DEVELOPING BODILY MOVEMENT GAMES TO TEACH BASIC LIFE SKILLS FOR CHILDREN WITH MENTAL DISABILITIES

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ABSTRACT

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Students with mental disabilities often have trouble generalizing concepts and skills from one setting to another. An alternative way to teach generalization is to teach students solve problems pertinent to their daily lives and to reinforce behaviors that would occur in the natural environment. In this thesis, we propose a system to augment the environment for mentally disabled students in order to easily cope with life skills by game and fun. The games were developed for motion sensing input devices by following spiral iterative methodology. In the start, game concepts were approved by a special education subject matter expert and then prototypes were developed and tested. In the next step, feedback used to improve prototypes. This process continued until a satisfactory bodily movement game for special education children is developed. In addition to this, we also tested and improved usability approach for bodily movement games for special education children. The results show positive effects of the developed game in special education.

Keywords: Game, Kinect, Special Education, Motion Detection, Mental Disability

ÖZ

ZİHİNSEL ENGELLİ ÇOCUKLAR İÇİN TEMEL YAŞAM BECERİLERİ ÖĞRETMEK AMAÇLI BEDENSEL HAREKET OYUNLARI GELİŞTİRİLMESİ

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Zihinsel engelli öğrencilerin bir ortamdan diğerine kavram ve beceri genelleştirmesinde sorunları vardır. Genelleme öğretmek için alternatif yollardan birisi, öğrencilere günlük yaşamları ile ilgili sorunları çözmeyi öğretmek ve doğal ortamda oluşacak davranışları güçlendirmektir. Bu tezde, oyun ve eğlence öğeleri kullanarak, günlük yaşam becerileri ile başa çıkmaları amacıyla zihinsel engelli öğrencilere yönelik oyun tabanlı bir öğretim sistemi geliştirilmiştir. Oyunlar spiral yöntemi izleyerek hareket algılama giriş aygıtları için geliştirilmiştir. Öncelikle, oyun konuları özel eğitim uzmanı tarafından onaylanmış ve daha sonra, prototip geliştirilmiş ve test edilmiştir. Sonraki adımda geri bildirim, prototip geliştirmek için kullanılmıştır. Tatmin edici bir bedensel hareket oyun geliştirilene kadar bu işlem devam etmiştir. Buna ek olarak, özel eğitim çocukları için bedensel hareket oyunların kullanılabilirlik yaklaşımı test edilip ve geliştirilmiştir. Sonuçlar geliştirilen oyunun özel eğitim için etkili olduğunu göstermiştir.

Anahtar Kelimeler: Oyun, Özel Eğitim, Kinect, Hareket Algılama, Zihinsel Engel

To my beloved wife

Behrokh

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LIST OF ABBREVIATIONS

AT	Assistive Technology
FSA	Finite-State Automaton
HCI	Human Computer Interaction
HUD	Head-Up Display or Status Bar
IR	Infrared
LED	Light Emitting Diode
MDD	Motion Detection Device
MR	Mentally Retardation
NES	Nintendo Entertainment System
OS	Operating system
PC	Personal Computer
PILE	Physical Interactive Learning Environment
PS3	PlayStation 3
PT	Physical therapy
RGB	Red Green Blue
SDK	Software Development Kit
TUBITAK	The Scientific and Technological Research Council of TURKEY
TV	Television

CHAPTER 1

INTRODUCTION

The amount of time which has been spent by young people playing digital video games has increased over the past 10 years (Rideout, Foehr, & Roberts., 2011). This time may be spent appropriately and efficiently. One way to achieve this goal is by designing video games with specific aims. Fortunately, there are a lot of games available in the market whose aims are more than just fun. The games are released in different genres, one of which is games with educational aims.

It is obvious that learning is a fundamental part of human life. We spend many hours each day learning new things. Education can happen in school or other places, and it can be divided in two parts, formal education and informal education. Formal education occurs in a school setting and informal education happens out of schools. Special education is a form of formal education. People with disabilities need to get special education with respect to their specific disabilities. Unlike other students, those with mental disabilities need additional support to learn efficiently. The motivation and learning process of the students with learning disabilities are different from students without disabilities ("Special Educational Needs: Curriculum Issues Discussion Paper", 1999). Additionally, teaching skills have a direct effect in special education. Jordan, Schwartz, and McGhie-Richmond (2009) recommend that effective teaching skills in elementary classrooms are beneficial for both regular and special students. To teach any task to mentally disabled children, it is necessary to repeat it frequently. If there is no repeat in the mentally disabled children education process, the children soon forget. The digital technology can help to fulfill this task. Computers, tablets, cellphones and other technologies can be used to help teachers to achieve the best performance in special education. There are various devices and methods which are used in special education to facilitate the education process.

This thesis' aim is to teach a specific daily life skill, "the vacuum cleaner supported cleaning skills", to children with mental disabilities by using a game based environment. A first person game is developed using Unity3D game engine and Microsoft Kinect by considering special education expert's concerns, then its performance is benchmarked.

1.1 Background of the Study

This section describes the general and essential information about the digital video games, video games and education, and video games in special education.

1.1.1 Digital Video Games

Nowadays, digital video games are almost everywhere. Explosive growth in the video game industry implies that digital video games are potentially attractive for many people. The various type of devices such as game consoles, smart phones, tablets, laptops and so on, are also available to play video games. While game consoles are evolving, so are game controllers and other input devices for playing games. These devices were designed by considering the players' satisfaction and game's structure to be as user friendly as possible. Digital video games can be categorized with different aspects. Some important classifications are gameplay, objective, interaction, and graphical perspective and so on. For instance, from graphical perspective aspect, the games can be considered as 2D, 2.5D, 3D, first person, third person and so forth. The video game genre classifies the digital video games with respect to the gameplay interaction (Apperley, 2006).

Some common video game genres are: Action Games, Adventure Games, Board Games, Puzzle Games, Simulation Games, Strategy Games, Sport Games, and Video game genres by purpose. Every video game can be designed based on one of these genres or mixture of them. Some of these game genres can be assumed as sub-genres for the others. Classification of video games depending on their genres make it easy for the users to find the perfect games to play.

1.1.2 Video Games and Education

Video games are currently widely used in education. Some researchers state that video games are the best learning techniques compared to classical teaching materials and techniques because the video games are closer to children's world and easily accepted by them (Kafai, 2006; López & Cáceres, 2010; Young, 1993). Moreover, learning by games is more fun for the children. Computer games have potential as a learning environment because they are a form of playing that motivate students through entertainment (Blumberg, Rosenthal, & Randall, 2008; Chuang & Chen, 2009; Shih, Shih, Shih, Su, & Chuang, 2010). Students should master simple skills to achieve the higher-level abilities during the learning process based on cognitive theory. Additionally the processes of learning are moving from simple to complex, progressively (Yien, Hung, Hwang, & lin, 2011). The purpose of cognitive theory from psychology aspect is to find the human thinking context by perception of thinking processes. Also cognitive theory is considered as being connected to the game-based learning method. In addition, the emphasis of the cognitive theory is on the learners (Yien, Hung, Hwang, & lin, 2011). It is the teachers responsibility to ensure that students have sufficient understanding and comprehension about the technologies that are available (Carey & Sale, 1994).

1.1.3 Video Games in Special Education

Special education's main goal is to help the people with any kind of disabilities to completely benefit from their education by adequate intervention and specialized instruction. From many aspects special education is more intensive than regular education. Some differences between the regular education and special education are:

- An extensive diversity of teaching strategies used by special education teachers (Hocutt, 1996).

- Additional services such as specialized teachers, speech therapists, and physical therapists should be provided for the special students with considering each student needs individually.

Besides the traditional education content in special education, a functional curriculum is applied to help the student to learn the daily life skills, specifically for the skills which have not been developed such as using money, asking for their basic needs, tooth brushing, etc. This functional curriculum goes along with the teachers' directions. It is designed to teach the simple required life skills to the special students so that they can live more independently. Children in special education schools may receive intervention services include physical therapy (PT), speech and language therapy, and other related services. These services help them by teaching students how to accomplish wanted tasks with consideration of their disabilities. These therapies also prevent small problems from becoming more severe and can control the side effects of their disability (Oswalt, 2010).

Digital video games can be designed to a form of assistive technology (AT) to help people with various type of disabilities. Hedrick et al. (2012) have indicated in their studies "If an individual needs help with three or more of the six activities of daily living–eating, dressing, bathing, transferring, using the toilet, and walking across a small room–the individual has a severe physical disability." (p.165).

AT can be used with many types of disabilities and AT devices can be portable. It is not only for the schools; it can be used anywhere. AT may allow children to interact with others and help them develop social, physical, and cognitive skills that are necessary for future growth.

1.2 Purpose of the Study

There are people with varying degrees of the mental disabilities around us. They are part of our society and need our help. They should benefit from everything in society as other people do, and in some areas they should benefit more than people without disabilities. Each of these mentally disabled people's condition should be considered individually to get specific help with respect to his/her impairment level. Also their families are encounter with many difficulties to raise their children appropriately, and they deserve to use new technologies to help them to overcome the problems.

Mary Pat Radabaugh said (cited in Wendt, Quist, & Lloyd., 2010), "For people without disabilities, technology makes things easier. For persons with disabilities, technology makes things possible" (p.1). There are many basic life skills which people without disabilities learn easily just by interacting with the society. For the mentally disabled person, only being in the society is not enough to learn, he/she needs special help to be able to learn the basic life skills. Using related Assistive Technology during the learning process could be very effective for them. Computers or other digital devices keep motivation high to do a task several times. Also by using the AT in education, the educational environment can be everywhere. There are very few studies in the area of educational games for special students and there are many things to accomplish.

The main aim of the current study is to design a user-friendly 3D game by Unity3D game engine using Microsoft Kinect to helps mentally disabled people to learn daily basic life skills on an individual basis. The second aim is to present a road map for the other developers who are working in the special education area.

Children with mental disability need special education. They learn more slowly than a typical child. These children may spend longer time to learn language, develop social skills, and take care of their personal needs such as dressing or eating. For this group, learning will take longer, require more repetition, and skills may need to be adapted to their learning levels. Nevertheless, virtually every child is able to learn, develop and become a participating member of the community. Thus, the game developed in this study may help teachers to use technology without any controller and only by body movements, which makes the learning more fun, to teach children with mental disabilities sweeping as a life skill.

1.3 Research Questions

1. Is it possible to use motion detection based games to teach basic life skills to special education children?
2. Are motion detection systems suitable for the children with mental disorder as gaming controllers?
3. How to design a user friendly motion detection technology based game for special education children?

1.4 Significance of the study

There are several studies related with special education, but most of them focus on the physical rehabilitation. The current study is to design and test an interactive educational game for mentally disabled children to teach them a basic life skill. There are some games which also have been designed to teach life skills. Puspitasari, Ummah, and Pambudy (2013) have designed a software prototype called KIDEA, This software has some features, but the relevant feature to the current study is the Brain Game feature. This feature has two parts, Basic Math and Miss Mach. In Miss Mach game, children should find the objects correct places and put each object in its specific place.

In the present study, a 3D game was developed by using iterative spiral methodology, in each iteration game was changed depending on the situation. Cleaning skills have some steps which should be done sequentially to meet efficient results. The game was designed based on the special education experts' advice, and after each prototype their comments were considered for the upcoming prototypes. The game is designed in a way which covers a vast spectrum of mentally disabled people. The levels' difficulty was designed from basic to difficult. And the user interface is made user-friendly and simple to use. Ease of use user interface allows the users to choose the levels which fit to their skills level. All aspects of the cleaning skills were considered carefully by the help of a special education expert. The game is a 3D game which was developed by using more realistic models to provide a natural environment to education. Feedbacks are the important part of the study, in first levels to familiarize the children with the Kinect environment, feedbacks are used more. By evolving the disabled children skills, feedbacks are going to reduce in next levels.

We could not find any study about teaching basic life skills to the children with mental disabilities using Microsoft Kinect. This study's prominence is to combine the special education experts' experience and Microsoft Kinect technology to produce a user friendly educational game for mentally disabled children.

The proposed game helps special education students learn better, increases their motivation to learn, helps special education teachers to teach efficiently, helps to solve a societal problem, and helps families to teach their children at home, and so forth.

1.5 Definition of Terms

1. Skill: All of the steps which children should know to be able to do the desired tasks independently.
2. Mental disability: It is a disorder which affects both mental functioning and adaptive behavior.
3. Gameplay: It is a way of interaction between player and video game.
4. Bodily interactive games: The games which should be played by using body movements.
5. Special education: Education for children who need special care due to physical or learning disabilities.
6. Use Case Diagram: Tells us what the system should do.
7. Activity Diagram: Shows all the actions which occur to achieve the final goal of the system.

CHAPTER 2

LITERATURE REVIEW

The current study focuses on the development of a physically interactive educational video game for special education children. To make it clear for the reader to have a background about the topic, related work to this study is going to be discussed in this chapter.

2.1 Motion Detection and Motion Gaming

Movement can be a move of the whole body or just the movement of some small muscles of body parts. New technologies have made it possible to detect movement of any part of the body. A motion detection device (MDD) captures any symptom of motion. When motion occurs, the system responds appropriately based on its structure. Motion can be detected in different forms, some of them are by using:

- IR sensors
- Video and Voice recording devices
- Radio Frequency Energy
- Magnetic sensors

Motion detectors are the simplest type of MDD. Motion detectors are widely used in automated systems like security systems, automated lighting control systems, and many other useful systems.

Le Stick is a first motion sensitive game controller. Le Stick was released in 1981 ("Le Stick – The First Motion Sensitive Joystick Controller", 2014). Power Glove is the first home consoles' motion-control device which was released in 1989 for the Nintendo Entertainment System (NES). Power Glove was designed as an additional controller for NES, which had three interlinked sensors and were compatible with few games. It was difficult to play the game by Power Glow ("Backwards Compatible - The Power Glove", 2008).

Various type of game consoles are now available in the markets such as home video game consoles, handheld game consoles, micro consoles and so on. Game consoles are designed particularly for gaming. Several game consoles have a capability to detect the body motion, these game consoles have been released along with motion detectors such as Microsoft Kinect, Sony Move, and Nintendo Wii.

2.1.1 Microsoft Kinect

Microsoft Kinect is a popular MDD. A MDD, tracks body movements by tracking the body joints' positions and extracts the skeleton data of the body. The skeleton data is mapped to the 3D human model. Players can control the avatar by their body movements. Microsoft Kinect is one of the pioneer technologies which provides this interaction.

Figure 2.1: Microsoft Kinect

Kinect (Figure 2.1) is a MDD which was released by Microsoft in 2010 for Xbox 360 (Figure 2.2) and 2012 for windows. It has many applications in health, medicine, education, and gaming. For instance, with Kinect, surgeons can manipulate scans and X-rays without any direct contact (O'Hara et al., 2014).

Figure 2.2: Xbox360

To be able to develop the applications compatible with the Kinect sensor, computer application developers should use the Microsoft Kinect Software Development kit (SDK), which is a necessary tool to design the Kinect applications on Microsoft Windows. Microsoft Kinect SDK recognizes gestures and voices through the Kinect sensors. The first version of the Kinect SDK was released on June 16, 2011 for Windows (Meisner, 2011) and enabled the developers to design the Kinecting applications. The latest version of the Kinect SDK was released by Microsoft on October 21, 2014 ("Kinect for Windows SDK 2.0", 2014).

Controlling the Kinect is possible by voice and body movement. It is capable of tracking the users' body movements by detecting his/her bodies joints. Kinect is a very useful device which can be applicable in many areas such as any kind of simulations, rehabilitation, and education process. Teachers and students can easily interact with Kinect camera. Because it provides a more natural environment for the users, and does not bother them by dealing with wired or other kind of controllers, users are their own controller.

As Figure 2.3 shows, Microsoft Kinect is composed of:

1. The RGB camera: This RGB camera by recording the environment enables Kinect to catch useful information about the objects and people which are inside the view port of the Kinect camera.

2. IR projector (IR Emitter): Emits the invisible IR lights to the environment. This light has a pattern which is distorted after hitting the objects. This deformed pattern is read by IR sensor (Depth Camera).

3. IR Sensor: Interpret the IR light pattern to provide 3D maps of the environment and objects.

4. Microphone Array: Recognize the voices of the players. It also filters the ambient noises.

5. Tilt Motor: Adjust the Kinect position with respect to the in-front objects. Tilt Motor angular field of view is horizontally 57° and 43° vertically . It can move either up or down, maximum 27°.

