trying to cope with the research question, teaching methods applied manually for LD children in classrooms have been investigated. The main idea is that there are some guidelines to follow while teaching a new concept to LD children. Examples of this would be: giving extra time for the children, repeating the information more that once, speaking slowly to them, grabbing their attention with visual aids, and many other tips. These methods are traditionally used inside the class rooms using the regular teaching methods (like human teachers, hand crafts, and presentation slides). This might be hindering teachers inside the classrooms, specially if the LD children are not isolated from their normal peers, which is the case of most of the classes in the developing countries.

Accordingly, the main objective of this study is to embed the special learning methods and guidelines in a set of serious games (or a platform), and test their effect on LD children, compared to the regular teaching methods that are already used in the classrooms, like the presentation slides.

The problem lies in the fact that learning disabilities come in different forms, or happen because of different reasons. This means that there are many deficit areas representing the learning disabilities, and the child suffering from learning disabilities might face one or many of them. Each deficit area has its own teaching strategies and guidelines.

Thus, the platform *"Super Hawwaz"* was implemented to tackle most of the common deficit areas and their recommended teaching methods. This was achieved through including different games in the platform, each of them is tackling one learning skill or

deficit area in a way that can cover most of the common symptoms of learning disabilities among children. This also helps in making the platform tailored for the needs of the children individually.

The main aim of implementing *Super Hawwaz* is to teach LD children the Arabic alphabet in an engaging way. As mentioned in the literature review, teaching the Arabic language is quite challenging because of the varieties in the forms of the Arabic alphabet letters. The curriculum chosen to be taught in this study is the well known **"Montessori"** syllabus. Montessori is an educational strategy that is used worldwide for children. It is built upon using self-directed activities, collaborative play, and letting the children extract the knowledge themselves [52]. The main feature that was incorporated into our methodology is that the Montesorri method is based on allowing the children to make creative choices during their learning process. This is achieved in *Super Hawwaz* through letting the child choose the letter and the game to play with at any time. The platform does not restrict the LD children to a certain order of learning the Arabic alphabet letters.

Moreover, the Montesorri method in learning languages depends on directing the children to learn the shape of the word as a whole before knowing how to spell or produce it letter by letter [32]. Choosing the Montesorri syllabus was based on an interview that was held with a board of some specialists in the field in an intervention center for intellectually disabled children in Cairo. The reason behind choosing the Arabic language is the lack of such software means nowadays. Deciding the curriculum to be taught was built based on the opinions of the experts in the different children rehabilitation and teaching centers for LD children we were collaborating with. This is discussed in the following section.

3.2 Curriculum

By the end of playing all the games with all levels in the platform, the LD child should be capable of recognizing the sound and the shape of each Arabic alphabet letter, along with distinguishing between the three different forms of each diacritic sign, in addition to a corresponding word to each sign. The diacritic signs in the Arabic language are short vowel marks used as phonetic guides [18]. The three diacritic signs embedded in the curriculum are the main short signs used in the Arabic letters, these signs are: *"Fa-hah, Kasrah, and Dhammah"*. They differ in the way they are pronounced and written on he letter in the following manner [7]:

- **Fat-hah:** it is the accent mark put over the letter when a short sound of "A" is supposed to be pronounced along with the letter. It looks like a small diagonal line, and it should be placed above the corresponding Arabic letter.
- **Kasrah:** it is the accent mark put below the letter when a short sound of "I" is supposed to be pronounced along with the letter. It looks like a small diagonal line, and it should be placed under the corresponding Arabic letter.

Figure 3.1: Different diacritic signs with the second letter of the Alphabet.

- **Dhammah:** it is the accent mark put over the letter when a short sound of "U" is supposed to be pronounced along with the letter. It looks like a small diagonal line, and it should be placed above the corresponding Arabic letter.

An example of the three diacritic signs on a letter of the Arabic alphabet is shown in Figure 3.1.

Learning the three diacritic signs of each letter was achieved through having different examples of objects that start with each diacritic sign of each letter. These examples were embedded in different off the shelf engaging games like Hangman, Memory Matching Cards, and Puzzle.
This curriculum has been chosen for three main reasons:

1. It can be easily and effectively assessed: since the main aim of this platform is to test the effectiveness of serious games on LD children, a curriculum that can be easily evaluated with such special target group is required.

2. It does not need any previous background from the child: this is important for the testing phase, in order to have reliable results and collected data, most of the control group members are preferred to be on the same academic level without having edges on one another.

3. It tackles recognizing not production: the process of learning any language includes two main stages: recognizing and production. This study is mostly interested in recognizing not production because production in general needs extra observation and extensive care of the teacher inside the classroom - especially for the LD children-, which will not be provided through the serious game.

According to the experts, the Montessori syllabus followed to learn an Arabic letter along with its corresponding words includes different stages of learning. These stages are:

1. Recognizing an object.

2. Recognizing the letter that the object starts with.

3. Recognizing the word of the object among different words starting with different letters.

4. Recognizing the word of the object among different words starting with the same letter.

5. Recognizing the diacritic sign of the letter that the object starts with.

The methodology in this study depends on designing the platform, the presentation slides, and the evaluation means in an identical way. Which means that they were all designed in a way that copes with the previously defined Montessori syllabus structure.

3.3 Platform Structure

As mentioned previously, the main objective of the platform is to teach LD children the Arabic Alphabet shapes, sounds, and different forms of diacritics along with examples for each. This was achieved through designing and implementing a collection of games that the children play, where they can pass different levels in each game knowing the letters and their words.

The platform is designed to be as engaging as possible, the letters are multi-sensory presented, which means that the child gets to learn them using visually and auditory materials. The Arabic words that the child needs to learn are presented in form of cards. Each card is provided with an image of the object to be taught, the word representing this object, and a friendly voice over pronouncing the word in a clear manner whenever the card is triggered or clicked on. This is designed in order to make sure that the child recognizes the sound of the letters and the words that start with this letter in different forms properly. An example of three cards that represent the three diacritic signs for three words starting with a certain letter in the Arabic Alphabet is present in Figure3.2.

According to the input of the experts in the field, children with learning disabilities need hints to help them in answering any question. Since the platform includes different games, the children will start playing each game, and whenever they face a problem passing a certain level or answering a question, they get to have a hint if needed. More details about the hints are present in Subsection 3.5.4

The main theme of the platform is a Super Hero who tries to save a certain city, in order to save the city, the hero has to win seven different battles. A battle is represented by a game. Each game tackles a certain learning skill that helps a certain area deficit area in learning disabilities.

In order to win a battle or a game, all letters must be accomplished successfully, which means that the child has to pass all stages that contain different questions on a certain letter that he/she has chosen to play in the game.

Figure 3.2: Three cards representing three Arabic words starting with the same letter.

All the games include five different levels. These levels are organized from the easiest to the hardest based on the Montessori curriculum explained in Section 3.2. A detailed description of all the games included in *Super Hawwaz* is presented in the following section.

3.4 Games

As described before, the platform contains a group of different games, each game tackles a certain deficit area of learning disabilities.
The deficit areas that have been covered in our platform are:

- Memory deficit.
- Organizational deficit.
- Attention deficit.
- Visual deficit.
- Auditory deficit.
- Language deficit.
- Writing deficit.

The goal of this design is to cover most of the needs of the LD children, as a single child can share some or many of the different deficit areas that have been mentioned in

the literature review. This is for the purpose of making the learning process as convenient and customized as possible for the child.

There are several reasons behind choosing the approach of including different games in the platform. Firstly, [13] is a study with some findings clarifying that there is no single educational technique that suits all children. Accordingly, the platform implemented in our study was built to combine the existing teaching strategies for LD children. This was done through having general guidelines of teaching techniques, while having a variety of activities and games that can suit different needs at the same time.

Another reason behind having seven content identical games in the platform (i.e they share the same material) is the need of the LD children for repetition. According to (Whalen, et al., 2010)[77], the key components for successful computer games for children are using multiple exemplars, variety in methods, on-repetitive trials, and customization. Regarding the multiple examplars method, it means presenting one concept for the child using different examples. Concerning the variety in methods used to teach concepts, the study clarified that the concept that the game want to deliver should be presented using different activities (ex: matching, labeling, selecting, sorting,etc.), and that is what we did in *Super Hawwaz*. For the on-repetitive trials method, they mean repeating the same trial or activity that the game presents over and over again, especially for learning disabled children as they already have memory deficits. The repetitive trials should start on a single example, and then the game starts to introduce other examples in the same context when the child grasps the concept. Finally, customization means that the game should customize as much as possible the game mechanics to the individual needs of the child. That is why the platform was implemented following the approach of using multiple content identical games.

Each game in *Super Hawwaz* has different levels that represent the different learning stages needed for the child to learn a certain letter in the alphabet (Montesorri alphabet learning stages are listed in Section 3.2).

These stages were translated in *Super Hawwaz* into five different levels in the 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 letter with the images of the objects starting with it.
- **Level 5 :** Distinguishing between different words starting with the same letter but with different diacritics.

The games that will be available in the platform along with the deficit area that each one tackles are listed below :

3.4.1 Hangman

This game is a typical normal Hangman game where the child is asked to fill in the gaps of the missing letters of a certain word. The hints in this game are embedded into the cards that are represented in each level, the child can ask for a hint by clicking on the listening button that pronounces the correct answer in a friendly voice.
the deficit area it handles : **Language Deficit.**

Hangman was picked to handle the language deficit because the language deficit learning methodology depends mainly on introducing key vocab in context, and stressing on the spelling exercises, along with modeling slow and easy speech processing [49].

This game It may also help in : Written, organizational, and auditory deficits.

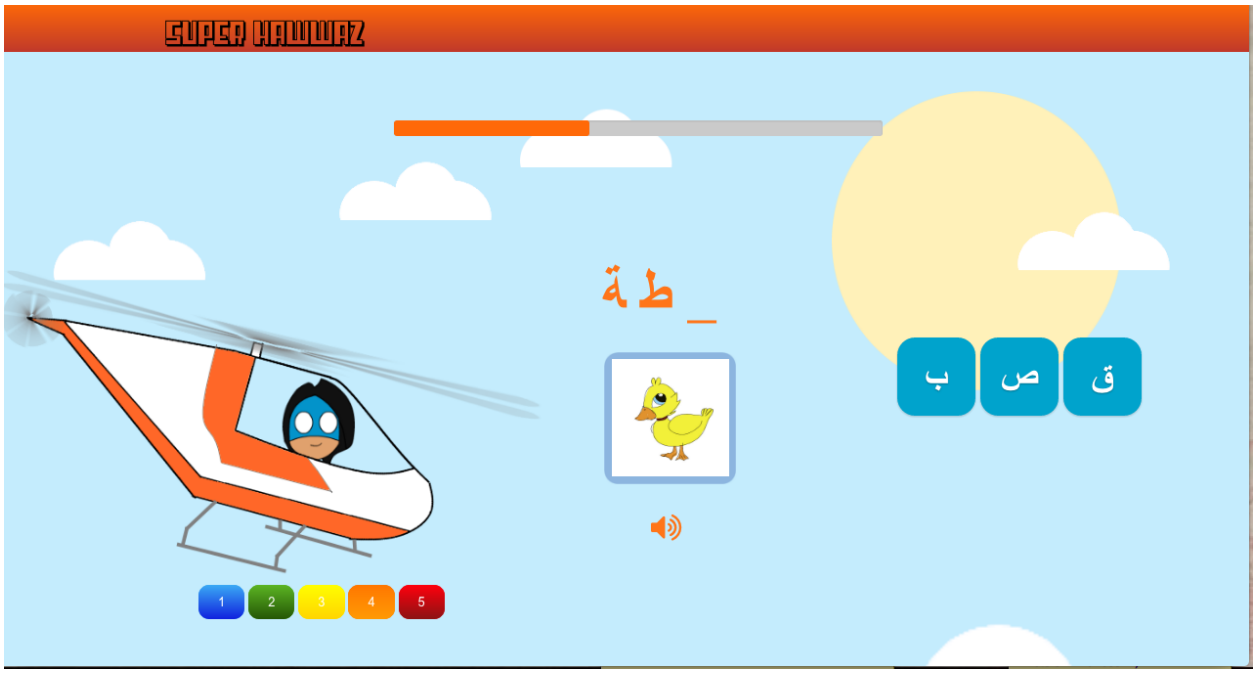

Figure 3.3: Hangman Game.

Hangman Levels:

1. Hiding the first letter in an object given its picture and name as a hint.
2. Hiding the first letter in an object given only its name as a hint.
3. Hiding the first letter of an object given only its image as a hint.
4. Choosing to complete the missing letter among different diacritic signs given the word.

5. Choosing to complete the missing letters among different diacritic signs given only the image.

3.4.2 Maze with MCQs

This game is like the regular maze game. The player is asked to go through a maze to reach the goal or the destination. What is different in this game is the presence of some obstacles along the way. These obstacles are represented as MCQs. The player can always listen to the Arabic words included in the questions by clicking on the cards. In order to pass the obstacle, the corresponding question has to be answered correctly. It is done in a fashion of traffic lights so that the player gets more engaged. When the child hits an obstacle, the yellow light is led, if the player answers correctly the yellow light becomes green and the child has the chance to pass. If he/she answers wrongly then red light is led. This keeps going till the player recognizes the correct answer and pass. This game also has a hint which is a star icon that reveals the correct MCQ answer vocally when clicked.
The deficit area it handles : **Auditory Deficit.**

Maze game was chosen to handle the auditory deficit because its learning methodology depends mainly on using a lot of auditory components, emphasizing key words and word endings, giving instructions in non verbal manner(Like using arrows to guide the child through the maze), avoiding spelling activities, and giving extra time for the child to answer any question [49]. Accordingly, all the MCQs are audio questions that are narrated in a clear, and slow manner.
It may also help in : Language, organizational, and memory deficits.

Maze Levels:

1. Choosing an object given its picture and name.
2. Choosing an object given its name only.
3. Choosing an object given the letter it begins with.
4. Choosing an object given the letter it begins with without having the word written in front of the child.
5. Choosing an object given the letter with its diacritic sign.

3.4.3 Memory Flipping Cards

This game is like the regular memory flipping cards game, where the player is asked to match two identical cards that are flipped down on the table after seeking the whole

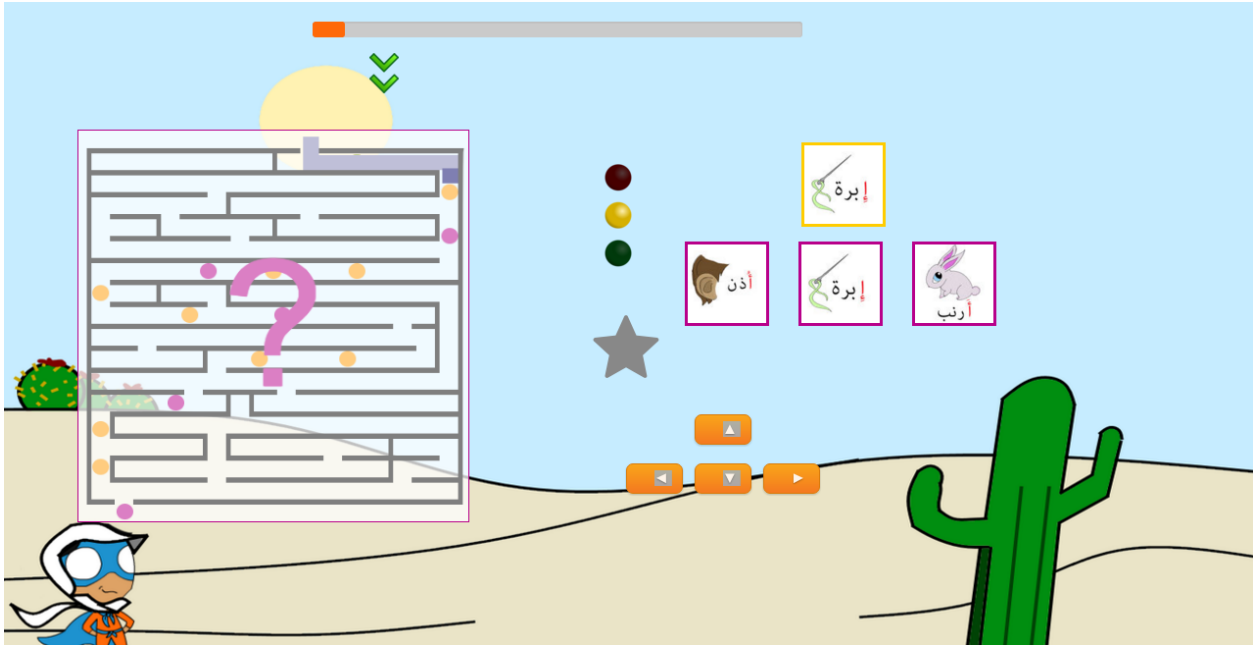

Figure 3.4: Maze Game.

board for a short span of time.
The deficit area it handles : **Memory Deficit.**

This game was picked to the LD children with the memory deficit because they need to enhance their short memory performance, using such a game will make them practice remembering the letters and their corresponding words. In addition to the fact that the memory deficit learning methodology depends on having repetitive memory exercises, keeping number of cards of vocabulary in hands, using simple questions like matching and MCQs, and providing examples [49] .
It may also help in : Auditory and Attention deficits.

Memory Cards Levels:
The levels the same as the maze game, but instead of choosing among many cards, the child is asked match them out from the set of cards available on the table of the game.

3.4.4 Puzzle

This game is a puzzle game where the child gets to reorganize the scattered parts of the letter's image along with the images of the objects that start with this letter. Exceptionally, the player has first to pick the correct image that he/she will be required to solve as a puzzle. This will come along with a preview image as an example for the child to imitate.

Figure 3.5: Flipping Cards Game.

The deficit area it handles : **Organizational Deficit.**

The organizational deficit learning methodology depends mainly on enhancing the structured way of thinking of the child, following clear directions, providing questions with organizational skills (like MCQ), giving examples, and testing the ability of putting things at their place [49].
It may also help in : Attention, and auditory deficits.

Puzzle Levels:

1. Giving the image and word in preview and reordering them without having to choose.

2. Picking the correct identical image of a given object and reordering it.

3. Picking the correct picture and reordering it given the the letter it starts with.

4. Picking the correct diacritic sign of a letter given the word, and reordering the letter's image.

5. Picking the correct diacritic sign of a letter given the image only without the word, and reordering the object's image.

Figure 3.6: Puzzle Game.

3.4.5 Painting Letters

This game stresses on the writing skills of the child by having the Arabic letter on the screen and asking the children to color or fill it with their fingers, under the condition that they do not go outside the letter nor color a small part of it.
The deficit area it handles: **Writing Deficit.**

This game was designed this way for the writing deficit because the learning methodology of this deficit depends mainly on providing practice in following directions, writing, knowing the shapes of the letters, using activities of visual aids, along with avoiding complicated hand tasks [49].
It may also help in : Visual deficit.

Painting Letters Levels:
Since the game is a bit unique and does not include many components, the levels difficulties will depend on making the task harder for the kid. (i.e making the letter thinner for the child to paint and requiring a higher percentage of accuracy).

3.4.6 Drag and Drop

The classical matching game using drag and drop method, we will have a set of empty cards written on them the Arabic words or letters, and below them a collection of images where the child is required to drag and drop the corrsponding cards in the correct slot.

