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# A Computer-Enhanced Money Teaching Application for Individuals with Autism Spectrum Disorders

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**ABSTRACT**

In this paper, a novel money teaching method which is based on computer-aided techniques worked on tablets and smartphones has been developed for Autism Spectrum Disorder (ASD) individuals. Our study focused on teaching money use aiming to solve one of the most frequently encountered daily life problem of ASD individual. The teaching method was applied using event-based fiction and a pilot study has been executed on an Android-based tablet and cell phones. The developed system that has been constructed on a combination of enjoyable sound, color, and movement attraction. The system evaluation and data collection were conducted with an observational study upon 15 ASD individuals using the prototype system by an expert on autism. The results demonstrated that the developed system is capable of teaching money by reducing the need for additional guidance.

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## 1. Introduction

Autism is characterized by three core deficits which are challenges in social integration, communication difficulties, and getting stuck in repetitive behaviors, interests, or activities (American Psychiatric Association-2013). However, it appears not only in general symptoms but also strong individual symptoms and difficulties. Autism is usually diagnosed between 2 and 3 years of age. In some cases, making a diagnosis may be before 18 months. From the viewpoint of challenges in social integration, the ASD individual seems like depersonalized and being out of step (Hartley, Papp, Blumenstock, Floyd and Goetz, 2016). In terms of social communication difficulties, they do not clearly comprehend facial expressions, voice tone, and humor. With regard to adhering to the iterant behaviors, they want to travel the same way, in other words, they do not prefer changing their existing habits. Every year, the number of children diagnosed with autism is increasing tremendously. Centers for Disease Control and Prevention(CDC) has declared that the rate of autism in the world changed from approximately one in 150 children during 2000–2002 to one in 68 during 2010–2012 whereby the latest rate as 1 in 59 children (Redfield et al., 2014). These numbers show the importance of finding new and appropriate ways of teaching these groups.

Continuous and intensive education in the early phases of their life is the only proven intervention for ASD. Therefore, education as a continuous process for individuals with special needs and for their parents gains more importance. It encourages them to independence, developing social interaction

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and communication and enhancing life quality (Bodenhorn, 2012). Private schools, materials, inclusive classes, professionals supporting families and individuals, and computer-driven education are used for these children in their training and education. From main education modules like learning figures, numeration, alphabet, and understanding vocabulary to enjoyable modules like counting games, visual encyclopedia, and virtual piano applications require to develop abilities in the area of computer-aided education (Chakraborty, 2017), (Goldsmith and Leblack, 2004). Social interaction, voice recognition, vocabulary, and linguistic skills may be improved using technological devices (Bodenhorn, 2012). The technological device rates used for ASD individual can be divided into four groups (Tsai, 2012), (Esposito and Venuti, 2009) and analysis of their studies have highlighted that tablet and smartphones can be used to improve the various abilities of ASD individuals with a rate of 34.8%. With regards to that, the key areas affected by the ASD are improved such as communication and interaction (40.5%), social learning and imitation skills (37.8%).

More generally, technology can also be used to carry out important missions that improve the ASD individual's strengths and support pinpoint areas where they may face challenges. The technological devices used in the education of ASD are known as touch-operated and acoustic stimulation devices, video-based teaching and feedback, virtual reality and robotics applications (Goldsmith and Leblack, 2004). Especially, the smartphones and tablet technologies are useful devices for addressing and overcoming several issues of ASD (Shoaib, Hussain, Mirza, & Tayyab, 2017). The touch screen and user interfaces provide an easy learning environment by combining the different set of skills such as fine or visual motor activities just via sliding and tapping (Cardon, 2016).