6. Status LED: Shows the device status as on or off.

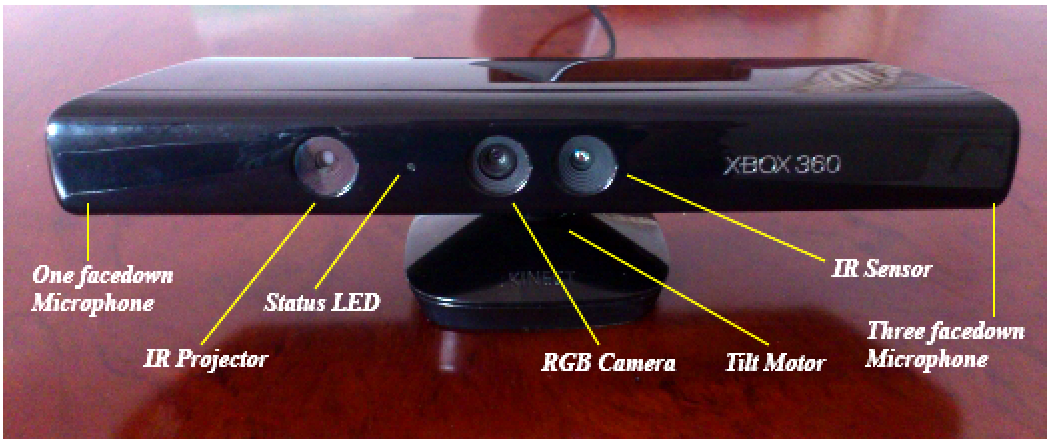


Figure 2.3: Microsoft Kinect ("Kinect for Windows Sensor Components and Specifications", 2014)

Kinect transfers data by a USB cable to the computer or Xbox360 game console. Full body Motion detection and facial and voice recognition are provided by these features. Kinect recognize the objects distance and extracts the users' skeleton data by its IR projector and IR sensor. Developers can simulate the players' movements by mapping this these data on a 3D model. These specific components of the Microsoft Kinect attract developers to design remarkable applications without limitations of the casual controllers. There is no need to have any physical controller to interact with applications anymore.

2.1.2 Nintendo's Wii

Figure 2.4 demonstrates the Nintendo's Wii. It is a home video game console released by Nintendo on November 19, 2006.

Figure 2.4: Nintendo's Wii

Different kind of controllers with special purposes are available for Wii. The Figures 2.5 illustrate the Wii accessories. The Nunchuck controller is a complementary controller for Wiimote controller. It is used in games which need two hand movements like boxing. Nunchuck is connected to the Wiimote by USB.

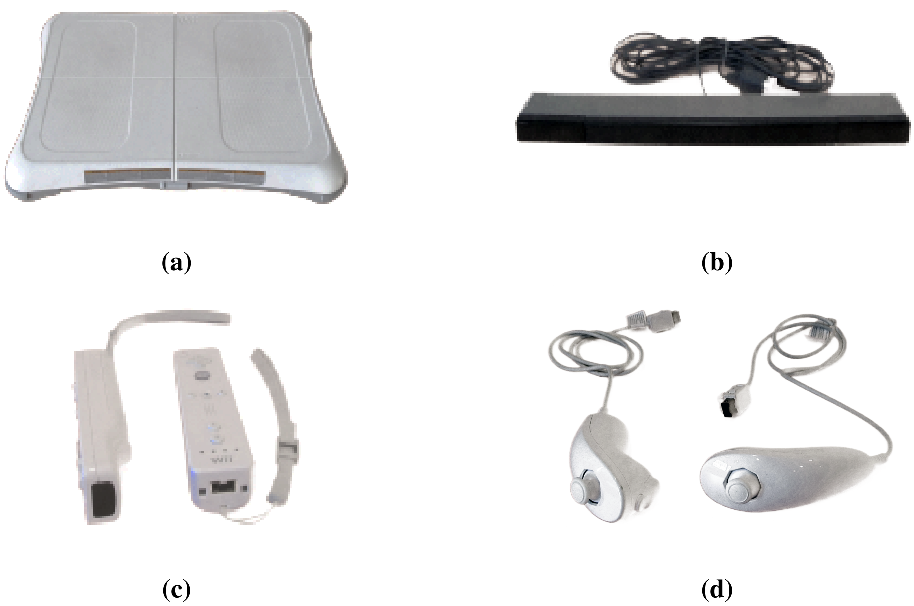


Figure 2.5: Wii Accessories: (a) Wii balance board, (b) Wii sensor, (c) Wiimote, and (d) Nunchuck controller

Wii balance board works with four AA batteries and it is a Bluetooth device. It has four pressure sensors which calculate the user's center of balance.

Wii sensor has 10 IR LED. Five of them are on the right side of the Wii sensor and other five are on the left side. The Wii sensor emits the IR light.

To make it simple, Wiimote can determine the controller movement direction by an accelerometer and sends the information to the Wii console using the Buletooth technology. The lights which come from the Wii sensor are detected by IR filter which perch in front of the Wiimote. Cursor position on the screen is changed based on this process. If IR lights are emitted to the top side of the Wiimote IR filter, it means the cursor should pointed towards the bottom of the screen (“Wii Official Site at Nintendo”, 2012).

2.1.3 PlayStation Move

PlayStation Move is a motion detecting video game add-on which was released by Sony computer entertainment in September 2010 for PlayStation 3 (“PLAYSTATION®MOVE MOTION CONTROLLER TO HIT WORLDWIDE MARKET STARTING THIS SEPTEMBER”, 2010). Move competes with Wiimote and Kinect but it is more similar to Wiimote than Kinect. Move is a hand-held device with buttons on it like Wii, and can be accompanied with additional controllers as it is shown in Figure 2.6. PlayStation Move accessories.

(a) **(b)**

Figure 2.6: PS3 Accessories: (a) PS3, and (b) Move

2.2 Gesture and Gestures Recognition

The definition of the gesture outside of the Human Computer Interaction (HCI) environment is a hand or body movement due to communication. However, the definition of gesture in the HCI area is different. It defined as using of hand or body movement in both human- machine communication and as a manipulator (Kendon, 1986). Generally passing information from a person to another person by hands or body movement are figure out as gestures (Liang & Ouhyoung, 1988). Like spoken language, hand gestures are a means of communication. Nowadays, using this feature to control the electronic devices and games is more evident. The goal is to make an easier communication between human and electronic devices.

Schlömer, Poppinga, Henze, and Boll (2008) proposed a system which makes it possible to use Wii controller’s (Wiimote) acceleration sensor as an independent device from Wii console. Their aim was to define an optional gestures and recognize them. Defined gestures can be used to control the other devices such as smart TVs, sound systems, and so on. Their gesture recognition library is also available for public (http://wiigee.sourceforge.net). They claim that their gesture recognition system is fast and efficient.

In their article Biswas and Basu (2011) present a method to recognize hand gestures by Microsoft Kinect camera. Eight specific gestures were defined in their method and their methods’ performance were observed. They believe that depth images taken by Kinect depth camera is enough to define the gestures.

2.3 Mentally Disabled Children

In this section, the types of disabilities of the participants are discussed. The children with mental disabilities which have participated in this experiment suffer from Mental Retardation (MR), Autism, and Down syndrome. An a brief overview of information about these are presented below:

1. MR: It is considered as an intelligence development and adaptive behavior shortage which arise when children are growing up (Bregman, 1991). There are many factors which can cause MR such as: Pregnancy at older age, genetics, and unknown factors.

2. Autism: Before the age of 3 years, qualitative disorders in social relationship and reciprocal action, and limited, dull, and stereotyped patterns of behaviors, interests, and activities, with weaknesses in one of these territories are defined as an autistic disorder (Corsello, 2005).

   Autism is a lifelong developmental disability that influences how a person communicates with, and relates to, other people. It also affects how they make sense of the world around them ("What is autism?", 2015).

3. Down syndrome: It is a developmental disorder caused by an additional chromosome. Some individuals with Down syndrome have some special physical characteristics such as: oval face shape, small nose, unusual teeth order, and small ears. By evolving medical treatment, life expectancy increases for the people affected by Down syndrome. Also early interventions increase the quality of their life.(Evans-Martin, 2009).

2.4 Physically Interactive Games

In the present era, by tremendous growth of the technologies, humans' lives are changing to the automated life. These technologies makes our life easier from many aspects but they also have a negative effects on our life too. Reducing physical activities are one of the more important disadvantage of technologies. In the past, in the lack of the digital entertainment environments such as TV, computer games, and so forth, children spent most of their time by playing the traditional physical activity games together. These days children spent their time by playing various digital video games and other types of entertainment technologies. Traditional games , most of them needing physical activity to play, gradually are going to be forgotten.

In their research (Bekker, van den Hoven, Peters, & klein Hemmink, 2007) a group designed two products to encourage children to do physical activities by providing a different and attractive opportunities, one of which is a car game; children should control a battle-tank toy by their body movements. There are two sensors, one of which is placed in a vest, and one in a glove. Children can control the remote controller battle-tank by his body moment and by pressing the sensor which is placed in their glove, they can shoot the target. The other game is named Flash-Poles. There are different poles with red, yellow, and blue colored rings on each. These rings can be pressed and rotate. By pressing the ring, it emits the same color light and by rotating the ring it causes to trigger a timer. Until the timer starts, nobody can change the light colors. The players are divided into two groups and each one tries to turn on their own group light color. They claim that children play both game with enthusiasm.

Designing video games based on the physical activities and compatible with new generation demands are essential to persuade children to do more enjoyable physical activities. To reach this goal, various type of game consoles (Xbox, PlayStation, Nintendo's Wii) and motion detection controllers (Microsoft Kinect, PlayStation Move, Wiimote), are used by game developers to develop the physical interactive video games. Interaction with these games is very simple, a player controls the games by moving his/her body.

There are various types of video games which combine physical exercise and gameplay. These are known as exergames. In these kind of games, a player is usually led by a virtual mentor in the middle of gameplay, and their performance's feedback shows how well their performance is(Kim, Prestopnik, & Biocca, 2014). Exergames are a complementary technology; they are not substitute for regular exercise (Rizzo, Lange, Suma, & Bolas, 2011).

Some studies have shown that physical interactive games are useful from many aspects. Exergames are being used as physical therapy tools for balance rehabilitation (Lange et al., 2011). The effectiveness of Exergames in controlling the subsyndromal depression is obvious in elders(Rosenberg et al., 2010). Also the energy expenditure of a player who plays active video games is more than a player who plays inactive video games(Leatherdale, Woodruff, & Manske, 2010).

2.5 Physically Interactive Educational Video Games

Physical activity is an important part of our lives. With respect to changing life styles, the need for physical activity is undeniable. Video games have a great potential to make players exercise. Immersion in interactive media raises the learning via situated experience (Dede, 2009).

Höysniemi, Aula, Auvinen, Hännikäinen, and Hämäläinen (2004) presented the Shadow Boxer game. Shadow Boxer is a fitness game in which the player interacts by physical movement. The player motion is detected by a web-cam. When playing the game it was detected that player's heart beat rate increased notably, and it is in the range of optimal exercise. They claim that Shadow Boxer can be used as an effective exercise method.

In their study Yang, Lin, Wu, and Chien (Yang, Lin, Wu, & Chien, 2008) studied the effects of the PILE (Physical Interactive Learning Environment) system on English learning performance, by designing and assessing a digital video game-based learning system, applying video capture virtual reality technologies, and by using them in learning environments with learning activity design. The result of the experiment reveals that integrating the PILE system into English learning activity with game-based learning design, increases student achievement with higher motivation and more positive attitude towards learning English.

A set of movement based game guidelines have been presented by Mueller and Isbister (Mueller & Isbister, 2014) based on their 20-years-research on the relevant domains. Their approach and the limitation to achieve this guideline is discussed completely. These set of guidelines were verified by 14 game design experts with various expertises. This set consists of 10 guidelines. Each guideline was presented along with an example to clarify the issue. In addition they propose a set of Instructions for the game developers to guide them in their ways. They also suggested what the developer should do and what they should not do to fulfill their projects. They have tried to establish a balance among being too broad and being too specific.

In his study İnal (2011) presented a set of design principles which can be used as a guideline to development of physically interactive educational games for children. Four physically interactive video games were designed based on these principles. The results of the study informs that usage of big camera screen increases the children's motivation during gameplay.

2.6 Kinect and Educational Video Games

Microsoft Kinect has opened new gates for game developers to make their dreams possible. It is an astonishing device which human beings could not invent until now. As many other devices in the game industry, Kinect also has many different application forms, for instance, for education, simulation, fun, and rehabilitation. The usage of the Kinect as an educational material is going to be discussed in this section.

In one of the earlier studies about Kinect and its potential in education (Hsu, 2011) which is one of the earlier, Hsu found that Kinect will increase the children creativity and classroom interaction. She believe that Microsoft Kinect (in comparison with interactive whiteboards) is more applicable.

In their study Richards-Rissetto et al. (2012) tried to perceive the results of using Kinect in teaching archeology. They developed a 3D GIS prototype of an ancient city and integrated it with information about the city. By applying Kinect technology, navigation through the 3D model is possible. This study shows the feasibility of using Kinect in teaching archeology.

Ayala, Mendívil, Salinas, and Rios (2013) proposed a kinesthetic learning application using Unity3D and Microsoft Kinect. They stated that Learning mathematical concepts by the kinesthetic learning method shows a positive effect in math education.

Zeid, Taqi, ElKhatib, Al-Yaseen, and AlMayyan (2014) presented in their article KinEd platform, which is designed for Kinect and consists of mini-games to teach biology, chemistry, mathematics, and physics. KinEd provides a safe virtual lab for learning science with a low cost.

In the most of the reviewed studies, the motivation to use Microsoft Kinect was to get rid of any kind of wired or hand-held controllers.

2.7 Video Games in Special Education

The power of the digital video games are clear to everyone. Video games have many applications such as entertainment apps, educational apps, and simulation apps. There are plenty of video games which have been designed for fun. There is a big gap in the areas of educational games, special education games, and specially games for the mentally disabled children.

Video games have a positive effect on children with special needs, and should be used continuously in special education(Ruggiero, 2013).

Griffiths (2002) mentions that video games which have been designed to teach a specific skill are notably successful. Educational games make the game flow attractive for their players by combining the fun and education. Design the game as an educational material is not easy, but is of importance. Simpson (2005) stated that the serious consideration is needed to use video games as a teaching material.

Video games can improve the social skills in the people with severe developmental disorders (Sedlak, Doyle, & Schloss, 1982).

From (González, Cabrera, & Gutiérrez, 2007) point of view, old methods of learning give pressure to children. They also mentioned that there are few educational games for children with special needs, and existing games are more concentrated on the education part rather than the game part. They proposed a Sc@ut DS tool, which is composed of Nintendo ds hardware device and game concept, to teach communication skills to children with communication problem such as autism and ictus. They have defined some rules as a guideline to design educational games for people with communication problems. Their study results confirm the effectiveness of the educational games for special students.

2.8 Kinect in Special Education

In their research (Lange et al., 2012) proposed a physical interactive game("JewelMine") to improve motor skills in the disabled people by using Microsoft Kinect. There are some objects in the screen which are placed around the players' current positions. A player should retrieve these objects one by one based on their orders.

Zafrulla, Brashear, Starner, Hamilton, and Presti (2011) assessed the effects of the Microsoft Kinect to teach sign language to the deaf people. They used to teach sign language to deaf people by a CopyCat system. This system consists of a computer game which is designed specifically to teach sign language along with a wearable controller and a camera to track eye and hand movements. The wearable controller is composed of two accelerometer which are placed in one pair of colored gloves to track the users' hand movements. Three set of data were collected by them, and based on the results, playing the game using Kinect in seated position was not satisfactory. With respect to some problems with Kinect in standing position, it was determined that the usage of CopyCat game by Kinect camera in standing position is beneficial. Although the performance of using wearable controllers is better than Kinect, from many other aspects Kinect is preferable.

In their studies (Soltani, Eskandari, & Golestan, 2012) modified Microsoft Kinect's "Shape Game" in such a way to be used by deaf peoples. By Microsoft Kinect SDK and their proposed Finite-State Automaton (FSA) algorithm, they defined new gestures and made it possible for deaf people to interact with the game easily. Furthermore, they claim that this method can be used in some public places like courts, and it make it easy to communicate between deaf people and those who do not know the sign language.

In their research, Giannis Altanis, Michalis Boloudakis, Symeon Retalis, and Nikos Nikou (Altanis, Boloudakis, Retalis, & Nikou, 2013) assessed the efficiency of the Kinect learning games for teaching children with motor impairment by conducting a case study. The Uni_Pac_Girl game was designed based on Kinems Approach ("Kinems Approach", 2013) and presented. Their experiment had two phases; in the first phase children should do the basic movements. In second phase they should do the same movements while playing the game. The children's performances in these two phases were considered based on time and number of efforts.

The results of the first case indicate that movement improvement was 73% of the Uni Pac Girl game criteria and for the number of attempts until doing right hand movement was 11%. For the second case, the number of attempts to doing correct hand movement was 44%.

As result for the first case the improvement for doing movement was 73% of the Uni_Pac_Girl game criteria and for the number of attempts till doing right hand movement was 11%. For the second case, the number of attempts to doing correct hand movement was 44%. By these results they confirm that the learning games are beneficiary for disabled children, but to find the valid results about the effectiveness of this kind of games, more studies are needed in this area.

Evgenia Boutsika (Boutsika, 2013) recommends the usage of Kinect as an assistive device for children with autism along with "Mnemonic Techniques". The researcher focuses on the existing games and their potential to be used in especial education like "Kinect Adventures".

In the proposed study by (Chang, Chou, Wang, & Chen, 2013), they offered a system called Kinempt. It is designed to help the individuals with cognitive impairments to be able to be involved in food preparation training by using Kinect gesture recognition service.

2.9 ÖZTEK Project

ÖZTEK project (http://www.oztek.metu.edu.tr/) is conducted at METU University and is supported by TUBITAK. ÖZTEK project's purpose is to increase the special education efficiency by designing and developing the educational materials using new technologies such as smart toys and bodily movement interactive games. The proposed projects help the parents who have children with special needs, to provide an effective environment for their children's learning. These projects are being applied as an assistive technology in special education schools to teach the children with special needs. ÖZTEK project's aim is to consider the following:

- Is there significant improvement in the special students' learning using ÖZTEK materials?
- Are ÖZTEK materials effective or ineffective in group working among special students?
- What are the teachers' comments about the ÖZTEK materials?

