

DEVELOPING A GESTURE-BASED GAME FOR MENTALLY DISABLED PEOPLE TO TEACH BASIC LIFE SKILLS

Mohammad Javad Nazirzadeh¹, Kürşat Çağiltay¹ and Necdet Karasu²

¹*Department of Modeling and Simulation, Middle East Technical University, Ankara, Turkey*

²*Department of Special Education, Gazi University, Ankara, Turkey*

ABSTRACT

It is understood that, for mentally disabled people, it is hard to generalize skills and concepts from one setting to another. One approach to teach generalization is solving the problems related to their daily lives, which helps them to reinforce some of their behaviors that would occur in the natural environment. The aim of this study is to develop a gesture based game to teach basic life skills to mentally disabled kids by a motion sensing device. To this end, a vacuum cleaning digital video game was designed by using the Unity3D game engine, and Microsoft Kinect, based on spiral development methodology. Tests were conducted in two special education schools with the help of a special education expert. The game prototypes were tested on various spectrum of mentally disabled children, and a final game was designed after several iterations. Results were extracted by observation of the participant's performances. Results have shown that this system positively helps children's basic life skills learning.

KEYWORDS

Special Education, Game, Motion Detection, Basic Life Skills

1. INTRODUCTION

Nowadays, usage of the digital video games in education is common in the world. Papastergiou (2009) and Griffiths (2002) confirm the positive effects of the digital video games in education.

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

An Augmented Reality based motion-sensing software, could enhance the learning desire on pupils, and it may positively affect their learning procedure (Cai, Chiang, Sun, Lin, & Lee, 2017). In one of the earlier studies about the Kinect and its potential in education, Hsu (2011) found that it increases children's creativity and classroom interaction. She argues that the Microsoft Kinect, in comparison with interactive whiteboards, is more useful.

Recently, researchers have started to pay attention to use Microsoft Kinect in special education. Teaching methods in special education usually get along with the additional specific services such as rehabilitation, speech therapies, and so forth, to teach the disable children efficiently. Unlike the general education, in special education, people need individual help with considering their level of disabilities, and educational methods should be considered individually for them. Video games may have a positive effect on children with special needs and may be used continuously in special education (Ruggiero, 2013). In their research Zafrulla, Brashear, Starner, Hamilton, and Presti (2011), assessed the effects of the Microsoft Kinect to teach sign language to deaf people. They used to teach the sign language to deaf people by a CopyCat system. This system consists of a computer game which is designed specifically to teach the sign language along with a wearable controller and a camera to tracking the eye and hand movements. Although the performance of using wearable controllers is better than Kinect, from many other aspects Kinect is preferable. In their research, Lange et al. (2012) proposed a physical interactive game ("JewelMine") to improve motor skills of

disable people by using Microsoft Kinect. There are some objects on the screen which are placed around the players' current positions. A player should retrieve these objects one by one based on their orders. Results confirmed the effectiveness of the game as a rehabilitation tool. In addition, a study by Camara et al. (2017) confirms that Kinect could be an effective device to rehabilitate the motor skills in teenagers with Cerebral Palsy. Boutsika (2014) recommends the usage of Kinect as an assistive device for children with autism along with "Mnemonic Techniques". The researcher focuses on the existing games such as "Kinect Adventures" and their potential application in special education. Chang, Chou, Wang, and Chen (2013) offered a system called Kinempt. It is designed to help the individuals with cognitive impairments to involve in food preparation training by using Kinect gesture recognition service. The study results indicated that Kinempt and image recognition technology may facilitate to learn job skills by children with cognitive disabilities.

This study overview shows that interactive body movement games have many applications in various areas and may be helpful in both traditional education and special education. There are various types of special students. Mentally disabled people with a various spectrum of disability are the most vulnerable group of the special students. Students with mental disabilities often have problem in generalizing information from one setting to another. An alternative way to teach generalization is to teach students to solve problems pertinent to their daily lives and to reinforce behaviors that would occur in the natural environment. In this study, we propose a system to augment the learning environment for mentally disabled students in order to easily cope with life skills by game and fun. The game was developed for motion sensing input devices by following a spiral iterative methodology. Therefore, we postulate that it is necessary to design body movement games for children with mental disabilities to teach the basic life skills.