Technological devices such as tablets and phones can also contribute to the motivation of ASD individual by interacting with games. Nature of computer games is to be interactive rather than surrendering to the storyline of a game (Isabela, Adam and Rutger, 2014). It allows students to gain experience by creating different environments that enable them to demonstrate their abilities (Bayram and Çalışkan, 2019). For instance, the use of a smartphone-based game application can provide as a reward for positive behavior such as the fulfillment of a chore or a homework assignment (Autismspeaks.org, 2015). ASD individuals often suffer from assessments which are conducted by pen and paper, so those available through computer-supported devices and tablets have been appeared to be very constructive. These kinds of assessments benefit their learning programs in an important way which improves their abilities, thinking criteria, and strengths and also advances on skills they have trouble with as shown in Table 1 (Aresti-Bartolome and Garcia-Zapirain, 2014).

**Table 1.** The Effects of Technological Devices Diagnosis on ASD Individual (Autismspeaks, 2015)

| Author | Clinical Group, Age, Area | Method | Results |
|---|---|---|---|
| Grynszpan et al., 2008 | 10 adolescents, Unknown, Communication Skills | Subtitled dialogues (irony, sarcasm, and metaphors); images of facial expression | Participants with ASD performed poorly on rich multimedia interfaces |
| Piktoplus, 2019 | Unknown, Unknown, Communication | Piktoplus: Communicator using pictograms | The system which works on language, behavior guidelines, Motricity |
| Delano, 2007 and DeQuinzio et. al, 2007 | 3 Asperger Syndrome students, Unknown, Writing | Video self-modeling | each student watched a video and gains in the number of words written and the number of functional essay elements. |
| Torii et al, 2012 and 2013 | 1 autistic child, 8 years, Communication | Let's Talk! | Bad behavior and learning to express thoughts enhancement |
| Ganz et al., 2013 | 3 preschoolers with ASD., Communication | Tablet as a communicator | 2 of 3 children preferred the new system |
| Dillon and Underwood., 2012 | 10 ASD children and 10 typically developing children, Average 8 year, Imagination | Application-based on creating stories | Both groups produce a similar number of bubbles for fantasy and reality-based stories, but the ASD children made more errors |

A study conducted on the importance of computer-aided education for ASD children showed that teachers face problems in computer-aided education which is related to the applications that they used.

In the study, the discussion and interview were realized by 11 special education teachers (Abidoğlu, Ertuğruloğlu, and Büyükeğilmez, 2017). The participants remarked that there are imperfections in the software design for the focus age group. Furthermore, the deficiencies are also in the individual differences of the children. Besides, all these problems occur regarding with scenario organization within the programs, the majority of the applications that are used in today's market tend to center upon mainly on teaching academic skills.

According to the research from the University of Missouri carried out an investigation on teenagers and young adults with autism reach adulthood, they are often worried about how to overcome with new adult responsibilities such as using money, paying bills (Cheak-Zamora, TETİ, Peters and Maurer-Batjer, 2017). These findings motivate the educational institutions to include the financial issues into early education of young adults with ASD to enhance the ability to do daily tasks. The investigation result claims that helping ASD individuals with teaching them money to purchase for items from a store can provide the confidence needed to comprehend daily financial matters.

The aim of this study is to build and evaluate a tablet game for teaching money usage to the ASD individual to improve their ability to meet the daily requirement, to develop independency and related skills. Our focus is to seek the answers for the following research questions: "How can an interactive application be effective in the development of money using in ASD?", "Which supports in the application are the most appropriate in terms of being successful the money using outcomes in ASD?" and "How should technological ways for ASD be improved and adapted in order to meet their needs?". The training, learning, and comparison modes are the key parts of the game to examine behavioral reactions of ASD individual. Evaluation sheet plays an important role to evaluate the interest of an ASD individual in the developed system.

The remaining part of this paper is structured as follows. In Section II, the detail of the proposed game application is presented in detail. In Section III the participant profile and evaluation method are explained. Section IV mentions the results of the proposed system which was obtained by a specialist in the ASD field. Finally, Section V draws the decisions in terms of future works to be improved with regards to the evaluation of the results.