The current study's perspective is to design and develop a bodily movement interactive game which helps the children to learn the basic cleaning skills using a vacuum cleaner.

CHAPTER 3

GAME DEVELOPMENT METHODOLOGY

In this chapter, game development methodology is discussed. For this purpose, the following issues were considered: spiral model, game development procedure, and critical challenges during the software development.

In the beginning, according to the July 15, 2013 meeting of the Öztek group, 9 games were determined with a high priority to be designed for the mentally disabled children. The project's topics were: identify the vehicles types, put the toy vehicles in wanted place, color verification, object verification, kick the colorful balls, set the table, cleaning around, shopping at the grocery store, and self-care. After than the project's development process was started, cleaning around was selected to be considered in the current study. It was decided in the same meeting to design a 3D digital video game by utilizing the Unity3D game engine and Microsoft Kinect motion detector camera, to teach the vacuuming skills to the mentally disabled children. Using Unity3D game engine and Microsoft Kinect made it possible to simulate the cleaning skill.

The earlier game concepts were approved by a special education subject matter expert and then prototypes were developed and tested in special education schools. In the next step, feedback from the special education teachers and special education experts were collected to improve prototypes. This process continued until a satisfactory bodily movement game was developed. In addition to this, we also tested and improved usability approach for bodily movement games for special education children.

A digital vacuum cleaner game was planned to teach the cleaning skills efficiently to the mentally disabled children. Thus the game development process was started, and the first prototype of the game was ready on November 29, 2013. The first prototype of the game was planned to have a messy furnished 3D room model, a 3D character model, and a 3D vacuum cleaner model. Children were able to control the game character and vacuum cleaner model by moving their hands and bodies in front of the Kinect camera to clean the virtual room.

This prototype just was designed to show the possibility of the implementation of the project. Then a special education expert checked the prototype and approved it. This was the first prototype of the vacuum cleaner game. Feedback from the special education expert were considered and the game development process continued until September 2014, in a special student school (Bilge Özel Eğitim ve Rehabilitasyon Merkezi) in Ankara, Turkey. In December 2014 the camera-ready version of the game was tested in the same school. To get more reliable results, another school (Sait Ulusoy Özel Eğitim Uygulama Merkezi) in Ankara, Turkey was selected to test the final product.

Figure 3.1 depicts the timeline of the project development process. Most parts of the product

Figure 3.1: Project development timeline

were designed in the Bilge Özel Eğitim special education school, and a usability test was conducted along with systematic observation in the presence of a special education expert to determine how well students could play the game and learn the skills of the game. Our aim was to design and develop a beneficial game, which would help the children who need to learn this skill effectively.

It is essential to divide the tasks into the subtasks to teach the basic life skills to the mentally disabled children.

Learning the subtask is easier for the mentally disabled children. There are 7 steps in the vacuuming skill by vacuum cleaner (M.E.B, 2002), and children should know them to clean the room by vacuum cleaner very well. These fundamental steps are:

1. Children show the vacuum cleaner.
2. Children plug in the vacuum cleaner to an electricity source.
3. Children turn on the vacuum cleaner by pushing the on/off button.
4. Children should take the vacuum cleaner's sticks correctly.
5. Children should clean the room completely by moving his/her hand back and forth.
6. Children should turn off the vacuum cleaner by pushing on/off button.
7. Children should unplug vacuum cleaner from the electricity source.

Another important item was suggested by the special education expert: the children should distinguish and grab the non-garbage objects and put them out of the way in a desired place. All of these steps were not compatible to implement with Microsoft Kinect motion detection device, some of them were not feasible to design and others were the minor steps which can be learned by the simplest techniques. Based on these steps, it was decided to design and evaluate the game with following 4 items which were determined by a special education expert with a high priority to be taught to the mentally disabled children by using Kinect technology:

1. Children take the vacuum cleaner handle correctly.
2. Vacuum the whole carpet by moving their hands to the forward and backward.
3. Distinguish the garbage from the non-garbage objects, and take the non-garbage objects and put them in their own desired places.
4. Vacuum the whole carpet by walking to right and left side and, forward and backward.

The proposed vacuum cleaner game has two categories, a tutorial category and an evaluation category. Tutorial section was designed to teach the vacuum skills to the children, and the evaluation section was designed to assess the children's vacuuming performance in the virtual environment.

The 4 mentioned compatible vacuum steps with Kinect device were designed as an individual level under the tutorial category. All of them were developed based on body movements. All skills which children should know before starting to vacuum with a digital vacuum cleaner can be learned by playing the tutorial section.

In the evaluation category, all of the steps of the vacuum skills are united in one level. The evaluation level simulates the vacuuming process for children to practice vacuuming skill in virtual environment. The mentally disabled children's performance in virtual environment were evaluated by playing the evaluation level. It is essential to mention that the order of the skills in teaching to a special education student is very important. Based on the children's knowledge about the vacuum task, the proper level should be selected to start the education.

Those children who learned the vacuum skills from the tutorial category completely were eligible to play the evaluation section, because the evaluation section is more complicated than the tutorial section for the mentally disabled children.

Verbal cues were used more in the basic levels of the tutorial section, but reduced through the following levels. Reinforcement and feedback also were used in the tutorial part to increase the motivation and usability. Target groups for this study were the:

1. People who could not do the task individually and did not know about vacuum skill.
2. People who knew some steps but not all steps.
3. People who knew the all steps of the vacuum skill but still do not know the orders of the task.

The target group had problems with cleaning skills and needed help. To select the target group for the study, the children's vacuum performance in the real environment was assessed by using a real vacuum cleaner machine. Those who had any problems in the vacuum skills were selected as participants of the study. Then the teaching and development processes started. After the children learned the skills, a post-test in the real environment began. Then their performances in post-test were assessed and compared by their pre-test results.

This game gave us an opportunity to evaluate each level separately. In each level there is a button which turns the game sounds on or off. By turning the level sounds off, the level can be used for evaluation of the children. In tutorial section we evaluated each level individually.

The evaluation category helps to assess the children's improvement during the learning process, and check whether their performances are good to be assessed by post-test or not. Assessment is based on individual participant abilities. Each level was evaluated by different people. Corrections were considered. Because the objective was to improve and expand the game, evaluation helped to recognize which children were suitable for a real environment evaluation.

In the Bilge Özel Eğitim School 22 people participated in the usability test process. Ten of these students met our conditions. Children were asked to clean up the furnished room by a real vacuum cleaner in presence of an expert teacher and then play the digital vacuum cleaner game in the suitable environment which did not distract the children. Observers observed and took notes and recorded the event during the children's gameplay. Each experiment was recorded to use in the future. These processes were iterated for 8 weeks and the results of each iteration were gathered. The study continued with the 10 students.

In the Sait Ulusoy School 34 children participated in the usability test. They were asked to clean the carpet by the vacuum cleaner machine, and those children who had a problem with vacuum process were selected to participate in the experiment. Nine of them were qualified to continue the experiment. Their performances were observed and recorded, and the final result was extracted. The experiment results of both special education schools were gathered and analyzed and are explained in the results chapter comprehensively.

There are some preconditions which should be considered before starting to develop or play the game. Also some essential equipment should be prepared before playing the vacuum cleaner game:

- A big empty space: The place must be big enough to establish the Kinect system appropriately. No unnecessary objects should be between the player and Kinect camera. The desired place should not have too much ambient light, which affects the Kinect performance negatively. Using indoor lighting is preferred, because its infrared light is plenty less than sunlight.
- A computer: The game is designed for playing on a PC. It can be built for the Xbox360 game console as well.
- A Microsoft Kinect: By emitting the IR patterned light to the environment and process the distorted lights by depth camera, Kinect is able to detect the motions of the players.
- A big screen or a projector: Because the player is far from the monitor it is essential to have a big screen. It is possible to use either a big monitor or a big TV, or the game can be projected by projector to the wall to make it easy to see for the players.

3.1 Game Development Methodology: Spiral Model

A digital vacuum cleaner game was developed for motion sensing input devices by following spiral iterative methodology (Figure 3.2). Spiral model reduce the risk of the project by dividing it to the smallest parts. This simplify any changes during the development process.

In the game procedure section, all details of the spiral model for the current study are discussed completely. A brief explanation of spiral model for the current study is considered as following:

1. Determine objectives: The requirements of the vacuum cleaner game were: game story, Unity3D game engine, a Kinect camera, 3D models, Kinect SDK, a big space, a carpet, a vacuum cleaner, some toys, garbage, and a trash can. These requirements are the requirements of the all iterations of the vacuum cleaner game.
2. Identify and resolve risk: A prototype of the game was designed at the end of this phase. If there was any risk during the design process, suggested alternative solutions would be undertaken.
3. Development and Test: Game was developed and tested in this phase. The test process happened at the end of this phase for any iteration, it was tested by mentally disabled children.

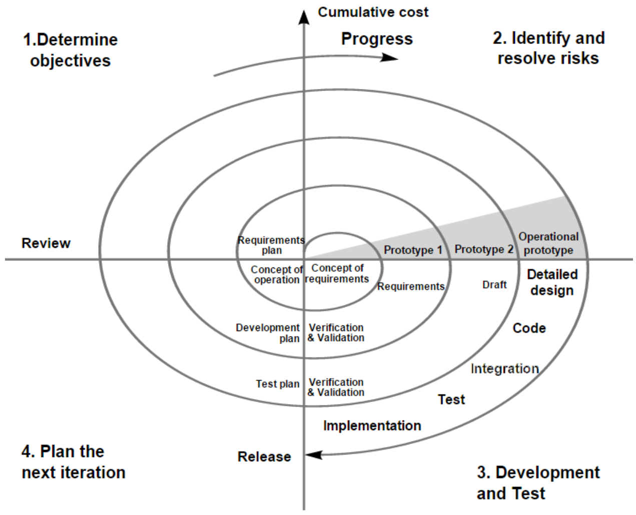


Figure 3.2: Spiral model (Boehm, 1988)

4. Evaluation phase: Before the next spiral started, designed game was evaluated by the special education experts. In this phase the children played the game and the evaluation results showed whether the students should continue to the new phase.

The spiral iteration process was continued until to reaching the suitable product.

3.2 Game Development Procedure

The development procedure of the game is discussed in this section. The main focus is on the designing and developing parts, but needed information about the special education section of the study is also discussed. Furthermore, Use Case diagram and Activity diagram of the study are explained completely to make the game development process clearer and more understandable.

Before the project started, a permission had been taken from the Human Subjects Ethics Committee. Then a prototype of the digital vacuum cleaner game was designed by using Unity3D game engine and Microsoft Kinect, based on the special education expert comments. This game was designed to teach the vacuum skills to the mentally disabled children precisely. Players can stand in front of the Kinect device and by moving their hands and their bodies, they are able to control the game and simulate the real cleaning act. During this experience verbal cues direct the children appropriately to do the wanted tasks based on desired level approach. Development and test process of the game took place at the Bilge Özel Eğitim ve Rehabilitasyon Merkezi and Sait Ulusoy Özel Eğitim Uygulama Merkezi special education schools in Ankara, Turkey. Software development in special education school started by collecting feedback from the special education experts and by observation of the mentally disabled children. Each week participants' performances were benchmarked and the results were considered in the development process of the game until achieving the project's criteria. The final project was tested by the participants in the presence of a special education expert and the final results were obtained. It was decided to test the final product in another school as well. In January and February 2015, the game was tested by the special students in the Sait Ulusoy Özel Eğitim Uygulama Merkezi. These results were also gathered and analyzed.

As mentioned before, the game development process was main done in Özel Bilge school. Now it is the time to look deeper to the game development procedure of this study with respect to the spiral model. The vacuum cleaner game was designed in Özel Bilge school considering spiral model. The final game was completed at the end of third iteration of spiral model. The spiral model iterations for current study are:

3.2.1 First Iteration

The first iteration of the spiral model with considering the each phase prerequisite started on September 19th, 2014 at "Bilge Özel Eğitim ve Rehabilitasyon Merkezi" special education school. There were 22 participants in the first iteration. It took 11 days to finish the first iteration.

1. Determine objectives: All of the requirements for this iteration were gathered based on the mentioned Oztek group meeting's decisions. It was determined to use Unity3D game engine and Microsoft Kinect to develop the vacuum cleaner game. The permission was taken from Human Subjects Ethics Committees. Bilge Özel Eğitim ve Rehabilitasyon Merkezi in Ankara was selected to do the experiments in the presence of the special education experts.
2. Identify and resolve risk: Identification of the risk helps to reduce the chance factor in the project development process, and it avoids encounters with unexpected situations. Additionally, the confidence to be successful in the project increases. Also repeating and duplication in project development process will decrease due to risk analysis. (Bannerman, 2008). Risk management for the first prototype of the project was more challenging because of the lack of adequate experience at the beginning of the project. Time is needed for us to be familiar with the all aspects of the project.
   The risks of the first iteration and corresponding solutions are:
   - Risk: Is the selected game engine and operating system platform proper for the current project? Unity3D was used as a game engine in this study and target operating system platform was Microsoft Windows.
   - Solution: Usage of the alternative game engines like unreal engine or different platforms such as Mac OS or Linux. If there were any problem with software development tools, alternative solutions would be considered in this step.
   - Risk: Time limitation risk. Finish the game development process as soon as possible reduces the cost of the project from many aspects.
   - Solution: Making the game development time period shorter is possible by having good organization and time management. To reduce the time limitation problem, it is essential to do the tasks based on their priority. The most important features should be designed and developed first.
   - Risk: Risk of the project size. The size of the project should be as light as possible to decrease the usage of the resources.
   - Solution: We can reduce the textures size, use the low polygon models, proper sound formats, and use prefabs (in Unity3D) instead of duplicating the same models and materials.
   - Risk: Working together. To increase the efficiency of the project development, it is better to work with the all persons who are somehow dealing with the same project such as teachers and students.
   - Solution: It is better to go in a special education school and work there.

- Risk: Technical obstacles such as high quality voice recording in the studio, quality of the textures and materials, and that the Kinect camera does not detect the body joints from some angles. Player should stand in front of the Kinect and the overlap between body joints may cause a problem.
- Solution: Using high quality microphone to record the game voices. By purchasing the material from online stores instead of designing from scratch. For Kinect camera risk, there is not a comprehensive solution at the moment, just by designing the levels in such a way which reduces the player strange movements.

The main risk was the timing risk. A simple game was decided to be designed to reduce the time wasting risk. It would have one level without any menu. The aim was to see the ability of the Kinect to fulfillment the project goals and using the special education experts ideas' to improve it precisely.

3. Development and Test: The first prototype was designed with considering the risks. In this prototype children would be able to control the character (avatar) by moving their bodies, and move around the room and clean the carpet with a digital vacuum cleaner. The first prototype was composed of one level.
4. Evaluation phase: Participants were asked to play the game. All of the participants' Performances were observed during the real room vacuuming process by using the real vacuum cleaner machine before playing this specific game. Then the prototype was tested by 22 mentally disabled children. It took some minutes to teach them how the game works. Because of the lack of experience, it was difficult to familiarize them with Kinect technology at first try.

3.2.2 Second Iteration

The second iteration of the spiral model with considering the each phase prerequisite started on September 30th, 2014 at Bilge Özel Eğitim ve Rehabilitasyon Merkezi special education school. There were 13 participants in the first iteration. It took 20 days to finish the second iteration.

1. Determine objectives: From the first iteration results, it was obtained that there were some technical problems with camera position, 3d model room size, type of the room, lightening, colors, type of garbage, character model, placement of the vacuum cleaner and its' pipe flexibility, vacuum cleaner sticks' which were needed to be fixed on the next iterations.
2. Identify and resolve risk:
   - Risk: In this phase there were some problems, and it was determined that children should be familiar with interaction with the game and Kinect camera.
   - Solution: It was decided to add three levels as a warm up levels before starting to learn the vacuum skills. These three levels were developed for teaching the basic rules of usage of the game and Kinect camera.
     Also, it was decided to add some new parts such as menu, feedbacks, audio, and verbal cues.

3. Development and Test: It took one week to complete the first iteration defects. To clarify the issue, a brief explanation about the first iteration defects solutions are as follows:

- To make the environment look real and produce the perfect perspective, the camera should be put in the best position. Perspective is all about depth. Figure 3.3 illustrates a 3D cube shape. It is made of 12 2D lines with a 90 degree angle between them. It is nearly impossible to consider this image as a flat image, because our brain perceive it as a 3D object. It is feasible to look the same cube from another angle and see it as a flat square.

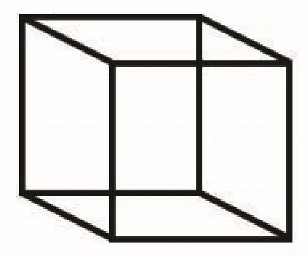


Figure 3.3: A 3D cube shape

The perspective is shown by a vanishing point and a horizon line. In this study it was determined that the one point perspective is more effective.
- There was a problem in the 3D models' proportion, the room was too big and the players didn't have enough space to go everywhere in the room. Thus it should be resized.
- Objects in the room should be placed in a way that do not distract the children. For instance, there should be a distance between objects. Overlapping is not acceptable and the number of objects should be reasonable. Too much objects could confuse the children.
- The environment light was equal everywhere in the room. To increase the children's attention, the important place in the environment should be lit, and the less important places such as walls, watch, and so forth, should be dim to concentrate the children's attention to a specific point in the game world. For instance, in Figure 3.4, light is focused on carpet. Walls and other non-important objects are darker than carpet, which causes children to focus on the carpet more than other places in the room.

