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The effects of augmented reality and video games on mental skills of students with learning disabilities

Vasiliki Michalopoulou ^{1,*}, Maria Sarantiti ¹, Christina Chatzimbey ¹ and Athanasios Drigas ²

¹ Department of Greek Philology, Democritus University of Thrace, Greece.

² Net Media Lab Mind-Brain R&D, IIT, R&D NCSR Demokritos

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Abstract

It is a narrative collection of information related to the specific topic of video games and augmented reality, providing an evaluation of each element and its importance in relation to the students' mental skills. The notes are intended to give the reader an insight into the relevance and accuracy of the data, as well as the caliber of the sources used.

Keywords: Executive Functions; Video Games; Augmented Reality; Memory; Attention; Concentration; Learning Difficulties

1. Introduction

This article reviews the research conducted to date, with the aim of presenting the impact of video games and augmented reality applications on the mental skills of students with learning difficulties. The article was written in an annotated bibliography format, meaning that each source was analyzed independently and is not related to any of the other studies reviewed. A concise and informative summary of each article is generated and links are made to the findings and decisions made. Finally, a single part is given that describes the overall conclusions.

2. Chapter I

2.1. The Bounded Generalized Reciprocity (BGR) theory

Many teenagers spend many hours a week playing video games with their friends. The approach in which peers play these titles can affect their interactions and relationship. This defined exploration assessed the impact of the game mode on adolescents' behavior while playing and on their quality of connection and social actions after playing. The effects of competitive or cooperative video games on behaviors and attitudes toward a teammate are often explained through Verheijen et al.'s (2019) Bounded Generalized Reciprocity (BGR) theory.

Two Dutch secondary schools participated in the study and adolescents were encouraged to work with a same-sex partner (pair) from their class during school hours. Individual behavior was analysed on five indicators: positive, negative, dominant, submissive and antagonistic, using a 5-point rating system (1 being not at all, 5 indicating very much). Interactions between dyads were assessed on six parameters: positive attachment, prosocial behavior, amount of matching, disharmony, disagreement and power inequality. No significant relationships were observed between observational indicators and social behavior activity.

* Corresponding author: Vasiliki Michalopoulou
Department of Greek Philology, Democritus University of Thrace, Greece.

Therefore, it can be said that when playing video games, if adolescents cooperate with each other, they will show better behavior compared to when fighting. This is in line with what is expected, with more pleasant behavior occurring in a collaborative context. At the same time, it became apparent that teammates displayed more competitive moves and there was a noticeable difference in strength between the two sides during cooperative play.

2.2. Video games and academic achievement

Wright. J. (2011) in his research attempted to inspect the influence of video games on students' academic outcomes. It is widely accepted that the modern world is mainly shaped by innovation. Technology has permeated people's daily lives, including YouTube, television, Facebook and movies. However, none of these inventions are as frequently marketed and prominent as video games. Every day, thousands of young people buy or rent video games.

Some studies report that increased involvement with video games has been linked to lower academic achievement in certain areas among American children. However, many research projects show that playing engaging video games can, in fact, improve academic performance. The use of these activities has been noted to enhance visual-spatial skills, which can be beneficial in disciplines such as math, science, and technology. In addition, video games can also improve language skills, critical thinking skills, creativity and problem-solving ability. Because of this, this paper needs to evaluate whether video games have either a detrimental or beneficial effect on students' academic achievement.

By investigating students' academic performance, the impact of playing video games on SDS was assessed. It was observed that the average SDS of a player was significantly lower than the average SDS of those who did not play ($M = 3.2$, $SDS = 0.51$ compared to $M = 3.4$, $SDS = 0.47$). The statistical analyses highlighted at the $p < 0.01$ revealed a notable difference, with $F(1,169) = 7.08$, $p = 0.009$. Thus, it appears that there is a statistically significant association

2.3. Video games and learning English vocabulary

The study by Yilmaz et al. (2018) aims to analyse the effects of video game addiction on the relationships between video game addicts and those around them, particularly in the school environment. This is achieved by conducting focus groups and interviews with affected individuals in order to gain insight into how video game addiction can affect the dynamics between peers and teachers in the school environment.

The results of the study showed that players had difficulty engaging in positive social behaviors in the school environment, such as communicating with others and following school-related rules. They were also found to prefer staying at home and playing video games rather than attending school activities. Finally, gamers felt more comfortable spending time with other gamers or male peers as they shared common interests, unlike girls who did not understand these interests. Although the teachers noticed that students who played video games a lot performed poorly in school, the English teacher found that the students' English vocabulary had improved.