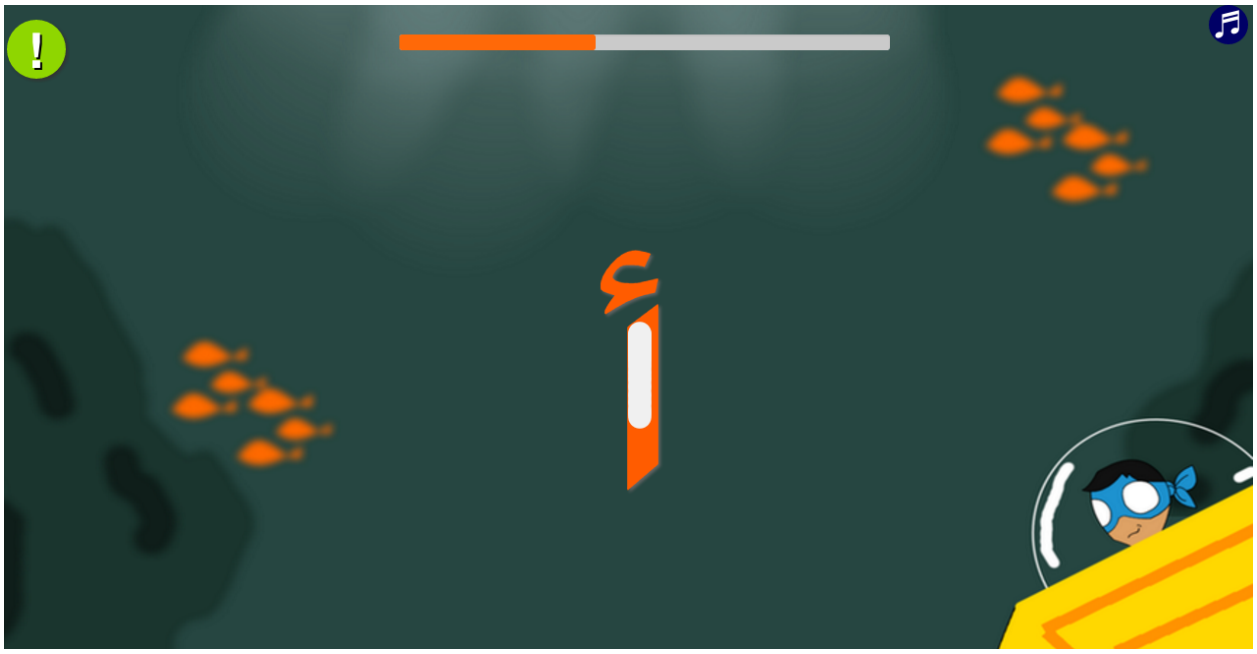

Figure 3.7: Painting Letters Game.

The deficit area it handles : **Visual Deficit.**

Since children with visual deficits are highly recommended to avoid tasks or activities that includes complicated visual components [49]. A game like the drag and drop game with empty cards that need to be filled is considered to be a good candidate for them. Moreover, the visual deficit learning methodology depends mainly on highlighting the important components, having a few number of tasks at a time, providing examples, and reducing the visual information.
It may also help in : Auditory, and organizational deficits.

Drag and Drop Levels:
The levels of the drag and drop game are almost the same as the levels of the flipping cards game. But, instead of mapping the two corresponding cards, the child just drags the correct card and drops it in the correct slot.

3.4.7 Shooting

The idea of this game is to shoot the correct components out of a group of moving objects on a board. (Example: Shoot all the words that starts with a certain letter).
the deficit area it handles : **Attention Deficit.**

Figure 3.8: Drag and Drop Game.

The reason behind choosing this deficit area for the shooting game is the fact that the attention deficit learning methodology depends mainly on introducing tasks that use signals to draw the attention of the child back (i.e the moving objects that the child is asked to shoot will be this signal), along with providing visual examples, and giving extra praise to the child.
It may also help in : Language, and auditory deficits.

Shooting Levels:

1. Shooting all components of the same exact object shown in the category slot.
2. Shooting all components of the same exact word shown in the category slot.
3. Shooting all components of the words that start with the letter shown in the category slot.
4. Shooting all components of the objects that start with the letter shown in the category slot.
5. Shooting all the components of the objects that start with the letter with a certain diacritic sign shown in the category slot.

One important thing to remark is that there are some border lines to follow in all games like giving extra time for the child to finish the task (probably one and a half amount of time of the regular timings made for normal children). Moreover, giving constant hints to

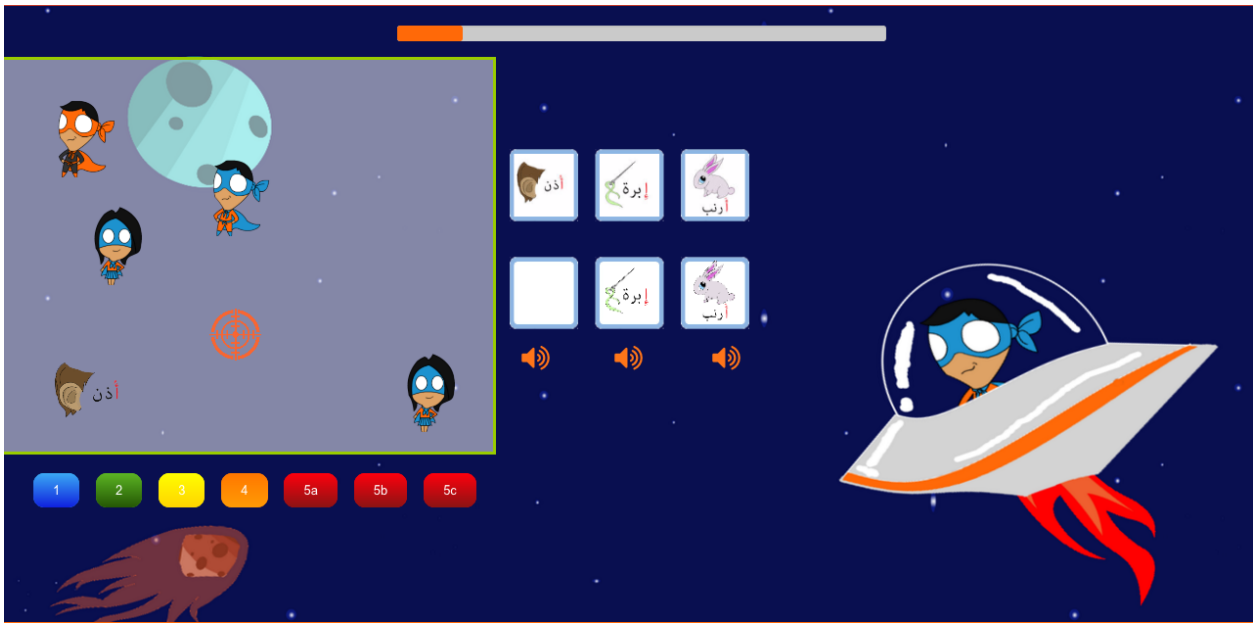

Figure 3.9: Shooting Game.

the children while playing, allowing them to have a look on the words bank whenever they would like to, and finally, providing them with detailed instant feedback in any game.

The next section describes in the game mechanics harnessed in the platform, along with the features embedded in each game (specially made for the LD children). Such mechanics and features were applied based on the reviews and the input of the LD experts in the learning field.

3.5 Features and Mechanics

This section describes the the available features in each game in *Super Hawwaz*. These features are based on the reviews made about the educational game design, learning disabilities, special teaching strategies, and the evaluation methods used with LD children according to their needs. The reviews and recommendations of the experts in the field were taken into consideration while embedding these features in the platform.

3.5.1 Theme

As mentioned previously, the main theme of the platform is a super hero who tries to save a certain city, in order to save the city, the hero has to win seven different battles. A battle is represented by a game. Each game tackles a certain learning skill that helps a certain area deficit area in learning disabilities.

Each game of the seven games has a certain theme representing a different location of the battle played by the child as an incentive. Each game along with its battle are listed

below :

- Maze Game : The theme is a desert where the super hero is lost and the player is required to lead the hero through the correct way in the maze.
- Shooting Game: The theme is a space battle where the super hero tries to shoot the different objects in order to beat the space invaders.
- Hangman Game: The theme is in the sky where the hero drives a helicopter and tries to answer the question correctly to win the battle.
- Memory Flipping Cards Game: The theme is an electronic battle, where the heroes are required to win a regular computer game to win using the memory game.
- Puzzle Game: The battle field is a garden where the heroes try to find the different pieces around the place and put them together as fast as possible.
- Drag and Drop Game: The battle field is in the city center where the heroes are required to bring the objects and match them with their corresponding words across the street.
- Painting Letters Game: An under the sea battle where the hero is driving a submarine trying too follow the directions of the letter as accurately as possible.

  The seven fields are illustrated in the games' images listed in section 3.4.

3.5.2 Playing Scenario

The first page to meet the child or the teacher in the platform is the home page, this page includes a menu of the different seven games included in *Super Hawwaz*. They represent the battle that the child wants to enter. The experts have recommended that the child should be given the freedom to choose the game to play with. Figure 3.10 represents the Home page.

After that, the child enters the letters page, where the child gets the chance to choose the letter to play with in this game (See Figure 3.11). The completed letters are marked as completed if the child managed to pass all the five levels in this letters. The child can play the letter numerous times even if it is completed. However, the child has to complete all the five levels in the twenty eight letters in order to complete one battle out of the seven battles represented by the seven games presented in the home page. The platform is intended to serve a long term goal (which is winning the seven battles through finishing the twenty eight letters in each battle) so that we maintain the incentive to play the game among the children.

After the child picks the game and the letter to play, the chosen game interface for the chosen letter appears. Then, the child starts playing the five consecutive levels. The

Figure 3.10: Home Page of SuperHawwaz.

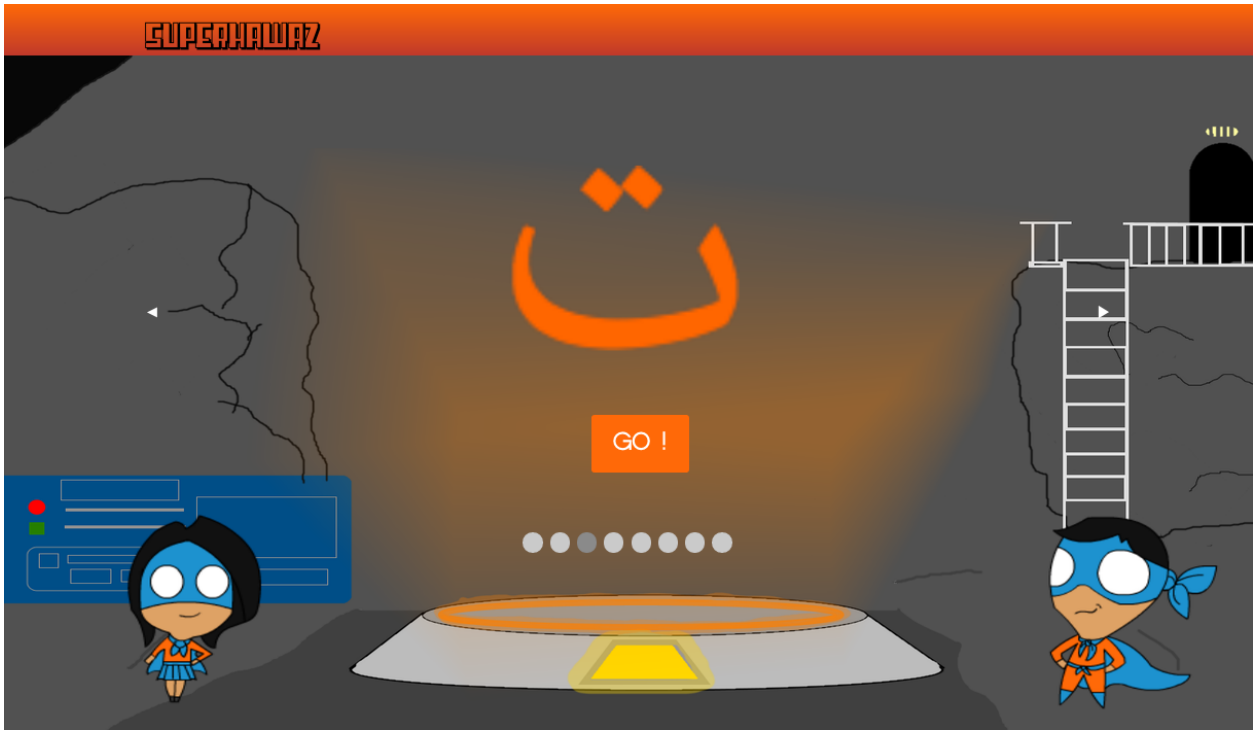

Figure 3.11: Choosing Letters Page of SuperHawwaz.

levels are designed to get upgraded automatically by passing the previous ones with sound and visual praising gestures for the child when passing each level to motivate him/her. If the child left the game, the last passed level is saved as a checkpoint to come back to whenever needed.

3.5.3 Cards

The main game mechanism depends on learning using the cards as known by the Montessori syllabus. Each letter in the game is learnt through three different words starting with this letter, each representing a different diacritic sign. Each word is represented by an object card. An object card consists of a picture of the object to be learnt followed by the word representing this object. The first letter is always colored in red to attract the child to it and the diacritic sign is written on this letter as shown in Figure 3.2.

The recommendations of the teachers about the material embedded in the games was to use the same pictures of the objects in all games so that the LD child does not get confused, and gets attached to the object with multiple examples in the seven different games. Accordingly, we used the help of a graphic designer who drew all the objects needed for each letter and designed the cards that were embedded in all the games. This was planned in order to maintain the consistency as well as the identity of the platform.

3.5.4 Hints

One methodology used in *Super Hawwaz* is providing the child with hints along the different game levels. The games include many questions in different forms, the child can not pass any level unless he/she answers the questions of this level completely and correctly. Accordingly, the hints strategy was applied in order not to make the child feel anxious nor frustrated.

Since the platform includes different games, the children will start playing each game, and whenever they faces a problem passing a certain level or answering a question, they can ask for a hint. This is achieved through hitting a star icon that is available at each game as a hint. The hint can either be a voice over of the correct answer or a visual aid according to the nature of the game itself. This is done based on the learning strategies applied for LD children that have been reviewed, as most of them recommended that the learning process come in an unsupervised way and that the LD children should get hints whenever they would like to.

Since most of the questions are depending on choosing the matching word, object, or diacritic signs. Most of the hints are used as an auditory material to help the child pick the correct answer. Originally, using hints used to deduct from the child's score. However, after consulting the experts in the field, it was advised that the child does not get less score upon asking for hint in order to encourage them to learn.

3.5.5 Scoring System

The scoring system in *Super Hawwaz* is built upon score bars not numbers, as it is easier for the children to interpret the colored bar rather then recognizing the numbers. The score bar is shown in Figure 3.12.

In each game the score bar is filled after passing each question in each level, and when the bar is completed, the letter in this game is marked to be accomplished and animating fireworks appear to the child encouraging him/her to go play another game or another letter. The score bar does not get decreased upon wrong answers nor using hints as recommended by the teachers.

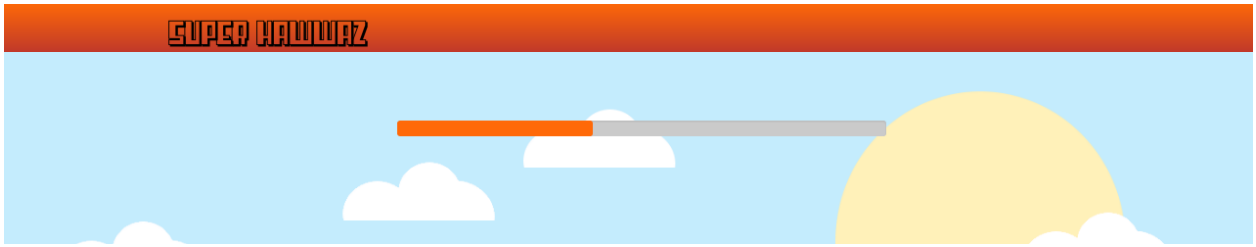

Figure 3.12: Score Bar used in Super Hawwaz.

3.5.6 Auditory material

Super Hawwaz depends on teaching the LD children the Arabic alphabet using multi-sensory material. Which means that the platform includes visual, as well as auditory material to promote the learning process for the children, as they need to learn the sounds of the letters and words along with their shapes.

Accordingly, whenever the child clicks on any card in any game, a female friendly voice reads the word in an Arabic clear and slow manner so that the child connects the object with its letter and word's sound. Auditory material are also used in hints, as in any game there is a star shape, when clicked, the same voice over gives the child a hint about the correct answer.

Feedback used in the platform is mainly used in an auditory manner. Cheering, and other encouraging sounds play whenever the child answers a question correctly or passes a level. By the end of each battle, a congratulating sound plays and a screen showing the played letter with fireworks visual gesture is displayed to encourage the children to play more battles and praise their work.

The features of the platform were not designed all at once. We had to go through different feedback sessions with the experts in the field and iterative processes of design and implementation in order to reach a suitable design that is specially made for LD children The next section describes the details of our first visit to one of the main centers specialized in helping children with learning disabilities.

3.6 First Prototype

The first released prototype was tested with **Caritas** Egypt. Caritas is an international confederation that works on helping those who are in need in almost every country of the world. It offers help in many aspects. What we are interested in is the educational support with the children with cognitive or mental disabilities. This is done through **Support, Education, Training for Inclusion (SETI)** center (a sub-project that is executed in Caritas branch in Egypt) [33].

SETI is a community based rehabilitation and consultancy centre that tackles the problems of mental, cognitive, and learning disabilities among children and adolescents. Its main objective is to help the children as well as their families to overcome the disabilities problems educationally, as well as socially [21].

A first prototype was presented to the experts and teachers in the center. The purpose of this visit was to get feedback from the experts in the learning disabilities field there and enhance the different features of the platform according to the needs of the LD children.

The main changes that were made upon the feedback of the experts in the centre were related to the material embedded in the games, they have helped in constructing the syllabus followed by the Montessori method and translating it into the game levels, the details of this transformation are discussed in Section 3.4.

The first prototype used to enforce the child to play the letters in a certain order. However, the teachers have requested to change this feature so that the the child can have the freedom to play any letter in any game according to his/her preference. Also, the prototype used to correct the wrong answer of the child right after the first failing attempt in any game. This was changed, and the rules of the game turned to be that the child cannot pass any level in any game unless he/she answers the question correctly using the help of the hints.

Additionally, the teachers have asked to make the icons and cards representing the material bigger and clearer, along with their request to make the first letter of each learnt word in a different color, an example of this can be shown in Figure 3.2. Another thing to change in the first prototype was the applause encouraging sound played when answering a question correctly. They have commented that it is disturbing as well as distracting for them (unlike the non LD children who liked it). Accordingly, the applause sound was changed with a less distracting cheering sound.

One important aspect to take feedback on was the scoring system. Originally, the scoring system was the normal numbering system used in many games. However, after presenting the first prototype to the experts, they have recommended that the score should be in meters not numbers. This way, children who play the game would understand their performance in a more vivid manner.

One old feature that was implemented in the first prototype was the *"Learning mode"* feature. The learning mode depends on presenting the material to be taught before each

game in a direct way. This means that the letter along with its words and different diacritic signs will be presented in a supervised learning approach before the child gets into the game and solves the questions. Teachers in Caritas have suggested to eliminate this mode and leave the platform to follow the interactive unsupervised learning approach. They claimed that unsupervised learning has a better effect on the learning process of the LD child compared to the normal supervised approach.

According to the platform's features mentioned in Section 3.5, auditory material is used to help the LD children recognize the sound of the Arabic letters and words. The sounds of the Arabic words and letters used in the old prototype were generated using an Arabic text to speech library that is compatible with javascript. After presenting the first prototype to the teachers, they did not encourage the usage of neither the male voice used nor the accent generated by the tool. Accordingly, the auditory material presented in the games were changed to be generated using a female friendly, and clear voice in order to be familiar to the students.