In the present paper, a digital vacuum cleaner game was designed by using the Unity3D game engine and Microsoft Kinect. Before the project started, a permission had been taken from the Human Subjects Ethics Committee. The game was based on the designed scenario to teach vacuuming skills to mentally disabled people precisely by moving their hands and bodies like a real vacuuming act. As a result of this study, the effects of this game on the mentally disabled children performance were assessed.

2. GAME DEVELOPMENT PROCESS

A digital vacuum cleaning game was developed by using the Unity3D game engine and Microsoft Kinect motion sensing input device by following a spiral iterative methodology. At the beginning, game concepts were approved by a special education subject matter expert and then prototypes were developed and tested. In the next step, feedback was collected to improve prototypes. This process continued until a satisfactory body movement game is developed. In addition, we also tested and improved usability testing approach for body movement games for special education children. The designed game has two sections:

2.1 Training Section

Which was designed to teach how children can interact with Kinect camera and the game. Training section is composed of 6 levels which were designed with considering the level of the children's disabilities. First level's aim is to familiarize the children with the Kinect environment. Second and third levels teach the depth concept in a virtual environment. In 3rd level there is not any verbal cues. The fourth level aim is to teach the correct hand movements during the cleaning process. The fifth level provides an environment which children clean the dirty carpet by body movements. The sixth level aims to teach to distinguish garbage from non-garbage. This level is designed to teach the children how to clean the carpet and grab the garbage and put them into the garbage can. Verbal cues help children to learn the skills. Figures 1-5 show a preview of the training section.

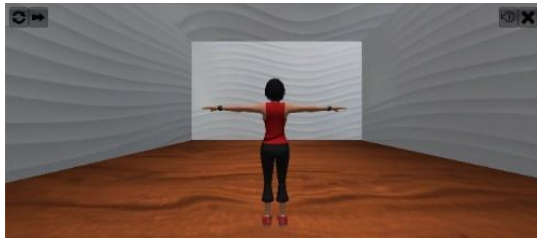


Figure 1. First Level of Training Section



Figure 2. Second & Third Levels of Training Section

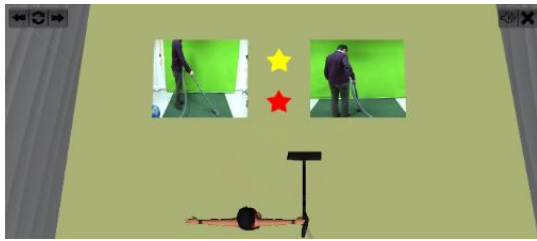


Figure 3. The Fourth Level of Training Section



Figure 4. The Fifth Level of Training Section



Figure 5. The Sixth Level of Training Section

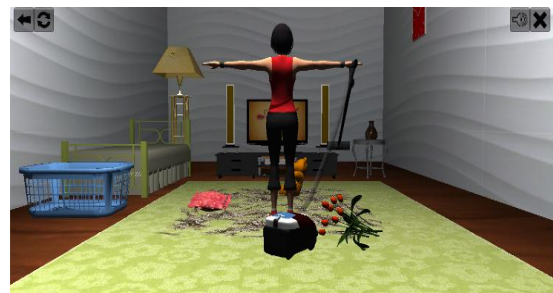


Figure 6. A Preview of The Evaluation Section

2.2 Evaluation Section

In this step, user's performances can be assessed. A user can use whatever he/she has learned from the training section to finish the required tasks. The evaluation section consists of one level. This level is the final part of the vacuum cleaner game. The evaluation is done without any intervention to check the child's performance results. Figure 6 shows the evaluation level, in this step, it is expected from the children to grab all non-garbage objects and put them in proper places. The evaluation was accomplished without any verbal cues. By activating the audio button in this level, verbal cues are active then the level can be used as a training level too.

Verbal cues are used more in the basic levels of training part and they are reduced through the following levels. Reinforcement and feedback are also used in the training part to increase the motivation and usability.