2.4. The impact of video games on children's cognitive and social skills.

The study by Kovess-Masfety et al. (2016) attempts to investigate the relationship between the time children spend playing video games and their mental health, cognitive (learning and thinking) and social skills. The aim of the study is to determine whether more time spent playing video games is associated with poorer mental health, cognitive and social skills in children. The data used in the reported method was collected by School Children Mental Health Europe, which is a research project conducted in six EU countries.

The results of the data showed that 20% of children play video games for more than five hours a week. In addition, the results showed that there are several factors that influence this amount of gaming, such as gender, age, number of family members, psychological status and social class. In addition, those living in a poor family or with a low level of education are less likely to play video games, compared to those from Western European countries. After analysing the factors that could contribute to high usage, it was found that this usage is associated with a reduction in relationship issues between people in conversation and social difficulties. The findings were determined to be statistically significant.

2.5. The effect of video games on brain development

The study by Gong et al. (2019) examines how reducing video game play time affects brain development in experts and non-experts. It focuses on male participants aged 20-24 years and collects MRI data at the beginning and end of the study to compare the effects of reduced video game play time. Prior to an MRI, participants had to complete a series of tests, including a questionnaire, an IQ assessment and a self-report of their video game experience. The results of these tests showed that the participants were similar in age, IQ and education and that they also had similar home situations.

This was done to ensure that any potential influence of factors unrelated to video game experience would be minimized when measuring the impact of video game experience on human development.

The results showed that those who played video games had a significantly higher level of brain activity and video game skills at the beginning of the study than those who did not play. At the end of the study, however, those who played had a greater decline in video game skill than those who did not play, suggesting that brain development may also decline over time due to gaming. Finally, comparisons between the two groups showed that after a year of gaming time restriction, participants from both groups had similar levels of brain activity, demonstrating that limiting gaming time may help maintain brain activity.

2.6. Students with attention deficit disorder and learning disabilities can enhance their cognitive skills through videogames

García-Redondo's (2019) study aims to investigate how a serious game (SG) can help students with attention deficit disorder (ADHD) and learning disabilities (SLD) improve their cognitive skills. The analysis focuses on the Tree of Intelligences (ToI) method, which combines serious games and the multiple intelligence approach to assess an individual's cognitive abilities. The use of two digital tools (Boogies Academy and Cuibrain) to improve the attention profiles of students with learning disabilities such as ADHD and SLD is explored. An experiment was conducted with two groups (experimental and control) to compare the attention profiles of both groups using performance and observation measures (questionnaires). The aim of the study is to measure the improvement in attentional variables in the experimental group after the intervention.

Attention Performance (D2) results showed improvements in accuracy, concentration and efficiency (TOT, CON and CR) for both the experimental and control groups after the trial. There was greater improvement in the experimental group compared to the control group. Although the groups did not differ significantly at pre-test, there were statistically significant differences at post-test, which favored the experimental group. The largest effect size was observed in CR. There was no significant difference in performance based on age. Finally, neither group showed a significant reduction in symptoms.

2.7. Video games as an alternative effective educational tool

The research methodology adopted in the study by Alshammari, (2015) is based on a critical review to conduct a detailed survey of the overall literature on the impact of video games on improving student learning. The critical review of video games is conducted to seek answers about aspects of the impact of different video games, on cognitive response, gender and peer learning, as a supplementary tool for teaching and the related drawbacks. It seeks to understand how video games can be used to enhance reasoning skills and how they can provide a social experience that can benefit students academically and socially. In addition, it generates new ideas for further research on the effects of videogames.

The results suggest that video games can be a useful tool in the classroom to improve learning. Dividing the benefits into four categories, the research suggests that video games can help to engage students, increase motivation, enhance problem-solving skills and strengthen collaboration. Although there are some drawbacks, video games can be used with care and a positive attitude to help transfer knowledge to students.