The next section discusses the technology used in implementing the platform, along with the development choices made and the reasons behind them.

3.7 Implementation

3.7.1 Operating Environment

Super Hawwaz is a cross platform Web application that can be played either on personal computers available in the classrooms, or the portable tablets that the child interacts with in many environments.

Investigating the available implementation options, web application was chosen due to its availability, compatibility, and distribution. From a technical point of view, web applications depend only on the browser, and the internet connection to render the application data. They do not have the size constrains that are present in other options like native mobile applications. There is no process for installation, un-installation, nor updating. They remove the device constraints, as a URL can work on any operating system or device.

After going through the previously mentioned features, and going through the objectives, working environment and target group of the experiment. It was clear that a web application choice is the most suitable one. It is easier for the parents to open the link of the game for their children instead of downloading the games on their devices. Moreover, navigation is easier because the teacher or parent does not need any background with the applications, or the installation process, or accounts to open the game for the children. Which is a crucial point in this study, as most of the demographic data collected from the participants shows that the cultural background of the parents is not supported by technical details, nor technological usage. Additionally, web application was also chosen so that it can be available and easy to open in the different nurseries and schools.

3.7.2 Framework

When it comes to web development, there are many choices regarding the framework and the language to use. *Super Hawwaz* was implemented using the well known framework **Ruby On Rails (ROR)**.

Rails is a development tool that is written in a programming language called **Ruby**. Ruby is also the language used to develop using Rails. It is an object oriented language [64]. The main attracting feature about rails is that it provides a well structured framework for the developers to work on. The built in **Model View Controller (MVC)** model saves a lot of complications and redundant tasks. Moreover, the configurations and setup steps for rails are easy to follow which makes the process of building a web application faster.

Ruby On Rails gains its advantage from the availability of the open source codes, and the wide community of Rails. Adding features to a web application that is built upon Ruby on Rails is so easy, and there are many open source ready to use features that can be added up to the application in a flexible manner (gems), which saves the time and effort of building everything from scratch. Also, Ruby libraries are open source which is an edge over most of the other communities. ROR was also chosen because it is suitable for building web applications, as its programmable language is Ruby, which has conventions in the structure that are easy to understand and apply. Finally, ROR is an easy environment to deploy web applications from.

3.7.3 Agile Approach

Implementing *Super Hawwaz* followed the well known software engineering approach called *"The Agile web approach"*. Choosing Ruby on Rails as a framework was beneficial to it as the Rails community copes with the Agile method. Generally, the Agile approach organizes the software engineering process between the client and the developer[5]. In this study, the Agile approach was used to organize the communication between the experts in the learning disabilities field (teachers, psychologists, and doctors) and the developer. This approach was followed because it depends on working iteratively on the product in many cycles in order to enhance it. Abstractly, it starts with a prototype, takes feedback from the targeted audience, enhance the prototype, adapt to the changes, and goes all over again till the best version of the product is reached. The Agile approach also depends on the collaboration between the client and the developer which is what was needed in building *Super Hawwaz*, we went through many phases of prototypes and collected feedback to make the platform's feature suitable for the children as much as possible.

Following the Agile Approach, a first prototype *Super Hawwaz* was implemented at the beginning and presented to the experts in the field, the details of the prototype and the applied changes are discussed in Section 3.6.

3.7.4 Front End

Following the MVC model, the language used in the views to build the interface in *Super Hawwaz* is Hypertext Markup Language (HTML5), along with Javascript and JQuery. HTML5 is widely used for the views in web applications due to its accessibility, easiness, and flexibilty in coding.

HTML5

HTML5 allows the development of dynamic web applications and games. It includes interactive components like animation, and drawing tools like canvas. Accordingly, It was chosen because it suits the nature of *Super Hawwaz*, as the platform is mainly based on game implementation and canvas elements. Additionally, the platform includes many features that requires audio processing, which is easily accessible using HTML5 using the audio tag.

One important feature of HTML5 is that it is cross browser friendly, it supports *Chrome, Firefox, Safari, IE9 and Opera*. This was a crucial point as the game is to be launched in governmental schools. Accordingly, we did not want to put a restriction neither on the device nor on the browser available. Finally, HTML5 is adopted by mobile browsers, so the web applications become mobile ready in a flexible, fast, and easy manner. Since the platform is originally made to be played as an extra curricular activity for the LD children, it was required to be available on small touch screens. HTML5 includes the "view port" feature that allows the developer to create specific sizes and zooming features for different device window sizes. In addition to the full screen browsing availability specially on IOS devices (The games is *Super Hawwaz* can be played iPads), which was helpful from the compatibility perspective [19].

Javascript and JQuery

Javascript and JQuery were used along with HTML5 in the games' implementation. The reason behind choosing Javascript is that it is an object oriented programming language that runs across different browsers and devices, and it is easy to compile. It is suitable for *Super Hawwaz* because it is event based, which was used a lot in implementing the interactive features of the games.

On the technical side, Javascript when used with web applications saves bandwidth on the web server because it is executed on the client's side. Accordingly, it is considered to be fast to the end user [37].

JQuery is a large, easy to use, and various functions enabling library for Javascript. It makes using Javascript easier for the developer to use (comparing to other Javascript

libraries). JQuery has a helpful and wide open source community and plugins. Additionally, it enables using Ajax easily. Ajax is used to perform tasks and do changes to the web page without the need to reload the whole page [39].

To sum up, Javascript and JQuery were used alongside with HTML5 mainly because they all have a wide community and open source helpful material, in addition to the visibility of the code that makes it understandable and descriptive.

After discussing the underlying methodology behind the platform *"Super Hawwaz"*, its features, mechanics, structure, and implementation details. The next step after implementing is evaluating the platform's effect on the children. The next chapter explains in details the experimental design approach, elements, and planning of the evaluation phase. It describes the experimental conditions of the study, the sample selection phase, and other planned methodologies for holding a robust experiment to compare *Super Hawwaz* to the normal instructional mean which is the presentation slides.

Chapter 4

Experimental Design

Based on the literature review, it can be concluded that research does not really call for educational revolution based on games, and it considers it premature to call for this major change in different educational systems. However, recent studies encourage games that are focused on target learning objectives through aligning them with classroom activities [47].

This chapter presents the evaluation and experimental approach that was established to test the effect of using serious games with LD children, in addition to the means used to compare it with one of the traditionally used instructional means, namely the presentation slides.

In addition to trying to prove the effectiveness of serious games in general, or conducting research that claims that games in the implemented platform are beneficial for LD children, this study tries to describe the motivating properties of a successful game. In order to achieve that, the targeted games to be tested in *Super Hawwaz* were designed in a way that fits within the educational program that the LD children belong to. Moreover, it was taken into consideration that studies have shown that the learning outcome is not necessarily related to enjoyment [62]. Accordingly, the learning gain and the enjoyment factors were tested separately.

According to *(Alexander Repenning and Clayton Lewis, 2005)* [62], educational game design always has the limbo of enhancing the engagement factor versus the learning factor. In order to solve this, there exists two approaches that are followed in the design phase of any educational game [47]. The first approach is the "Educational Design" approach. The Educational Design approach puts learning mechanisms prior to engagement mechanism. Unlike the "Game Design" approach that concentrates more on the engagement rather that the educational aspects. In this study, the educational approach was selected, as all the games in *Super Hawwaz* are mainly built based on the educational needs of the LD children not the enjoyability of the game mechanics.

(Richard E.Mayer, 2016) [47]defined three types of game research that can be tackled. These types are :

- **Value added research:** This type of research tries to find out which game feature improves learning better. It is based on comparing the learning outcome of users who play two different versions of the game -one with the feature and one without-, then analyzing the results.
- **Cognitive consequences research:** This type tries to examine the effect of using an off the shelf game on the cognitive behavior of the users. This is done through comparing the learning gain of students who play off the shelf games versus those who are engaged in a control activity.
- **Media comparison research:** This type compares the learning outcome performance of students who learn academic content from a game versus those who learn the same content from other means or conventional media. [47].

The design that is followed in our study is a mixed structure between *"Cognitive consequences research"* and *"Media comparison research"*. As we have tested the learning gain of the LD children who played the off the shelf games included in the platform, and compared it to the normal instructional mean (presntation slides) at the same time. Moreover, this study was interested in testing the enjoyability factor and comparing it in both educational means used.

The experimental design approach that was followed in general is the methodology presented by *(Mohd Khairulnizam, Nor Ashikin, Norizan Diah and Marina Ismail, 2010)* form the faculty of computer science in Universiti Teknologi Mara, Malaysia. This design consists of the following stages: Test Planning, identifying the model to be used, preparing test material, selecting representative sample, defining the ethical issues in recruiting participants, conducting tests, debriefing participants, and finally, analyzing data [17].

The upcoming sections describe in details each stage, how it was applied in the study, and the modifications that were taken into consideration to cope with the nature of the special participants that the study was targeting.

4.1 Test Planning

Some empirical studies about LD children and their needs have shown that serious games can only be used as supplementary means of education, and not to replace the human teacher. Therefore, this model of the evaluation and experiment did not conduct the comparison between human teaching and tutoring through the game.

Instead, the experiment's main objective was to find out whether educational serious games are more motivating for LD children than the normal instructional means (presentation slides), while it is at least as effective with respect to the learning gain of the

LD children or not. Accordingly, the study focused on examining the null hypothesis stating that there is no statistically significant differences in the learning process of these children when they receive two different instructional treatments: The traditional computer assisted instructions, and the serious educational games included in *Super Hawwaz* (Subsection 1.3.3).

The testing model that was used is based on evaluating the educational effectiveness of the gamification factor on LD children. This was done through studying the impact of different types of instructional delivering strategies on the learning achievement of LD children. Hence, we investigated whether serious games can increase the LD child's learning gain or not ,in comparison to the presentation slides. This explains **(H1)** stating that LD children achieve equivalent academic results when they receive two different instructional means(Subsection 1.3.3).

In addition to testing the effect of serious games on the learning gain of the LD children. The study was also interested in testing the effect of using serious games on the enjoyability and engagement level of the students during their learning process. Accordingly, **H2** states that LD children experience the same level of engagement during the learning process when they receive two different instructional means (Subsection 1.3.3).

Consequently, as mentioned in Subsection 1.3.2, the **primary dependent variable** in this case would be he learning gain of LD children. While the **secondary dependent variable** would be the motivation towards playing an educational game (engagement). The **Independent variable** to be examined in this case is the type of learning. Two groups were identified for this variable: Computer assisted instruction using presentation slides, versus the serious games included in the platform.

Both instructional means had the same underlying educational material, and teaching theories, the main difference between them is going to be the "gamification" effect. The normal computer assisted instructional method used is normal presentation slides presenting the material in a normal way, while *Super Hawwaz* (the game) includes game elements such as rewarding system, theme, avatar, and score. The structure of the presentation slides as the instructional mean of the control group is discussed in details is Section 5.1.1.

The comparison of the learning achievement as well as the engagement level of the participants was done through a normal between group study that had both a control and an experimental group. These two groups resembled the computer assisted instruction users and the gamified platform users respectively. This model is discussed in the following section.

4.2 Model Identification

The experiment measured the learning gain as well as the engagement level of the children, and held a comparison between the regular presentation slides material and the

game in terms of the educational effectiveness and enjoyment. One thing to make sure of before holding the experiment was that all the participants should have been familiar with the use of the touch pads.

The model used is a normal *Between Group Design* study that divided the participants into two independent sub-groups of the same number of LD children. Between-group design is an experiment that has two or more groups of subjects each being tested by a different testing factor simultaneously [24]. In this study, the first subgroup used the presentation slides teaching approach, while the second used *Super Hawwaz*, the platform.

The second option we had in the experimental design model was the *Within Subject Design*. Withing subject design depends on exposing every single participant to the different treatments defined in the experiment [24]. This means that we would have had a single group of LD children, expose them all to the slides, test their learning gain. Then, exposing them all to the platform, and testing their learning gain. This model was rejected because it is insufficient to have the participants learning the same material one time after another. This leads to the problem of carryover effects, where the first treatment will influence the other, and we will not be able to compare between them both.

Although it was hard to find participants representing the special target group of the study, between subject design was chosen to be the experimental model because it is an independent experimental design of an educational experiment that should avoid any learning effects happening if the same child was exposed to two different treatments. Accordingly, the targeted participants were either subjected to the platform (treatment group), or the normal presentation slides (control group), but never both.

The disadvantages of this model are the main well known disadvantages of any between subject design like the complexity of finding a large number of participants, the individual variability, assignment bias, and the changing environmental factors [24].

These disadvantages were avoided as much as possible in this study. The individual variability was solved by ensuring the homogeneity of the sample by applying a demographic survey for the children before they were considered as part of the experiment, where the criteria of the participants was described and chosen upon them. The assignment bias was avoided by randomly dividing the LD children into two different groups without assessing any of them before the division process. The changing environmental factors problem was solved by trying as hard as possible to construct a robust research design, and conducting the experiments under the same circumstances.

The upcoming sections explain the environment, circumstances, tools, participants and tests used during the experiment.

4.3 Material Preparing

This phase includes:

- Defining the facilitators.
- Questionnaires Screening (Pre and post).
- Setting the testing environment.
- Identifying the task scenarios for the child to perform for each screen.
- Preparing the observation checklist, if any.

4.3.1 Facilitators

- Number : Two facilitators were present (the tester and the teacher).
- Position : The tester did sit at the back of the class observing and the teacher was closer next to the child.
- Roles : The teacher had to fill the observation forms while assisting the child during the game and making him/her feel at ease. While the tester was present to regulate the session and be there in case of any technical problems.

4.3.2 Questionnaire Screening

The study had the following questionnaires :

1. **Engagement post session questionnaire :** an interview after the session was held with the teacher, the questionnaire contained questions about the subjective inputs that were used to measure the engagement level of each child after interacting with any of the two the instructional means. More details on this questionnaire are present in Section 4.6, and Subsection 5.2.2
2. **Skill-Challenge post task questionnaire :** the teacher was asked to fill a questionnaire consisting of two questions rating the level of skill as well as the level challenge the child found in each level of each game played of the platform. This was done to test the flow of the platform. More details on this questionnaire are present in Section 4.6, and Subsection 5.2.3.

4.3.3 Setting Environment

- Place of the test : At the intervention center, or school of the LD child, in their corresponding special sessions room.
- Devices to be used : A touch pad to play on [1], in addition to a laptop in case of

[1] 9.5 inches iPad2

any technical problems.

- Hard copied observation forms for the teachers.
- Consent forms for the parents.

4.3.4 Task Scenarios

In order to identify the task scenarios, screens that were included in the experiment during each session had to be identified. We had two types of sessions: the sessions held to test *Super Hawwaz*, and the sessions held with the computer assisted mean that we used to compare the platform with (namely the presentation slides). For the platform, the screens included were : Home page, Choosing letter page, Game page (7 different games depending on the session, each game contains 5 levels yet they share the same screen), and the finishing page. Figures 3.10, and 3.11 in Section 3.5.2 show the Home page, and the Choosing Letter page respectively. While the rest of the game pages are present in Section 3.4.

For the presentation slides: The screens included were 5 consecutive screens representing the five levels of learning the Arabic letters the Montesorri way in addition to a slide that includes the letter's shape. More details on the screens of this instructional mean are discussed in Subsection 5.1.1.

4.4 Sample Selection

The sample selection process of the experiment used to select participants who reflect the characteristics of the target audience. In this study, the target audience are children with learning disabilities who have minor background about the Arabic alphabet. They were selected based on the answers of the demographic survey held with their teachers about the academic stage, age, and disability case.

Information about the study was sent to the correct places where we expected to find LD children. These places were different early intervention centers, or schools specialized in the learning disabilities in Egypt. These centers are specially built for LD and special needs children, they include different professional profiles such as teachers, admin people and psychologists who are there to help the LD children. Permissions from the participants' parents were seeked whenever we got in contact with them through the teachers. The children participating in the experiment were reached through contacting the previously mentioned kind of centers, nurseries and schools.

According to [17], performing many tests with a small number of participants could be more effective than performing shallow tests with a huge number of them. Thus, due to the lack of the availability of LD children who are diagnosed in this age, we did stick

to a limited number of participants (a total of 36 LD children), yet the platform was tested with them extensively (deeper not wider). Supporting that, there was a similar study that has conducted a similar experiment on a small number of children as a proof of concept [20]. Additionally, the reliability of the results was ensured by choosing a test analysis design that fits with small sample number (mentioned in Chapter 5).

The children were selected based on the academic level they have reached with their shadow teachers in the Arabic alphabet. One thing to mention here is that the age range of the participants did not matter as much as their academic phase. This is due to the fact that different levels of severeness can be found among LD children. For example, a six years old child can be placed in the same academic phase with an eight years old one. In this study, most of the participants age ranged between six to nine years old. Whenever we made sure that the targeted child's case is suitable, we started performing the experiment, after seeking permissions from their parents and teachers.

4.5 Ethical Aspect

The procedures that were taken into consideration regarding the ethical aspect can be listed as follows:

- Having the confirmation from the children's parents or teachers.
- Carefully explaining the goal of the study to them prior to the experiment.
- Scheduling breaks in the session so that the child does not feel frustrated.
- Video recording the sessions if the parent asked to (in order to guarantee safety).
- Scheduling prior visits to the children in the center in order to build good relationships with the participants and guarantee that the sessions are friendly enough.
- Preparing enjoyable activities -with and without computers- as a warm up before the session.

4.6 Test Conduction

In this section, the different types of conducted tests during the experiment, as well as the reasons behind holding them are presented. However, the structure and the actual content of the tests that were held are discussed in the testing chapter (Chapter 5).

This study conducted three main test types, these types are mentioned in the following subsections.

4.6.1 Learning Gain Test

The idea behind this test is to assess the academic level of the child in the Arabic Alphabet before and after using their perspective educational mean (the pre and post tests). By comparing the results of both tests we can calculate the learning gain of the child, and conclude whether each mean has affected the child's learning achievement level or not. Afterwards, the learning gain of each group is calculated separately. Then, the learning gain of both groups is compared to see which group achieved better academic results among the children.

Because the participants' performance in this pre-test was compared to their performance in a post-test that was given to them after the usage of the respective software. The post-test was decided to be identical to the pre-test to ensure that it was at the same level of difficulty and structure.

This comparison between the results of the participants in the pre and post tests allowed us to calculate the level of improvement that happened to the students in the two groups. By comparing the level of improvement of the two groups we were able to draw conclusions about the educational effectiveness of the serious game versus the regular teaching method using presentation slides. This test examines**(H1)** that aims at comparing between the learning achievement of the LD children being exposed to the serious games in the platform versus the normal presentation slides (Section 4.1).

4.6.2 Engagement Test

Many studies nowadays are stressing on the fact that using the motivating aspects of serious games in general can be harnessed to facilitate learning for children. Exploring how motivational components of popular off the shelf games (specially for LD children) is one of the main goals of this study.

This study is comparing between the involvement or engagement level of the LD children while receiving the educational content using serious games versus the normal instructional means **(H2)** (Section 4.1).

Thus, a test that aims at measuring the engagement level of the LD children being exposed to different learning means was held through using a **Likert Scale** survey that measures the overall flow experience that the participants have gone through by being exposed to both means.

The Likert Scale is a five (or seven) point scale that is used to rate the agreement or disagreement of the participant with a particular statement, or question. This approach is widely used in subjective research topics (specially usability related studies) [31].