Figure 3.4: Lightening of the scene

- Low polygon models should be applied to keep the game as light as possible. Models with more polygons need more calculation and more resources to be displayed.

- Feedback should be added. To have a good interaction between children and game, it is essential to use feedback. Feedback motivates the children to play more and more.
- Player should be able to change the avatars. The avatar selections are needed. It is better to have more than one avatar in the game. Figure 3.5 illustrates a screenshot of the avatar selection menu corresponding to the vacuum cleaner game.

Figure 3.5: Avatar selection menu

- Because the vacuum cleaner game has more than one level, it needs to have a start menu to make the settings and level selection possible. A start menu was designed. Figure 3.6 shows a screenshot of the designed start menu.

Figure 3.6: Start menu

- Audio and verbal cues should be considered. Verbal cues reduce the outside intervention during the gameplay.
- Game status bar (HUD) should be simple and user friendly. It helps the parents and teachers to easily deal with the software. Simple HUD motivates parents or teachers to execute the game continuously. The purposed HUD has 5 buttons: an exit button, an audio button, a repeat button, a go to the next button, and a go to the previous levels button. It is illustrated in Figure 3.7.

Figure 3.7: Status bar (HUD)

In this step three levels were designed and added to the first prototype: one preparation level and two tutorial levels.

4. Evaluation phase: At this time the second prototype of the game had a start menu and three levels. In the start menu, the player can change the avatar. This iteration started by testing the game on mentally disabled children. As with the first iteration, before starting the game it took some time to familiarize children with the usage of the Kinect technology. They should learn how to play in a limited space. The results from this iteration, along with a special expert's concern, reveal that the game needed to go to the next iteration.

3.2.3 Third Iteration

The third iteration of the spiral model with considering the each phase prerequisite started on November 19th, 2014 at Bilge Özel Eğitim ve Rehabilitasyon Merkezi special education school. There were 5 participants in first iteration. It took 1 month to finish the third iteration.

1. Determine objectives: By considering the results of the second iteration, it was found that a preparation level should be designed to reduce children dependency on the other people. Verbal cues and audio feedback should be clearer.
2. Identify and resolve risk:
   - Risk: The game still needed some levels to evaluate the learning skills by mentally disabled children. Is it possible to design such a level?
   - Solution: Design as simple as it possible.
3. Development and Test: In this iteration, the corrections from the past iteration were considered and another level for teaching the correct hand movements during the cleaning process were designed. Also in this iteration two levels were added to the game. In the first level, the player should collect the piece of papers and clean the rest of the room by vacuum cleaner. In the second level (the evaluation parts' level) children are asked to grab the non-garbage objects and put them on their own place, then clean the carpet by digital vacuum cleaner.
4. Evaluation phase: The final product was completed after 3 iterations. By pushing the sound icon, all of the verbal cues were off, and the evaluation level was tested by the mentally disabled children. This occurred at the Bilge Özel Eğitim special student school, and the results were satisfactory to finish the project development.

3.2.4 Final Game

The final version of the vacuum cleaner game consists of two sections:

1. Training section: It was designed to teach children to interact with Kinect Camera and Game. This section is composed of 6 levels which were designed considering the level of the children's disabilities. It is obvious that before starting the task, the essential skills should be learned. In the most games which are designed for people without disability, several levels are designed to teach the game rules. In these levels, the player learns how to interact with the game to fulfill the wanted tasks. Perhaps people without disability can jump these levels and go to the advanced levels, but mentally disabled

people should learn every specific skill step-by-step and consecutively to be able to finish the wanted tasks. In the present study, a level known as the preparation level was designed to familiarize the mentally disabled students with the Kinect technology and the environment of experiment (Figure 3.8). The students should be familiar with playing the game without using any controllers. In the Kinect technology there is not any physical controller in users' hands to control the game. Contrarily, Kinect makes themselves their own controller. In this level, the player stands in front of the Kinect. He/she is asked by the game's vocal instructions to raise his/her hands, and then to move forward and backward to get adapted to the Kinect and virtual environment. Children are free to do every movement to get accustomed to the Kinect atmosphere.

Figure 3.8: Preparation level (first level)

Two levels were designed to teach the mentally disabled children how to move towards the four main directions. These two levels have the same design but different verbal cues. Intervention in the second level is less than the first level. Figure 3.9 demonstrates the room with a carpet which is divided in four parts. Each part is informed by specific colors. Verbal cues ask the children to go and stand on a specific place which is indicated by a green arrow. When children go and stand on the indicated place, the arrow will disappear and the other arrow will show the next part of the carpet which the child should move to. The children should follow the arrow until he/she finishes the wanted task.

Figure 3.9: Education levels (second and third levels)

By doing this practice, children can understand the depth concept. When an arrow is pointed towards the top-left side of the carpet, the child should notice that he/she can reach that point by walking some steps forward. These levels were tested by participants. Figure 3.10 illustrates how a participant tries to follow the indicated arrow.

Figure 3.10: The participant is playing education levels

One level was designed to teach the precise hand movements during the cleaning process. Children should learn this step completely to be able to clean the room efficiently. Teaching this step to the mentally disabled children is one of the most important tasks of the present study. In this level, the camera angle is altered to show the player and the environment from above. This top-down perspective screenshot of the level is illustrated in the Figure 3.11. Other angles also were tested for the camera position. The current top-down camera position was the most understandable for the children. In this level, children are directed by verbal cue to moving forward and keep the vacuum cleaner stick on top of the red star. After waiting for seconds in this position, the next verbal cue tell the children to move the vacuum cleaner stick on top of the yellow star without moving their bodies. Children should be able to move their hands toward and backward while they are standing in a fixed position.

Figure 3.11: Hand movement training (forth level)

This iteration from red star to yellow star and vice versa can be repeated as many times as needed. Verbal cues are reduced after some repetitions and after while it stops completely. Children should be able to do the task without any intervention.

Figure 3.12: The participant is moving his hand backward

Figure 3.12 and Figure 3.13 have shown the participant action clearly. This student was asked to go in front of the Kinect camera and start to play from the starting spot. He did the task as it is requested. By pulling his hand backward or forward, his body's joints and position were detected by Kinect camera, and he was able to control the vacuum cleaner stick by his hand.

Figure 3.13: The participant is moving his hand forward

One level was developed to help the children practice cleaning skills by cleaning the whole room. Figure 3.14 depicts a screenshot of the level. Verbal cues were used to ask the children to clean the room.

Figure 3.14: Cleaning the room (fifth level)

Children should clean the room completely by vacuum cleaner. Varying the vacuum cleaner's volume during the cleaning process gives a feedback to children and they understand if are doing the wanted task truly. Figure 3.15 shows a snapshot of a child who is playing the current level.

Figure 3.15: The participant is playing the fifth level

One level was designed to familiarize the participant with the grabbing objects along with the cleaning process. In this level, the essential steps for cleaning the place up is taught to the users, such as: differences between garbage and non-garbage objects, and suitable places for putting the objects which should not be cleaned or cannot be cleaned by vacuum cleaner. A screenshot of the level is shown in Figure 3.16. In each section it is possible to move to the next or previous level. Also the sound can be muted to check the user performance without any intervention.

Figure 3.16: Last level of the tutorial section (sixth level)

2. Evaluation section: People can use their understanding from the tutorial section to finish the wanted tasks for the level. The evaluation section consists of one level. This level is the last level of the vacuum cleaner game. By turning on the all verbal cues, it can be used as a tutorial level too. This section's aim is for the mentally disabled children to grab the non-garbage objects and put them in the proper place along with vacuuming the place by digital vacuum cleaner. Figure 3.17 shows a screenshot of the evaluation level.

Figure 3.17: The evaluation level

Figure 3.18 illustrates a snapshot of a student who is playing the evaluation level of the game.

Figure 3.18: The participant is playing the evaluation level

3.2.5 Use Case Diagram

In this study, a use case diagram was designed based on the expected results of the study. Figure 3.19 shows the use case diagram of this research, the interaction between the actor and system is shown on the figure. It is expected that the player with mental disabilities will have an improvement in vacuuming skills after playing this game. Three major goals are expected from the mentally disabled players, first: object recognition, second: Improving his or her mental performance, third: Improving his or her physical performance.

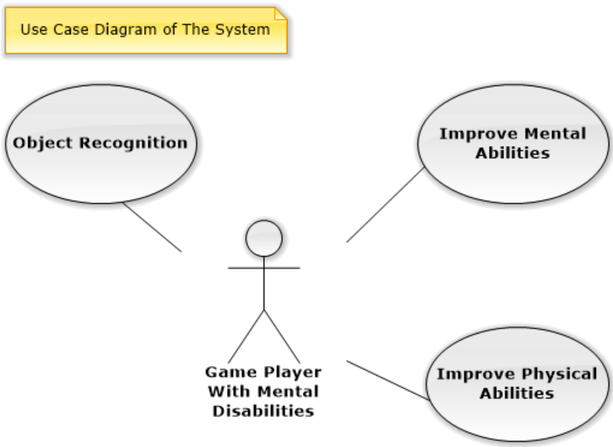


Figure 3.19: Use case diagram of the current study

In the object recognition part, it is anticipated that the player be able to distinguish the objects which can be cleaned by vacuum cleaner from the objects which should be grabbed by hand. In addition he/she should place the non-garbage objects in their own places.

Improving the player's mental abilities was planned in this study and its effectiveness was measured. This process is the most important part of this study, because there are various types of mental disabilities and each case should be considered individually by an expert. The data from the expert teachers were gathered and the levels were designed with respect to the comments of the experts in this area.

Physical improvement is another fundamental section of the study. In the gameplay, players should do certain tasks based on the level structure. Players are asked to move his/her body like raising hands or legs, sitting, and moving in different directions.

3.2.6 Activity Diagram

The following Activity Diagram shows all the actions which occur to achieve the final goal of the system and the diagram has been designed to give high level understanding of the system functionalities.

The Activity Diagram of the present study is illustrated in the Figures 3.20, 3.21, and 3.22. Figure 3.20 shows that by starting the game, the main menu will appear. In main menu three actions are possible: starting to play the game by default settings, quit the game, or go to the setting menu.

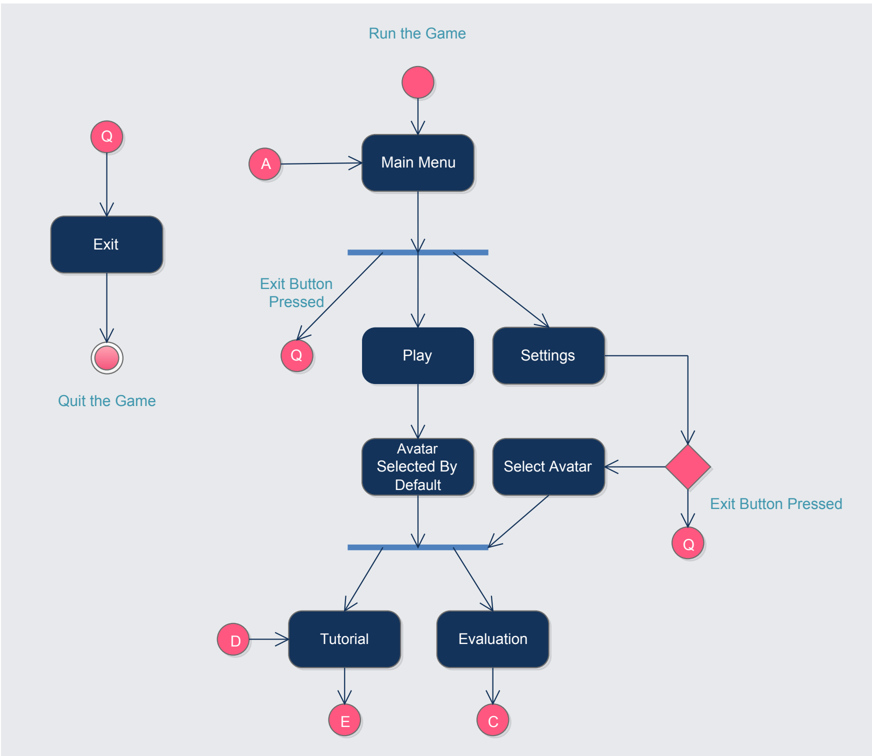


Figure 3.20: Activity diagram of the current study (first part)

If the play button is pressed, an avatar will be selected by default and the player will continue the game. If the settings button is pressed, the user has two choices, to quit the game or to select the avatar. By choosing the avatar by default or an avatar chosen by the user, the game level selection menu will appear. The player has two choices in this step. He/she can select the tutorial level to learn the essential information about the game and dealing with Microsoft Kinect, and learn the vacuum skills completely, or they can select the evaluation level. In the tutorial part, cleaning skills will be taught to the player and it consists of some levels from basic to advanced. The evaluation part is designed to evaluate the players' performance.

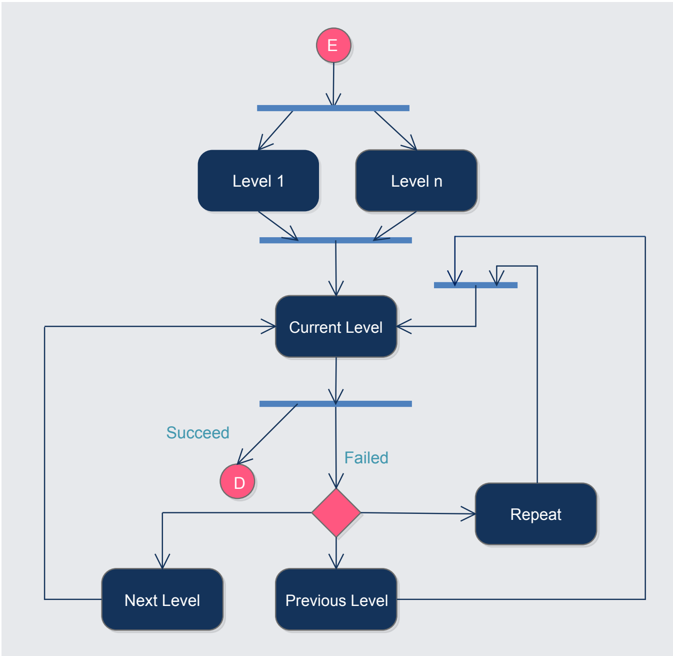


Figure 3.21: Activity diagram of the current study (second part)

It is supposed that the player chooses the sections sequentially from left to right. First scenario: he/she choses the tutorial section, and the player is able to choose which level he/she wants in this section. He/she can play the game or repeat the levels or quite the game. If the player completes the levels, the game will come back to the main menu where the player can decide to continue or choose to: repeat the game, go back to the previous level or go to the next level. In the first level of the Education part, players are not allowed to go to the previous level, also in the last level of the Education part, players are not allowed to go to the next level because there are no further levels.

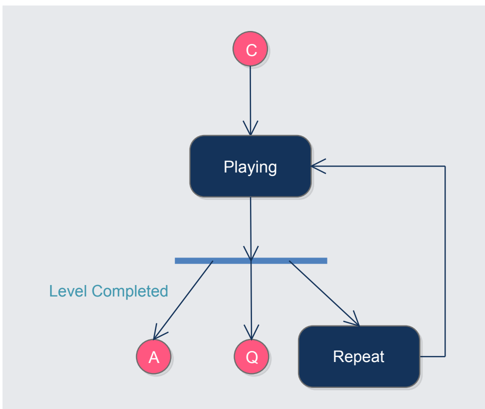


Figure 3.22: Activity diagram of the current study (third part)

Second scenario: Player choose the evaluation section. In this part his/her performance will be assessed. He/she has a three choices here, playing the game, quit the game or repeat the game.

3.3 Critical Challenges

Challenges are an inseparable part of each project. Current study encountered some challenges. A few of them were technically restrictions and the others were about children's mood, their presence and so on.

3.3.1 Technical Restrictions

There are always some restrictions in projects which may affect the final results. Mostly these limitations are caused because of the technical restrictions. This study was not an exception. The most important restriction was a technical issue with Microsoft Kinect motion sensing device. Microsoft Kinect does not support all body movement positions. To detect the body skeleton joints perfectly, the player should be face to face with the Kinect camera (Figure 3.23). General body movements in a 3D environment is the strong reason for using Kinect. According to the instructions manual of the Kinect ("Kinect Manual", 2010), the recommended room size is between 6-12ft (1.8-3.6m). Players should stand back approximately 6 feet (1.8 m) for single player and 8 feet (2.4 m) for two players from the Kinect sensor. With respect to the Kinect sensor position and other factors, a different play space can be chosen("Kinect Manual", 2010).

