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Work-in-Progress—Teaching Traffic Safety Skills to People with Moderate Intellectual Disability Using Augmented Reality

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Abstract. Teaching Traffic Safety skills to individuals with intellectual disability is a demanding task since real-life experiences on busy roads can be dangerous and overwhelming. The aim of the present work-in-progress, single-case study is to investigate the effectiveness and feasibility of a game-based intervention using Augmented Reality in teaching traffic signs and vehicles to individuals with mild or moderate intellectual disability. The specific variables have been selected with the aim of enhancing the participants' autonomous home-to-school transport and reversely, as well as to fill in the research gap. The participants were two individuals diagnosed with intellectual disability from the city of Ioannina, Greece. The descriptive outcomes indicated an improvement both in educational and autonomous living skills, as well as increased motivation and interest in the learning process. As this is a work-in-progress study, the exact measurable results are to be evaluated through an experimental research design, where the effectiveness of the AR intervention will be compared with a traditional teaching method, implemented in a control group.

Keywords: Intellectual Disability, Augmented Reality, Social Skills, Autonomy, Traffic Safety Education.

1 Introduction

Teaching functional daily living and independent living skills to individuals with intellectual disability (ID) is a prerequisite for their independence and smooth integration into society [1]. Individuals with ID living semi-independently are twice as likely to be involved in accidents compared to those living in residential settings [1]. Due to the risks they face in real-life environments, acquiring traffic education skills cannot be achieved through trial and error in the actual roads of their city. Therefore, controlled environments come to the forefront, ensuring that individuals with disabilities acquire the necessary knowledge safely [2]. In this context, augmented reality practices are considered to make an exceptional contribution to special education and training. Augmented Reality (AR) environments have the capability to blend elements of virtual reality with elements of the real world, adding images, data, and other content to the latter [3]. Therefore, users can come into contact with the real environment while interacting with virtual objects through their devices [4]. By utilizing images and videos from the participants' actual environment, the AR videos will be more personalized and facilitate them in linking the virtual with the real world.

2 Theoretical Background

2.1 Definition & Classifications of Intellectual Disability

"Intellectual Disability (Intellectual Developmental Disorder) is a disorder starting during the developmental period of the individual, which includes both intellectual deficits and deficits in adaptive functioning in various domains" [5]. The levels of intellectual disability include:

A. Mild intellectual disability, which is encountered in approximately 85% of individuals with intellectual disability. Individuals with mild ID can achieve some level of academic success [6].

B. Moderate intellectual disability, affecting around 10% of individuals with intellectual disability. Individuals at this level have limited conceptual and social skills and may require guidance during stressful situations. Self-care can be performed independently with occasional support [6].

2.2 Relevant Studies

After searching the academic databases ERIC, Scopus, Google Scholar, IEEE Xplore, Web of Science, SpringerLink and ACM Digital Library, we identified 15 candidate papers for further analysis. Most of them used a mix of AR and Virtual Reality (VR) or VR solely, while others did not use the features of AR correctly in practice. Specifically, the creators of most AR apps and interventions do not belong to both the technological and special education field. Thus, they focused more on the technological aspects of the intervention rather than on how they can cater for the needs of individuals with special needs through these interventions. Only two papers met our study criteria and focused on teaching some aspects of traffic safety and navigation to people with disabilities. One study [2] used AR environments to teach students with disabilities how to meet their basic navigation needs autonomously. Researchers focused, among other things, on traffic rules (red-yellow-green pedestrian light signals) and basic emergency vehicles (fire truck, ambulance). Based on the results, the students were more eager and enthusiastic about the lesson, their readiness and interest in the topics increased and they were able to understand the concepts without the educators' assistance.