The Likert Scale survey used in our study is a standardized questionnaire that is generally used to test the engagement level or the overall flow state that the user experiences

Figure 4.1: Smileyometer Example [73].

during performing any activity. It depends on asking the user a set of questions that determine many aspects regarding how amused, in control, and engaged the user was during the activity. In our study, the questions were presented to the teachers of the LD children right after the session of the child (whether it was the platform or the slides). By comparing the results of these Likert scale questions on both groups, conclusions had been drawn about the engagement factor of LD children using different educational means. The exact details of the test are mentioned in Section 5.2.2.

There were many options regarding the way the children answer the Likert scale questions in the engagement test. One of them is using the *"Smilyometer"* and letting the child answer the question on his/her own. Another option was to use the *Visual Analogue Scale (VAS)*. Both options were rejected and it has been decided that the teachers are the ones to answer the survey questions. The reasons behind rejecting each option are discussed in the following parts of this section.

Smileyometer

The Smileyometer is a way that substitutes the different possible answers on a Likert scale with images of smiley faces to make the answers more clear, visualized, and recognizable for the children than the verbal ones (See Figure 4.1).

[73] is a study that was evaluating the effectiveness of using the Smileyometer to measure fun and enjoyment of children going through a certain activity. The experiment took place in a science educational museum in Netherlands, it aimed at raising the cultural and educational knowledge of the kids in an engaging way. This was achieved through having quests along the museum tour that the children interacted with on touch tables.

The results of the study showed that the Smileyometer did not manage to solve the problem of the children reporting extreme answers on any scale. However, it was reported that younger children give higher ratings. Which has lead us to eliminate the Smileyometer as an option to measure the engagement of the LD children in our study, specially that they are young and they suffer from lower levels of self-evaluation and self-reporting abilities.

Visual Analogue Scale

The other option was to use the VAS. It also uses pictorial representations at the beginning and at the end of a visual scale for the children to express how they feel about

different things. It is mostly used in clinical research to assess the level of pain for the children as well as adults. According to [61], using VAS with young children in evaluating software products is not reliable as the tend to pick the highest score on the scale like the Smileyometer. Hence, VAS was also eliminated from our study as an option to take the children's opinion.

To sum up, collecting subjective measurements from children using the normal self-reporting ratings is a hard option to go with specially with LD children. Such ratings need the child to have an acceptable level of self-regulation, attention control, self-monitoring and evaluation, which is not the case with the target group in our study.

Accordingly, it was decided that the shadow teachers who attended the sessions with the children are the ones who are going to rate their control as well as enjoyment level for them. This choice is based on the previous studies that has shown that children are more biased towards selecting the extremes of a Likert scale, regardless of how they really feel. In addition to the fact that the teachers of the LD children are qualified to know about their impression from their facial expressions, body language, and many other signs.

Human tutors were present during the experiment and they were asked to observe their students while they interact with the game, and fill in the survey that rates the flow of the platform through measuring the control as well as the enjoyment level of the child playing the game. Moreover, a post interview with the teacher was held after each game where they get to express how did they evaluate the child with each game.

4.6.3 Flow Analysis Test

The previous section discussed the test that was used to compare between the engagement of both groups in the experiment (The group that used the game versus the group that used the presentation slides). It is a standardized test that can be used to any activity. It was held to prove or disprove the hypothesis stating that LD children experience the same level of engagement during the learning process when they receive two different instructional means **(H2)**.

An extra test was held to analyse the flow of the platform *"Super Hawwaz"* without comparing it to the normal computer assisted mean. This was done in order to have detailed analysis about the acceptance of the LD children for each game in the platform separately. Also, it was used to understand the changes that happen to the LD children during the learning process.

According to *(Jeanne Nakamura and Mihaly Csikszentmihalyi, 2014)* [54], flow is a model that describes how absorbed or engaged the user in any activity. They defined the flow as *" The holistic sensation that people feel when they can act with total involvement."*. Relating this definition to the aim of our study, It was important to experiment

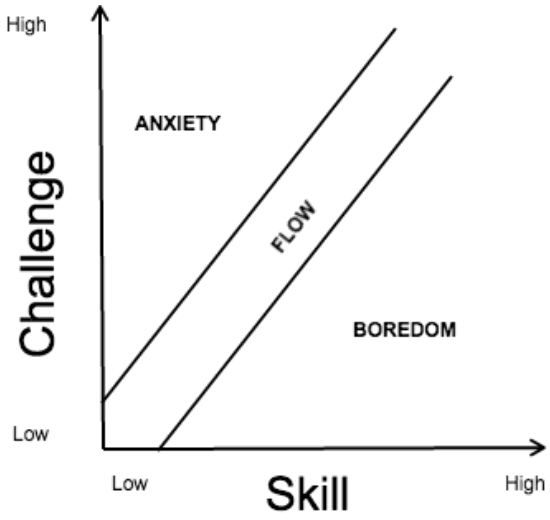

Figure 4.2: Flow Channel [54].

how engaged LD children are when it comes to holding an educational activity for them through a serious game.

There are many models describing flow. Many studies have used Csikszentmihalyi's representation of flow as a channel on a plot of the level of challenge that the users have found in an activity versus their own rating of their skill at the same activity. Figure 4.2 explains this relation between them in a vivid manner.

As shown in the figure, flow is present in an activity where there exists a balance between the challenge and the skill (the ratio between them is 1:1). If the challenge is higher than the skill, the user will experience anxiety. On the other hand, if the skill is higher than the challenge of the activity, the user will suffer from boredom. These are the basic two states that were defined at the beginning. Afterwards, the model was improved to include up to 16 different states that the user can experience during an activity [54]. In this study, we are focusing on the "Challenge-Skill" measurement as it was described as *" the most meaningful reference point for the presence or absence of the flow "*, *(Massimini and Carli, 1988)*[46].

Since flow is achieved by balancing the challenge level of the activity with the skill level of the activity performer. Some studies suggest testing it more than once throught the activity. According to [73], flow is considered to be more of a continuous process rather than a final state. Which means that it is important to monitor how the flow experienced by the user is changed throughout the activity, not just how the user felt after the last moment of activity. A study by *(Van der Sluis F., Van Dijk E. and Perloy L., 2012)* was held in order to monitor the continuous process of flow of an online learning activity. The study's main aim was to hold a comparison between the final flow state measurement and the continuous flow measurement throughout the activity. In addition to giving an insight about the *"Skill-Challenge"* changing behavior of the different types of online learners' and its relation with their learning outcome[73].

The experimental data and the analysed results of this study has shown that flow is better to be considered as a continuous process not a final state. Although the analysis has revealed some consistencies and inconsistencies between the two types of measurements, and it was hard to find a link between them both, it was concluded that both representations can be regarded as useful tools for drawing conclusions about the learning process of online learners.

Accordingly, a continuous flow process test was held with those who were assigned to *Super Hawwaz* as their learning mean. This test was held by monitoring the skill and challenge levels of the children during each level of each game in the platform. As for the final flow sate measurement, it was already achieved through the previously mentioned engagemnt test (Section 4.6.2).

The details of the design as well as the procedures of the flow process test are mentioned in section5.2.3.

4.6.4 Tests distribution

This is the last stage of the test conduction phase in our experimental design approach. The learning gain tests were distributed twice. One time before using the respective version of educational software, (this was an ordinary pre-test in the material embedded in the game), and the second time after being exposed to the learning mean(post-test).

After holding the experiment, the post-test was given to the children after the usage of the respective software (either *Super Hawwaz* or the presentation slides). The post test was identical to the pre-test in order to ensure that they were both at the same level of difficulty, and had the same structure. This test distribution manner was held in order to test the learning gain of both groups.

For the engagement test, the 9-items Likert scale survey was distributed to the teachers after the experiment was done with the child through the respective software. This was done i order to be able to decide which of the two groups enjoyed their learning mean more.

For the continuous flow test, another questionnaire was filled after each level of each game in order to be able to measure the flow process, but this happened only for the *Super Hawwaz* experimental group. this test is explained in Section 5.2.3.

4.7 Debriefing Participants

Going back to the experimental Design phases. Debriefing participants comes after holding the tests with them. This phase includes taking feedback notes from the children and the teachers on how they felt about the game after performing the test. This was

done through an interview with the child if he/she is old enough to express their feelings. It was quantified by analysing the observational checklists handled to the teachers during the experiment. According to [40] and [4], the observational checklists has proven to be a successful way to reflect the feelings of the child during holding the usability tests.

4.8 Data Analysis

The last step of any experimental design approach is analysing data. Data collected from the distributed tests were analyzed in order to have an overview about the effectiveness as well as the usability of the games included in the platform.

This was achieved through using two software statistical analysis programs:

1. **Statistical Package for the Social Sciences (SPSS) :** It is a statistical analysis software that is widely known and used to hold tests about within-subject as well as between-group design tests [35]. It can be used to examine main and potential effects of categorical variables on multiple dependent variables. In this study, Statistical Package for Social Science (SPSS) was mainly used to hold the independent t-tests that were used to accept or reject the Hypotheses of the study. More details on how this test was used are mentioned in Section 5.3.

2. **R:** It is a language that is used for statistical analysis and graphical techniques, it includes classical analysis as well as clustering models and many other options. In this study, it was used due to its strength point of the well-designed plots and graphs that can be produced and visualized. All the graphs and plots used in this study were produced using it[70].

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Chapter 5

Testing

This chapter illustrates the test conduction analogy. First, it discusses in details the material embedded in the traditional computer assisted instructional mean that we used to compare the platform with (presentation slides). Also, it describes the structure of the pre-tests and post-tests used during the experiment. Then, it holds a comparison between the structure of the games, the slides, and the tests that were held in order to ensure the presence of the homogeneity factor in the experiment, and that all the variables were unified except for the gamification one, in order to increase the reliability of the results.

Additionally, it discusses the actual procedure taken to apply the strategies of the experimental design model that were discussed in Chapter 4. The detailed design and structure of tests held along with the procedure taken with the participants during each test are also described.

Finally, the chapter explains the statistical data analysis test types of the tests held in the experiment, along with the reasons they were chosen for.

5.1 Testing Homogeneity

The aim of this section is to explain how was the homogeneity of the experiment achieved. This was done through structuring the material embedded in the two different types of instructional means, as well as the learning tests in an equivalent manner so that the only changing factor between the two groups be the gamification effect.

The first subsection (Subsection 5.1.1) explains the material embedded in the presentation slides. The second subsection explains the material included in the tests that were used to test the instructional means. Finally, the last subsection holds a comparison between the three structures: The game, the slides, and the tests, to give an insight about the compatibility of these three aspects of the experiments.

The material embedded in *Super Hawwaz* was discussed in details in Section 3.4.

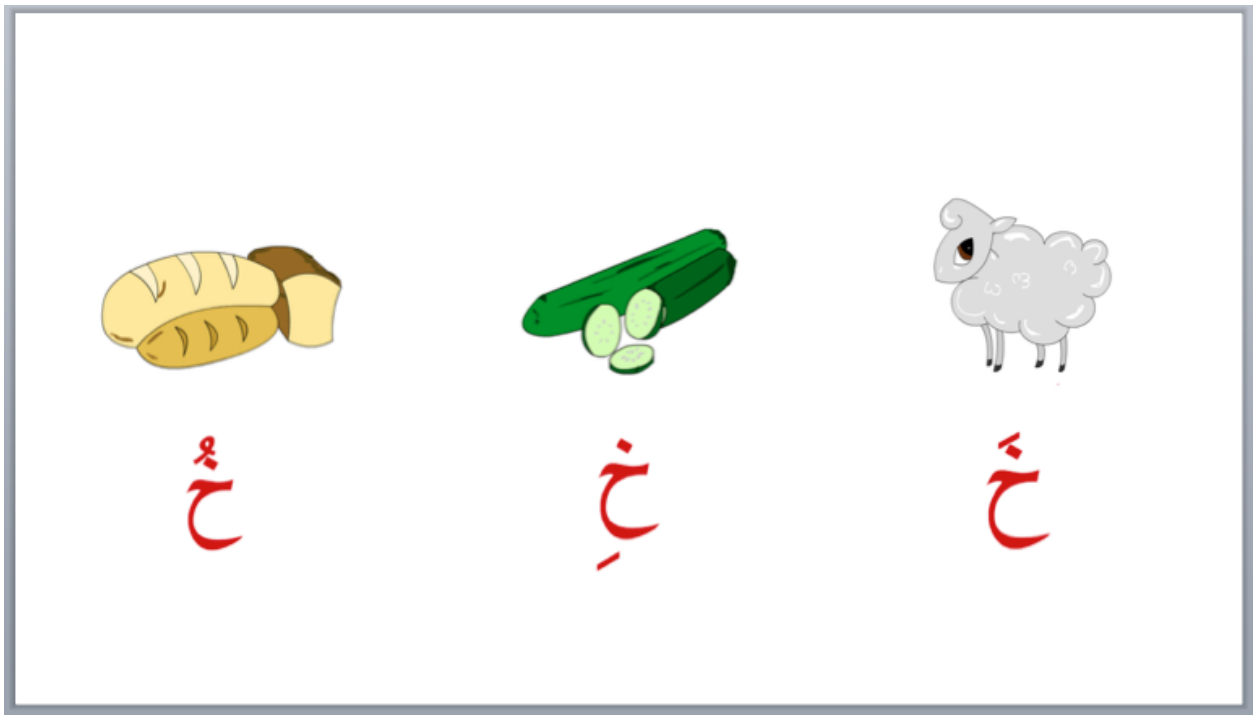

Figure 5.1: Presentation slides example (Level 5)

5.1.1 Computer Assisted Mean Material

In order to make sure that that the computer assisted mean had an equivalent content comparing to the material presented by the platform, the presentation slides were designed in a fashion that is identical to the games structure, following the Montesorri syllabus.

The platform consists of seven games, six of them are content-identical games presenting three different words starting with each Arabic letter, along with three diacritic signs. The remaining game is a painting game for the writing deficit. Each game consists of five different levels organized from the easiest to the hardest representing the different phases of learning a word with its diacritic sign. The different phases of learning the Arabic letters in Montesorri are present in Section 3.2. While the different game levels in the platform are listed in details in Section 3.4.

Accordingly, the presentation slides for each letter contained five different slides representing the five different stages of learning the Montesorri way. Each slide is almost identical to each level in the games, except that the material is represented in an informative way, rather than a questioning one (like the one used with the platform). Figure 5.1 shows an example of the of one of the slides representing the fifth level of the Montesorri syllabus (which is recognizing the diacritic signs).

The slides are repeated six times in order to make sure the children in different groups get the same amount of material repetition (since the group playing through the platform

will be exposed to six content-identical games), to make the only changing factor the gamification one. As for the writing game, it was equated in the presentation slides by including a slide with the shape of the letter and asking the child to follow it in order to recognize how to write the letter. The material embedded in the slides was in the cards fashion explained in Subsection 3.2 and present in Figure 3.2. Moreover, the same auditory material that was used with *Super Hawwaz* was also used in the slides to make sure that the platform does not have any edge on the slides other than the game elements.

The process of designing the instructional mean material was similar to the process that took place during planning the design of the material embedded in *Super Hawwaz*. The computer assisted mean (presentation slides) material was designed with the help of the input of the experts, and shadow teachers in the targeted early intervention centres for learning disabilities. The teachers have approved the equivalency between these two instructional means. Accordingly, we have approved the homogeneity level of the experiment, specially regarding the learning gain aspect.

5.1.2 Pre and Post Tests Material

The pre and post tests were used to assess the learning gain of the LD children being exposed to the different instructional means (Subsection 4.6.1). The pre and post tests were identical in order to be able to measure the learning gain and assess the knowledge of the participants correctly. The vocabulary learning measurement test that was used in this study is adapted from *Kaufman Test of Educational Achievement, Woodcock Reading Mastery Test* [22].

The test is basically a hard copied multiple choice exam on a single letter of the Arabic alphabet (the letter to be presented either on the game or on the slides). Each exam consists of four sections divided as follows:

- The first three sections are identical ones testing the three different words starting with this letter but with different diacritic signs. Each section starts with an image of the object starting with this letter and followed by four different MCQs asking about the object and its diacritic sign from the easiest to the hardest. These questions typically resemble the content of the different difficulty levels presented in the game as well as the presentation slides. All of them are compatible with the well-known five stages of Montessorri syllabus illustrated in Section 3.2. One remarkable note here is that they are only four questions asking about the five stages of Montessori syllabus because the first level is all about recognizing the image of the object to be asked about, which was done orally with the child during the experiment, and almost all the participants succeeded in it. Figure 5.2 shows an example of the four sections regarding one word starting with one of the Arabic alphabet letters.

- The last and fourth section is tackling the writing ability, as an assessment of the writing deficit to be equivalent to the painting game, and the writing slide. This

section contains an image of the letter and the child is asked to follow it like the connecting dots game and trace it with a pencil.

This collectively ends up with thirteen questions per test for each letter.

The process of designing the tests was similar to the process that took place during planning the material embedded in the two tested instructional means. The tests were designed with the help of the input of the experts, and shadow teachers in the field. The teachers have approved the equivalency between the tests and the two instructional means. Accordingly, we have approved the homogeneity level of the experiment that tested the learning gain of the participants.

The pre-test was given to the children prior to the experiment, whether the game or the slides. Then, an identical copy of the same test was given right after the experiment was held on the same letter. Participants were given ten minutes to answer the test with no help from the teacher unless there was a problem understanding the question itself. More details about the procedure itself are described in (Section 5.2.1).

5.1.3 Material Comparison

This section presents a comparison between the material embedded in each instructional mean used in the experiment, namely the platform versus the presentation slides. Along with the way they were equated with the original material of the curriculum chosen (the Montessori syllabus five stages of learning a letter in Section 3.2). Moreover, the equivalent pre and post test sections evaluating each stage of the five stages.

The aim of this comparison is proving that the educational material was relevant to the curriculum in all means of teaching as well as evaluation. Accordingly, making sure that the only changing factor in the experiment was the gamification one. The comparison is shown in Table 5.1.

The rows of the comparison table represent the five stages or levels of learning an Arabic alphabet letter, and its diacritic signs, along with an example of each sign represented in an object or a word. Each row in the table represents one of these levels ascending from the easiest to the hardest as defined by the Montesorri syllabus.

The columns in the table (from left to right) represent the Montesorri syllabus structure, then the equivalent levels of the games implemented in *Super hawwaz* as our first instructional mean, then the compatible presentation slides as the second mean. The last column in the table represents the five items represented in each section of the pre and post tests presented to the participants to evaluate their learning achievement.

The upcoming section presents the exact design of the tests used to compare between the two instructional means, along with the testing procedure that took place during the experiment.

Equating Learning Material				
Learning Stages or Levels	**Montessori**	**Super Hawwaz**	**Presentation Slides**	**Pre/Post Tests**
Level 1	Recognizing an object.	Matching two identical objects and their names.	Images of the objects presented	Asking the child about the objects' names given their images
Level 2	Recognizing the letter that the object starts with.	Recognizing a word of an object given its image.	Letter presented along with audio	Choosing the letter that the presented object starts with.
Level 3	Recognizing the word of the object among different words starting with different letters.	Matching letter with the words it starts with.	Each object presented along with its word.	Choosing the word of the presented object among words starting with different letters.
Level 4	Recognizing the word of the object among different words starting with the same letter.	Matching letter with the images of the objects it starts with.	All words starting with the same letter presented along with audio	Choosing the word of the presented object among words starting with the same letter.
Level 5	Recognizing the diacritic sign of the letter that the object starts with.	Distinguishing between different words starting with the same letter but with different diacritics.	Objects are presented along with audio and diacritic signs.	Choosing the diacritic sign of the letter of the presented object.