2.8. Video games, stress and heart rate

This article by Szabo et al. (2005) aims to evaluate the effects of a video game on the QT interval, to better understand how this interval may be affected by stress, excitement and other psychological factors related to the neurological response to playing a video game. The results of this study may help to further explain the cardiovascular responses of young people and adolescents to video games and could potentially help in the development of preventive measures. This experiment aimed to measure people's performance while playing a videogame -Noah's Ark -in laboratory conditions. Participants were asked to refrain from activities such as smoking, drinking, etc. and to complete the game in two minutes. Analysis of variance (ANOVA) was then used to evaluate the results, with any differences significant at a p value of 0.05 or less.

The results of the study showed that in stress responders (13 participants) the increase in heart rate during the video game was significant, while in non-responders the heart rate did not change. In conclusion, found significant prolongation of the QT interval during the video game in stress responders, while it remained unchanged in non-stress responders. This suggests that the QT interval changes during stress depending on how the person reacts to the stress. Finally, more studies are needed to clarify the significance of this finding.

2.9. Video Games and Addiction

The study by Brunborg, et al. (2014) examines the possible relationship between video game addiction and harmful consequences in students. It suggests that while some negative outcomes can be associated with playing video games, it does not necessarily apply to everyone, as there are different individual and environmental factors that can influence how games affect each individual. In terms of measuring addiction, a seven-item version of the 'Adolescent Game Addiction Scale' was used. Each of the seven items measured one of the DSM criteria for addiction: primacy, tolerance, mood modification, withdrawal, relapse, conflict, and problems to indicate how often each event had occurred in the past six months.

The results revealed that while video game addiction was associated with psychological difficulties and hindered educational success, time spent playing video games was not associated with any of the detrimental traits examined.

2.10. Video Games and Mathematics

The study by Ridhuan et al. (2012) describes a three-year research project with students in a Malaysian primary school using a video game to enhance multiplication learning in mathematics class. This study attempts to investigate whether video games could contribute positively to learning. In conducting the study, the researchers took a neutral stance in the research so that the result would be unbiased. The study adopted a causal-comparative research design to investigate the impact of including a video game designed to teach multiplication to primary school students.

The results showed that video games as a supplementary activity in the classroom have a significant and positive effect. They have a significant impact on students' attention retention and learning of multiplication compared to students who did not do this extra activity and relied only on traditional teaching.

Early mathematical experiences in a child's development can influence their mathematical ability and perform later in high school. The focus of the Moyer-Packenham (2019) study was to assess how elements of 12 digital math games affected a student's understanding. Thus it focused on two general research questions:

Question 1: How do interactions with digital math games affect children's ability? The answer was answered by collecting and evaluating prior and subsequent assessment data through numerical data survey methods.

Question 2: How do design features in digital math games support learning and promote mathematical connections? ? The answer was answered by examining and analysing the videos, using qualitative procedures to identify patterns in the material.

This analysis showed that playing digital games can improve a child's performance in relevant areas. By recognising the design features present in digital games, children were able to use them better to their advantage, resulting in increased scores. In summary, the results of the study showed that playing digital games improved children's mathematical knowledge and facilitated their understanding of the mathematical objectives behind the game. In addition, certain design features were revealed to be important in promoting and improving learning benefits

2.11. Video games and aggressive behavior

The article by Allahverdipour, H., Bazargan, M., Farhadinasab, A. et al. (2010). aims to investigate the association and patterns of excessive video game use in a sample of randomly selected high school students in Iran. Specifically, it examines the relationship between video game use and psychological well-being, the manifestation of aggressive behaviors, and perceived threat of video game play.

The results of the study reported that children who said they were not gamers, as well as those who spent a lot of time playing, had poor mental health compared to children who had low or moderate times in video games. Participants who started gambling at a younger age had lower scores on mental health measures. Specifically, it appeared that those who started gaming at a younger age and played for more years were more likely to score poorer mental health.

In conclusion, the data show a curvilinear relationship between video game play and mental health outcomes. Gamers with less time had better scores while gamers with more time in front of the screen showed mild increases in problem behaviors. Interestingly, however, those who didn't play had the worst results. Comprehensive action is needed to reduce the excessive time spent playing video games among adolescents in general and boys in particular.