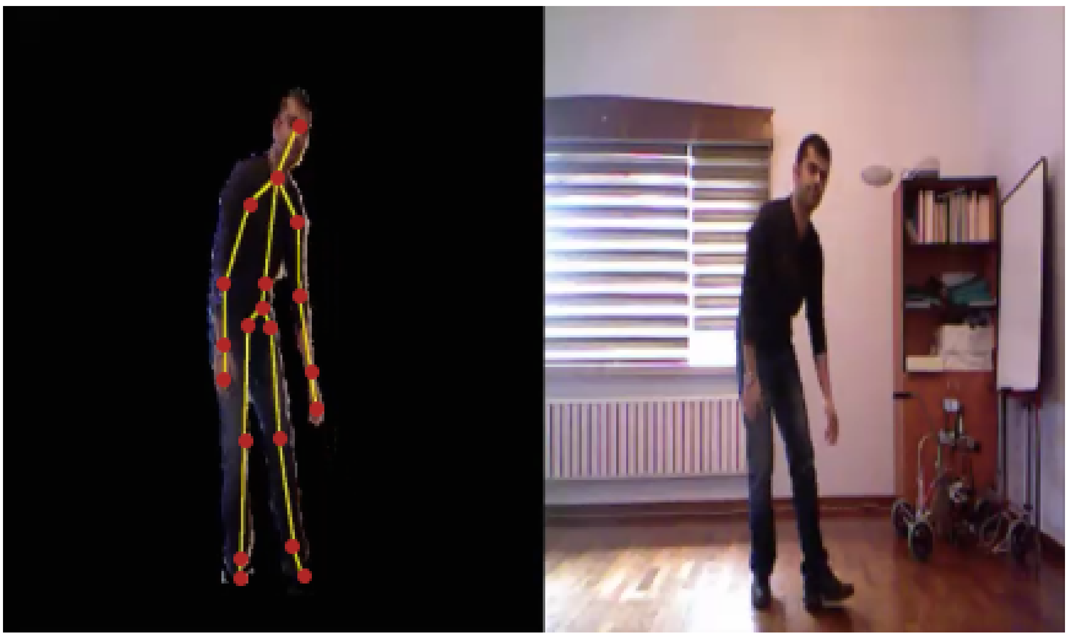
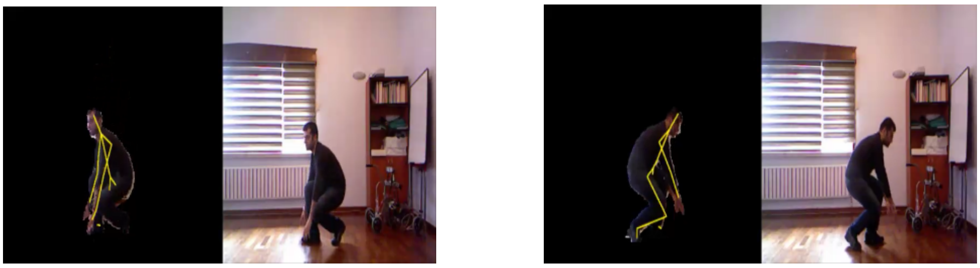


Figure 3.23: Snapshot of the correct standing style

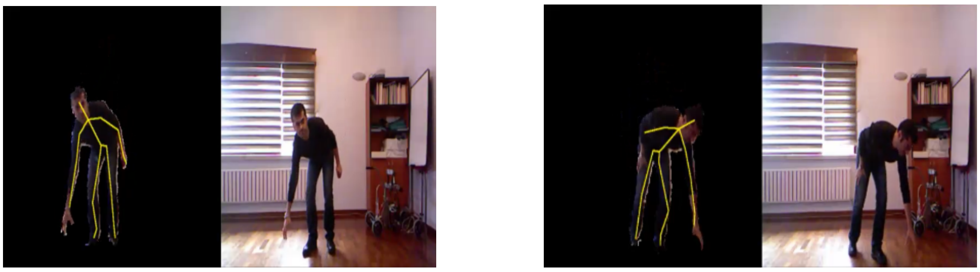


(a) (b)

Figure 3.24: Snapshot of the wrong sitting styles which may cause the problem

In the gameplay, the player should grab objects from the floor, and to accomplish this task he/she should sit down and take the defined objects. When he/she is sitting his/her body should be straight forward towards the Kinect camera. The Figures 3.24a and 3.24b shows the sitting positions which are not detected properly by Microsoft Kinect camera. In the positions where the player's body is not toward the Kinect camera, overlap happans between the body joints, and Kinect camera is not able to interpret it.

Figures 3.25a and 3.25b depict the right sitting positions which should be used by children in order for them not to encounter the joints overlapping problem. The correct way of taking the vacuum cleaner stick is depicted in Figure 3.26



(a) (b)

Figure 3.25: Snapshot of the correct sitting position to grab the object perfectly

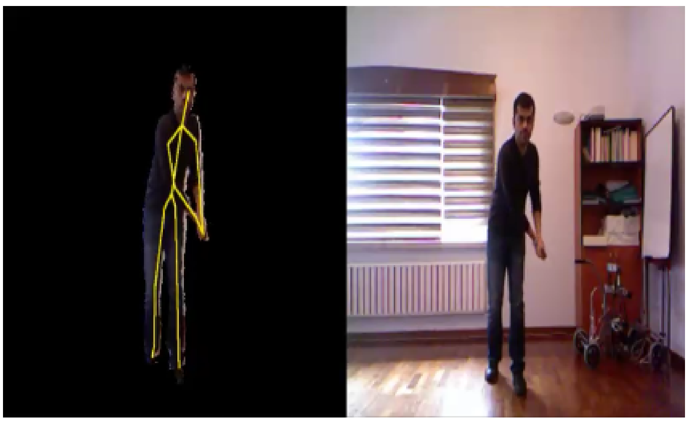


Figure 3.26: Snapshot of the correct position of taking vacuum cleaner sticks by hand

3.3.2 Other Restrictions

There were some restrictions which made the experiment time longer. Some of them will be mentioned in this section.

Sometimes there was a meeting in the experiment room, which caused the experiment to start later. When children were not in a good mood, they did not prefer to participate in the experiment. We had to do the experiment in the following days. Sometimes the unwanted noises made it difficult to do experiment for a while. Sometimes parents were on hurry to take the children home. Some children's parents did not allow them to participate in the experiment.

CHAPTER 4

RESULTS

The process of teaching to special education students, specifically mentally disabled children is quite complex and time consuming. Every skill should be divided into the simplest steps before teaching to mentally disabled children. The compatible vacuuming skills with Microsoft Kinect device are shown as a checklist in Table 4.1.

Table 4.1: The checklist of the compatible vacuuming skills with Kinect

1. Children take the vacuum cleaner handle correctly.	
2. Vacuuming the whole carpet by moving their hands forward and backward.	
3. Distinguish garbage from the non-garbage objects, and take the non-garbage objects and put them in their own designated places.	
4. Vacuuming the whole carpet by walking to the right and left and forward and backward.	

The checklist was approved by a special education expert, and was used to evaluate the children's performance. The final results were achieved based on this checklist. In the current chapter, results of the experiments which have done in both Bilge Özel Eğitim Ve Rehabilitasyon Merkezi and Sait Ulusoy Öazel Eğitim Uygulama Merkezi special education schools, were depicted.

4.1 Bilge Özel Eğitim Ve Rehabilitasyon Merkezi

There were 22 participants from Bilge Özel Eğitim Ve Rehabilitasyon Merkezi special education school. They attended the experiments several times. Each session was between 5 and 15 minutes. Fifteen of them participated for less than 5 weeks. Among of these participants, some of them were familiar with the vacuuming skill and for some others, teaching the vacuuming skill was impossible. These were eliminated from the experiment. Seven suitable children participated from 5 to 8 weeks and finished the experiment completely.

In total, 10 participants were determined with the ability to participate in the experiment and their performances are going to be discussed. Three of them are girls and rest of them are boys. Table 4.2 shows the Bilge Özel Eğitim Ve Rehabilitasyon Merkezi special education school participants' status.

The students were divided in two groups. In the first group, the children finished the experiment completely. They participated on time and their performances also were acceptable in

Table 4.2: Participants' status

total participants	< 5 weeks	5-8 weeks	qualified participants	girls	boys
22	15	7	10	3	7

the real vacuuming process. In the second group, the attendance levels were not high enough to be evaluated. They had a potential to learn but unfortunately they were not available for the experiments. For some of them, more time was needed to learn, and some others did not participate in the experiment on time. Due to the confidentiality of the participants' personal information, their names are mentioned by numbers and letters. Table 4.3 demonstrates the total cases ages and types of disability. There were seven boys and three girls who had participated completely in our study. They were between 9 and 20 years old. One child had autism, one child had Down syndrome, and the others had mild MR.

Table 4.3: Participants' characteristics

Case	Age	Gender	Type of disabilities
1A	11	Male	Autism
2A	9	Female	Mild MR
3A	20	Male	Mild MR
4A	10	Male	Mild MR
5A	17	Male	Mild MR
6A	12	Male	Down syndrome
7A	16	Female	Mild MR
8A	16	Male	Mild MR
9A	16	Male	Mild MR
10A	16	Female	Mild MR

Figure 4.1: Pre-Test experiment

At first, as shown in Figures 4.1 and 4.2, the children were observed in a natural environment, and graded in terms of their ability, according to the Table 4.1 checklists. They were asked to clean the carpet by the vacuum cleaner.

Figure 4.2: Pre-Test experiment

Then with respect to their actions in the real setting, they were asked to play the vacuum cleaner game. Those who knew the task were eliminated and the experiment continued with the children who had a problem in the vacuuming skill. After finishing the education to the children unfamiliar with the vacuuming skill, the evaluation step started. The children were asked to clean the room by a real vacuum cleaner. Again, their performances were graded based on the Table 4.1 checklists. Then the pre-test and the post-test results were compared.

Before considering each case, some factors must be taken into consideration. Some of the problems were common between the cases, so to avoid duplication, only for the first case will the problems be discussed completely; for the other cases just unmentioned problems will be discussed for all of the prototypes. The maximum time which is needed to teach the vacuuming skills to the mentally disabled children by the vacuum cleaner game is 45 minutes. In Bilge Özel Eğitim Ve Rehabilitasyon Merkezi school, the children only participated for less than 10 minutes in each experiment, thus it took more than 2 months to finish the experiment completely. We had to finish the experiment before the end of the semester, for this reason some of the children did not attend in the last evaluation experiment. Participants were divided in two groups, those ones who finished the all of the tasks and participated in the pre-test and post-test evaluations formed the first group. In the second group, the children who did not finish the task are gathered.

4.1.1 First Group Experiments' Results :

The children in the first group are between 9 and 20 years old. There were four males and 1 female. They have participated in all steps of the experiment and also their pre-test and post-test evaluation results are available in Figure 4.3.

4.1.1.1 Case 1A

He was an 11-year-old boy suffering with autism. Distinguishing him from children without disabilities was very difficult. He had a special character. While he was playing the game, he was making noises by his mouth and was repeating some words continuously. He did not have any specific problem which affects the experiment negatively. He participated in the study for 8 weeks.

- Pre-Test: His first experiment was on September 24th, 2014, and He was asked to clean the messy room by real vacuum cleaner. He did not use his hands correctly. He took the vacuum cleaner sticks and his hands were fixed, then he was trying to clean the room by moving his body. He should have moved the vacuum cleaner sticks toward and backward with his hands. During the cleaning process he was not concentrated on the experiment. He was looking around and was walking in random directions while cleaning. He had vacuuming experience before. His family taught him the vacuuming skill, but it was not enough for him to do the task individually. He was selected as a good case for this study and we asked him to play the first prototype of the game.

- Gamelplay: His Second experiment was on October 1st, 2014. He started to play the first prototype of the game. According to observation, encouragement was very important to him. He encouraged himself after doing a skill well. His concentration on the screen was very acceptable. He was not distracted easily. He played the game very well. In this step it was detected that there should be a level to teach the correct hand movement to the children. Also feedbacks should be added to the game. He was moving very fast and it caused a problem with Kinect device. Microsoft Kinect was not able to detect the body joints perfectly in fast displacement. This technical problem was solved in the second prototype. The third experiment was on October 8th, 2014. He started to play the second prototype. He played all levels of the game and it was very exciting for him. He learned the correct hand movements. The fourth experiment was on October 15th, 2014. He played the second prototype again, this time with low intervention. The fifth experiment was on October 22nd, 2014. At this time the third prototype was developed, and he was asked to play the third prototype to find the defects of the prototype. In the third prototype he should grab the non-garbage objects and put them in the desired place. For these reasons two levels were designed. One of them was tested in this step. He was asked to grab the crumpled paper and put them in the trashcan. There was a technical problem with child's height. The game was not able to detect his height perfectly. This defect was considered to be fixed. The six experiment was on November 5th, 2014. The same level which was tested in the previous experiment, after solving the problems, was tested again. He did the wanted task well and grabbed the crumpled papers and put them in the trashcan. Here there was a problem with grabbing the garbage; the child should not sit completely to grab the garbage because it makes the overlap between body joints and Kinect cannot detect the player bodies' joints exactly. To solve this problem collision detection rolls were changed in a way that children would be able to grab the objects by little bending. The seventh experiment was on November 9th, 2014. He was asked to play the complete version of the third prototype. He played very well there was not any major problems in this step.

- Post-Test: The last experiment was on December 10th, 2014. This experiment's aim was to observe his performance while he was doing the vacuuming task on the real room using a vacuum cleaner.

4.1.1.2 Case 2A

She was a 9-year-old girl and she was categorized as mild MR.

- Pre-Test: Her first experiment was on September 24th, 2014 and she was asked to clean the messy room with a real vacuum cleaner. She was familiar with using the vacuum cleaner, but she was cleaning the room randomly. She cleaned the same place more than one time, and her hand movements were not acceptable. She was eligible to participate in the experiment.

- Gameplay: She was asked to play the game. She played first prototype of the game, and in this experiment she became familiar with Kinect camera. Her second experiment was on October 1st, 2014. She played the second prototype of the vacuum cleaner game and there was not any major difficulties for her during the experiment. She played all levels of the second prototype. She was playing very fast, and she became distracted easily by outside events. The third experiment was on October 8th, 2014, and she was asked to play the second prototype again to become more familiar with game environment. She was playing too fast. She learned the correct hand movements by playing the respective level. Her fourth experiment was on October 15th, 2014. She did not have time to participate completely. She played the game for less than 5 minutes. The fifth experiment was on October 22nd, 2014. She was asked to play the third prototype. She was very active, and she was still walking very fast. Her sixth experiment was on November 12th, 2014. She was asked to play the third prototype of the game. She completed her experiment in this step.

- Post-Test: The last experiment happened on November 19th, 2014, and her performance was observed. Firstly she grabbed the non-garbage objects and put them in their places, then she started to clean the room with the vacuum cleaner machine. She did all of the expected tasks very well.

4.1.1.3 Case 3A

He was a 20-year-old boy with mild MR. He was lethargic and reluctant to do anything. He did not do anything without taking a cup of tea or another prize. Dealing with him was challenging as he only accepted his teachers' comments.

- Pre-Test: The first experiment started on September 29th, 2014. His teacher asked him to clean the room with the real vacuum cleaner, and his performance was observed. His hand movements were quite well. He did not take the crumpled paper. He cleaned small part of the carpet.

- Gameplay: Then he was asked to play the game. He started to play the second prototype of the vacuum cleaner game. During the experiment his hands were in his pockets. It took time to forget this habit, and then he played well. His second experiment was on October 13th, 2014. Most of the times he participated after 5 pm, therefore he was tired. In this experiment correct hand movements were taught to him. He understood what we was expected of him, but he did not wanted to listen well on purpose; he was waiting for a prize to do the task. He learned the skill, but he was moving both of his hands simultaneously. His third experiment was on October 27th, 2014. In this experiment he played with the third prototype of the vacuum cleaner game. He played for some minutes, then he left the experiment. The fourth experiment was on November 3rd, 2014, and he played for only three minutes. He played the third prototype and his performance was very helpful to improve the game, specially his style of grabbing objects. The fifth experiment was on November 2nd, 2014, and he was full of energy. He played the game very well without any intervention. His sixth experiment was on December 12th, 2014. He attended for less than 5 minutes. He only played the last level of the last prototype.

- Post-Test: His last experiment was on December 8th, 2014, and his performance was evaluated and observed. He did all of the wanted tasks completely.

4.1.1.4 Case 4A

He was a 10-year-old boy with mild MR. He participated 6 times in the experiment. For him it was very important to be encouraged, repeatedly he was asking about his performances.

- Pre-Test: His first experiment was on September 30th, 2014, and he was asked to clean the room with the real vacuum cleaner machine. He did it, but he did not clean the room precisely. He was familiar with plugging in and starting the vacuum cleaner.
- Gameplay: He was asked to play the second prototype. He had many problems to interact with the game and Kinect camera. His second experiment was on October 15th, 2014. He was asked to play the second prototype again, and this time he did better than his previous try. Still there were some problems, but they can be avoided. The third experiment was on November 22nd, 2014. He was playing the second prototype. He wanted a real vacuum cleaner to start the game. By giving him a vacuum cleaner stick, we persuade him to play the game. The fourth experiment was on October 5th, 2014. He played the final game, and he was in a hurry to finish the task. His hand movements were good. He was walking to the all parts of the carpet. He had problems in sitting and grabbing the objects. He was sitting completely instead of bending. The fifth experiment was on November 12th, 2014. He was in a hurry to finish the task as soon as possible. He played last prototype of the game again.
- Post-Test: The sixth experiment was on December 19th, 2014, and his performance was considered. He learned the task completely, but he also wanted to finish it quickly.

4.1.1.5 Case 5A

He was a 17-year-old boy and diagnosed with mild MR. He was like a normal child. He participated four times. There was enough time to work with him.