Table 5.1: A Comparison between the Material of the Curriculum, Instructional Methods, and Tests of the Five Levels of Learning an Arabic Letter

5.2 Tests Design and Procedure

As mentioned previously, the null hypothesis of this study states that: *"There is no statistically significant differences in LD children's learning process when they receive two different instructional treatments: traditional computer assisted instruction; and a serious game"*. Trying to prove or disprove this hypothesis, an experiment was held on a number of LD children with the characteristics mentioned in Section 4.4 as a sample for both treatment types (the game and the slides).

Target population of thirty six children with learning disabilities from Egypt were randomly assigned into two groups (control group: n=18, and experimental group: n=18).

5.2.1 Learning Gain Test

Design

The first hypothesis of this study **(H1)** claims that LD children achieve equivalent academic results when they receive the two different instructional means.

In order to prove or disprove this hypothesis, pre and post tests that evaluate the material that the child has learnt were designed. The pre and post learning gain tests were held to test the learning achievement of the children before and after their perscpective treatment. Subsection 4.6.1 describes the idea of the test, while Subsection 5.1.2 describes the design of the test in details. The upcoming subsection will explain the procedures taken to hold the test.

By designing the pre and post tests to be the same, the dependent variable (which is the improvement level or the learning gain) was easily tested. The learning gain was calculated by subtracting the number of correct answers (out of thirteen) that the participant got in the pre-test from the number of correct answers received in the post-test. Positive values indicated an improvement in the knowledge of this letter, negative values indicated decaying in the letter knowledge, and zero values indicated no improvement. The higher the value is, the more knowledge the participant has learned from the material presented during the experiment.

Procedure

Each participant participated in three instructional sessions. One for the pre-test, one for the instructional method (whether for the slides or the game), and the last one for the post test. Estimates were calculated such that each session of the tests would take five to ten minutes, as for the experiment itself it would take twenty to thirty minutes (according to the child), for a total of forty-five to fifty minutes with breaks between the sessions.

In the first session, the participants were given the pre-test described previously on the chosen letter and were asked to solve it without help.

In the second session, the control group received presentation slides about the letter to be tested. While the experimental group was asked to play *"Super Hawwaz"*, our platform.

In the third session, the participants were required to take the posttest quiz to allow assessing their learning achievement on the chosen letter. They were also asked to solve it without help.

5.2.2 Engagement Test

The second hypothesis of this study **(H2)** claims that LD children experience the same level of engagement during the learning process when they receive the two different instructional means.

In order to prove or disprove this, an engagement test was held for the LD children on both means of learning groups (the game as well as the presentation slides) and the results of both tests were compared. Subsection 4.6.1 describes the idea of the test, while the upcoming subsection will explain the design as well as the procedures taken to hold the test.

Design

The test is a five Likert scale questionnaire inherited from *(Trevino and Webster, 1992)* [72]. The questionnaire consists of 9 items (listed in Appendix A) that measure the overall flow of any activity through measuring three factors: Control, enjoyment, and engagement, the background and the overall idea of this test were described in Subsection 4.6.2. This subsection describes the details of the survey used.

The test that was held was a five points Likert scale survey that consisted of 9-items (questions). It measures the overall flow of of any activity through asking the user different questions rating their level of enjoyment and percieved control felt during the activity. Flow is one of the engagement states that the child faces during interacting with any activity.

According to [58] and other previous studies *(Trevino and Webster, 1992) [72]*, this survey can be used to give an indication about the flow of the game played in general. The survey originally consisted of eleven items testing the engagement, enjoyment, and perceived control in the form of five-Likert-scale questions asked to the player after holding the activity. However, after applying principal component analysis on the eleven items, it has been concluded that measuring control and enjoyment through only nine of these items would give a reliable over-all state measurement about the flow (which is the final state of absorption and engagement of the activity). Thus, two of the eleven items were

dropped because they did not load clearly neither on enjoyment nor on control. Which has resulted into only 9 items (Listed in Appendix A). According to [58], removing any other factors would not have improved the results.

To sum up, the survey items scores about the control and enjoyment can be summed to produce a value representing the final flow state of any learning activity. Thus, applying this test on the participants from different groups of the different instructional means can give insights about how engaging each educational mean was for the LD children.

Procedure

The procedure of the test went as follows: A hard copy of the questionnaire with the 9 questions and 5 possible Likert scale answers for each question was handled to the shadow teachers right after the session of the LD child. They were asked to fill it according to their observations for their students while interacting with the different learning means. The reason behind choosing the teachers to fill the survey is mentioned in Section 4.6.

This test was used both with the group of children who played the game as well as the group of children who used the presentation slides as the learning mean. By comparing the results of both, we had concluded which learning mean was more amusing for the LD children.

5.2.3 Process Flow Test

In this study, we have conducted two types of engagement tests: the previously described overall engagement and flow state questionnaire that was held to compare between both types of treatments (the games and the slides), and the test that measured the flow that the participants who played *Super Hawwaz* have experienced throughout the playing sessions of the five different levels in each of the seven games, the idea of this test and the background are mentioned in details in Subsection 4.6.3. We were aiming at evaluating the flow of the each game in the platform by monitoring the changing ratings of the skill, challenge and behaviour of the LD children playing with it as a process not a final overall experience.

Design

Flow can be measured by many methods like surveys, post-questionnaires, and self-reporting software applications. It can be measured as an overall state or as a process. An over-all state measure of flow means measuring the entire experience of the user once right after exposing him/her to the activity. This final state can be reached using the well known Likert scale questionnaires that rate the factors of the flow (like engagement, control, and enjoyment) through asking many different questions to the users about their overall experience.

On the other hand, measuring flow as a process requires the users to rate their perception about the level of challenge as well as how well they were skilled during different points or phases of a single activity. The questions to be answered in such case are two Likert scale direct questions rating the skill versus the challenge as shown in Figure 5.3.

In this study, we have conducted both tests. The overall state questionnaire (introduced by *Trevino and Webster* [72]). This test was used in order to prove or disprove **H2**, it was held with both groups. The questionnaire in this case tested the final flow or the engagement level of the LD children being exposed to different educational activities.

The continuous flow process measurement test was only held with the platform experimental group with the purpose of monitoring the changing behaviour of the LD child while playing with the platform. Such type of tests gives insights about the difficulty of the different levels designed in the platform and described in Chapter 3. Moreover, it was a good opportunity to compare the flow of the seven different games included in the platform, in order to measure the usability of each.

Procedure

The procedure of this test in our study worked as follows: During the session of the LD child playing through *Super Hawwaz*, the shadow teacher was asked to rate the skill versus the challenge of the child after each level of the five levels in each game of the seven games. The reason behind choosing the teachers to fill the survey is mentioned in Section 4.6.

Two five Likert scale questions were presented to the human tutors of the child to answer. The first question is asking the teacher to rate the challenge or the level of the difficulty of the activity relative to the child, and the second one asking about the rating of how skilled did the child feel going through the same activity (Figure 5.3). This has taken place during the session after each level of the five levels in each game of the seven games. Which gives a total of (5x7 = 35) items per participant. The detailed results of this test are discussed in Section 6.3.

Figure 5.4 represents the complete procedure followed during the experiment for both groups. The experiment started by handling the pre-test of the learning gain to the participant. Then, the participant is exposed either to *Super Hawwaz* or the normal computer based instructional mean (presentation slides), according to the group the participant is assigned to. Both means are equated as described in Subection 5.1.3. After interacting with the instructional mean, the post-test is handled to the participant to solve in order to calculate the learning gain. After that, the tutor is asked to fill the engagement survey consisting of the nine items measuring the control and enjoyment levels of the child (the survey is discussed in Subsection 5.2.2).

An extra step in the experimental procedure takes place only if the participant is assigned to the game group. This step is filling the two items flow test questionnaire

(discussed in Subsection 5.2.3). This survey is filled by the tutor during the session. The two items were filled after each level of each game in the platform.

The next section discusses the data analyses test types used to analyze the data collected from the tests held during the experiment.

5.3 Statistical Data Analysis Test types

There are different testing types that were used in this study. Different data analysis approaches took place according to the type and the nature of the different tests being held.

5.3.1 Learning Gain Test Analysis

For testing the learning gain of both groups and comparing them, data was collected to be analyzed on Statistical Package for the Social Sciences (SPSS) in order to have an understanding about the effectiveness of the game. This has been achieved through holding an independent sample t-test between the two groups: the one that played the game, and the one that was exposed to the presentation slides.

Independent t-test

An independent t-test was held between the two groups in order to compare between the learning gain of the two groups.

Independent-samples t-test is a statistical test that compares the means between two unrelated groups on the same continuous dependent variable, and tells whether there exists a significant difference between them or not [24]. In our case, the independent t-test has been used to understand whether the learning gain of the LD children differed based on the mean they received the material on or not. The dependent variable in this case was the learning achievement of the LD children, and our independent variable was the instructional mean they learnt through, which has two groups: "game" and "computer assisted instruction (presentation slides)". The dependent variable was tested by subtracting the pre-test score from the post-test score as mentioned in Section 5.2.1.

This test has been chosen because it is a between group design model where the two groups are randomly selected and the two different treatments are not applied on the same sample. Additionally, it compares the means between two different samples, and it is easy to conduct. Other tests were an option to conduct like the Analysis of Variance (ANOVA) test. However, it was not used because we only had two groups to compare their means. It is necessary to use the ANOVA test when the design of a study has more than two conditions to compare, which is not the case in this study.

5.3.2 Engagement Test Analysis

An SPSS independent test was also used for analyzing the Likert scale data collected from the 9-items engagement questionnaire that was held on both groups in order to compare between the engagement level of the children exposed to the two different activities (mentioned in Subsection 5.2.2).

The independent t-test in this case investigates whether the engagement level of the LD children differed based on the mean they received the material on. The dependent variable in this case was the engagement level of the LD children, and the independent variable was the instructional mean they learnt through, which has two groups: "game" and "computer assisted instruction (presentation slides)".

The dependent variable was tested by merging all the questionnaire items in one variable, this was done by calculating the mean of all items of the questionnaire to represent the final flow state. One remark on this test was that the 9 items are separated as follows: two items representing the control level, and the rest seven items representing the enjoyment level. Which after all gives an indication about the final flow state of the game or the slides. This can successfully test the engagement because flow is defined to be the state of engagement and absorption of any activity [54].

5.3.3 Platform Flow Test Analysis

For the separate flow test that was held for measuring the skill versus the challenge of each level in each game for the participants, **"R"** [1] was used to draw graphs that show the skill changing behaviour as well as the challenge changing behaviour throughout the time line of the five levels of each game. The graphs are present in the results chapter (Chapter 6). This sums up to seven graphs showing how the skill and the challenge evolved when the children played the different games.

Another representation was conducted also using **R**'s well known library *"ggplot2"* [70], this representation was mainly concerned with displaying the total flow state of each game instead of showing the challenge and the skill separately. Referring to [58], the overall engagement of any activity can be tested by calculating how far from the flow channel was the activity at its different points. The "from-flow distance" can be calculated using the following equation that was inherited from *(Pearce et.al, 2005)* [58]:

$$From - FlowDistance = 0.25x(Skill - Challenge)$$

This representation of the data is easier to digest as we can conclude how far was the game from achieving the required flow level. The graphs and results of this test are mentioned in details in Section 6.3.

The upcoming chapter discusses in the results of each one of these tests separately, as well the conclusion drawn form the data analysis process as a whole.

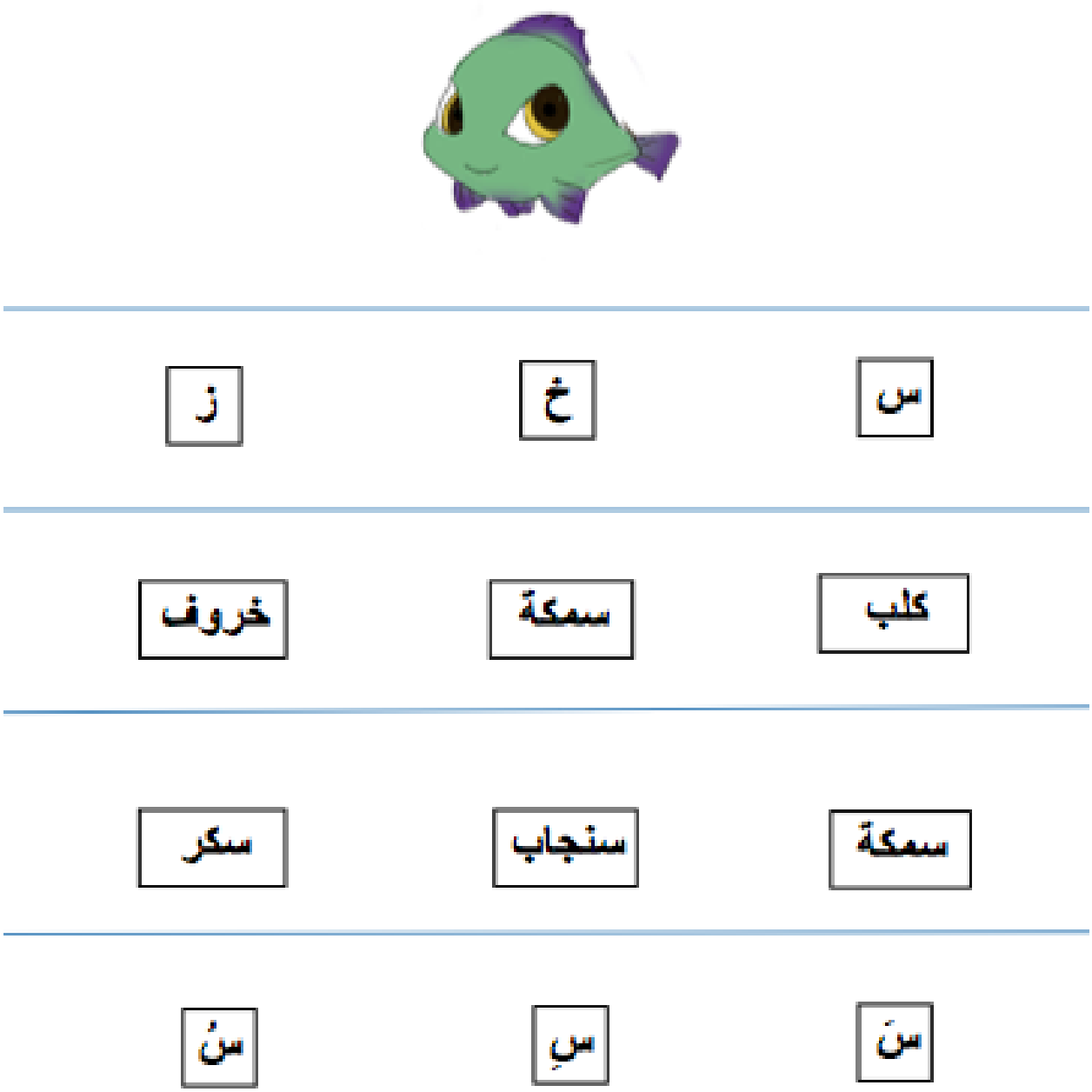

Figure 5.2: Pre-Post test example

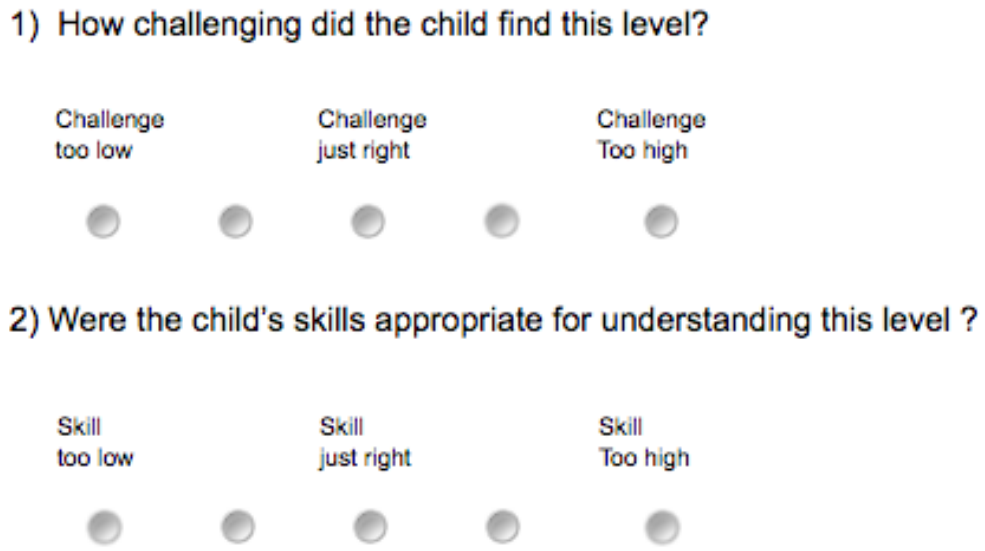

Figure 5.3: Skill-Challenge survey questions

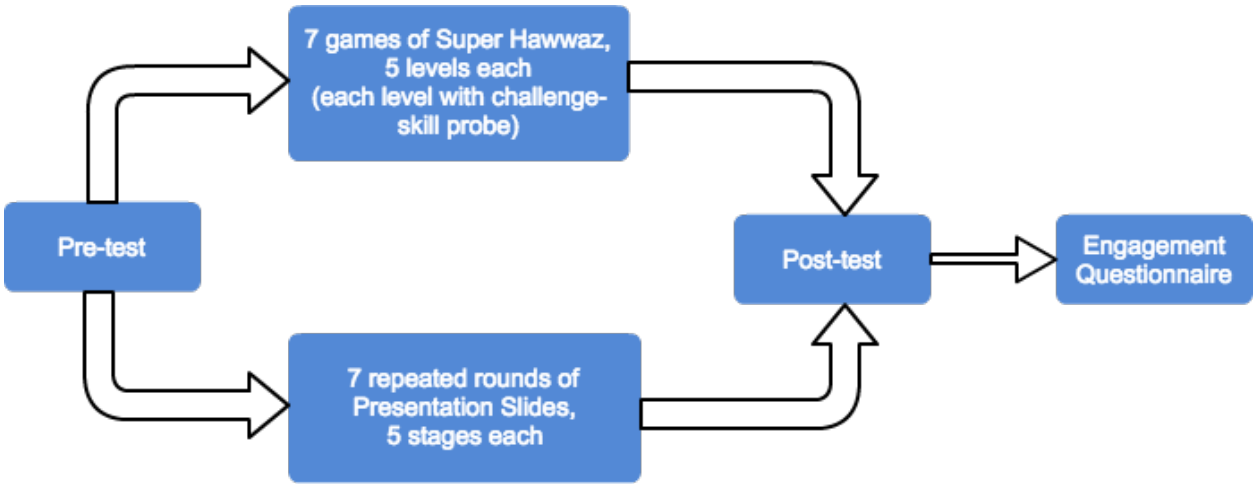

Figure 5.4: Experimental procedure

Chapter 6

Results

The results of all the tests that have been held during the experiment are reported in details in the following sections. The tests that were held can be separated into three main aspects:

- Learning gain test : This test measures the learning achievement of both groups and compares them trying to examine the first hypothesis **(H1)** (Section 4.6).
- Engagement level test : This test measures the overall engagement level of both groups and compares them to examine the second hypothesis **(H2)** (Section 4.6).
- Flow test: This test gives an overall insight about the flow of *Super Hawwaz* as a platform and all the serious games included in it.

6.1 Learning Gain Test Results

This section describes the findings behind holding the learning gain tests (the paper based pre and post tests) that the children of both groups have been exposed to. The design of this test is mentioned in Section 5.2.1.