2.12. Video Games and Memory

The study by Farchakh, Y., Haddad, C., Sacre, H. et al. (2020) aimed to investigate the relationship between video game addiction and memory, attention and learning abilities among a sample of Lebanese children. The first part of the questionnaire assessed the socio-demographic details of the participants (e.g., age, gender, father's and mother's grade and level of education) while the second part included the following scales:

- Game Addiction Scale for Children (GASC), an instrument based on DSM criteria for assessing game addiction.
- Child Memory Questionnaire (CMQ), a 36-item questionnaire designed to assess parents' perceptions of their children's memory.
- Clinical Attention Scale measuring frequency of activity and attention, asking the parent and teacher to answer 12 questions.
- Learning, Executive and Attention Function Scale (LEAF) a self-report questionnaire that assesses executive functions, related neurocognitive functions and academic skills in children and adults. SPSS software version 23 was used to conduct data analysis.

In conclusion, the results showed that there is a correlation between video game addiction and worse memory, attention, and cognitive and academic abilities of students. The confounding findings suggest the need for more extensive research and serve to highlight vital next steps needed in future work, such as identifying predictive factors that could help in the early detection of video game addiction in children.

2.13. Video Games and Study Time

Thus, the primary objective of the study by Navaneetham, J. & Chandran, J.M. (2018) was to examine the socio-demographic profile and behavioral patterns of video game addiction in school-going children, while the second objective was to assess the increase in video game addiction and its impact on children's study habits.

Each student completed an anonymous questionnaire, which asks for information on personal details, family details, leisure activities, study habits and video game use. For this study, a ten-question video game addiction scale and checklist was used to assess the study habits of the students. The study revealed that almost half of the children reported that they did not play video games, 18% of the students used video games with control, 20% of the students used video games excessively and 17.5% of the students fell into the addiction category. The study found that 19% of children spent more than 3 hours on gaming and that girls and boys had similar study habits.

In conclusion, it was found that a significant proportion of children's study time affects not only their learning but also their relationship with their family and school. Therefore, special attention should be paid to those children who are vulnerable to video game and Internet addiction. Finally, the problems caused by the indiscriminate use of video games demonstrate the need for intervention for children in the form of preventive and promotional mental health activities at school and family level.

2.14. Video Games and Domestic Violence

Ruiz-Fernández A. et al., (2021) studied child-to-parent violence (CPV). Children's behavior may cause terror towards parents, intimidation or emotional blackmail, and even threats of suicide or leaving home. The aim of this study was to analyze the bipolar between exposure to video game violence and CPV against mother and father, to study the relationship between exposure to video game violence and engagement, and finally to analyze the relationship between loyalty and CPV.

Exposure to video games was assessed through a questionnaire developed by the researchers. Loyalty was assessed through the game loyalty questionnaire and CPV through the child-to-parent aggression questionnaire. Regarding the results of the study, these showed that exposure to violent video games was associated with lower CPV scores in both parents, i.e., an inverse relationship appears, such that the greater the use of violent video games, the less violent behavior of both parents. Regarding the relationship between violent video game consumption and engagement, in line with the hypothesis, engagement was found to differ depending on whether the violence was against the mother or the father. In the case of the mother, there was an influence of violent video games on the dimensions of flow, presence and immersion, whereas in the case of the father, there was an influence on the dimensions of flow and presence.

In conclusion, CPV is not associated with video game consumption in general or with specific violent video game play, but with altered states of consciousness from game involvement. It is therefore necessary to take preventive measures against these situations, such as guidance to schools and families on the prevention of CPV.

2.15. Behavioral changes from video game use

A study that aims to assess video game use and determine the effect of video games on adolescent behavior is by Shirley, P. et al., (2019).

From the analysis of the data, it appeared that out of the total 211 participants, 97 (45.9%) preferred to play at night and most of the participants 114 (54.1%) preferred adventure and racing games. Also, the findings showed the existence of behavioral change in 79 participants, in various domains with symptoms such as sleep skipping observed in 20 participants (25.3%), using bad language (22 participants, 27.8%), gambling game in 40 participants (50.6%) and 38 participants did dangerous stunts. Moreover, regarding the health of the participants due to video game use, about half of the participants (46%) complained about various health problems, more specifically about pain in the fingers (34.1%), pain in the wrist (29.8%) and finally pain in the neck and eyes (26%).

In conclusion, the study concluded that changes in behavior, generally from video game use, are worrying and self-monitoring is necessary in the age group of the study.

Alongside their research, Masoudnia, E. & Pourrahimian, E. (2016) attempted to determine the relationship between computer games and behavioral disorders such as conduct disorder, delinquent tendencies, anxiety and distraction.