- Pre-Test: The first experiment was on September 29th, 2014. He was asked to clean the room with a vacuum cleaner machine and he only cleaned the specific part of the carpet, and he finished the game in some seconds. But his hand movements were fine. Then he was asked to play the game.
- Gameplay: He got the point easily and did the task well. His second experiment was on October 13th, 2014. The second prototype was played by him, and there was not

a significant problem. The third experiment was on October 20th, 2014, and the last prototype was played by him. The fourth experiment was on November 3rd, 2014.

- Post-Test: The last experiment was on December 8th, 2014. He grabbed the non-garbage objects and put them in the desired place, then he tried to clean the room but he only cleaned a small part of the room.

4.1.1.6 Final results of the first group

Figure 4.3 shows the results of the first group of the children experiment:

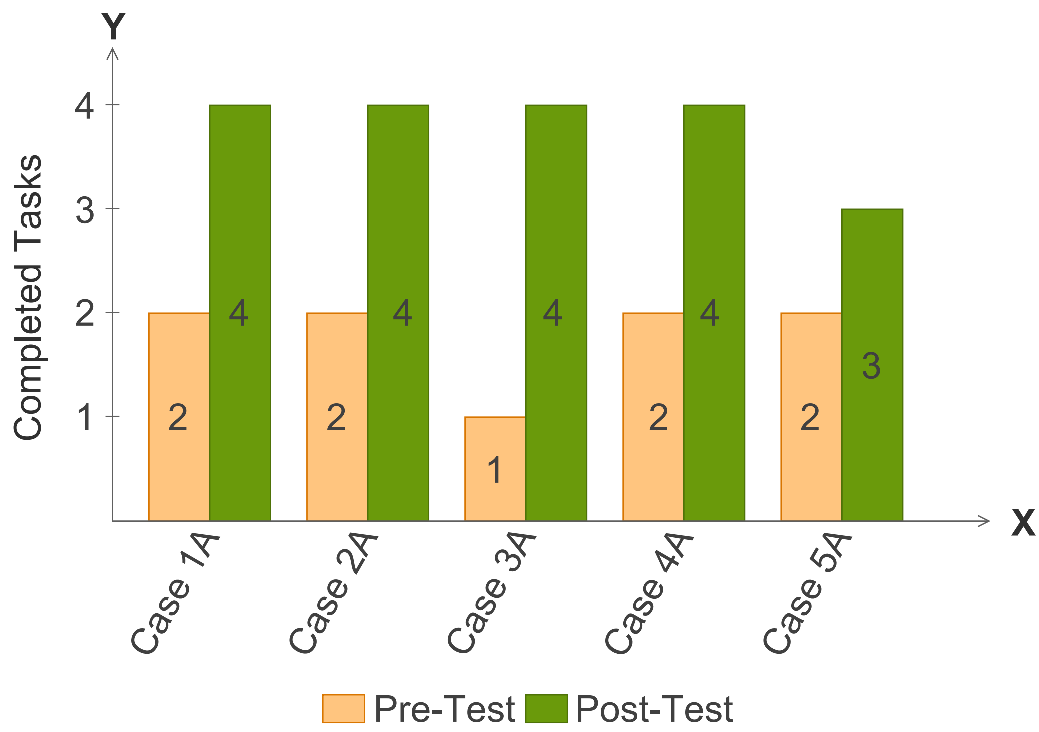


Figure 4.3: Final results of the first group

The plot's Y axis shows the number of the completed task (Vacuuming skills which are compatible with Kinect technology) by the children, and each subject identification. It is obvious from the figure that, significant improvement happened on the children performances. Cases 1A, 2A, and 4A were knowledgeable about the first two skills. After playing the game, they also learned all of the steps. Case 3A made the major progress, because he only performed the first skill in the pre-test, but after playing the game he learned all of the steps. The results shows that case 5A also had a small improvement.

4.1.2 Second Group Experiments' Results

The second group participants were a good case for the current study, but unfortunately some of them did not participate after a while, and others did not participate at evaluation. The results of this section are not considered. Their performances were very useful during the development process. Thus, in this section just their participation event is going to be discussed.

4.1.2.1 Case 6A

He was a 12-year-old boy and suffered from Down syndrome.

- Pre-Test: On September 19th, 2014, his first experiment started. He was asked to clean the messy room with a real vacuum cleaner device. In the beginning he struggled for a minute to plug the vacuum cleaner in to the electricity source. After plugging it in, he turned the vacuum cleaner on and started to clean the room. He started from the center of the carpet, he cleaned the same places several times and he forgot to clean all of the carpet. He took the vacuum cleaner handle correctly and his hand movements were good. He did not stop cleaning process until his teacher asked him whether the task is done. The child said yes, and he stopped the cleaning and did not do anything. The teacher asked him what he should do now. He asked the teacher if she was referring to what he should do with the vaccum cleaner, the teacher told him to turn it off. Then he was asked to play the vacuum cleaner game.
- Gameplay: He played the first prototype of the game. At that time, the game consisted of the three levels. There was not any level to teach him how to interact with the Kinect camera. By intervention of the teacher he learned and was able to play the game without any interventions. He earned the points fast. He learned and understood how to interact with the Kinect easily. This case had a good motivation to learn. He did not do anything strange. It was obvious that he knew the vacuuming steps, but he was unable to do all the steps without intervention. Thus he was good case for this study and he needed to learn the steps priority and how to do the task completely. He participated two times in our study. The time was not enough to teach him all of the vacuuming skills steps by the designed motion based vacuum cleaner game. His second experiment happened on October 17th, 2014. In that time he asked to play the second prototype of the vacuum cleaner game. The game consisted of the 4 levels, two levels for familiarizing the child with the game and Kinect environments, one level to teach him correct hand movements, and one level for cleaning the whole room. He was asked to play these levels. His performances were acceptable.
- Post-Test: He did not participate in evaluation.

4.1.2.2 Case 7A

She was a 16-year-old girl, and diagnosed with mild MR. She participated in three experiments.

- Pre-Test: She did not participate in pre-test experiment.
- Gameplay: Her first experiment was started at October 20th, 2014. She was asked to play the second prototype of the vacuum cleaner game. She was a sensitive girl. Feedbacks and encouragement were important to her. She was talking and encouraging herself during the experiment. It was difficult for her to interact with Kinect. Her second experiment was on October 27th, 2014. In this experiment she learned how to interact with the game and Kinect. She had become distracted very soon. She was making noises by her mouth during the gameplay. Her third experiment was on December 9th, 2014. She was told to play the final prototype of the game. In the experiment day the

weather was rainy, she was distracted by the sound of the rain and the gloomy weather. She did not move her hands correctly. Feedbacks were very important for her, she was answering to the coming feedback from the game.

- Post-Test: She did not participate in evaluation.

4.1.2.3 Case 8A

He was a 16-year-old boy and he was diagnosed with mild MR. He participated in the 5 experiments between October 15th and November 11th of 2014. He was very shy.

- Pre-Test: He did not participate in the pre-test experiment.

- Gameplay: In his first experiment he played a second prototype of the game. His performance was good. He learned the vacuuming skills related to the second prototype without any significant problems. Only he did not use his hands correctly. In the other experiments, his hand movements improved. In his fourth experiment, he played the final prototype of the game. He was the only child which was available in the school most of the time. He was familiar with the skill, but his problem was in combining them; for instance, he should have grabbed the non-garbage objects while was cleaning the room.

- Post-Test: He did not participate in the evaluation experiment.

4.1.2.4 Case 9A

He was a 16-year-old boy and was diagnosed with mild MR. He participated in 5 experiments. His experiment took place between October 13th and November 5th of 2014.

- Pre-Test: In pre-test he was told to clean the room with a real vacuum cleaner. His hand movements were good, but he did not move to other parts of the carpet and he was repeatedly cleaning the same place.

- Gameplay: Then he was asked to play the game. During his experiments it was determined his disability was severe. He did not perceive the feedbacks, and the vacuuming game was not good for him.

- Post-Test: He did not participate in the final evaluation.

4.1.2.5 Case 10A

She was a 16-year-old girl, and she was diagnosed with mild MR. She also had a small problem in walking. She had participated in four experiments.

- Pre-Test: Her first experiment was on September 29th, 2014, and she was asked to clean the room with a real vacuum cleaner machine. Her performance was observed. She did not clean all parts of the room, but her performance was acceptable.

- Gameplay: Then she was asked to play the second prototype of the game. The second experiment was on October 20th, 2014. She played the game and did the task very well. Her third prototype was on the November 10th, 2014, and she was asked to do the last prototype of the game. She did the task as they were expected. The fourth experiment started on November 17th, 2014, and he finished the all of the tasks of the vacuum cleaner game.
- Post-Test: Unfortunately she did not participated in the final evaluation.

4.2 Sait Ulusoy Özel Eğitim Uygulama Merkezi

All of the participants were available in this school and there was not any time limitation problem. Thus in one session the vacuuming skills were taught to the children by the vacuum cleaner game. In the previous school it took some weeks to finish the experiments completely, but in Sait Ulusoy Özel Eğitim Uygulama Merkezi special education school everything was ready before the implementation of the experiment. The experiment started on January 19th, 2015 and continued for three days. It was the last days of the first semester. After three days of the experiment, the semester ended and the experiment was on hold for 15 days. In the second semester, the experiment continued from February 9th to February 24th, 2015. Then the experiment finished. All of the pre-test, education, and evaluation or post-test happened in one session for each player. On March 4th, 2015, the children who had learned the vacuuming skills by the vacuum cleaner game were evaluated. The aim of the second evaluation was to compare the children's performance after some days. In the Sait Ulusoy special education school, there were 34 participants. They suffer from either mild MR or Down syndrome (Table 4.4). All of the children who participated were between 8 and 24 years old. Six children had been familiar with the vacuuming skills before. As shown in Figure 4.5, nine children were qualified and their performances were satisfactory to be evaluated in this study.

Table 4.4: Participants' characteristics

Case	Age	Gender	Type of disabilities
1B	11	Male	Down syndrome
2B	18	Male	Mild MR
3B	14	Male	Mild MR
4B	12	Male	Down syndrome
5B	12	Male	Down syndrome
6B	11	Male	Mild MR
7B	24	Male	Mild MR
8B	21	Female	Mild MR
9B	16	Female	Down syndrome

Table 4.5: Participants' status

Total participants	qualified participants	qualified girl	qualified boy
34	9	2	7

Among the qualified children, there were 7 boys and 2 girls. All of the 34 participants had enough time to do the experiment.

4.2.1 Case Study

Before starting to explain the cases, it is essential to explain the prerequisites of the experiment. For the pre-test and post-test experiments, a big room with a $2m \times 3m$ carpet in it was needed. The experiment was done on a big class in the SAIT ULUSOY School. Three balls with different colors were used as objects on the carpet and 2 pieces of crumpled newspaper were used as garbage on the carpet (Figure 4.4). Also some small pieces of paper were used as a dust which should be taken by vacuum cleaner machine. For education, only part of a room with carpet was enough. For all of the cases the condition was same. They were asked to play the final prototype of the game, and by observation their performances was evaluated.

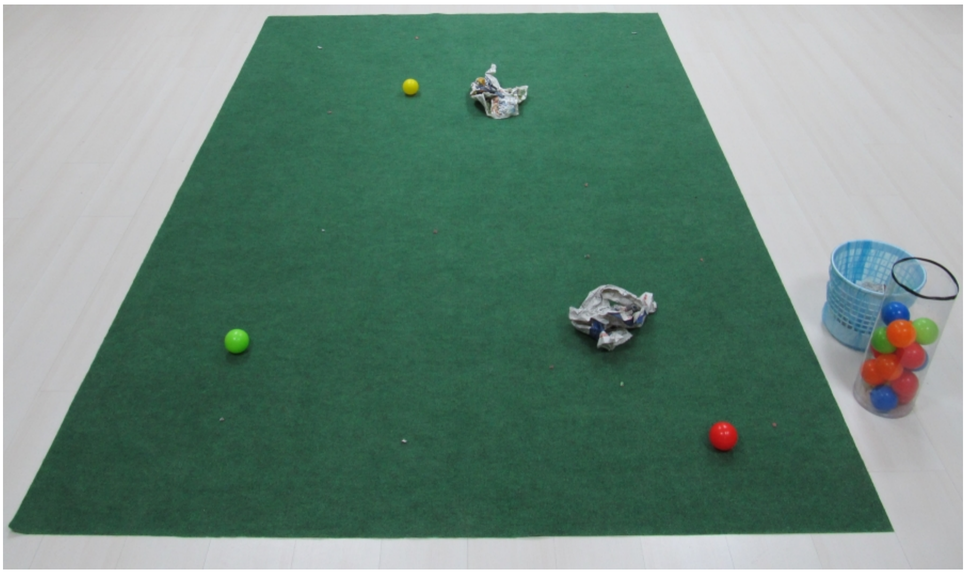


Figure 4.4: Experiment environment

4.2.1.1 Case 1B

He was an 11-year-old boy distinguished as Down syndrome. His experiment was done on January 19th, 2015.

- Pre-Test: He was asked to clean the room by vacuum cleaner machine. He was starting the vacuuming process by taking the vacuum cleaner handles accurately and moving his hand forward and backward, but he did not move. He also did not grab the non-garbage objects or the larger garbage which could not be cleaned by vacuum cleaner.
- Gameplay: Then he was told to play the game, especially the levels in which he needed to be able to clean the carpet completely and precisely He was a calm boy, and he was listening carefully to the feedbacks of the game. He did the experiment completely. His experiment was started at 12:11 PM and finished at 13:14 PM. At most it took 5 minutes to finish a level of the game. After each level the children were told to rest for a few minutes. Then the experiment was continued.
- Post-Test: He was asked to clean the messy carpet in the real environment. He started to clean the carpet, without any problem he did the wanted tasks completely.

In this case there was an unexpected problem with Kinect camera settings which had been solved.

Table 4.6: First case experiment status

Experiment Date	1/19/2015
Pre-test Total Time	3 minutes and 53 seconds
Gameplay Total Time	20 minutes and 20 seconds
Post-Test Total Time	3 minutes and 27 seconds
Experiment Optimal Time	27 minutes and 41 seconds
Approximate Experiment Time	1 hour and 15 minute's

Table 4.6 depicts the experiment date and amount of time which was spent during the experiment for each steps. It took more than 1 hour to finish the experiment because of some unexpected problems with Kinect camera settings.

4.2.1.2 Case 2B

He was an 18-year-old boy and he was diagnosed with MR. His experiment started at 2:33 PM on February 9th, 2015.

He had been distracted by the environmental sounds, and he was unaccustomed to the atmosphere. He was also continuously looking at his watch, so just pre-test experiment was down in the first day, and the next experiment was postponed to the next day. This time experiment started at 11:09 AM on February 10th, 2015 and finished at 11:44 AM. He finished all of the experiment without any problem.

Table 4.7 demonstrates the child's experiment details.

Table 4.7: Second case experiment status

Experiment Date	2/9/2015
Pre-test Total Time	2 minutes and 41 seconds
Gameplay Total Time	18 minutes and 50 seconds
Post-Test Total Time	4 minutes and 25 seconds
Experiment Optimal Time	25 minutes and 56 seconds
Approximate Experiment Time	45 minutes

- Pre-Test: In pre-test he was asked to clean the carpet by the vacuum cleaner machine. He grabbed the non-garbage objects and put them in their desired places, then he stopped. The task was asked of him again then he used the vacuum cleaner machine to clean the carpet. He did not move or walk at all, he was standing in a fixed position and cleaned a specific point. His hand movements were good. After few seconds he was told that the experiment was done.

- Gameplay: Then he was asked to play the game. He played and finished it successfully.

- Post-Test: The post-test started, he grabbed the objects first and then he was distracted and forgot the task. He was asked what he should do. The wanted task was repeated and he continued the cleaning process. He started to clean the room by vacuum cleaner. This time he moved and cleaned half of the carpet then he stopped and said that the experiment was done.

4.2.1.3 Case 3B

He was a 14-year-old boy and diagnosed with mild MR. His experiment started at 10:58 AM and finished at 11:46 AM on February 12th, 2015.

- Pre-Test: He was asked to clean the messy carpet with the vacuum cleaner machine, and he started to clean. He took the vacuum cleaner sticks accurately, but without moving his hands he just walked through the carpet. He did not grab any objects from the carpet. Then he was asked to play the vacuum cleaner game.
- Gameplay: After the education part finished, the post-test started.
- Post-Test: He started to clean the messy carpet by real vacuum cleaner. He took the vacuum cleaner sticks accurately and walked through the carpet and cleaned the carpet by moving his hand forward and backward. He cleaned the carpet, but he did not grab the objects. Then he was asked what he should do. He remembered and grabbed the objects and put them in their own places, which in pre-test he did not do. Because he grabbed the non-garbage objects after asking him, this step was not considered in his final performance results.

Table 4.8 shows the child's experiment status.

Table 4.8: Third case experiment status

Experiment Date	2/12/2015
Pre-test Total Time	1 minutes and 51 seconds
Gameplay Total Time	21 minutes and 17 seconds
Post-Test Total Time	2 minutes and 37 seconds
Experiment Optimal Time	25 minutes and 45 seconds
Approximate Experiment Time	48 minutes

4.2.1.4 Case 4B

He was a 12-year-old boy and he was diagnosed with Down syndrome. His experiment started at 2:09 PM and finished at 2:44 PM on February 12th, 2015.

- Pre-Test: At the start point he was asked to clean the messy carpet using the vacuum cleaner machine. He started the cleaning process, and cleaned the carpet totally by walking to all parts of the carpet along with moving his hand forward and backward. The carpet was cleaned by vacuum cleaner but objects were there. The child did not grab the objects. He was asked what he should do at that time. He did not do anything. Then he was asked to play the game.
- Gameplay: He did it well. After that the pos-test experiment started.