6.1.1 Platform Group

The results of the tests of the group of children who have played the games in the platform revealed that playing *"Super Hawwaz"* improved the scores of the children in the Arabic alphabet MCQs of the pos-test comparing to the pre-test. The children had an average pre-test score of 9 out of 13 points (n=18, M=8.944, SD=1.984), and an average post-test score of 12 out of 13 points (n=18, M=12.111, SD=1.0226). This has achieved a significant learning gain by an average of 3 points (n=18, M =3.000, SD= 1.36277). The results of the tests of this group are present in Table 6.1.

Game Group Results		
	Mean	Std.Deviation
Pre-test	8.9444	1.984
Post-test	12.111	1.0226
Gain	3.000	1.36277

Table 6.1: Super Hawwaz group test results

Presentation Slides Group Results		
	Mean	Std.Deviation
Pre-test	9.444	2.12
Post-test	9.5	2.43
Gain	0.667	1.279

Table 6.2: Computer assisted mean group test results

6.1.2 Presentation Slides Group

The results of the tests of the group of children who have been exposed to the traditional instructional mean revealed that using the presentation slides as an educational mean has not significantly improved the scores of the children in the Arabic alphabet MCQs of the pos-test comparing to the pre-test. The children had an average pre-test score of 9.4 out of 13 points (n=18, M=9.444, SD=2.12), and an average post-test score of 9.5 out of 13 points (n=18, M=9.5, SD=2.43). This has achieved a learning gain by an average of 0.7 points (M =0.667 , SD= 1.279). The results of the tests of this group are present in Table 6.2.

6.1.3 Independent t-Test Results

The analysis test type that was held for the learning gain test is the well known independent t-test. The aim of this test is to compare between the two instructional means tested in the experiment (Subsection 5.3.1).

The results of the independent t-test between the two groups revealed that there was homogeneity of variance in the learning gain as assessed by Levene's test for equality of variances (p= 0.675). Therefore, an independent t-test was run on the data as well as 95 percent confidence intervals (CI) for the mean difference.

By applying the treatment, it was found that after the two interventions, the learning gain resulting from the group that used the platform as the educational mean (M = 3.000, SD= 1.36277) was significantly higher than the gain of the other group that used the computer assisted mean of the presentation slides (M= 0.667, SD=1.27988) (t(18) = 6.077, p = 0.000) with a mean difference of 1.977 (95% CI, 1.945 to 3.922).

This rejects **(H1)** stating that there is no difference between the two instructional means on the knowledge gain of the LD children. The results of this test are present in

Learning Gain Test of Both Groups			
Group	Mean	Std.Deviation	Std.Error Mean
Game	2.933	1.3627	0.3304
Slides	0.667	1.2798	0.3255

Table 6.3: Independent t-test results of the learning gain

Independent Sample Test Results (Learning Gain)						
	t	Significance (2-tailed)	Mean Difference	Std.Error Difference	95%confidence interval	
					lower	higher
Difference	6.134	0.000	2.8666	0.4673	1.910	3.823

Table 6.4: Independent t-test results of the learning gain

Tables 6.3 and 6.4.

6.2 Engagement Level Test Results

Concerning the engagement level measurement at the end of the educational activities held during the experiment, this test was held to evaluate the overall involvement state of the children being exposed to both the platform and the regular computer assisted mean. It compares between the results of the two means in order to determine which has achieved a better engagement level for the participants (Subsections 5.2.2 and 5.3.2).

The results of the independent t-test between the two groups revealed that the engagement level was normally distributed for both groups. It was found that after the two interventions, the engagement level ratings that represent how absorbed the children were while using the game as the educational mean (M = 4.284, SD= 0.476) were significantly higher than the engagement level ratings of the other group that used the computer assisted mean of the presentation slides (M= 2.35, SD=0.665) (t(18) = 9.953, p = 0.000) with a mean difference of 1.92 (95% CI, 1.5 to 2.31).

This rejects **(H2)** stating that there is no difference between the two instructional means on the engagement level of the LD children. The results of this test are present in

Engagement Level Test of Both Groups			
Group	Mean	Std.Deviation	Std.Error Mean
Game	4.2840	0.47634	0.11228
Slides	2.3642	0.66536	0.15683

Table 6.5: Independent t-test results of the engagement level

Independent Sample Test Results (Engagement Level)						
	t	Significance (2-tailed)	Mean Difference	Std.Error Difference	95%confidence interval	
					lower	higher
Difference	9.953	0.000	1.91975	0.19287	1.528	2.311

Table 6.6: Independent t-test results of the engagement level

Engagement Level Test Items of Both Groups				
Item	Group	Mean	Std.Deviation	Std.Error Mean
Control	Game	4.0000	0.78591	0.18524
	Slides	2.7778	1.31978	0.31108
Enjoyment	Game	4.3651	0.43337	0.10215
	Slides	2.2460	0.51579	0.11228

Table 6.7: Independent t-test results of engagement level test items (Control and Enjoyment)

Tables 6.5 and 6.6.

On a more detailed level, the questionnaire consisted of 9-items that tested the overall flow or engagement. Seven of them tested the enjoyment factor, and the remaining two tested the control perceived during the activity.

The results of the independent t-test between the two groups revealed that the **enjoyment level** of the children using the platform as the educational mean (M = 4.365, SD= 0.433) was higher than the enjoyment level of the other group that used the computer assisted mean of the presentation slides (M= 2.246, SD=0.515) (t(18) = 13.345, p = 0.000) with a difference of 2.12 (95% CI, 1.8 to 2.4).

Moreover, The results of the independent t-test between the two groups revealed that the **control level** of the children using the platform as the educational mean (M = 4.000, SD= 0.789) was higher than the control level of the other group that used the computer

Independent Sample Test Results (Engagement Level Items : Control and Enjoyment)						
	t	Significance (2-tailed)	Mean Difference	Std.Error Difference	95%confidence interval	
					lower	higher
Control Difference	3.376	0.002	1.22222	0.36205	0.486	1.958
Enjoyment Difference	13.345	0.000	12.11905	0.15879	1.796	2.441

Table 6.8: Independent t-test results of engagement level test items (Control and Enjoyment)

assisted mean of the presentation slides (M= 2.777, SD=1.319) (t(18) = 3.376, p = 0.002) with a difference of 1.222 (95 percent CI, 0.4 to 1.9).

To sum up, the results comparing the ratings of the level of control, enjoyment, and the overall engagement and flow states reveal that the platform games were more interesting for the group of the LD children who played them rather that the other group that was exposed to the presentation slides. The results of this test can be shown from Tables 6.7 and 6.8.

By analysing the learning gain test results as well as the engagement test results (Sections 6.1 and 6.2), it can be concluded that the platform had an overall better effect than the presentation slides on the learning process of the LD children from both aspects: the knowledge gain as well as the engagement level. This rejects the null hypothesis stating that there is no difference between the two instructional means on the learning process of the LD children .

6.3 Flow Test Results

This test was mainly focusing on reporting the results of monitoring the flow of the sequence of each game and its impact on the children interacting with it (Subsections 5.2.3 and 5.3.3). It was held only with the platform group in order to monitor the changing reactions of the LD children towards the usability of each game. Five Likert scale point data were collected rating the skill as well as the challenge levels perceived by the children throughout the five concrete levels of each game. The skill and challenge collected data were analysed and plotted as shown in Figure 6.1 so that we can collect some insights about the flow.

Another more elaborate measurement was done using this data which is calculating how far or distant was the actual flow level of each game from the perfect flow rate (where the ratio between the skill and challenge is 1:1). This distance was calculated using the equation present in Subsection 5.3.3, and Figure 6.2 illustrates this type of analysis.

Figure 6.1 shows the skill versus challenge rates for each game separately. While Figure 6.2 shows how far each game was from the standard desired flow level. The desired distance from the flow level should be equal to zero (skill = challenge). Positive values represent boredom (skill < challenge), while negative values represent anxiousness (challenge > skill). This section describes in details the results of the flow process test of each game:

6.3.1 Drag and Drop

From the partition of the Drag and Drop game in Figure 6.1, it can be concluded that the five levels of this game in *Super Hawwaz* are ascending in their challenging level for most of the children who played it. The skill level of the children in most of the levels is

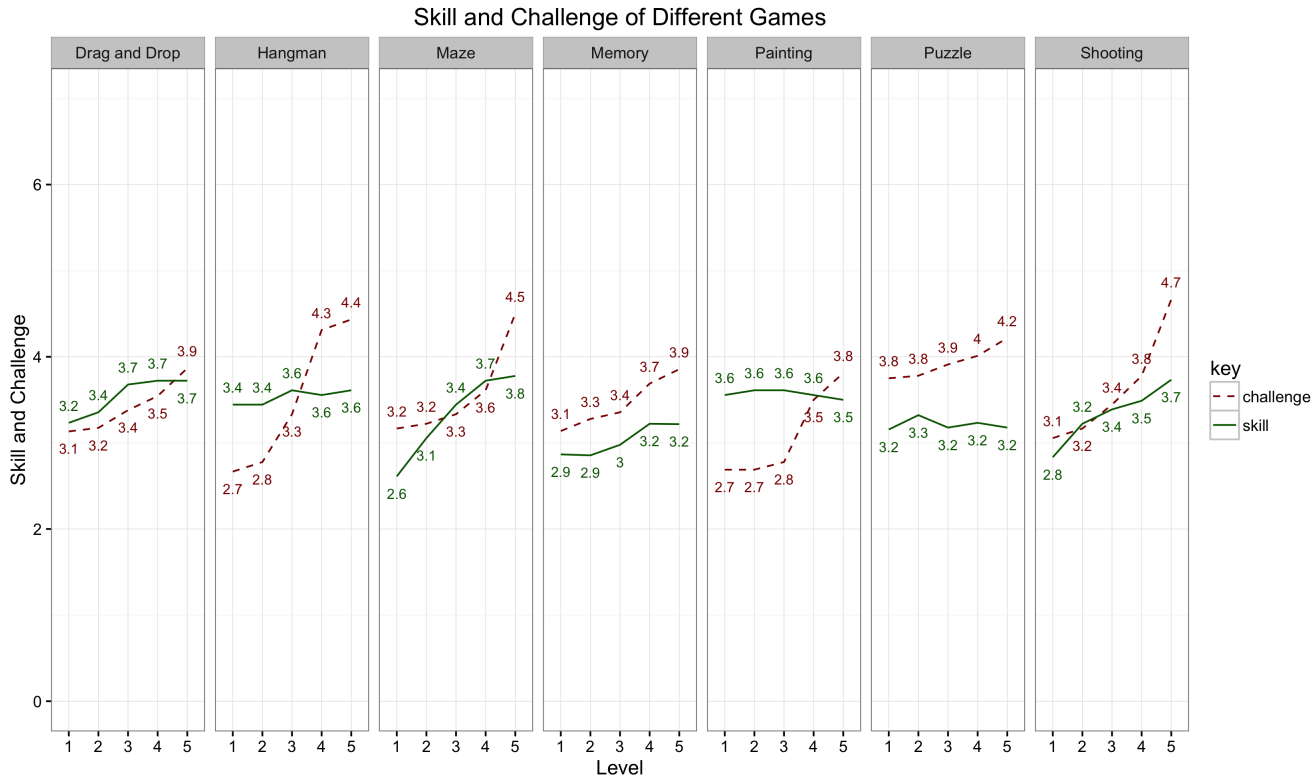

Figure 6.1: Skill-Challenge results for each game in the platform

close to the challenge level. This shows that the design of the difficulty of the Drag and Drop game levels was suitable for the children playing it. The averages of the challenge level in the five levels of this game are :(3.1, 3.2, 3.3, 3.5, 3.9). While, the averages of the skill level in the five levels of the same game are : (3.2, 3.4, 3.7, 3.7, 3.7), ascending from the first to the fifth level.

The Drag and Drop "from flow distance" graph in Figure 6.2 shows how smoothly the learning process went while playing the game. The flow line of the game in all levels is always close to the desired flow line (zero line). The averages of the from flow distance in the five levels of this game are :(0, 0, 0.1, 0, 0), ascending from the first to the fifth level.

The overall review about this game shows its usability and consistency in the design of the different levels. The shadow teachers have also reported that the children seemed to like and enjoy the game.

6.3.2 Hangman

The skill-challenge graph of the Hangman game is unique comparing to most of the games. Although the challenge levels of the game are ascending like other games, the partition referring to the game in Figure 6.1 shows the easiness of the early levels of the game,

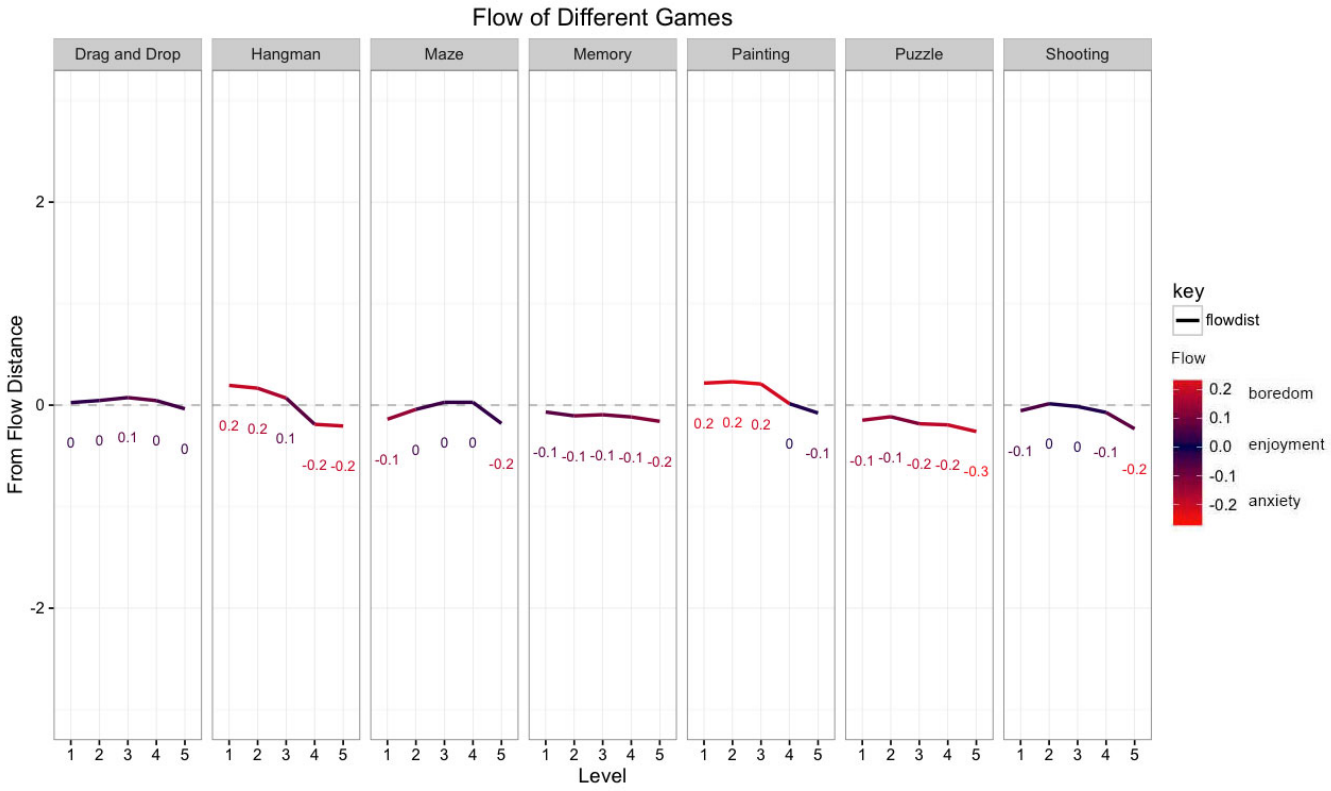

Figure 6.2: Far from flow distance for each game in the platform

where the skill is higher than the challenge (this indicates boredom). As the challenge level increases, the skill becomes closer to it. The skill level in this game is close to the challenge level till we reach the levels at the end, this is where the children experienced some anxiousness and difficulties, specially in level five (challenge > skill). The averages of the challenge level in the five levels of this game are :(2.7, 2.8, 3.3, 4.3, 4.4). While, the averages of the skill level in the five levels of the same game are : (3.4, 3.4, 3.6, 3.6, 3.6), ascending from the first to the fifth level.

The reason behind the previously mentioned results is that the early levels of the Hangman game were easy. They try to deliver to the child only the shape and sound of the letter through easy questions. This is compatible with the corresponding partition of the Hangman game in Figure 6.2, as the flow line of the game starts far from the desired flow level on the positive side (which indicates boredom), then it is normalized to be within the accepted range of the flow level. At the end, it decays a little towards the negative side which represents the difficulty found in levels four and five. The averages of the from flow distance in the five levels of this game are :(0.2, 0.2, 0.1, -0.2, -0.2), ascending from the first to the fifth level.

6.3.3 Maze with MCQs

The five levels of the Maze game were ascending in their challenge level for most of the children who played it. The skill level started much lower than the challenge level. Then, the skill level increased to be close to the challenging level till level four in the Maze game. The averages of the challenge level in the five levels of this game are :(3.2, 3.2, 3.3, 3.6, 4.5). While, the averages of the skill level in the five levels of the same game are : (2.6, 3.1, 3.4, 3.7, 3.8), ascending from the first to the fifth level.

The results show that the design of the difficulty in the Maze game was suitable for the children playing it. However, they had some difficulties at the early levels of the game trying to understand what it is aiming at. The Maze game's partition in Figure 6.2 shows that the flow of the game is acceptable due to its closeness from the desired flow line. The averages of the from flow distance in the five levels of this game are :(-0.1, 0, 0, 0, -0.2), ascending from the first to the fifth level.

6.3.4 Memory Flipping Cards

The Flipping Cards game was one of the most difficult games for the LD children while playing it. It appears from the third partition in Figure 6.1, that the challenge level was always far from the skill level. Most of the children have experienced lower skill level than the challenge they have faced. The averages of the challenge level in the five levels of this game are :(3.1, 3.3, 3.4, 3.7, 3.9). The average of the skill level in the five levels of the same game are : (2.9, 2.0, 3.0, 3.2, 3.2), ascending from the first to the fifth level.

Moreover, it appears from the corresponding partition of the graph in Figure 6.1 that the flow line of the Memory Cards game was slightly lower than the desired flow level in the five levels of the game. The averages of the from flow distance in the five levels of this game are: (-0.1, -0.1, -0.1, -0.1, -0.2), ascending from the first to the fifth level.

The flow level of this game translates the difficulty and the anxiousness the children might have faced during playing this game. The reason behind such flow level is that the memory deficit is of the most remarkable symptoms of learning disabilities that the children suffer from. Moreover, teachers have reported that it is a common deficit that is hard to deal with. Accordingly, the design of this game should have taken into consideration such issue.

6.3.5 Painting Letters

The Painting game is one of the most special games in the platform, starting from the design, and ending with the children's experience interacting with it. This game's skill-challenge graph is unique comparing to most of the games.

The challenge level is significantly lower than the skill level in the early stages. Then, it starts ascending with the following levels. The partition of the Painting game in Figure 6.1 shows the easiness of the game in almost all levels, where skill is higher than the challenge. Although it reflects boredom, the children enjoyed it as a snack game between the hardcore ones discussed before.

The last level is the only level that has the challenge greater than the skill. This is due to the fact that the levels of this game are all about having smaller letter one level after another, and letting the child follow it with his/her finger. Level five was difficult to follow accurately for most of the children. However, it did not reflect severe anxiousness like the Puzzle game. This is the case in the Painting Letters game because its early levels were very easy with big letters to draw. Then, the letters became smaller with the advanced levels. The averages of the challenge level in the five levels of this game are :(2.7, 2.7, 2.8, 3.5, 3.8). While, the average of the skill level in the five levels of the same game are : (3.6, 3.6, 3.6, 3.6, 3.5), ascending from the first to the fifth level.