3. CASE STUDIES

The most parts of the game were designed and developed in a private special education school in companion with special education students. To evaluate the final product, a case study was conducted in the same school and after a while to have more reliable results another case study was conducted in a public special education school. After one week, the participant's performances in public special education schools were assessed again to check the consistency of their obtained skills.

In the case studies, usability tests were conducted along with systematic observation in the presence of a special education expert to determine how well children can play the game and learn the skills from the game. Before starting the experiment, each participant was asked to clean a real carpet by a real vacuum cleaner. The goal was to observe the child's performance during the cleaning process. Children should be able to grab the non-garbage objects by their hands and put them in the desired place and clean the carpet by a vacuum cleaner. The aim of this process is to check whether children can detect and distinguish the garbage from the other objects or not and whether they can clean the whole carpet precisely. If a child knows the skill, the experiment should be stopped, otherwise, the experiment continues. Those who could not do the task completely were accepted as a participant of the study. In the first special education school, there were fifteen children participated in the usability test process. Eight of them met our conditions.

Children were asked to vacuum a furnished room by a real vacuum cleaner (Figure 7(a)) in presence of an expert teacher and then play the digital vacuum cleaner game (Figure 7(b,c)) in the suitable environment which does not distract their attention.

Researcher watched and took notes and recorded the events while the children were performing a list of tasks by playing the game and being tested.

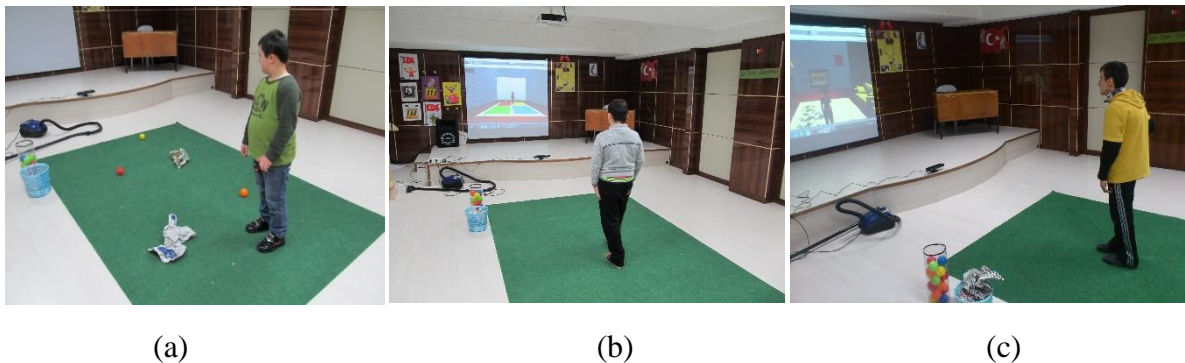


Figure 7. (a) Child is Going to Clean the Carpet. (b,c) Children Playing the Game

Post-test questionnaires were also used to gather feedback from the expert teacher on the game. Figure 8, shows photos of the children while playing the game.

The video was recorded from each test to be analyzed later. This process iterated for 12 weeks and the results of each iteration were gathered. The study continued by 5 participants, one of which was an autistic child and one with Down syndrome. The other three were with mild MR.

In the second case study, which was conducted in a public special education school, there were 34 students. They suffer from either mild MR or Down syndrome. All the children who participated were between 8 and 24 years old. Six children had been familiar with the vacuuming skills before. Nine children were qualified and their performances were satisfactory to be evaluated in this study. Among the qualified children, there were 7 boys and 2 girls. The first evaluation was conducted and the second evaluation started 8 days after the first evaluation. The aim was to test the children's skills over the time. On the evaluation day, just 6 of the 9 participants were available at the school. All 6 participants were told to vacuum the messy carpet by vacuum cleaner machine. The perfect result was to vacuum the whole carpet by moving their hands forward and backward, and grabbing the objects and put them in their own desired places.

4. RESULTS AND DISCUSSION

The process of teaching to special students, specifically mentally disabled people is very complex and takes a considerable amount of time. Every skill should be divided into the simplest steps before teaching to the mentally disabled children. The compatible vacuuming skills with Microsoft Kinect device which are essential to teaching to the mentally disabled children are divided into 4 steps:

1. Children take the vacuum cleaner handle correctly.
2. Vacuuming the carpet precisely 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 carpet precisely by walking to the right and left and forward and backward.