## 2. The System Development

The prototype game software's structure and components are designed to meet the requirements of teaching money concept and to increase the learning capabilities.

### 2.1 System Design

In order to create a simulated environment to teach Money for ASD individual, a tablet game has been developed. The methodology used in this system is supported by five system engineering and education techniques: cross-platform game application development (LibGDX), prototyping, teaching money concept using education sciences techniques, an event-based scenario using education sciences techniques, and social interaction responses from the application using education sciences techniques.

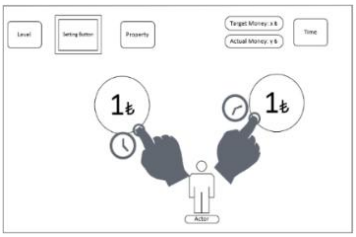
A cross-platform game development framework has been chosen to develop a game application via a common code base and the ability to publish the game on different operating system and platforms. This development structure has huge advantages when it is considered as a fast-prototyped application, releasing an application to many technological devices at once, and cheaper than the other application development cycle (Heitkötter et al., 2013). The cross-platform game application development was chosen as Java programming language based LibGDX. Besides, It helps you add low-level definitions, so it can be easily added OpenGL calls and it is broadly used as high level with its built-in functions which are audio, input handling, File I/O and storage, math and physics, tools, and high-level 2D-3D APIs.

2.1 System Content

The prototype application was realized for teaching money concept and social interaction on a tablet and smart phone. Each screen's structure aims to educate different concepts using images, sounds, and transactions. The training mode is used first for teaching a concept then the testing mode is used to evaluate the learning outcome of an ASD child. The application's login screen is shown in Figure 1.


**Figure 1.** Login Screen

The screen displayed in Figure 2 reflects the training mode of the proposed system. The system starts with an amusing sound. The user continues using direction buttons. The next page of the system has a voiced training mode which introduces the 1 Turkish Liras as actual size. Because the ASD individuals have difficulties to evaluate the value of the money, the system was designed to allow them to understand the real money appearance. When they click the money image which includes both sides, the motivational sound is vocalized.




a) The Scenario for Training Money Concept


(b) The Prototype for Training Money Concept

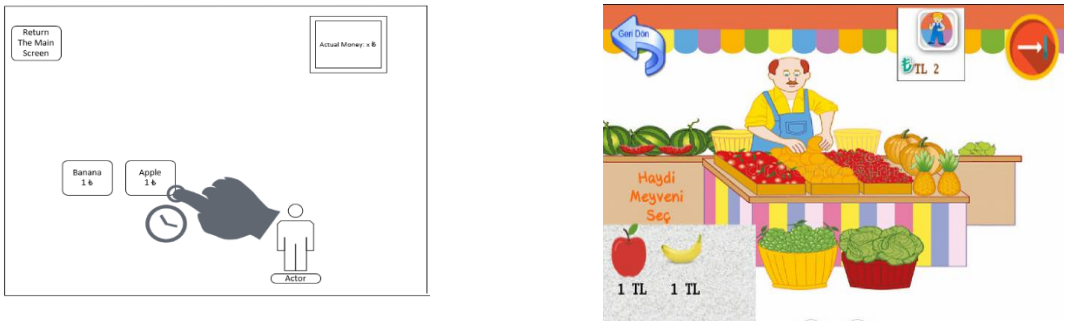

(c) The Touch-Mode for Training-Learning Money Concept

**Figure 2.** Training Money Concept

The screen in Figure 3 includes specialist advised next level picture and songs that motivate and encourage ASD individuals to achieve new targets.