- Post-Test: He did the post-test like the pre-test experiment, but this time after cleaning the carpet by vacuum cleaner machine when he was asked what he should do, He got the point and grabbed the non-garbage objects and put them in their own places. Because of the intervention the result of the grabbing objects is not considered on the final results of the experiment.

The child's experiment status is shown on Table 4.9.

Table 4.9: Fourth case experiment status

Experiment Date	2/12/2015
Pre-test Total Time	2 minutes and 54 seconds
Gameplay Total Time	9 minutes and 43 seconds
Post-Test Total Time	2 minutes and 46 seconds
Experiment Optimal Time	15 minutes and 23 seconds
Approximate Experiment Time	35 minutes

4.2.1.5 Case 5B

He was a 12-year-old boy and diagnosed with Down syndrome. His experiment started at 1:27 PM and finished at 2:00 PM on February 12th, 2015. Table 4.10 shows the child's experiment status.

Table 4.10: Fifth case experiment status

Experiment Date	2/12/2015
Pre-test Total Time	3 minutes and 36 seconds
Gameplay Total Time	12 minutes and 26 seconds
Post-Test Total Time	2 minutes and 10 seconds
Experiment Optimal Time	18 minutes and 12 seconds
Approximate Experiment Time	35 minutes

- Pre-Test: He was asked to clean the messy carpet with vacuum cleaner machine. He started to clean. He quickly cleaned the carpet precisely, but he did not know that the objects should be grabbed during the cleaning process.
- Gameplay: Then he was said to play the game. He played the vacuum cleaner game and he finished it with not any difficulties.
- Post-Test: After that the post-test was started, and the child performances were observed. He was asked to clean the messy carpet in the real room by digital vacuum cleaner machine. Without any intervention, he did the all of the wanted tasks carefully.

4.2.1.6 Case 6B

He was an 11-year-old boy diagnosed with mild MR. His experiment started at 11:24 AM and finished at 11:54 AM on February 13th, 2015.

- Pre-Test: He was told to clean the messy carpet by the vacuum cleaner machine. He was starting to vacuum the carpet, suddenly he kicked a small ball on the carpet, then he took it and again put it on the carpet. He did not know what he should do with the non-garbage objects. But he cleaned all of the carpet very precisely by moving his hand toward and backward. Then he was asked to play the vacuum cleaning game.
- Gameplay: He played and learned the points from the game, soon after he started the post-test.
- Post-Test: In post-test he cleaned the carpet carefully and grabbed the object and put them in desired places.

Table 4.11 shows the child's experiment status.

Table 4.11: Sixth case experiment status

Experiment Date	2/13/2015
Pre-test Total Time	2 minutes and 13 seconds
Gameplay Total Time	10 minutes and 57 seconds
Post-Test Total Time	3 minutes and 43 seconds
Experiment Optimal Time	16 minutes and 53 seconds
Approximate Experiment Time	30 minutes

4.2.1.7 Case 7B

He was a 24-year-old boy and diagnosed with mild MR. His experiment started at 1:56 PM and finished at 2:18 PM on February 17th, 2015.

Table 4.12 shows the child's experiment status.

Table 4.12: Seventh case experiment status

Experiment Date	2/17/2015
Pre-test Total Time	2 minutes and 32 seconds
Gameplay Total Time	6 minutes and 32 seconds
Post-Test Total Time	2 minutes and 21 seconds
Experiment Optimal Time	11 minutes and 25 seconds
Approximate Experiment Time	22 minutes

- Pre-Test: He started to vacuum the messy carpet, by moving his hand forward and backward he cleaned the all of the carpet rightly. He did not grab the objects from the carpet.
- Gameplay: Then he was told to play the game to learn the vacuuming skills. He played well.
- Post-Test: Then the post-test started and he started to clean the messy carpet again to look at his performance after learning the skills. This time he cleaned the carpet totally and grabbed the objects and put them in their own places.

4.2.1.8 Case 8B

She was a 21-year-old girl and diagnosed with MR. Her experiment was started at 1:33 PM and finished at 2:03 PM on February 20th, 2015. Table 4.13 shows the child's experiment status.

- Pre-Test: She was told to clean the carpet by vacuum cleaner machine. She started cleaning and suddenly she hit a box of balls and spilled the balls on the floor, but she did not try to gather them. She turned vacuum cleaner on and vacuumed the carpet totally. Then it was told to her to play the game.

- Gameplay: She played the game and did all of the game tasks well. Then the post-test was started.

- Post-Test: She cleaned the room by vacuum cleaner and cleaned the carpet completely. This time she grabbed the crumpled newspapers and threw them in trashcan. But she did not grab the balls. Thus her results was considered based on the fact that she did not learn the differences between garbage and non-garbage objects.

Table 4.13: Eighth case experiment status

Experiment Date	2/20/2015
Pre-test Total Time	1 minutes and 57 seconds
Gameplay Total Time	12 minutes and 51 seconds
Post-Test Total Time	2 minutes and 23 seconds
Experiment Optimal Time	17 minutes and 11 seconds
Approximate Experiment Time	30 minutes

4.2.1.9 Case 9B

She was a 16-year-old girl and diagnosed with Down syndrome. Her experiment started at 12:02 PM and finished at 12:39 PM on February 23th, 2015. She was too shy.

Table 4.14 shows the child's experiment status.

Table 4.14: Ninth case experiment status

Experiment Date	2/23/2015
Pre-test Total Time	3 minutes and 14 seconds
Gameplay Total Time	14 minutes and 29 seconds
Post-Test Total Time	3 minutes and 34 seconds
Experiment Optimal Time	21 minutes and 17 seconds
Approximate Experiment Time	37 minutes

- Pre-Test: She was told to clean the carpet using vacuum cleaner machine. She started to clean. Her hand movement was acceptable, but she did not clean all part of the carpet and she did not grab the objects.

- Gameplay: Then it was asked of her to play the vacuum cleaner game. She finished the game. Then the post-test started.

- Post-Test: She turned the vacuum cleaner on and took the vacuum cleaner sticks, then started to vacuum the carpet. She cleaned all of the carpet and also gathered the balls and crumpled newspaper and put them in their own places.

4.2.2 First Evaluation Results

By precise observation of the participants' performances in their first evaluation. The checklist was filled out for each child based on his/her performance.
Figure 4.5 depicts the result of the each experiment, case by case.

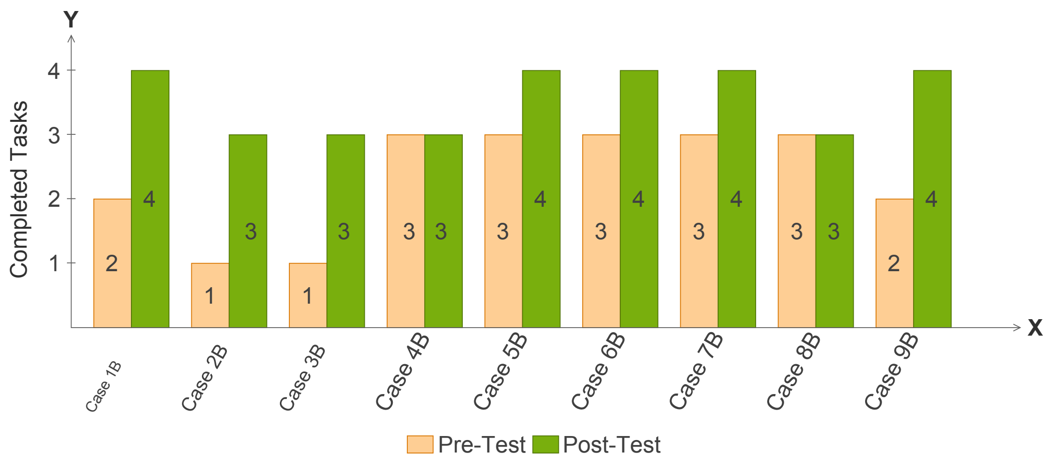


Figure 4.5: Final results of the first evaluation

As it is shown in the Figure 4.5, there are nine cases in the current study experiment. The significant improvements happened on Cases 1B, 2B, 3B and Case 9B, but among them case 2B and case 3B performances are admirable because they were less familiar with the vacuuming skills at the start point. For two cases 4B and 8B, they had a small improvement but it was not satisfactory to be considered in the results. Finally cases 5B, 6B, and 7B, were familiar with the vacuuming process, but they had a problem to garbing the objects from the carpet. The results confirm their improvement at the post-test experiment. Seven children had an improvement in their experiments.

Completion time of each participant's experiment is shown in Figure 4.6 . The average time of the experiments is approximately 19 minutes and 58 seconds. As it was mentioned, the significant improvements happened on Cases 1B, 2B, 3B and Case 9B (Figure 4.5), Figure 4.6 informs that all of these cases experiment's time are above the average time. This finding confirms that the children with mental disabilities need more time to show perfect performance.

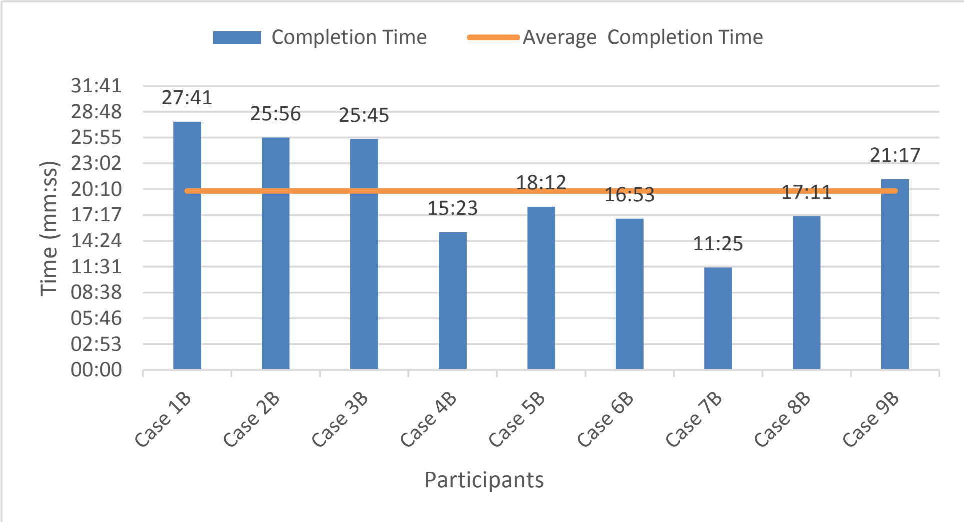


Figure 4.6: First evaluation's completion times

4.2.2.1 First Evaluation Results Category by Category

There were 9 participants in the first evaluation. The participants' progress average based on their disabilities is shown in Figures 4.7 and 4.8.

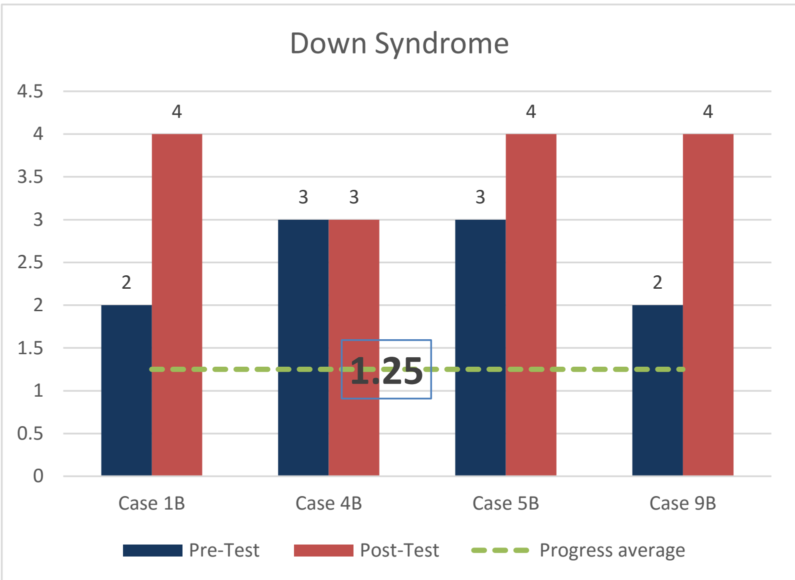


Figure 4.7: First evaluation's results for children diagnosed with Down Syndrome

The participants were divided in two categories: Down syndrome and mild MR. There were 4 children who had been diagnosed with Down syndrome, and there were 5 children who had mild MR. The progress average for children who had Down syndrome is 1.25 and the progress average for children who had mild MR is 1.2. Based on the progress average it is determined that children who had Down syndrome in comparison to the children with mild MR have a better performance.

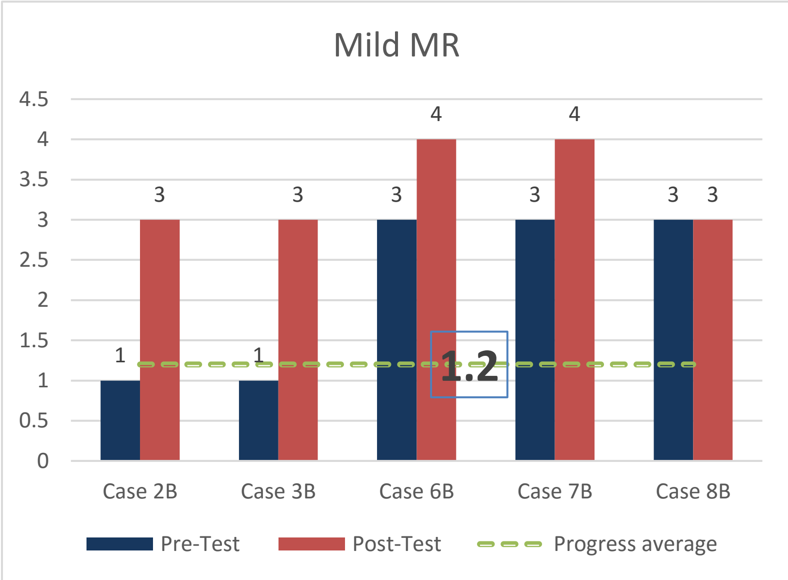


Figure 4.8: First evaluation's results for children diagnosed with mild MR

4.2.3 Second Evaluation Results

The second evaluation started 8 days after the first evaluation, on March 4th, 2015. The aim was to test the children's skills over the time. On the evaluation day, just 6 of the 9 participants were available in the school. All 6 participants were told to vacuum the messy carpet by vacuum cleaner machine. The perfect result was to vacuuming the whole carpet by moving their hands forward and backward, and grabbing the objects and put them in their own desired places. The cases number 2B, 3B, 4B, 5B, 6B, and 7B were participated in the second evaluation. Only three cases (cases 5B, 6B, and 7B) did not forget the task, and completed the wanted tasks precisely.

The second evaluation completion times is shown in Figure 4.9. The average time is 2

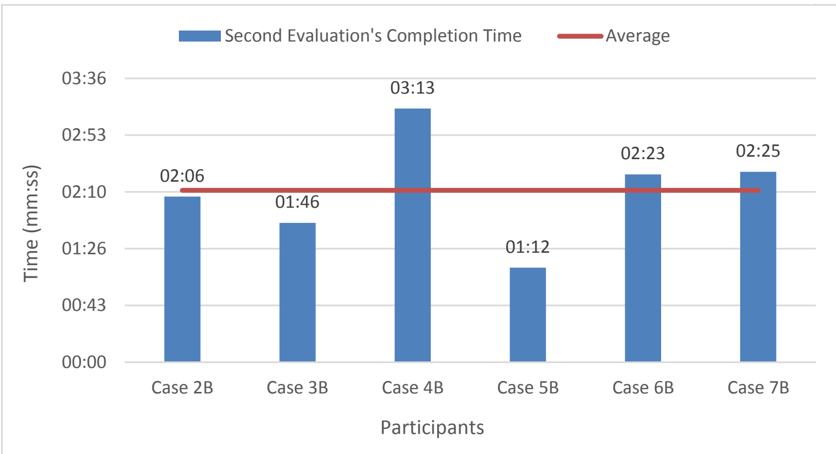


Figure 4.9: Second evaluation's completion times

minutes and 11 seconds. Case 5B finished the wanted task in 1 minute and 12 seconds. He was quicker than others.

To compare the first and second evaluation's results, the number of completed tasks in the first evaluation and second evaluation are depicted in the Figure 4.10.

Red columns inform the first evaluation pre-test outcomes, green columns show the first evaluation results, and blue columns depict the second evaluation results (Figure 4.10).