These steps were also used in the evaluation section. The results were achieved based on these steps.

It is assumed that children know all the prerequisites before starting the cleaning process. In the experiment, children were observed, and the experiment was continued by those children who know the prerequisites but do not know the task completely. Target groups for this study are the participants who:

- Cannot do the task individually and do not know about vacuuming skills.
- Children which know some steps but not all steps.
- Children who know all steps of vacuuming skills separately but still do not know how to combine them to finish the task.

These groups have a problem with vacuuming skill and need help. 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. From pre-test evaluation, the participants who met the experiment, criteria were selected. The selected group also played all levels of the game individually. Corrections were considered, and the game improved and expanded based on their acts.

4.1 The First Case Study's Evaluation Result

The Figure 8 shows the results of each participant's performance in the first special education school based on their capability of doing the tasks separately.

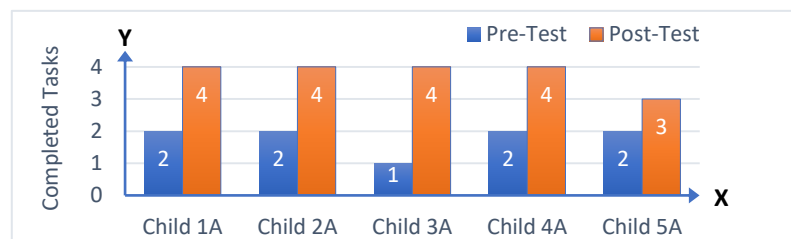


Figure 8. The Results of the Experiment in the First School

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

4.2 The Second Case Study's Evaluation Result

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

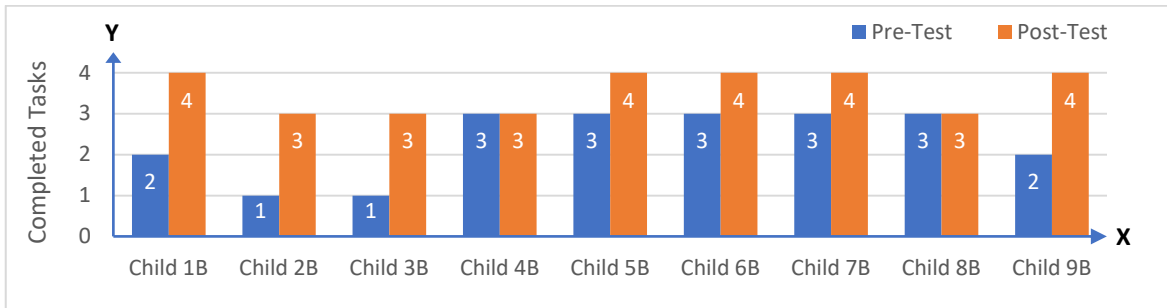


Figure 9. Results of the First Evaluation

The second evaluation started 8 days after the first evaluation. 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 vacuum the whole carpet by moving their hands forward and backward, and grabbing the objects and put them in their own desired places. The children 2B, 3B, 4B, 5B, 6B, and 7B participated in the second evaluation. Only three children (child 5B, 6B, and 7B) did not forget the task and completed the wanted tasks precisely (Figure 10). To compare the first and second evaluation's results, the number of completed tasks in the first evaluation and second evaluation is also depicted in Figure 10. First columns inform the first evaluation pre-test outcomes, second columns show the first evaluation results, and third columns depict the second evaluation results.