Figure 6.2; in the corresponding partition; illustrates the previously mentioned analysis in a more vivid manner. It can be noticed that the flow line is above the desired zero line in most of the levels of the game. This translates the easiness of the early tasks of the different levels of the painting game, which shows that the painting game's design was easier than the capabilities of most of the participants. The averages of the from flow distance in the five levels of this game are :(0.2, 0.2, 0.2, 0, -0.1), ascending from the first to the fifth level.

Their teachers commented on that and reasoned it to the fact that most of the LD children enjoy coloring, and the task was amusing for them.

6.3.6 Puzzle

The skill and challenge ratings of the Puzzle game were close to the ratings of the Memory Flipping Cards game (challenge is higher than the skill). This is due to the high organizational skills that any puzzle game requires from the players. As it appears from the sixth partition in Figure 6.1, the skill level of the children is significantly far from the challenge level in all levels of the Puzzle game, the children faced anxiety trying to solve the puzzle, specially with the last two levels. The averages of the challenge level in the five levels of this game are :(3.8, 3.8, 3.9, 4.0, 4.2). While, the averages of the skill level in the five levels of the same game are : (3.2, 3.3, 3.2, 3.2, 3.2), ascending from the first to the fifth level.

Figure 6.2; in the corresponding partition; shows the same results. It can be noticed that the flow line is always below zero. This translates the difficulty that the children where exposed to during playing the game. Moreover, it shows that the Puzzle game's design was not compatible with the LD children's capabilities. The averages of the from

flow distance in the five levels of this game are : (-0.1, -0.1, -0.2, -0.2, -0.3), ascending from the first to the fifth level.

Their teachers commented on that and reasoned it to the fact that most of the LD children has their problems in concentration, organization, and memory. They need special techniques and long term treatment. Which means that this game needed more precautions while designing it for the needs of the LD children.

6.3.7 Shooting

From the partition of the Shooting game in Figure 6.1, it can be concluded that the five levels of the game are ascending in their challenge level for most of the children who played it. The skill started lower than the challenge. Then, they became closer throughout the rest of the levels of the game. This shows that the design of the difficulty of the game was suitable for the children. The averages of the challenge level in the five levels of this game are :(3.1, 3.2, 3.4, 3.8, 3.7). While, the averages of the skill level in the five levels of the same game are : (2.8, 3.2, 3.4, 3.5, 3.7), ascending from the first to the fifth level.

The Shooting game's flow graph partition in Figure 6.2 reassures on the previously mentioned conclusion. The flow of the Shooting game is very close to the desired flow line, except for some anxiousness experienced at the last level of the game. The averages of the from flow distance in the five levels of this game are :(-0.1, 0, 0, -0.1, -0.2), ascending from the first to the fifth level.

This review is also compatible with the corresponding partition of the Shooting game in Figure 6.2. The flow line of the game starts far from the desired flow level on the positive side in most of the levels. Then, it is normalized to be within the accepted range of the flow level. At the end, it decays a little towards the negative side which is the last level. The averages of the from flow distance in the five levels of this game are :(-0.1, 0.0, 0.0, -0.1, -0.2), ascending from the first to the fifth level.

6.3.8 Flow Results: Summary

The border lines about the flow test results of the games included in *Super Hawwaz* show the following: most of the games have given the required ascending effect of the difficulty or the challenge for the child (as designed by the Montessorri syllabus). Some games reflected a very good flow rate and enjoyability with the children. This was achieved throughout the sessions of some games like Drag and Drop, Maze, and Shooting games. Other games were easier than the expected. The children passed the earlier levels of these games easily, they did not suffer from the challenge. The games that reflected these results are: Hangman game and Painting Letters game. The rest of the games were more challenging for the children. They have experienced some anxiety trying to pass their different levels successfully. The games that were challenging in an overall aspect are the

Puzzle game as well as the Memory Flipping Cards game.

Another common observation about the flow results is that level five in all games was challenging for the children. This level represents the hardest part in the Montesorri syllabus. This part is about recognising and distinguishing between the three different diacritic signs of each letter. The teachers have confirmed that this part is always challenging for the LD children, even with the manual teaching means. Some statistics about this part are presented in Subsection 6.4.3.

To sum up, as shown from the "from-flow distance" graphs in Figure 6.2, the overall flow of the games of *Super Hawwaz* is acceptable. The results show that most of the children had an enjoyable experience going through the different levels of the different games in the platform. This indicates some consistency in designing the five different levels of each game.

The following section includes some extra statistics that were held on the data collected from the experiments. These statistics give insights about the performance of the children in the platform from different aspects comparing to the ones that were tackled in the previous sections (the original tests analyses).

6.4 Extra Statistics

This section discusses the extra statistics that were performed on the collected data. These statistics give better insights about the effectiveness of *Super Hawwaz* compared to the regular educational means on LD children.

6.4.1 Learning Gain - Engagement Correlation

One important perspective to investigate in this study was trying to find the correlation between the learning achievement of the children, and the engagement level that they have experienced during performing the learning activity.

Figure 6.3 shows this type of correlation, where the x-axis represents the engagement level data collected from each child on the formerly described engagement questionnaire that was used to answer **H2** (Section 5.2.2). The y-axis represents the learning gain of each corresponding child, the learning gain of each child is calculated by subtracting the score of the pre-test from the score of the post-test he/she has got during the experiment (Section 5.1.2).

Two lines are plotted on the graph, one that represents the correlation between the learning gain and engagement for the group of participants who were exposed to *Super*

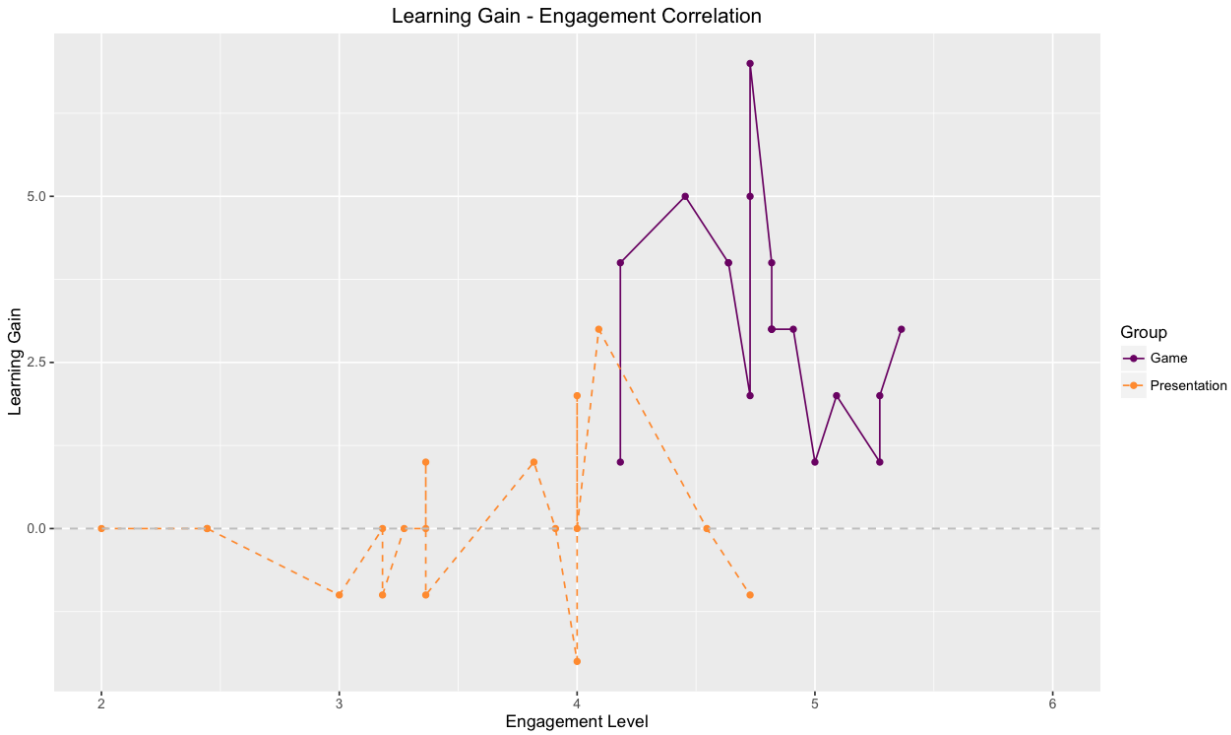

Figure 6.3: Correlation between engagement level and learning gain

Hawwaz as the educational mean. The other dashed line represents the same correlation for the other group of the participants (those who used the presentation slides as as their instructional educational mean).

The results of the collected data show that there is a significant correlation between the engagement level of the LD child, and his/her learning gain. As Figure 6.3 shows, the group of LD children who used the presentation slides had relatively low levels of engagement and corresponding low learning gain levels. On the other hand, the group of LD children who played through the platform had high engagement levels as well as corresponding high learning gain rates.

It appears from the graph that the relation between the learning gain and the engagement level of the participants is not linear. However, it gives some evidence that the difference in the learning gain between both groups happened due to the difference of the engagement level the participants have experienced, since it is the only changing factor in the experiment. The difference in the learning gain, and the difference in the engagement level of the two groups are reported in Sections 6.1 and 6.2 respectively.

To sum up, the experiment gives some indications about the correlation between the engagement level of the LD children, and their ability to achieve better in their academic

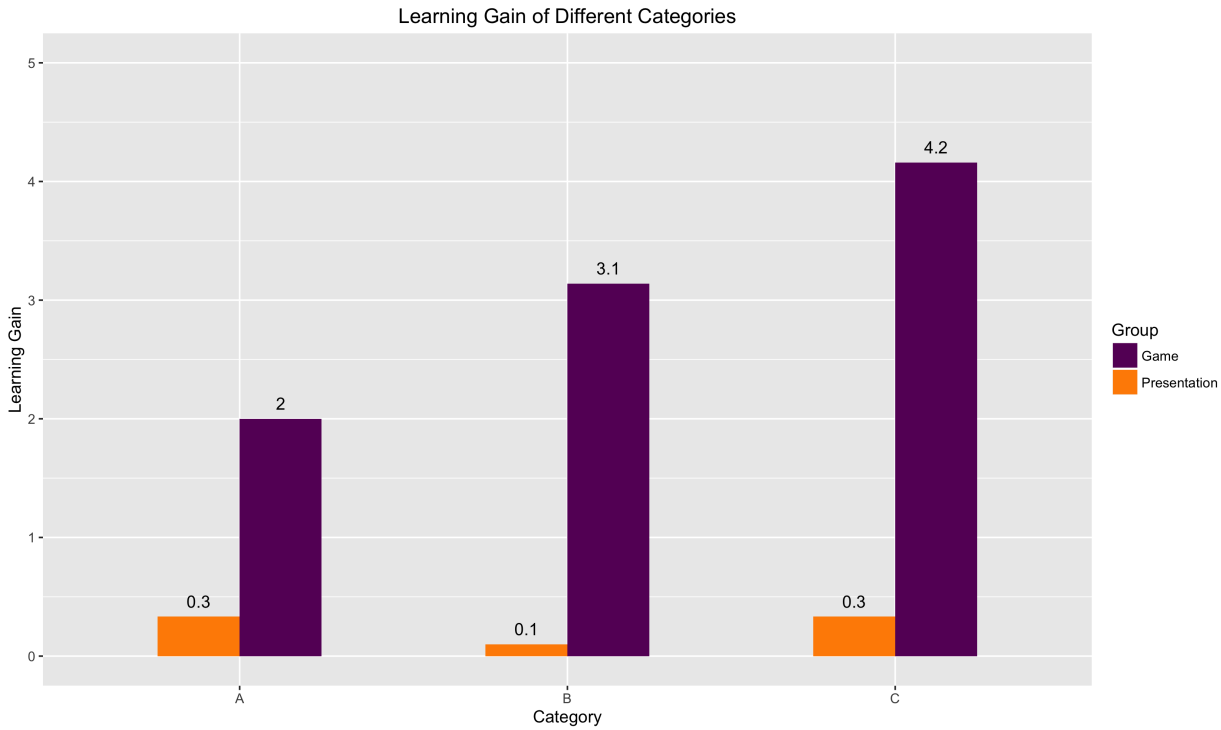

Figure 6.4: Different academic level categories of LD children and their learning gain

activities. This correlation needs to be furtherly investigated in details in the future studies.

6.4.2 Learning Gain of Different Categories

More detailed statistics about the learning gain of both groups of LD children who had participated in the experiment are represented in Figure 6.4. The participants were categorized based on their academic level, this category was given according to the grade that they got in the pre-test. It was used as an evaluation to their performance in the Arabic language syllabus before executing the experiment. Accordingly, the pre-test grade of each participant was assigned to a category. The categories have a range from A to C . Where "A" is the best, or the above average performing children (scores from 11 to 13 points), "B" is for the mediocre, or average performing children in the test (scores from 8 to 10 points), and "C" is the worst, or the below average performing children (scores from 5 to 7 points). No category was assigned to scores from 0 to 4 points, as none of the children got score less than 5 points in the pre-tests.

Each group of participants in each category is divided into two independent sub-groups of LD children. The first subgroup represents the participants using the presentation slides teaching approach. While the second subgroup represents the participants who used our platform.

Each category in the graph in Figure 6.4 is presented on the x-axis. Two bars are plotted for each category. The first bar (to the right) represents the learning gain of this category for the group of participants that had *Super Hawwaz* as the instructional mean during the experiment. The second bar represents the learning gain of the same category for the group of participants that had the presentation slides as the instructional mean.

The results of this graph show that the games have a higher learning gain than the presentation slides in all categories (which is proven using the independent t-test in Section 6.1).

For the platform categorized results, it appears that group "C" was the most benefiting group of children from playing the different games of the platform. The participants of this group had the highest learning gain average of 4.2. Categories "B" and "A" had less learning gain averages of 3.1 and 2 respectively. Which gives an intuition about what the low performing LD children might need in the classrooms. Having an interactive environment and engaging ways to learn is a suggested solution as represented by the experiment's results. For the presentation slides group, the categorized results show that categories "A" and "C" had higher learning gain average than category "B".

Reflecting on these results, there could be a potential in exposing the below average LD children to serious games in general, as the results show that they were highly affected from being exposed to the seven games in *Super Hawwaz*.

6.4.3 Game Design of Montessori Levels

Trying to infer some information about how well the different levels were designed in each game of *Supwe Hawwaz*, some analysis were made on the learning gain of each level of the Montesorri syllabus. As described in Chapter 3 (Section 3.2), the curriculum that was chosen to be the educational material of the platform was learning the Alphabet letters of the Arabic language using the Montessorri syllabus.

Five concrete levels of learning were defined by the teachers as well as the experts in the field. These levels were designed to be followed in the classrooms with the LD children in order to make them learn the letters the Montessorri way. The different games in *Super Hawwaz* were designed to follow this method, which resulted in each game having five levels. The Montesorri stages are presented in Section 3.2.

To ensure the existence of the compatibility in the experiment, the pre and post tests that were used to evaluate the LD children during the experiment were also designed to be compatible with the material presented in the instructional means. The test was divided into five sections. Each section targets one of the five Montesorri stages. This was planned so that the consistency of the material is preserved in the experiment. Using this feature in the experiment, data were collected, and scores of each section were calculated and analysed for each child.

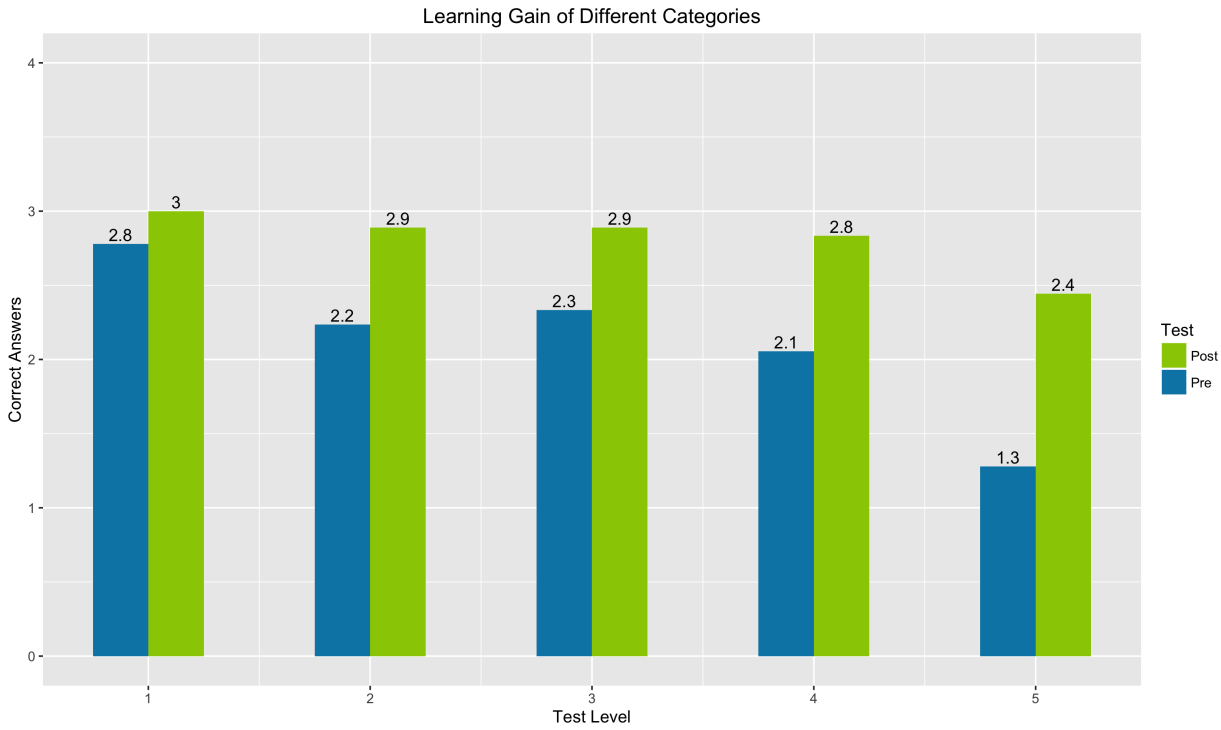

Figure 6.5: Grades of Super Hawwaz participants in each section of the test

By reporting the results of the pre-test of each section separately for the group of children who interacted with the platform as their learning mean, and comparing them to the results of the same sections in the identical post test for the same group, conclusions were drawn about how well designed each level in the platform was, in addition to how it affected the learning achievement of the participants.

The analysis results that represent this aspect are present in Figure 6.5. The graph shows the average score of each level for the children who interacted with *Super Hawwaz's* different games. It compares the pre-test results with the post-test results for each section in the test (since each section is represented by a level in all games in the platform).

The Figure shows the results of each section separately for the platform group, each partition in the test has two results: pre and post. The results show that *Super Hawwaz* had a positive effect in all sections of the well known Montesorri stages in the tests. The most remarkable thing to notice is the effect on the last and the hardest level among them (Level five : recognizing the diacritic signs).

The platform had the greatest effect on this stage in the Montesorri syllabus. This is surprising, as the teachers have reported that this stage is the most challenging one. They claim that the children's performance in this level of the curriculum is the weakest. This was clear from their results in the pretest, as they have reported an average of 1.3 out of 3 points in level 5. After the treatment, the children's average score in the same level has escalated to be with an average of 2.4 points out of 3. On the other side, the

least effect that the platform caused to the LD children's learning achievement was on the first and easiest section (Level 1 : recognizing the object given its image). As shown, most of the children got high scores in this section even before they got the treatment using the platform games, with an average of 2.8 points out of 3.