**Figure 3.** Developed Break Screen for Motivation

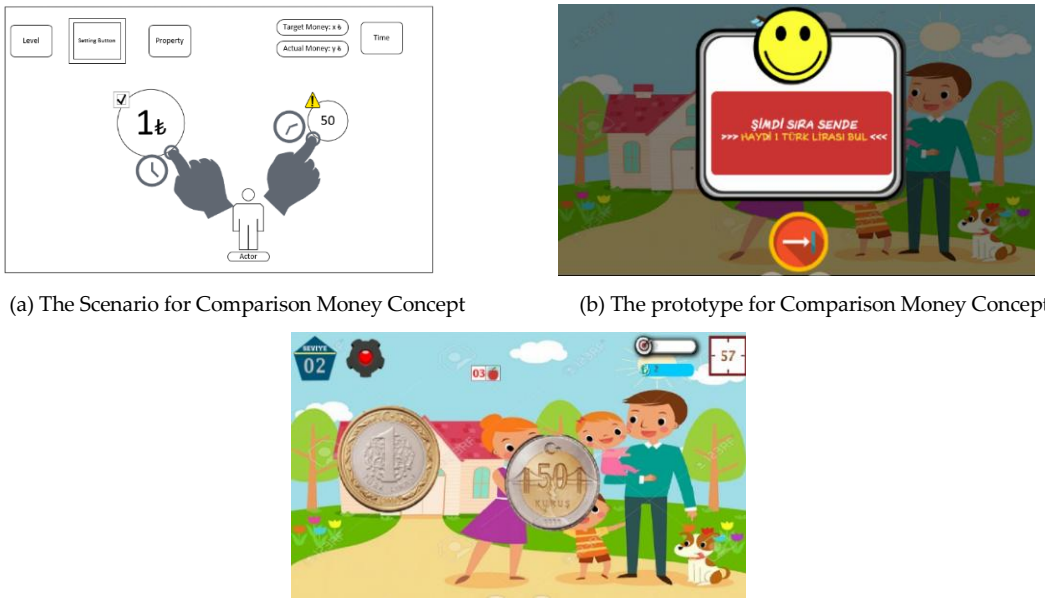
The screen indicated in Figure 4 is the second scenario of the system. The objective is to support the ASD individuals to understand money and item relationship, so, an ASD individual can purchase the required or desired items from the market.




(a) The Scenario for Shopping Concept (b) The Prototype for Shopping Concept

**Figure 4.** Shopping Concept

The screen is shown in Figure 5 targets ASD individuals to compare the objects with their size and values truly then select the correct one. When an ASD individual makes a mistake, it is warned with a motivational sound that says "Haydi, tekrar deneyelim." - "Lets, try again".




(a) The Scenario for Comparison Money Concept (b) The prototype for Comparison Money Concept

(c) The Comparison and Motivation When Mistakes Occurred

**Figure 5.** The Comparison of Money Concept

## 3. Method

### 3.1 Participants

15 ASD diagnosed individuals were observed by a specialist in education to evaluate the result of the proposed system. These individuals are at the school of Autism Association in Turkey. The participants are aged between 12 to 18 years. Nearly all the participants have suffered from speech difficulties and 5-6 of them should be forced to negotiate even their requirements.

### 3.2 Data Collection

The individuals were observed by Esra Macaroglu Akgul, who is a specialist in education, to evaluate the result of the proposed system. The one-to-one evaluation has been used to evaluate the usability of the game and the learning effects on ASD individual. The measures are the learning outcome, the reaction of participants against the system, the components that participants like. The observation was

conducted in different environments in the school. All behaviors of the participants in the application have been reported in observation document.

## 4. Results

All measures have been saved in text and reevaluated to understand the effectiveness of the system on teaching money on each participant. The results are as shown in Table 2.