McMahon, Cihak, and Wright [7] used AR to improve the navigation skills of three individuals with ID and one individual with autism, to assist them in job finding. By scanning the environment around them with their mobile phone, information regarding potential job opportunities as well as the distance from the business of interest would appear on screen. The results showed that the use of AR helped the participants navigate the streets safely, understanding and following the information with ease. Despite its advantages, the use of AR in teaching traffic safety skills to individuals with ID has not been extensively researched in the international literature. One app that has been developed for typically developing students, is called Arility. After scanning the printed logo of the app, students can move their virtual character around a 3D town and overcome various difficult situations (e.g. crossing the road) by making the right choice. However, this app has not been empirically investigated and there are no results regarding its effectiveness. Due to this gap in literature, we developed an AR board game, with the aim of investigating its effectiveness in teaching safe mobility skills to individuals with mild or moderate ID.

3 The Present Study

3.1 The Present Study

The aim of the present work-in-progress, single case study is for participants to successfully recognize vehicles and traffic signs, as well as to exhibit the appropriate behavior upon encountering them. For this reason, we opted for the single-case study design, which refers to a set of experimental methods that can be used to control the effectiveness of an intervention by involving a small number of participants [8]. Specifically, the researchers created two tests, one regarding the baseline phase, aiming at measuring the participants knowledge before the intervention and a post-test to measure the acquired knowledge. Specifically, the researcher-created baseline and post-tests indicated a functional relationship between the game-based AR intervention (independent variable) and the cognitive skills to be acquired (dependent variables). This research design is considered appropriate for designing educational interventions in Special Education due to its capacity for frequent and repetitive assessment of individual learning performance. Consequently, each participant effectively serves as their own individual control [8]. The research questions of the study are: a) Is the use of Augmented Reality (AR) effective in teaching Traffic Safety Skills to people with intellectual disability? b) Can participants readily recognize traffic signs and vehicles, as well as demonstrate proper traffic behavior after the intervention phase?

3.2 Research Tools

Two assessment tests (baseline, post-test) were utilized to measure the participants' relevant knowledge and skills before and after the intervention, completed by the researchers. Moreover, they created a board game, enriched with AR, which was used by the participants during the intervention phase. The AR game design was based on the Model for the design of Immersive Learning Enactments for Students with disabilities (MILES-D), which was adapted for people with ID [9]. Based on this model an immersive educational environment needs to include specific tasks. Two of those are "Design of safe immersive learning environments" and "Data presentation and

interpretation, modeling and simulation of real systems, phenomena, situations" [9 pp 142]. The present AR board game offers a safe alternative in learning about the correct traffic behavior and through the audio and video-models used for the augmentations, real-life road scenarios were brought to the digital world.

3.3 Sample & Settings

The study sample consists of one male and one female, diagnosed with ID, from Ioannina, Greece. Henceforth, we will refer to the research participants as Participant 1 and Participant 2. Participant 1 is 46 years old and has been diagnosed with Down syndrome and moderate intellectual disability, while participant 2, aged 33, has a diagnosis of moderate intellectual disability and exhibits some features of autism spectrum disorder. The participants were diagnosed from the Disability Certification Centre before moving into the supported living accommodation, where they reside. The support staff provided the researchers with the detailed diagnoses.

Inclusion Criteria:

• Participants must be diagnosed with mild or moderate intellectual disability.

• They should be able to communicate using at least single-word phrases and they should understand oral speech (game rules, recordings).

• They must be able to work in group games and use technological devices (tablet, mobile phone, etc.).

The intervention phase and the completion of the baseline and post-tests and the memory game, used for assessment, took place in the participants' home. The evaluation of the participants' acquired knowledge, regarding the traffic signs, took place in the local traffic safety park. Permission for the participation to the study was obtained from the parents/guardians and caregivers of the participants.

3.4 Characteristics of Persons with Intellectual Disability Based on the Goals of the Present Study

a) Difficulty in utilizing community resources for transportation [10].

b) Difficulty in understanding complex concepts [10].

c) Difficulty in memorization and recall of information [10].

d) Limited social adaptability - difficulty in following social norms [10].

e) Difficulty in categorizing the information they receive in groups with common characteristics [10].