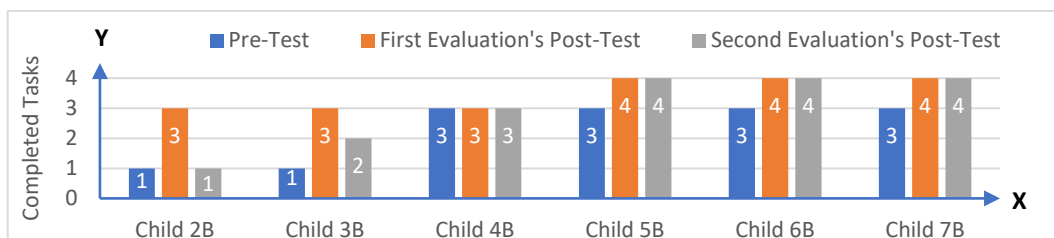


Figure 10. Results of the First Group's Second Evaluation

5. CONCLUSION

In this study, we designed a body movement vacuum cleaner game and tested it in two special education schools (Bilge Özel Eğitim Ve Rehabilitasyon Merkezi and Sait Ulusoy Özel Eğitim Uygulama Merkezi special education schools both located in ANKARA -TURKEY) by the help of a special education expert, and we found that the game is suitable for the children with mild spectrum of mental disabilities. This finding supports the previous studies about the effectiveness of body movement game as a rehabilitation tools (Lange et al., 2012; Vernadakis, Derri, Tsitskari, & Antoniou, 2014). Moreover, it confirms that interactive video games are compatible with the repetitive and stereotyped behaviors of autistic children which made it attractive to them (Boutsika, 2014).

Both realistic situation test, and virtual situation test results were compared, and the conclusions are as follows: The observation of the all children performance reveals that the children who can interact with game avatar, have more chances to finish all experiments, which shows that utilizing video games in special education have shown positive effects in the children learning (González, Cabrera, & Gutiérrez, 2007; Ruggiero, 2013). These findings support the current study findings, as the results of the study indicate, those children who could interact with the main avatar, finished the task completely and precisely. Those children who could not finish the wanted tasks mostly had problem in making interaction with the avatar.

The key factor of the proposed game is teaching the differences between garbage and non-garbage objects. Using appropriate body gestures increases children perception of being in the virtual world, and increases the personal self-sufficiency, and causes to finish the tasks by immersion into virtual reality.

Vacuuming the room completely and precisely is the main goal of the study but some pre-request steps are not compatible with Kinect. Some of them are not feasible to design because of the Kinect calibration problem in some conditions, and others are the minor steps which can be learned by the simplest technics. General body movements in the 3D environment were the strength reason for using Kinect.

The findings have shown that gesture based games may have a great potential in the education of special education children. Applying the Microsoft Kinect in education is impressive and increases the children's creativity and interaction in the class (Hsu, 2011). Some researchers inform the potential of using a gesture-based Kinect game to communicate with deaf people and confirm the positive effect of playing in a group for deaf people (Soltani, Eskandari, & Golestan, 2012; Zafrulla, Brashear, Starner, Hamilton, & Presti, 2011). Their finding supports the current study findings which children motivation is increased while playing vacuum cleaner interactive game.

The current study is a unique one 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 teaching vacuuming skills to children with mental disabilities.

Some of the children had physical disabilities too. The proposed vacuum cleaner game needs to be played by using body and hands movements which may have some positive results in their physical movement therapies. Hung, Chang & Han (Hung, Chang, & Han, 2016) investigated the use of Microsoft Kinect in increasing the motor control in children with cerebral palsy, and their research results indicate that the significant improvement was observed in three participants.

Finally, considering the results, the proposed vacuum cleaner game had a positive contributes to children learning by fun, especially for those with a mild spectrum of the mental disabilities, and it is a big step forward for teaching basic daily life skills to the mentally disabled children in an efficient manner.

5.1 Limitations of the Study

With respect to the high-tech devices which were used in this study, there are many areas which technologies do not support yet such as Kinect camera does not detect the body joints if there was any overlap. It causes wrong calibration. This supports Hsu (2011) findings of the needing re-calibration when students walk out of the range that Kinect can reach or when calibration is not done correctly. Some parents are not familiar with the computer, considering their level of knowledge is also important to design a user-friendly and easy to use the game. Finding the proper participants and taking permission from their parents to do the usability test, were also a big challenge.

ACKNOWLEDGEMENTS

This study was supported by TUBITAK SOBAG 111 K 394 project. We would like to thank TUBITAK and everybody who had a contribution in this unique project.

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