**Table 2**. Observation Results of Effect on 15 ASD Individuals and Improvement Advice

| | **Effect on ASD Individuals (Commented on by each autistic child)** | **How to improve (Technical Observer)** |
|---|---|---|
| Participant 1 | The application is eye-catching for her. She can understand money and value. Drag and drop should be added while selecting fruit to the box. It can be easily learned from different objects such as paper money. | Motivational balloons can be added. New scenarios can be added. It will be a novel idea for a new shopping concept in terms of drag and drop functionality |
| Participant 2 | The application user interface is easy for him. He quickly recognized the money in his life. Now, he knows what the money is. | Shopping concept can be optimized in a more colorful way for him because he cannot adapt to the same color fruits. |
| Participant 3 | Sounds are really interesting for him. Graphics are easy to understand. Sounds of notification are a little bit quiet for him. He easily finds money objects and understands the comparison. | Shopping concept is not easy for her because he did not understand what the screen is and how to select them. |
| Participant 4 | The application is fast for her. She did not like the color on the user interfaces. She wants more pink and purple colors. She likes the money screen because the objects are in real size. | The sounds and graphics need to be configured as her own choice. Adding a color choice for the objects can provide a good balance. |
| Participant 5 | She enjoys using the system. She is happy and can use money in the shopping scenario. She compared the object and learned what she can buy with its current money. | Voiced directives should be clearer. |
| Participant 6 | She thinks all other objects are perfect for the learning money. The comparison can be extended for other money types. | The only problem for her is adding a different type of money values. |
| Participant 7 | He liked the application organization. He has adapted to the program. He learned the real money value and its usage. | Sounds should be optimized with his choices. |
| Participant 8 | She liked the overall application but she faced difficulties during shopping concept because of selecting items. | Shopping concept can be improved using drag and drop concept for easiness. |
| Participant 9 | He liked graphics and objects in the game. The comparison can be extended by adding more different values. | More objects will be added to the system. |
| Participant 10 | He communicates with his market worker for basic level shopping in the real world. | He wants us to develop the game for further applications. |
| Participant 11 | She tried the application more than 10 times. She improved his abilities in learning money values and shopping. | More graphical backgrounds can be customized with the choice of the participants. |
| Participant 12 | He liked and wanted to use the application after the education. | More levels should be added. |
| Participant 13 | Good graphics in the game but shopping graphic can be dynamic. | Comparison skills should be improved by using more convenient voice for items. |
| Participant 14 | She did not like so much the sound and voices. | Graphics, sounds will be optimized with her choices. |
| Participant 15 | He can learn himself. He can tell his parent the money using and practices how much money is given in real-time. | Money comparison can be deeply included in new levels. |

As shown in Table 2, the ASD individuals had a huge interest in the application system. They found the application as motivative and learnable for money concept. Moreover, sounds, graphics, and usefulness of application are acceptable for participants. Some participants prefer extending the application to other levels such as paper money and new shopping objects. Participants 4 and 14 have encountered some difficulties. Their difficulties are based on the colour, sound, and sizes of the objects. On the other hand, other participants have easily adapted to the system. They can use money in their small shopping simulation of the mobile application such as buying some vegetables, fruits, and junks.

**Table 3.** Evaluation Results of Application Criteria for 15 Autistic Individuals on the basis of 1 to 5 scale (1 is the worst, 5 is the best)

| | Sound, Graphics Effectiveness | Learned Money Concept | Learned Shopping Concept | The Ability of Comparison Money |
|---|---|---|---|---|
| Participant 1 | 5 | 5 | 3 | 5 |
| Participant 2 | 5 | 5 | 4 | 5 |
| Participant 3 | 5 | 4 | 3 | 4 |
| Participant 4 | 3 | 4 | 3 | 3 |
| Participant 5 | 4 | 5 | 5 | 5 |
| Participant 6 | 5 | 5 | 4 | 4 |
| Participant 7 | 4 | 5 | 4 | 5 |
| Participant 8 | 5 | 4 | 3 | 4 |
| Participant 9 | 5 | 5 | 4 | 4 |
| Participant 10 | 5 | 5 | 5 | 5 |
| Participant 11 | 4 | 4 | 4 | 4 |
| Participant 12 | 5 | 5 | 4 | 5 |
| Participant 13 | 4 | 3 | 2 | 3 |
| Participant 14 | 3 | 3 | 4 | 3 |
| Participant 15 | 5 | 4 | 4 | 4 |