4 Intervention

The intervention phase is divided in 3 parts. In the first part, the researchers collected participants' data. By implementing free play and taking a walk around the area, they gathered all the information regarding their knowledge of Traffic Education. At this stage, the researchers completed the baseline phase test for each participant separately. The next stage is the intervention phase, during which the participants played the Augmented Reality board game (see Fig. 1). The AR Tutor application was used to create the augmentations [11]. The total duration of the intervention was 53 minutes. The two participants took turns rolling the dice. One chose the school-home route, while the other chose the home-school route. Depending on the number on the dice, they advanced to the corresponding station. At each station, they encountered a specific object related to Traffic Education (either a sign or a vehicle). Then they picked up the device with the scanner (mobile phone) and after scanning the QR code on the card, they could observe the corresponding augmentation. All augmentations were displayed 2 or 3 times by both participants, and they had to watch both theirs and their teammate's augmentations, in order to learn about all the objects. This was followed by a brief discussion regarding the objects and comprehension questions asked by the researchers to determine if the newly acquired knowledge had been understood. Once the game was completed, the two participants received the vehicles and signs as "prizes".

During the third phase, post-tests were completed for each participant separately. Two days after the intervention phase, a repetition of the game took place, but this time the participants started from the opposite route than the one followed the previous time. At this phase, the researchers participated in the game, creating two teams with the participants. The aim was to reinforce the already acquired knowledge and to complete the post-tests. In this way, data were collected regarding the effectiveness of the Augmented Reality board game and the objectives achieved through it. Lastly, in the intervention's evaluative part, the participants were taken to the Traffic Park of the area after one week.

Fig.1. Intervention Phase.

At this stage, the retention of the knowledge and skills acquired by the participants was examined. Specifically, the traffic signs of the park were enriched with augmentations created by the researchers. Participants had to move around, scanning the signs with their devices until they found the correct one. When they reached the sign indicated in the researchers' command, a reward video would appear, which was created using the Voki application (https://www.voki.com/) [12]. Two memory games were created in the Interacty application (https://interacty.me/) [13], in order for the participants to check their knowledge. The aim for each participant was to find the 8 pairs of vehicles and name them.

4.1 Description of the Augmented Reality Board Game

The board game presents two possible routes, the home-school route and the school-home route. The traffic signs encountered include the stop sign, pedestrian crossing, dead end, no entry sign, school zone, parking (for people with disabilities), mandatory straight path, and traffic lights (green and red). Similarly, the vehicles encountered include the ambulance, bus, fire truck, police car, motorcycle, bicycle, car, and airplane. When participants encounter any of the aforementioned signs or vehicles, they pick up the device with the scanner and scan the object. The object serves as the physical marker, which must be detected by the camera to display the digital content (see Fig. 2). People with ID show great difficulty in understanding abstract concepts, so visualization is an effective teaching principle [10]. The use of miniature signs and toy vehicles enable participants to handle them and understand their function in more concrete terms, in order to be able to apply this knowledge to the real world afterwards.

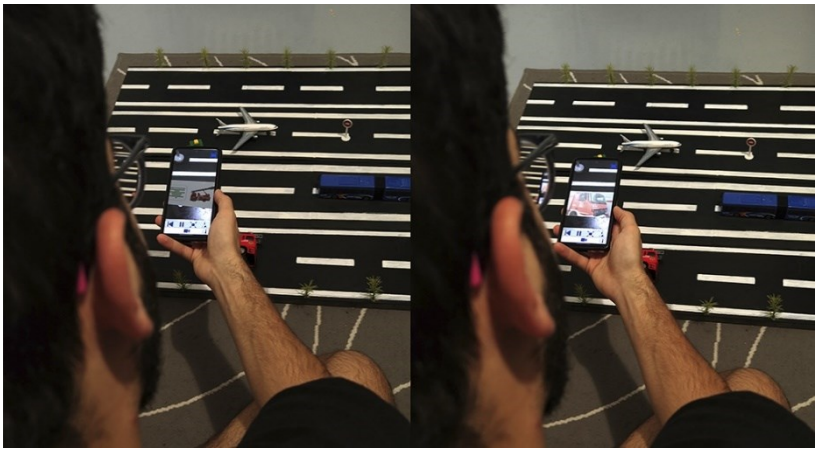

Fig. 2. The Augmented Reality board game- Scanning the physical marker and watching the augmentation.