The sample of the study was 314 primary school students, attending third to sixth grade, during the school year 2013-2014 in Yazd city, Iran and the students were selected using a multi-stage sampling method and the measurement tools were: a computer game questionnaire and a behavioral assessment test. Data were analyzed using MANOVA method.

The results showed that rates of delinquent tendencies were more frequent among students playing sports, rates of conduct disorder were higher among students playing adventure, car and motor games, while rates of anxiety disorder were higher among students playing computer war games. Also, behavioral problems among students were significantly correlated with the amount of time spent playing computer games as time spent on computer and video games may simply replace time spent on other activities, i.e. activities that control the development of abnormal behavior.

In conclusion, the use of computer games is an important and effective factor in the development of students with behavioral disorders and increases the risk of behavioral disorders. In order to reduce the negative effects of excessive use of computer games and behavioral disorders of elementary school students, it is necessary for parents to control their children more regarding the use of computer games.

2.16. Effect of active educational video games (AVG)

Sun, et al., (2016) examined the impact of an active educational video game (AVG) on children's motivation, science knowledge and physical activity. The new generation of video games includes activity games that require children to use physical movement in conjunction with ordinary cognitive functions during play.

A randomized control comparison design was used in this study. The experimental group was tested on an AVG. In contrast, the control group used the same educational video game without the required activity segment. Students' knowledge was measured before and after. The pre-test was conducted before the start of the intervention and the post-test was conducted after students completed the third level of the game.

The results showed that students in both groups performed better after the test than in the initial test. In addition, according to the findings, the HRs of the students in the experimental condition were within the target heart rate zone, at the moderate-intensity level (mean experimental HR = 134 bpm) and higher than the mean HR level of the comparison condition (mean comparison HR = 103 bpm).

In conclusion, it seemed that AVG benefited the students. In particular, while the AVG used in this study was not superior to a traditional educational video game for boosting students' science knowledge scores, the benefits that AVGs can provide to children and the motivation to have an enjoyable learning experience are shown.

It is well known that technologies such as computers and video games contribute significantly to physical inactivity and as a result traditional sedentary video games and/or electronic video games have been blamed for the sedentary lifestyle of players and have played a major role in the epidemic of paediatric obesity. On the other hand, many recently emerging technologies, including active video games (AVG, also known as exergaming), virtual reality and smart bands, have increasingly been used for physical activity and health promotion in children and adults. The main purpose of this

article is to examine the effect of active video games (AVGs) on children's energy expenditure (EE) and physical activity (PA), self-efficacy and social support.

The study by Gao Z, et al., (2019) considering the curricula of their participants divided them into two groups:

- Intervention group: children engaged in a 50-minute AVG session/week for 9 months in addition to the time spent in physical education.
- Control group: the children did not participate in any AVG game or other structured school education programmes other than physical education.

Children's daily caloric expenditure and mean daily metabolic equivalent (MET) values were measured by accelerometry, while self-efficacy, social support and outcome expectancy were assessed by psychometrically validated questionnaires. All measurements were completed at baseline, month 4 and month 9. Data were imported from Excel into SPSS 23.0 (IBM Inc. Armonk, NY, USA) for descriptive and inferential statistical analyses.

In conclusion, the study showed that the AVG intervention had positive effects on children's mean daily MET levels, daily caloric expenditure and social support, but that this intervention failed to promote improvements in self-efficacy and life expectancy. Future interventions could be implemented using a group randomized trial design with multiple school sites in underserved communities across a range of geographic areas.

3. Chapter II

3.1. Definition of Augmented Reality

Augmented reality can be considered a subset of mixed reality. (Azuma et al., 2001) define it as a system that complements the real world with potential (computationally enhanced) objects that exhibit coexistence within the same space as in the real world. In their formal form, these applications involve the superimposition of three-dimensional digital information on real-world views of the physical environment (Azuma, 1997).

The use of a mobile device can support real-time information feedback. In addition, it can enhance concentration and stimulate motivation to learn. Through the system, the "curiosity" about digital applications can enhance the interaction between students by making them participatory enabling them to develop more opportunities to interact with typical students, which could provide a great advantage to traditional learning methods. Finally, they can improve the frequency of operation and allow the learning process to use game models by increasing learning motivation.