It is important to note that the presentation slides also had the same structure of the five levels that addressed the Montessorri stages. This was done in order to ensure that the experiments tested the gamification factor only. However, this test was held to test the usability and the correctness of the game design only in *Super Hawwaz*.

To sum up, the results show evidence that the platform's game design methodology was addressing the targeted academic syllabus in a structured manner that has resulted into an acceptable learning gain rate.

6.5 Discussion

By collecting and analysing the test results of the experiments held for the platform. The results show that there exists statistically significant differences in the learning process of the LD children when they receive two different instructional treatments: (1) Traditional Computer assisted instructions (Presentation slides); and (2) Serious Game. Which rejects the null hypothesis.

Regarding the learning achievement, the independent t-test results show the existence of a significant difference between the two treatment groups (F=3.3, p=0.000). The participants who were exposed to *Super Hawwaz* showed better test results after playing the games. While the participants who were exposed to the presentation slides did not show significant difference in their learning achievement before and after the treatment. Accordingly, **(H1)**; stating that LD children achieve equivalent academic results when they receive the two different instructional means; was rejected.

Regarding the engagement level, the independent t-test results show the existence of a significant difference between the two treatment groups (F=3.3, p=0.000). Participants who played the different games in *Super Hawwaz* were more engaged, and showed interest during the learning process. While the other group of participants, who were exposed to the presentation slides, were not as engaged as their peers in the platform's group. Accordingly, **(H2)**; stating that LD children experience the same level of engagement during the learning process when they receive the two different instructional means; was also rejected.

The flow analysis conducted for *Super Hawwaz* shows that there was a balance between the skill and the challenge that the participants experienced throughout the sessions in most of the games. Howerver, some games were easier than expected (skill level was

higher than the challenge level). And, some games were more challenging than expected (challenge level was higher than the skill level). The summary of this test as well as its discussion are present in Section 6.3.8.

The extra statistics held using the data collected from the experiment tackled three aspects:

- The correlation between the learning gain and the engagement level of the LD children: The results in Figure 6.3 show that the learning gain and the engagement levels are highly correlated. The platform group showed high learning gain as well as engagement ratings, comparing to the normal mean group.
- The categorization of the academic level of the LD children in the pre-tests, and analysing the effect of the two instructional means on each category: The results in Figure 6.4 show that the category of the LD children who got the highest benefit from the platform are the below average performing students (academic achievement wise). On the other side, the above and below average performing students benefited equally from the normal instructional mean.
- Analysing the pre- and post-test results of each section in the Montesorri syllabus separately, and drawing conclusion about the performance of the LD children in them: The results in Figure 6.5 show that the platform had a positive effect in all sections of the Montessorri syllabus. The stages were represented in separate sections in the pre- and post-tests, and the levels in all games of *Super Hawwaz*. The platform had the greatest effect on the fifth and the hardest stage in the Montesorri syllabus (recognizing the diacritic signs). Moreover, the platform had the least effect on the first and the easiest level (recognizing an object given its picture).

To sum up, the statistical analysis of the test results clearly shows that using the educational gaming platform *Super Hawwaz* is more effective than using the normal computer assisted instructional mean for LD children's learning achievement, as well as their engagement and enjoyment levels. This might get back to the presence of the different game elements in the platform. As game elements offer a more interesting teaching fashion, compared to the teaching fashion of the conventional computer assisted mean they are used to, namely the presentation slides.

It can be concluded that LD children would benefit from educational games in classrooms as an assistive mean as they seemed to be more interested to work with the game rather than watching the slides. This might get back to the presence of the different motivational features in *Super Hawwaz*, as it seems to represent more amusing teaching techniques compared to other regular methods used in class.

Chapter 7

Conclusion

Promoting learning for children with learning disabilities (LD children) has attracted much of the interest of the theoretical and practical research nowadays. Based on the review of the previous studies, there are different effects of serious games in education. The evidence provided about the impact of games is mixed. Some studies found positive effects, some found negative effects and some found no difference in performance between the gaming and the normal teaching methods on the students. Thus, the focus of this study was to investigate the effect of using serious games with LD children on their learning process.

The main objective was examining the null hypothesis claiming that there is no statistically significant differences in LD children's learning process when they receive two different instructional treatments: (1) Traditional computer assisted instructions (presentation slides); and (2) Serious games.

Super Hawwaz is a serious gaming platform that was built based on the special teaching strategies applied for LD children as well as the input of the experts in the field. This platform was implemented, tested, and compared with the normal instructional teaching means used with LD children in their classrooms, namely the presentation slides regular mean.

An experiment was held targeting two main goals. The first goal was to compare the learning gain of the children being exposed to the two different instructional means, and the second one was to measure the engagement level of the children being exposed to the same means. Two groups were identified for the experiment. The first group used *Super Hawwaz* as an instructional mean. The second group used a regular instructional mean (presentation slides). A target population of 36 LD children were assigned randomly to both groups (18 each), and the experiment took place as follows:

The learning gain was measured by exposing the children before and after treatment to two similar tests on the material presented by their perspective instructional mean.

By subtracting the scores of both tests, the improvement level in the knowledge of the participants in each group; namely the "learning gain"; was calculated. By comparing the learning gain of both groups, conclusions about the effectiveness of each instructional mean were drawn.

The engagement level was measured in both groups using a standardized five Likert scale survey that tests the engagement level offered by any activity. The survey contains different questions that rates the level of absorption the children have experienced during their learning process (whether using the platform or the presentation slides).

Upon holding the experiment, collecting data, and analysing it, the following conclusions were drawn:

The results of the test comparing between the learning gain and the engagement level of the participants in both groups provided evidence that rejects the null hypothesis, and supports the use of serious games for LD children rather than other normal computer assisted means. The statistical analysis of the test results showed that using the educational gaming platform *Super Hawwaz* is more effective than using the normal computer assisted instructional mean (presentation slides) for LD children's learning achievement, as well as their engagement and enjoyment levels. This might get back to the presence of the different game elements in the platform like challenge, motivation, engagement, and flow. The computer assisted mean, they are used to, lacks the presence of such elements.

A flow analysis test was conducted with the aim of monitoring the changing behavior of the LD children being exposed to the serious games included in the platform. This test depends on measuring the skill and the challenge levels that the child has experienced throughout playing the games.

The results of this test showed that the overall flow of the games of *Super Hawwaz* is within the desired flow range. According to the tests and the feedback of the teachers, most of the participants enjoyed their time playing the different educational games included in the platform. Which indicates that the design and the structure of the five different levels for each game were consistent and suitable for the target group. However, some games were easier than expected. On the other hand, some games were more challenging than expected.

Some insights were drawn from the data collected during the experiment. The learning gain and the engagement level of the LD children in both experiments appear to be highly correlated. Which can give guidance about the reason behind the difference of the learning gain of both groups. It was due to the presence of the engagement element in *Super Hawwaz*. Since the only changing factor between the two instructional means is the gamification.

The data also showed that the category of the LD children who got the highest benefit from the platform is the category of the below average performing children in the targeted

curriculum. Which supports the trend of using extra assistive means in the classrooms for the children who suffer from having an academic gap between them and their peers. Additionally, *Super Hawwaz* had the greatest effect on the children's learning gain in the hardest stage in the Montesorri syllabus (Level 5, which is recognizing the diacritic signs). Teachers claim that this part is the hardest for the children to digest during their learning process, specially when they use the regular teaching means. Accordingly, the platform can be used to assist the professionals in their work.

To sum up, the results show that LD children were more motivated and showed higher knowledge gain levels being taught through the platform games rather than being exposed to the slides. Accordingly, *Super Hawwaz* can be considered as an effective assistive learning mean and an extra gate for the LD children to fill the academic gap that exists between them and their peers in class. This makes sense, as playing games is a matter of engagement for children in general. Hence, embedding the educational material in serious games in a professional way can make them learn with no pressure, boredom, or embarrassment.

However, the question that asks which game element exactly works best with LD children, as well as the effect of serious games of other cognitive abilities were not discussed in this study. It needs further investigations in future studies.

7.1 Limitations

There exists some limitations of this study that were concluded after conducting the experiment, the main obstacles and limitations faced in the study are listed below:

First, in the methodology of the experiment, many types of cognitive abilities of the LD children other than the knowledge gain could have been tested in order to build a conclusion about the relationship between serious games and the different cognitive abilities like attention, organization, memory and others. However, these types of cognitive abilities to be rewired for the LD child, they need a long term of experimenting and continuous observational strategies, unlike the learning achievement measurements.

Moreover, holding usability tests with LD children in general is very hard. This is due to their special nature and young age. Accordingly, self-reporting, evaluation and expressing is a hard thing to achieve. Thus, we have chosen an easy engagement test to hold using the help of the shadow teachers to measure their enjoyability level. However, a deeper usability test with our target group would require a special methodology, and a continuous, robust, and reliable psychological background with the help of a lot of specialists, which was not feasible during our study.

Another limitation faced was the small number of the participants of the sample. The reason behind this small number is that LD children are hardly diagnosed in general,

specially in the developing countries and middle eastern communities. Moreover, some parents refuse to admit the existence of such disabilities and their negative effect on their children. Accordingly, they do not ask for the help of the professionals publicly, and the early intervention centers are rarely contacted. As a result, finding an LD child to hold the experiment with was hard to achieve.

Another reason behind the small number of the sample is that each experiment was held separately with each child. This choice was based on the opinion of the experts in the field. They claimed that an LD child might be distracted if the experiment was held among his/her colleagues. Moreover, the experiments were not designed to be held in groups because of the nature of the experiment. As the teacher had to be present to help the child and observe his/her reactions. Accordingly, it was hard to have a huge number of participants per session.

This obstacle was overcome in the experiment by using the t-tests in measuring the learning achievement as well as the engagement levels, as t-tests are specially made for small sample analyses. However, larger number of participants of LD children would have been better so that the effect size would have a clearer indication about the results.

The previously mentioned limitations should be taken into consideration in the future studies.

7.2 Future Work

Concerning the future work, many aspects can be tackled regarding this study. This section discusses the available areas of enhancements and future experiments that can be held in the field. The future work areas can be divided into two aspects:

1. Technical features that can be added to the platform in order to enhance its effect.
2. Further tests and data collection mechanisms to infer more conclusions related to the field.

This section will tackle both sides. Additionally, a suggested extension to the platform that was made and tested will be discussed as a proof of concept to the idea of customizing serious games in general for the LD children.

7.2.1 Additional Features

Since each game in *Super Hawwaz* tackles a certain deficit area, further data collection process might be applied using the same experiment on the different deficit areas that the LD children suffer from. The effect of each game on the skill building ability of its corresponding deficit area can be inferred. This can be done to evaluate and monitor the

severeness of the LD symptoms upon the children's long term usage of the platform.

Moreover, extra games with special features can be implemented, and the same experiment might be held with different cognitive disabilities areas like Autism, Down Syndrome, ADHD, and others. The reviews of the previous work claim that they share most of the learning disabilities symptoms. A study can be done on different samples of the LD children and a comparison can be held to see which type of cognitive disabilities is affected the most by using serious games.

Additionally, the platform itself might be extended to include a wider range of activities for learning the Arabic alphabet letters, with different curricula other than the Montessorri one. It may include some of the pre-schooling activities as warming up tasks for the child to play with before getting involved with the game itself.

Finally, the assessment techniques applied in the experiment (the paper based pre and post tests) can be computerized and embedded as part of the platform. The results of such tests with a comment from the professionals can be sent to the parents of the child as a follow up report for the child's case. Accordingly, parents can be included in the learning process of the child. This can be achieved by giving the teachers as well as the parents access to the accounts of the children, and letting them communicate through the platform. Moreover, weekly performance reports and analysis can be sent to the parents on their personal E-mails in order to give them the ability to monitor the academic achievement level of their children.

7.2.2 Additional Tests

Firstly, further investigations need to be done on each game element in the platform in order to know which element affects the learning achievement the most for the LD children. The results that are concluded in this study give an evidence that the learning gain and the engagement levels are better in the platform comparing to the normal computer assisted mean due to the presence of the "gamification" factor (which is the only changing factor in the experiment). However, the study did not reveal the exact game element that caused this effect (e.g: motivation, flow, instant feedback, avatar, and others). Accordingly, an empirical matrix study is needed for *Super Hawwaz* to compare between the different game elements and their effect on the children with learning disabilities. Testing the correlation between knowledge gain and enjoyment in a more concrete manner is also needed.

Secondly, further experiments can be performed for *"Super Hawwaz "* in order to test usability level of each game as well as its correlation with the learning gain. The test that was held in this study to measure the engagement level through measuring the flow, enjoyment and control of the game, is sufficient enough for supporting or rejecting

(H2). However, a concrete usability test needs to be performed in order to enhance the features of the platform, and draw conclusions about the preferences of the LD children with different deficit areas in the serious games in general.

Finally, *Super Hawwaz* is a regular platform with special helpful features that is available for everyone. Accordingly, an extra study with another research question that tackles the issue from a different perspective can be held. The aim of such study would be to examine the effect of using the platform with children who do not suffer from learning disabilities, comparing to their officially diagnosed LD peers. The results of the current study give a hint that the non-LD children might benefit from the platform. However, most of the challenges in the games would be easier for them to solve, since the platform takes into consideration the below average capabilities of the LD children.

Although *Super Hawwaz* was built upon the needs of LD children (i.e its game mechanics, features, and theme were based on the input of the experts and the special learning techniques applied for them), its target group is not limited to them.

Hence, an extra experiment with two age range groups of non-LD children is suggested to be held: one group with a similar age range to our target group that we have experimented with (6-9 years old), and another group that includes younger participants (3-5 years old), so that they might posses the same level of capabilities that their older LD peers have. However, modifications should be done to the content of the curriculum presented in the platform, as well as the usability tests in order to suit the suggested target group and their age ranges (maybe pre-schooling activities would fit in this context). This future study is highly recommended to be held in order to draw conclusions about the different responses of the children with different capabilities to serious games.

7.3 Super Hawwaz: Extension

An additional feature that has been established and added as a second milestone or an extension to the games included in *Super Hawwaz* is offering the ability of generating, and controlling the material embedded in the platform's different games. Which means that the platform will be a flexible tool for the teachers to add, edit, or remove the content that they see suitable for the children according to their case given the regulations and the nature of each game.

This was done through implementing an extra off the shelf game and adding it to the platform. This game includes an interface that can be considered as a tool where the teachers upload the material and the content that they want to assign to the child. This game is the famous **"Word Search"** game.

7.3.1 Objectives and Description

The main aim of the game is to teach LD children a collection of Arabic words by giving the teachers the chance to feed their different material to the game. This was achieved

Figure 7.1: Arabic Word Search game: Player view.

through implementing two interfaces for the game: (1) The "player" interface, where the game gets played by the child, and (2) The "creator" interface, where the teacher generates the word list, and picks the size of the letters grid for the child to play with.

The implemented game is the famous "Word search" game (Figure 7.1). In this game, the child gets to face a grid of any size consisting of shuffled Arabic letters, and he/she is required to cross out the connected letters in this grid from the words list created by the teacher. The child has to cross out the existing words in any row, column, or diagonal line of correct answers in order to win the game.

The game was designed in a special way such that it suits LD children and their different individual needs. This is achieved by allowing the teacher to edit the material in a flexible manner. The teachers can also check the children's performance, and monitor their progress easily. Which facilitates the experience for both the LD children as well as their shadow teachers. Figures 7.1 and 7.2 show the game.

7.3.2 Tests and Results

This game was tested with a few number of LD children as an extra game of *Super Hawwaz* (our Arabic learning platform). The experiment included measuring the learning gain of the children before and after using the game. The pre- and post-tests were structured the same way we did in testing the different games of *Super Hawwaz*. However, they included different material, since the teachers now are the creators of the game.

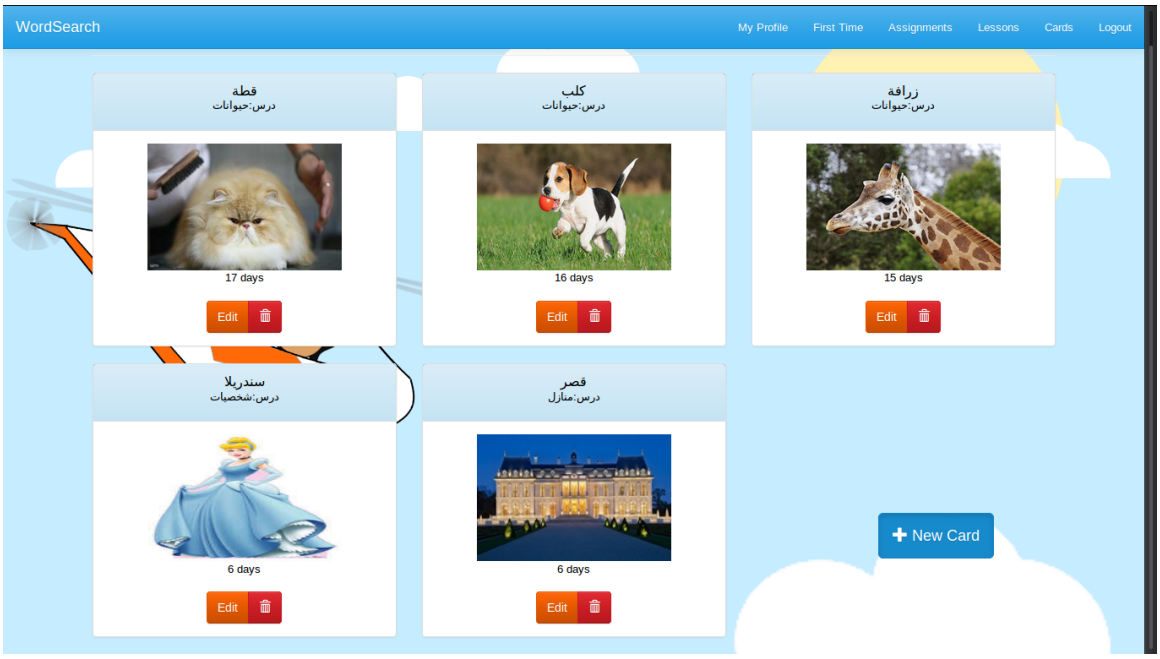

Figure 7.2: Arabic Word Search game: Teacher view.

Moreover, a post interview was held with the teachers to have their feedback about the game, as well as their own review about letting teachers create their own insight of the game material freely.

The results showed that the children seemed interested while playing the game. Most of them achieved better scores in the post-tests comparing to the pre-tests. Moreover, the teachers liked the idea of embedding their own material in the off the shelf games.

To sum up, having serious games that include dynamic material depending on the teacher's plan for the needs of the LD child seems to be promising, it is recommended to furtherly test such concept in the future work.

Appendix

Appendix A

Lists

LD	Learning Disabilities
SPSS	Statistical Package for Social Science
EFM	Effective learning environment, Flow, and Motivation
SETI	Support, Education, Training for Inclusion
ADHD	Attention Deficit Hyperactivity Disorder
ROR	Ruby On Rails
MVC	Model View Controller
MCQs	Multiple Choice Questions
CLES	Cognitive and Linguistic Element Stimulation
LD children	children with learning disabilities
HTML5	Hypertext Markup Language
VAS	Visual Analogue Scale
ANOVA	Analysis of Variance

List of Figures

List of Tables

A.1 Engagement Level Survey

1. The child felt in control of what he/she was doing
2. The child was absorbed intensely by the activity
3. The child found the activities enjoyable
4. The child found the activities interesting
5. The child was frustrated by what he/she was doing
6. The activities bored the child
7. The activities excited the curiosity of the child
8. The child knew the right thing to do
9. It required the child a lot of effort to concentrate on the activities

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