The Augmented Reality board game contributes to informing the person with disability about the meaning and use of each sign and vehicle, through specially designed videos that present the image, sound, and utility of each object. In practice, after the player rolls the dice, s/he moves the token to the corresponding object on the game board, scans it and watches the augmentation. The videos and audio instructions used for the augmentations have

been created by the researchers who serve as models-prototypes (see Fig. 3). The main learning method which was used was the "video-modeling" method which is based on Bandura's theoretical model of "Observational Learning". Participants observe the video models through the augmentations and are asked to mimic these behaviors in real-life environments [10].

Fig. 3. Video-models of the researchers used for the augmentations.

5 Results

The participants in the Augmented Reality board game were two individuals with moderate ID, who reside in a Supported Living Facility, receiving support from nurses and psychologists throughout the day. Both attend school in the morning and participate in afternoon activities such as theater and music. The participants were selected due to their lack of knowledge regarding traffic safety and vehicles, aiming to enhance their independent and safe mobility skills. The main phase of the intervention was the implementation of the board game, which lasted for 53 minutes. Both participants showed enthusiasm as soon as the game was announced and began playing with joy and motivation. Throughout the game, they followed the correct order and the rules consistently.

Out of all the vehicles, Participant 1 already knew about cars, airplanes, bicycles, and motorcycles, while the Participant 2 only recognized cars and airplanes. However, these vehicles were only recognized by sight, without knowledge of information such as seat belts, their sound, or their purpose and usage. After the intervention, both participants seemed to have acquired all the vehicles, except for one (the bus), which was not retained by participant 2. Participant 1 recognized and remembered its basic characteristics most of the times with some help. Specifically, vehicles with distinctive sounds (police cars, fire trucks, ambulances) were more easily memorized and recognized by both participants.

Regarding the traffic signs, most of them were unknown to the participants before the implementation of the game. Participant 1 recognized the traffic lights (red and green) and the bus stop sign. The second participant did not recognize any traffic sign at all. After the completion of the game, the participants managed to recognize and distinguish most of the traffic signs, except for the parking sign for people with disabilities, which was not recognized by both, the dead-end sign, which was only acquired by participant 1 and the mandatory straight-ahead sign, which was acquired by participant 2. This is likely because neither of the participants knows how to drive, so they may not have observed or followed the indications of the signs before. It is worth noting that the interest of the participants, especially participant 1, remained immutable throughout the game. However, due to the volume of information presented, it was decided to reintroduce the vehicles and signs gradually in subsequent sessions, to assess the effectiveness of the game and help the participants obtain as much information as possible.

One notable difference between the two participants is their different learning pace. Participant 1 understood and memorized information more quickly, while Participant 2 needed more encouragement and repetitions. Overall, the use of Augmented Reality proved beneficial for teaching Traffic Safety Skills to individuals with moderate ID, as it not only helped in conveying all the useful information in an understandable way, but also in capturing the participants' interest and attention. As a result, they learned through play, in an interactive and immersive way.

6 Discussion

The results of the study showed both improvements in the participants' academic knowledge, regarding the subjects to be learned, and increased focus and motivation for learning. While before the intervention they had minimal or no knowledge about traffic signs and vehicles, the post-tests showed that the participants acquired most of the objects and could transfer their knowledge in real-life environments. Similar results were obtained by Cakir and Korkmaz [2], where students with disabilities understood concepts (red-green traffic lights, ambulance, police car) independently, without the help of educators, using AR. Additionally, the participants in the present study were willing, excited, and maintained their attention throughout the game. They also felt confident in their ability to move around the streets, as they had learned the basic signs and vehicles and could move without significant support. Increased motivation for learning, a higher level of readiness, and a strong interest in the intervention topics were also observed in students in the study by Cakir and Korkmaz [2], confirming that the adoption of digital technology in the educational process is more effective than traditional methods for a large number of participants with different disability profiles and varying strengths and weaknesses.