As shown in Table 3, the application has an impact on 15 ASD individuals that can track and understand the money concept. 4 of ASD (%27) participants achieved the shopping concept with their money and 2 (%13) of participants learned the money but required an outside help from their parents in the shopping process The mean of participants' learning outcome scores have been summarized in Figure 6;

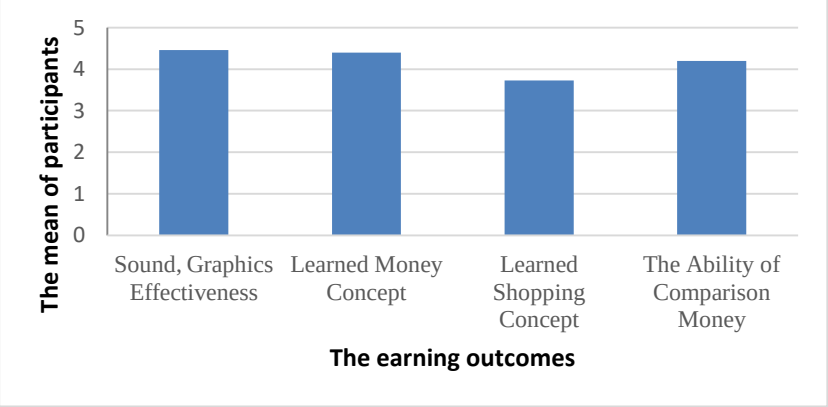



**Figure 6.** The summary of the evaluation result

The number of participants against the expectation types from Table 2 has been summarized in Figure 7. The results indicate that one third ASD individuals need customizable features such as color or sound to increase their motivation. The additional features should be added to the application to increase the usage for more than half ASD individuals (9/15).

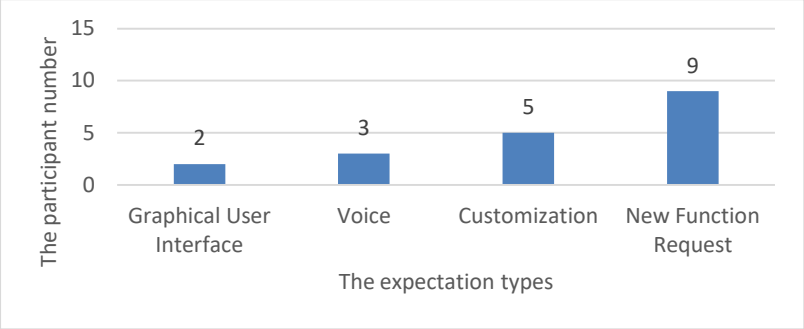



**Figure 7.** The new feature requests

As a result, conducted tests on 15 ASD individuals to understand the effectiveness of the system to teach use of money demonstrate that 4 of ASD (%27) individuals achieved to learn shopping with their money and 2 (%13) of ASD individual learned the money generally but they required an outside help from their parents in the shopping process, 86.6% of individuals found the application useful with regard to learning money value. 14% of individuals had difficulties for quickness and articulation on the system and were observed in the way of advancement in learning money concept. All of the ASD individuals had a huge interest in the sounds and graphics of the game and they found the application as motivative and learnable. The results demonstrated that the proposed system can interact with ASD individuals and help them identifying the value of money and using it. The more visual objects such as additional money and shopping figures can attract the attention of ASD individuals and increase the acceptability of the application.

## 5. Future Works

The individual characteristic based progress can be added to the proposed system so each ASD individual has its own progress in the application. The shopping part of the game can be improved for teaching ASD individuals how to successfully manage their money and use it for shopping. As a starting point for realizing this objective, a different type of shopping scenarios and color properties should be added to the system in the future. Progress measurement can be added in the background of the system such as the learning time, the correct and incorrect answer statistics in the time period. Skills that participants experienced with the application will be observed in real life.

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