3.2. Augmented Reality and ADHD

Tosto et al. (2021) investigated the AHA (ADHD-Augmented) project. This research focused specifically on the impact of the digital technology intervention on the literacy skills of children in the pilot study who were diagnosed with ADHD prior to the intervention. The AHA project aims to implement an evidence-based intervention to improve the reading and spelling skills of children with ADHD by enhancing an existing literacy program with AR functionality. The AHA system has been implemented by integrating the Words Worth Learning (WWL) program, an online educational tool aimed at enhancing English literacy, with a series of AR items. This paper reports preliminary findings of a pilot study to evaluate the effectiveness of the AHA system in promoting literacy skill acquisition in a sample of children diagnosed with ADHD compared to the usual literacy program. Basic information on the main characteristics and difficulties associated with the teaching and learning process associated with children with an ADHD diagnosis is presented for the first time.

The results showed that on average that the AR content embedded in the WWL program did not exert a gradual positive effect on children's acquisition of literacy skills, as measured by the questionnaires selected as learning outcomes, compared to the WWL program, because these questionnaires with which the measurements were made can be considered as a measure of children's learning of reading and spelling skills, but not standardized and validated measurement tools.

3.3. Augmented reality, ADHD and frustration levels

Ocay and colleagues (2018) report that according to the ADHD Society of the Philippines, ADHD is one of the common mental disorders among Filipino children and affects about 3% to 5% of the country's population. Statistics show that in the Philippines, there are an estimated 40% to 50% of children with ADHD who have learning disabilities and 20%

to 25% experience hyperactivity. Moreover, results show that 35% of children diagnosed with ADHD do not complete their studies in high school. The main objective of their research was to experiment whether the use of AR-based application can somehow improve the level of frustration of students with ADHD.

The results showed that ADHD tolerance and frustration rates were significantly low, based on the time recorded. Frustration indicates that ADHD may be directly related to low level of tolerance. This only demonstrated that students with ADHD show behaviors associated with a lower level of tolerance. Also the augmented reality based activities showed an exemplary increase in time spent engaging with the game... Another point of the findings was that students with ADHD had a greater tendency not to complete the task in its conventional form compared to when the task is in an AR environment and successfully completed all required levels of the tasks. The study strongly suggests that Augmented Reality may be a potential tool for enhancing frustration tolerance of students with ADHD. Through AR, children with ADHD are persuaded to tolerate certain behavioral problems that make them more confident and independent learners.

3.4. Augmented reality and interactive book

Panagopoulou (2017) conducted a research in which she studied the design, development and use of an interactive reality book for pre-teen students with learning difficulties. In this study, two stages of data collection were conducted: 1. During the administration of the app (in the learning sessions): qualitative observations of children by researcher-educator and special educators involved; and 2. After the administration of the app: Semi-structured interviews with both participating students and observing teachers.

The textbook of literary texts is enhanced by augmenting it with digital elements projected through a mobile device, in order to provide students with an engaging learning experience and to engage them in the lesson which is a prerequisite for meaningful learning. In particular, an excerpt from the novel of the same name by Menelaus Ludemis "A child counts the stars" was used.

The augmented reality book was created using the Aurasma augmented reality platform (<https://www.aurasma.com>), which consists of a web-based editor and a smartphone or tablet app. Glogster.edu (<http://edu.glogster.com/signup>), a platform for presentations, was also used, digital storytelling and interactive learning that allows users to combine all kinds of media (graphics, images, video, audio, text, web addresses) into digital canvases to create multimedia posters called glogs. The web address of each glog was part of an Aurasma overlay (video).

The results of the study are derived from students' observations during their interaction with the book, followed by semi-structured interviews with students and teachers, concluding that the augmented reality book is an emerging educational tool that can enhance students' engagement and enthusiasm for learning. Students showed motivation, interaction and collaboration, positive attitudes, student engagement and more involvement in the lesson. The AR book facilitated students' understanding, memory, concentration, imagination and learning, demonstrating that the use of mobile AR is an effective educational tool.

3.5. Augmented reality and reading comprehension

Kapetanaki et al. (2021) in their study proposed the design and development of an AR system integrating learning theories and personalization techniques to support students with learning disabilities in reading comprehension.

In order to examine whether the use of AR can have a positive impact in this area, they use the mixed method, which combines the collection of both qualitative and quantitative data. This study introduces a new framework, called AR-PeRCoSE, which uses AR technology combined with pedagogical theories and AI techniques to promote Reading Comprehension in special education. Towards this end, the researchers propose that textbooks should be textbooks that are enriched with AR content by providing real-time visual and audio feedback. The AR technology will be based on markers and a tablet that scans book pages and markers will locate a piece of information through an AR application. Markers and multimedia objects will be designed to store in the system's cloud database so that tablet camera tracking can be enabled. As the tablet camera tracks the markers, the screen will display supplementary material from which each student can choose what to use based on their needs and learning style.