Furthermore, the autonomy of the participants increased significantly, as they now know most of the signs and vehicles, allowing them to move without significant assistance from their home to various points of interest, such as school, café, park, etc. During the walk, the participants managed to navigate the streets effectively, using traffic lights and crosswalks and recognizing many of the vehicles they had seen in the augmented reality videos. They generalized their knowledge and applied it to the physical environment of the streets of Ioannina, Greece. However, repetition is crucial for the retention of the acquired knowledge and will enhance the autonomous and safe mobility of participants. According to Soulis [10], through repetition, the newly acquired information is established and maintained. Through the provision of different stimuli (miniature cars and signs, augmentations, real-life cars and signs on the streets and the traffic park, cars on the memory game), the items to be learned are constantly practiced and revised.

These results are consistent with the study of McMahon, Cihak, and Wright [7] who improved the autonomy of people with disabilities by teaching them navigation skills through AR, something that reduced the need for continuous support from others. Finally, there was a significant improvement in the mnemonic functions of the study participants, as they were able to store the acquired knowledge in long-term memory and retrieve it whenever needed. At the traffic park, they were able to remember most of the signs, and in the memory game, no mistakes were observed by any participant.

6.1 Limitations

A limitation of the present study is the small sample size, as the intervention was applied only to two individuals with ID. Additionally, the sample comes solely from the city of Ioannina, Greece, which, combined with the small sample size, does not allow for the generalization of the results. However, as regards towns with similar size and road structure as Ioannina, we assume that the findings can be generalizable, but this depends on the personal characteristics of the participants and the way the intervention will be implemented by the researchers. Furthermore, the sample presented a specific type of disability, specifically intellectual disability. Finally, the results regarding the retention of knowledge may not be representative, as ideally, the post-tests should be repeated approximately 2 months after the intervention phase.

6.2 Proposals for Future Research

Future researchers could implement the intervention on a larger number of individuals with moderate ID, to investigate its generalizability. Moreover, they could cover other types of disabilities, such as autism. Another suggestion is teaching different thematic units, such as weather phenomena, seasons, or colors. Also, it would be interesting to apply the above intervention to individuals with severe/profound intellectual disabilities, with minor modifications to the video contents. Lastly, the present intervention could be implemented in bigger towns, in order to identify potential problems that could be caused by the complexity of the traffic in such contexts.

7 Conclusions

The aim of the present single-case study was to identify the strengths and shortcomings of an AR board game, aiming at teaching Traffic Safety skills to individuals with mild/moderate ID. The use of AR helps individuals come into contact with the real world through its enrichment with multimedia, enhancing both their educational skills, as well as their performance, learning motivation, understanding and engagement in the learning process

[14]. Most augmentations consisted of video models videotaped by the researchers to provide a more realistic experience to participants. The board game is a miniature representation of real roads, helping participants to generalize and apply their knowledge to real-life situations.

However, in many studies, there is a misunderstanding about AR and its usage. Many times, it is confused with VR, other times it is misused in interventions, while in many studies, the term AR is used theoretically without being implemented in practice. In the present study, we tried to exploit all the features of AR and through physical markers, we combined the real with the virtual world, offering an interactive and educational experience to the participants. Furthermore, according to James [15], gamification is effective in integrating people with disabilities into the teaching-learning process, as it can minimize their academic "struggle". Gamification elements such as points and rewards, attract students' attention, thereby enhancing their learning performance, problem-solving skills and improving their self-confidence [16]. For all these reasons, we chose to create a board game and enrich it with the use of AR, in order to provide a comprehensive learning experience to people with intellectual disabilities and maximize their learning gains.