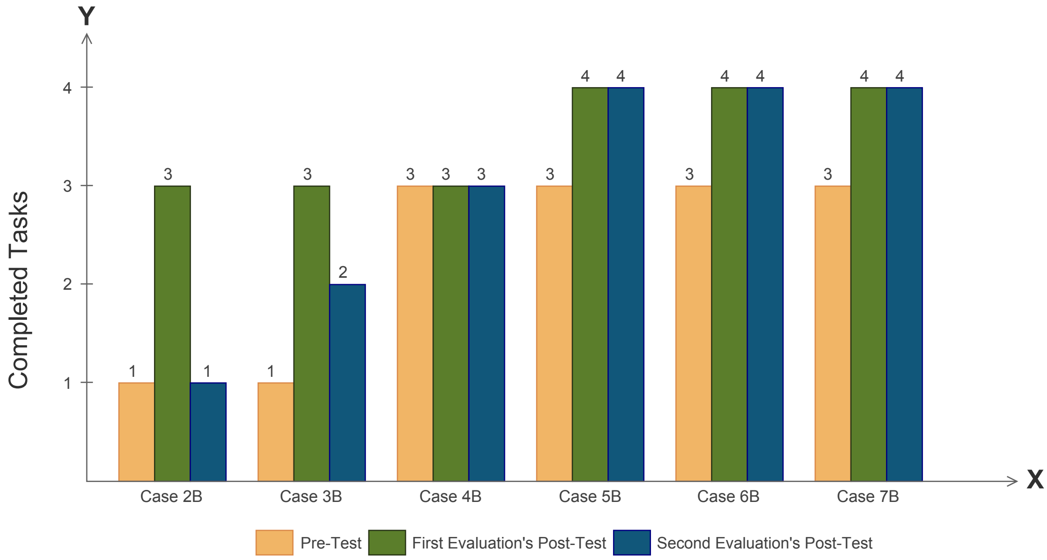


Figure 4.10: Final results of the first group's second evaluation

In Case 2B and Case 3B pre-test, it was confirmed that they know just one task of the vacuuming process. After playing the game, their post-test results revealed that they learned 2 tasks more and they knew 3 tasks at the end of the first evaluation. Then at the end of the second evaluation, Case 2B performances were unsatisfactory. He did just one task completely, but Case 2B did two tasks completely. He forget one task in comparison to his first evaluation result, but still his performance was better compare to his pre-test result.

For Case 4B, all of his evaluation and pre-test results were the same. There was not any improvement in his performance. He could not differentiate non-garbage objects.

In Case 5B, Case 6B and Case 7B pre-test, their knowledge about vacuuming skills was assessed and it was obtained that they knew 3 skills of the experiment. After playing the vacuum cleaner game, their first evaluation results depicted that they had learned all of the vacuuming essential skills. In the second evaluation they prove that they did not forget the skills.

Second evaluation result informed that approximately $\frac{4}{6} =\sim 66\%$ of the participants did not forget the vacuuming skills completely.

4.2.3.1 Second Evaluation Results Category by Category

There were 7 participants in the second evaluation. The participants' progress average based on their disabilities is shown in Figures 4.11 and 4.12.

As it is shown in Figure 4.11, Case 4B and Case 5B performances are the same as their first evaluation results.

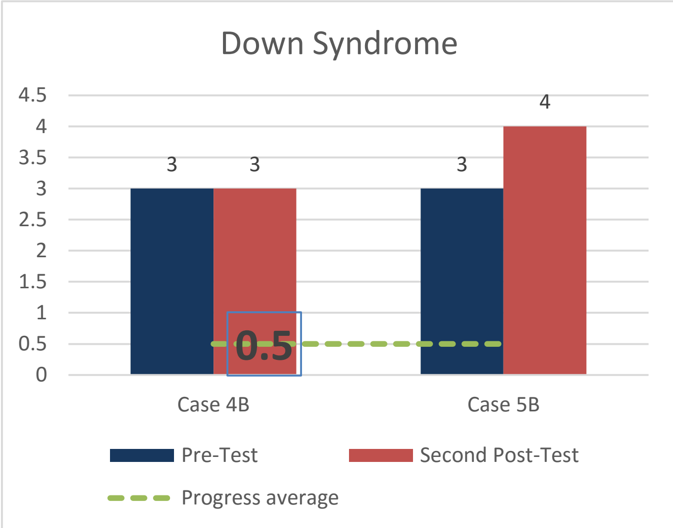


Figure 4.11: First evaluation's results for children diagnosed with Down syndrome

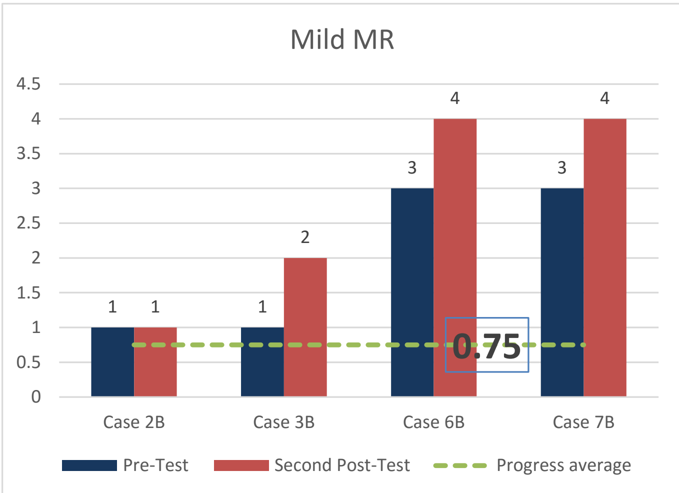


Figure 4.12: First Evaluation's results for children diagnosed with mild MR

For Case 6B and Case 7B the second evaluation results are the same as their first evaluation results. For Case 2B the second evaluation results show that this case forgot the tasks. Also Case 3B forgot one task in comparison with his first evaluation results.

CHAPTER 5

DISCUSSION AND CONCLUSION

It is very difficult to differentiate between games and simulations, because they are so close to each other (Dempsey, 1993). By looking at the humans and animals' behaviors, Huizinga (1971) confirms that a play is older than a culture. Neither humans nor animals wait for someone to teach them how to play. There are no physical or other kinds of pressures to play, it is an arbitrary activity. The play is very different from real life. Children are aware of that while playing; they pretend or they play for fun. Also play – unlike the real life – can be repeated.

As Prensky (2001) mentioned in his article, there are differences between games and simulations. By adding some elements such as play, a goal, rules and fun to a simulation, it can be called a game. Reality which is a big problem for a simulation with educational purpose, may cause boredom affecting learning negatively.

The proposed vacuum cleaner game can be called as a game from the following aspects:

- It is a play and participants played the game without any pressure because fun element are considered in it.
- It has a set of rules. Players by following the rules were able to progress in the game.
- It has an important goal which teaches daily basic life skills to children with mental disabilities.
- Accuracy is an essential part of simulation. The vacuum cleaner game is not designed based on accuracy; It was designed based on the children abilities and their restrictions.

The necessity of video games with an educational purpose is undeniable to increase children's motivation. Educational video games can be used as a teaching material to help teachers to increase the efficiency of the teaching. When computer games are combined inside the instructive procedure, more than half of the evaluated teachers stated that student motivation is increased notably (Wastiau, Kearney, & den Berghe, 2009).

Educational video games can be designed with specific aims to teach students with special needs. Utilizing video games in special education have shown positive effects in the children learning (González, Cabrera, & Gutiérrez, 2007; Ruggiero, 2013).

In this study we have designed a vacuum cleaner exergame to teach vacuuming skills to mentally disabled children. Jordan et al. (2009) mentioned that both regular and special students in elementary classrooms benefit from the effective teaching skills. To design an effective game with educational propose for mentally disabled children, a physically interactive vacuum cleaner game was designed by applying Microsoft Kinect motion detection camera, and was tested with a special education expert in two special education schools (Bilge Özel Eğitim ve Rehabilitasyon Merkezi and Sait Ulusoy Öazel Eğitim Uygulama Merkezi). The first school was a private school and the second school was a public school.

It is the time to answer the research questions of the study.

1. Is it possible to use motion detection based games to teach basic life skills to special education children?
   In their studies (Ayala, Mendívil, Salinas, & Rios, 2013; Hsu, 2011; Richards-Rissetto et al., 2012; Zeid, Taqi, ElKhatib, Al-Yaseen, & AlMayyan, 2014) confirmed the potential of usage of Microsoft Kinect in education. The games which have been designed to teach specific skills are tremendously successful (Griffiths, 2002). Many studies proposed a bodily movement game and confirmed the effectiveness of them as a rehabilitation tools (Lange et al., 2011, 2012; Vernadakis, Derri, Tsitskari, & Antoniou, 2014). Some researches inform the potential of using a gesture-based Kinect game to communicate with deaf people (Soltani, Eskandari, & Golestan, 2012; Zafrulla, Brashear, Starner, Hamilton, & Presti, 2011). There are few studies in the field of teaching daily life skills to the mentally disabled children. In their studies (Puspitasari, Ummah, & Pambudy, 2013) have designed an interactive learning media called KIDEA. This software prototype was designed to improve mentally disabled children's life skills. The effectiveness of the KIDEA was not measured.

   Current study is a unique study because:

   (a) The target groups of the study are the mentally disabled children with different disabilities.
   (b) It is a comprehensive study of using Microsoft Kinect in special education.
   (c) It focuses on teach vacuuming skills to children with mental disabilities.

   Vacuuming the whole room completely and precisely by mentally disabled children was the main goal of the study, but some prerequisite steps were not compatible with Kinect technology such as taking the vacuum cleaner to favorable place, plugging it in to the electricity source, and turning it on or off. Some of them were not feasible to design and others were the minor steps which could be learned by the simplest techniques. As the results shows, there are great improvement in the children performances. The improvement is observed at the $\frac{7}{9} =\sim 77\%$ of the children, which confirms the effectiveness of the using Microsoft Kinect motion detection device in the special education area.

2. Are motion detection systems suitable for the children with mental disorder as gaming controllers?

   Applying the Microsoft Kinect in education is impressive and increases the children's creativity and interaction in the class (Hsu, 2011). Interactive video games are compatible with the repetitive and stereotyped behaviors of autistic children which made it attractive to them (Boutsika, 2013). Both realistic situation test and virtual situation test results were compared, and we found that the game is suitable for the children with a mild spectrum of mental disabilities. The children with a severe mental disability did not show any positive pulses which convinced us to continue the experiment. There was no interaction between the children with severe mentally disability and the Kinect motion detection camera. The observation of all of the children's performances reveals that the children who can interact with a game avatar have more of a chance to finish the all tasks of the experiments.

With respect to the second evaluation results, case 5, case 6, and case 7 had not forgotten the skills after passing 8 days. By analyzing their results it was clear that they had a good performance in the pre-test and first evaluation, in comparison to the others. Cases number 2, 3, and 4 had forgotten some steps. They did not clean the carpet totally. Thus using the motion capture systems to teach the children with mild degree of disabilities is more effective than those with severe disabilities.

3. How to design a user friendly motion detection technology based game for special education children?

   In his study (İnal, 2011) proposed a set of design principles to develop physically interactive educational games for regular children. Four physically interactive games were designed based on these principles. Results confirmed that usage of physically interactive games for educational purposes is effective.

   Using appropriate body gestures increased the special education student's perception of being in the virtual world, and increased the personal self-sufficiency, and caused to them to finish the tasks by immersion into virtual reality. General body movements in 3D environment is the reason for using Microsoft Kinect camera. The findings have shown that gesture based games have a great potential in the special education system. Because of the mentioned restrictions about the Microsoft Kinect, most developers try to design a 2D games or 2.5D games for Kinect. Some 3D games also were designed, but in many of them, players are allowed to walk on the right or left side; walking forward or backward is not preferable. The experiment emphasize that using feedbacks is very effective in the children learning process.

   Lighting should be considered in a different way; unlike the normal games which the lighting looks natural, in special education it should be used in a way which helps the children to concentrate. The most important points in the game should be lighter and other non-important places or objects should be darker.

   Objects' placement in these kind of games should be considered perfectly to do not distract the children attentions from the main task. The strange shaped objects should be avoided to use. Highly saturated colors are not suitable

5.1 Conclusion

Encouragement of the mentally disabled children to do physical activities is essential for their health. New technologies can be used to persuade the mentally disabled children to do more physical activities.

Through this study we tried to teach the vacuuming basic life skills to children with mentally disabilities, indirectly. A vacuum cleaner motion based game using Microsoft Kinect and Unity3D game engine was designed to teach the basic daily life skills to the mentally disabled children. The proposed game was developed based on spiral model methodology and was tested in two special education schools. Feedbacks from the special education expert and special education teachers were considered.

The proposed learning tool tried to be close to a game, and fun should have been a part of it. The risks were taken to design a 3D educational video game for mentally disabled children using Microsoft Kinect motion detection device. Vacuuming the whole room completely and precisely was the main goal of the current study. To reduce the risks, some modification were done. The key factor of the game was teaching the differences between garbage and none garbage objects. To control the game, children should interact with the avatar using body motion. The children who had learned to distinguished the garbage from non-garbage objects before had more of a chance to learn the all of the vacuuming skills completely.

An interview was conducted by 5 special education teachers in Sait Ulusoy school. The interview was about the vacuum cleaner interactive game. One of the teachers was familiar with computer skills, the others had basic knowledge about the usage of computer, or they had common knowledge about the computer. At first, the vacuum cleaner game was played by a special education student and it was concurrently explained to the teachers, then the interview was started. All of the teachers confirmed the effectiveness of using body movements to improve basic motor skills in special education children. Teachers acknowledged that by playing the vacuum cleaner game children's motivation were increased and they understood which object can be cleaned and which object cannot be cleaned by a real vacuum cleaner. Also, teacher's emphasis was on the fun aspects of the game and suggested that the levels should be simple and clear, and have visual and acoustic help, the children movement and the character movement should be coordinated. All of the teachers confirmed that these kinds of technologies have a positive effects on the mentally disabled children's social behaviors. They said that the programs should be motivating and specially should be designed based on the various type of daily life skills to help the children's socialize. All of the teachers mentioned that after some modification and providing a safe environment, children will be able to play the game without any intervention. One of the teachers said that these kind of technologies are not suitable for every child.

Here are teachers' comments:

1. ***First Teacher:*** He suggested that during teaching basic motor motion, the Kinect camera boundaries should be fit with the real environment boundaries. Also he suggested to teach different skills.
2. ***Second Teacher:*** It can be useful to design bodily movement interaction games to teach self-care and wearing skills.
3. ***Third Teacher:*** This teacher suggested that to teach which objects can be cleaned by vacuum cleaner, a level should be added to the game as a first level of the game, and the cleanable objects should be appear in a way which attract the children's attention by exaggerated size of the objects. Also Kinect technology can be useful to design a games to teach how to prepare a bed, how to get on the bus, how to do a sport, and how to fold clothes.
4. ***Forth Teacher:*** This teacher offered that to use Kinect technology for teaching other skills. Also it was mentioned that some features need to be added to the vacuum cleaner game, and verbal cues should be revised.
5. ***Fifth Teacher:*** This teacher suggested that during gameplay children should take a vacuum cleaner stick in his/her hand. It is difficult to play the game without taking real vacuum cleaner stick. It is better to grab the non-garbage objects first then clean the carpet. After cleaning the dusts, carpet colors should be changed with high contrast. Color of the dusty place should be darker than clean parts. Before starting to play the vacuum cleaner game, it could be better to add a level which the objects appear on the screen in such a way that non-garbage object with a red multiply sign on it and garbage should be illustrated with a correct mark on it. He also recommended to apply

> Microsoft Kinect to design interactive games based on the following skills: Kitchen skills, ironing, using a laundry machine, making a bed, getting on the bus, and shopping skills. He especially emphasized on using Kinect to teach the phone call skills.

In special education, children's parents' role is very significant. If the parents become familiar with the technology, they can use the new technologies in their home to teach their child and help them to benefit from the education. In the experiment it was observed that if the children were in a good mood their performances were also satisfactory.

This study is new and original, thus we do not claim that the final product is a fantastic product, but it is a step forward and the results confirmed the effectiveness of using Microsoft Kinect in educational video games for mentally disabled children. The combination of the game and education is very helpful for mentally disabled children. They can learn along with doing physical activity.

Because of less outside intervention, children feels less pressure while they are playing the game in comparison to old methods of teaching. By observation of the children performance, it was observed that the children immersion in the virtual reality environment is notable.

5.2 Future Work

The aim of this study was to design and develop a bodily movement game using Microsoft Kinect for mentally disabled children. A motion based vacuum cleaner game was designed by using Unity3D game engine and Microsoft Kinect motion detection device. It was tested in two special education schools and the results confirmed the effectiveness of applying motion based game in special education.

In future studies, design and development of the other basic daily life skills, using Microsoft Kinect or combination of Kinect with other technologies for mentally disabled children is probable. We are looking forward to use combination of different technologies to design a new generation of the educational materials for children with any kind of disability. Also the final products will be tested in a wide range of special education schools to get more accurate results.

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APPENDIX A

UYGULAMALI ETİK ARAŞTIRMA MERKEZİ
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Danışmanlığını yapmış olduğunuz Oyun Teknolojileri Bölümü öğrencisi Mohammad Javad Nazirzadeh'in "Zihinsel Engelli Çocuklar İçin Temel Yaşam Becerileri Öğretmek Amaçlı Bedensel Hareket Oyunları Geliştirilmesi" isimli araştırması "İnsan Araştırmaları Komitesi" tarafından uygun görülerek gerekli onay verilmiştir.

Bilgilerinize saygılarımla sunarım.

Etik Komite Onayı

Uygundur

24/11/2014

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Figure A.1

APPENDIX B

EVALUATION FORM

Table B.1: Halı süpürme becerisi değerlendirme formu
Çocuğun Adı-Soyadı:. . . . .
Değerlendirme sonucu: . . . .
Sıra No: . . . .

1. Children take the vacuum cleaner handle correctly.	
2. Vacuuming the whole carpet by moving their hands forward and backward.	
3. Distinguish the garbage from the non-garbage objects, and take the non-garbage objects and put them in their own designated places.	
4. Vacuuming the whole carpet by walking to the right and left and forward and backward.	