The researchers believe that the interaction between students and the device is expected to stimulate their interest and encourage them to study texts effectively at their own pace.

3.6. Augmented reality and mathematics

Tobar-Muñoz (2015) and colleagues (2015), taking into account the specific requirements of ADHD and considering that addressing the specific needs of this population also benefits all students, chose to focus on logical-mathematical skills as they are fundamental to understanding mathematics in early childhood with a game based on a set of design principles based on ADHD treatment considerations and AR capabilities. They used two mini games: one for pairing and one for matching (called Gremling Rain and The Gremvolution respectively). Both are included in a game called Gremlings in my Mirror, with the DGBL (Digital Game-Based Learning) philosophy, which promotes learning through action and fun as the greatest motivation. Experience from the observational scenario suggests that Digital Game play achieves the inclusion of all children in the learning process. All students achieved the objectives of the game and felt strongly motivated in the learning process. The whole activity was also very convenient for children with special needs.

Cascales-Martínez et al (2017) argue that students with ASD cannot fully benefit from mathematics instruction and curriculum in general education classrooms due to the rapid pace of introducing new mathematical concepts, lack of examples and insufficient explanations, practices and reviews. Technology can adapt and personalise the teaching of mathematics for students with ASD. Efforts have been made to integrate technology into mathematics curricula for these students to improve their outcomes.

The desktop system they used implements an application protocol interface (API) based on the TUIO protocol (Kaltenbrunner, Bovermann, Bencina, & Constanza, 2005), which provides information about the state, position and orientation of the fingers and supports augmented reality applications. The system is able to recognize different types of augmented reality markers and return the position and orientation of the marker in 3D space. The main feature of this table design is its ability to transform any type of table into an interactive surface. Because of this, student desks can be used as interactive surfaces that allow for easy installation in any classroom. In addition, the auto-calibration feature is robust enough to allow the table system to be moved anywhere in the classroom without changing its configuration. A set of interactive 3D educational materials related to the European Monetary System was developed for this tabletop. The application allows the visualisation and manipulation of all coins and banknotes of the European monetary system. It also promotes the association of coins and banknotes with the corresponding amount, creating a scenario where students can solve mathematical problems in a virtual market simulation game.

The results showed that the use of the desktop system contributes significantly to the increase in knowledge acquired by the students. In addition, the data tests showed that all students improved in both identifying currencies and bills and selecting the indicated amount of money, although some had problems dealing with larger amounts of money. It can be concluded that students with special educational needs have increased their knowledge of mathematics and improved their money management skills using the desktop system.

Lorusso et al. (2018) in their paper describe the design, development and preliminary testing of an integrated system that combines the use of smart devices, an augmented reality (AR) cube, a smart TV and a software application specifically designed to stimulate cognitive and social functions in preschool children. The system was tested with three groups of children (25 children in total) during kindergarten activities. All children had previous experience with

electronic devices and at least one computer was present in each of the families, as reported by the parents in a questionnaire.

The "Giok the alien" app has been created to stimulate problem-solving skills in a variety of contexts, both for typically developing children and for those with specific social communication disabilities. Different scenarios have been designed.

Problem-solving strategies in children's groups tend to increase over time, with increasing practice and familiarity with the task. Interaction between peers is good and increases over time. Cooperation is high and shows an increasing trend. Regarding requests addressed to adults and caregivers, explanations and clarifications are rare.

3.7. Augmented reality and chemistry

In Chile, the use of technologies in education has increased significantly in response to changes in society, and technologies are used for both learning processes and teaching.

The method used was quantitative with an explanatory approach, as it focused on explaining whether the integration of AR affects the academic achievement of secondary school students in their chemistry knowledge. In educational experimentation, it is difficult to fully control for external characteristics. However, the within-subjects factor and the

design of the testing time, which had three levels: pre-test (the day before the intervention), post-test (the day after the end of the intervention), and follow-up (an average of 1 month after instruction), allowed for the measurement of effects on academic achievement.