Disclosure of Interests

The authors have no competing interests.

References

1. Batu, S., Ergenekon, Y., Erbas, D., Akmanoğlu, N.: Teaching Pedestrian Skills to Individuals with Developmental Disabilities. Journal of Behavioral Education. 13(3), 147-164 (2004). https://doi.org/10.1023/B:JOBE.0000037626.13530.96
2. Çakır, R., & Korkmaz, Ö.: The effectiveness of augmented reality environments on individuals with special education needs. Education and Information Technologies, 24(2), 1631–1659 (2018). https://doi.org/10.1007/s10639-018-98486
3. Solak, E. & Cakir, R.: Investigating the role of augmented reality technology in the language classroom. Online Submission, Croatian Journal of Education 4(18) 1067–1085 (2016). https://doi.org/10.15516/cje.v18i4.1729
4. Tan, Bhing-Leet., Guan, Frank-Yunqing., Leung, Ivy-Mun-Wah., Kee, Sharon Yi-May., Devilly, Oran-Zane and Medalia., Alice.: A gamified augmented reality vocational training program for adults with intellectual and developmental disabilities: A pilot study on acceptability and effectiveness. Frontiers in Psychiatry, 13, 966080 (2022). https://doi.org/10.3389/fpsyt.2022.966080
5. World Health Organization International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10): Version for 2016, Mental and behavioral disorders (2016). Retrieved from: https://icd.who.int/browse10/2016/en
6. American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders (5th ed.). DC, Washington (2013).
7. McMahon, D., Cihak, D. F., & Wright, R.: Augmented Reality as a Navigation Tool to Employment Opportunities for Postsecondary Education Students with Intellectual Disabilities and Autism. Journal of Research on Technology in Education, 47(3), 157-172 (2015). https://doi.org/10.1080/15391523.2015.1047698
8. Horner, R., H, Carr, E.G., Halle, J., McGee, G., Odom, S., Wolery, M.: The use of single-subject research to identify evidence-based practice in special education. Exceptional Children, 71(2), 165-179 (2005). https://doi.org/10.1177/001440290507100203
9. Delimitros, M., Stergiouli, A., Iatraki, G., Koutromanos, G., & Mikropoulos, T.: A model for the design of immersive learning enactments for students with intellectual disability. In 10th 2022 International Conference of Software Development and Technologies for Enhancing Accessibility and Fighting Info-Exclusion (DSAI 2022). Lisbon, Portugal, ACM, New York, USA, 7 pages August 28- September 04 (2022). https://doi.org/10.1145/3563137.3563145
10. Soulis, S-G.: Study in Intellectual Disability. Series: Special Education. Gutenberg, Athens (2020)
11. IHU: AR TUTOR Project (2022). Retrieved from: http://artutor.ihu.gr/artutor/php/login.php
12. Voki: Voki (2024). Retrieved from https://www.voki.com/
13. Interacty: Home (2024). Retrieved from: https://interacty.me/
14. Gómez-Puerta, M., Chiner, E., Melero-Pérez, P., & Lledó, G. L.: Research Review on Augmented Reality as an Educational Resource for People with Intellectual Disabilities. International Journal of Developmental and Educational Psychology, 1(2), 473–486 (2019). http://dx.doi.org/10.17060/ijodaep.2019.n1.v3.1523
15. Hussein, E., Kan'an, A., Rasheed, A., Alrashed, Y., Jdaitawi, M., Abas, A., Mabrouk, S., & Abdelmoneim, M.: Exploring the impact of gamification on skill development in special education: A systematic review. Contemporary Educational Technology, 15(3), ep443 (2023). https://doi.org/10.30935/cedtech/13335.
16. Tasadduq, M., Khan, S., Nawab, R., Jamal, H., & Chaudhry, T.: Exploring the effects of gamification on students with rote learning background while learning computer programming. Computer Applications in Engineering Education, 29(6), 1871-1891 (2021). https://doi.org/10.1002/cae.22428