After the first prediction, augmented reality improved knowledge retention. Interestingly, the students achieved knowledge retention one month after completing the educational intervention. Participants showed knowledge retention as they were able to identify concepts, relate ideas, and answer questions about chemistry content. The researchers reject the idea that the positive result was due to prior knowledge, as a different version of the test was administered in Phase 3. The second prediction was supported: augmented reality improved the motivational level of secondary school students in a chemistry knowledge intervention. Students showed a high level of motivation through the development of the pedagogical activity because by using immersive technologies, they could develop higher levels of engagement with their learning processes. The third prediction was supported: the level of students' acceptance of using augmented reality was high. Students' attitudes are positive and they like working with this type of technology.

3.8. Augmented reality, dyslexia and geography

Rega & Mennitto (2017) sought to use augmented reality as a support for people with dyslexia, trying to understand whether innovative and engaging applications of this AR technology can gain constructive value and can enhance specific skills. Specifically, they propose a research project called ASB (Augmented SmartBook), which is based on a technological tool called SmartBook consisting of a tablet, an app and QR codes for augmented reality. The aim was to prevent and also reduce the effects of dyslexia during the complex learning process.

The results showed that augmented reality technology helps learning for people with dyslexia. The innovation of the instrument put dyslexic subjects at the center of attention and therefore made them much more attentive and attentive to the lesson. Also the dyslexic subjects after activating and viewing the content of the QR Code, were required to do a whole class summary and this may have been a reason for better learning.

3.9. Augmented reality and map navigation

McMahon D., Cihak D. Wright R. (2015) conducted a study whose purpose was to examine the effects of augmented reality on navigation, compared to Google Maps and paper maps, on students with disabilities. The participants in this study were three students with intellectual disabilities and one student with autism spectrum disorder. The participants were one boy and three girls. Pseudonyms (Jamie, Catelyn, Jon, and Arya) were used to maintain confidentiality. Students participated in a digital literacy class and regularly used mobile devices for educational and recreational activities. As part of the PSE program, students regularly and independently traveled to classrooms on familiar routes. All students received special education services during their previous schooling. Two months prior to the start of this study, all participants were administered selected tests from the Woodcock-Johnson III Awareness, Cognitive Abilities Test, and Achievement Test. The study measured their ability to independently make navigational decisions in order to travel to unfamiliar locations; businesses in a city.

The baseline results for all participants showed that they were unable to navigate on their own in unfamiliar business locations and that the AR treatment condition was more effective with AR-favored forks. Students navigated more successfully using augmented reality than when using Google Maps and a paper map. Virtual reality training and educational activities for students with cognitive disabilities helps them so they can be transported to new locations, and allows them to engage in functional activities such as navigating a grocery store or making a purchase in a low-pressure, failure-free environment. Research has shown that there is an independence of movement when there is improved independent navigation of mobile devices compared to using a paper map. The AR condition was superior for meeting the criteria of three successful, 100%, independent navigation attempts and increased the chance of finding a job.

4. Discussion – the role of Digital Technologies

Finally, it is important to highlight the productive and effective role that all digital technologies play in the education sector. These technologies, such as mobile devices (34–35), a variety of ICT applications (36–47), AI & STEM ROBOTICS (48–51), and games (52), facilitate and enhance educational procedures such as assessment, intervention, and learning. Additionally, the use of ICTs in conjunction with theories and models of metacognition, mindfulness, meditation, and the cultivation of emotional intelligence [53–64], accelerates and improves educational practices and outcomes, particularly for students with learning disabilities.

5. Conclusion

The use of augmented reality in education can have positive effects in both general and special education. The use of multiple media is able to make the learning process more attractive and at the same time effective. The education of pupils with learning difficulties is a challenge. This technology can stimulate their interest and attention, boost their self-confidence and at the same time have positive learning outcomes. The technology used makes learning more interesting and interactive for students. The results of research conducted show that students can acquire knowledge using these applications by reducing learning barriers. Experience so far shows that when computer tools are used to assist in the learning process, students are encouraged to learn, participate and interact both with each other and their teachers. In these learning environments, student participation and motivation are crucial. Augmented reality supports the learning of ICT by encouraging students to discover knowledge on their own, applying a learning technique in which they take control of their own learning process, acquire information and use it to complete scenarios that may not be feasible to construct in reality due to time, space and learning constraints.

Compliance with ethical standards

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Disclosure of conflict of interest

The Authors proclaim no conflict of interest.

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