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The Challenges for Teachers: Augmented Reality as Educational Technology for Students with Dyslexia

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Abstract: *Nowadays, teachers face many technological challenges to improve learning and teaching process. Using modern educational tools in an inclusive educational setting is challenging, especially in teaching students with dyslexia. The paper describes dyslexia and the reasons to use IT tools in the teaching of students with dyslexia. In the second part of the paper, augmented reality was considered as an educational tool; this is based on the review of the researches on the advantages and disadvantages of educational implementation of augmented reality. The examples of augmented reality tools in learning and teaching students with dyslexia support the functionality of augmented reality as an educational technology in inclusive education.*

Keywords:*inclusive education, dyslexia, educational technology, augmented reality, multisensory learning*.

1. INTRODUCTION

Nowadays, teachers work in a technologically fast-changing environment that offers many opportunities and demands. While technologically developed learning and teaching environment enables the improvement of teaching, it also creates, from the teacher's standpoint, many challenges due to the constant necessity for the teacher adapting to and learning about new educational technologies and tools.

Learning and teaching process is empowered by the current technology (Ab Aziz et al., 2012; Quintero et al., 2019; Serin, 2017). Technology increases the effectiveness and attractiveness of learning and teaching. It is especially important in the educational programmes for students with disabilities, special educational needs, learning difficulties. Their education can be improved with multimedia technology.

Researches of technology-enhanced learning (TEL) considered different emergent technologies: virtual reality (VR), augmented reality (AR), ubiquitous learning (u-learning), mobile learning (m-learning), gamification, serious games, learning analytics (Bacca et al.,, 2014; Quintero et al., 2019). All of that is the basis for enriched multimodal learning environments. The goals of implementing a different form of technology-enhanced learning focused on "improving students' opportunities to pursue their education to the highest level possible, secure employment and live independently" (Ab Aziz et al., 2012, p. 335). The popularity of augmented reality applications has increased in the last decade (Serin, 2017).

According to the Serin's review, it was confirmed that the use of educational means in the educational environments has increased the level of success of the learners, "and made the process of learning amusing, active and effective"(Serin, 2015, p 4). Some forms of virtual reality, for example, augmented reality, keep the students busy; the materials can be transferred to the real world easily; they provide rich cognitive clues and multi-dimensional feedbacks; they get interaction with the content; they amuse during learning and make the learning process easy. In this context, augmented reality is recognised as technology "based on the natural and physical interaction by offering the visualization of the virtual objects without disintegrating the learners from the real environment" (Serin., 2017).

The focus of this paper is the implementation of augmented reality in inclusive education settings.

Members of UNESCO have implemented the policy of educational inclusion for more than two decades; the main objective of educational inclusion is a reduction of the marginalization and exclusion of students with different learning preferences in the education system (Quintero et al. 2019). The focus of the concept of inclusive education is on the right and chance of each child to participate in education according to their individual learning need.

Who is this review paper for? It is primarily intended for teachers who, when working with students, are to use the capacities of modern information and computer technologies (ICT) for learning. An important target group of this paper are also the experts in information technology and computer engineering, who are to develop technologies working as a team with teachers.

2. A REMINDER OF DYSLEXIA

IT support for specific learning disorders is one of the important implementations of IT in education. Specific learning disorders are considered in the context of school skills development, especially reading. There are four main diverse reasons a reader might struggle: (a) developmental issues, including learning disabilities like dyslexia, (b) lack of exposure to reading material, (c) poor health, and (d) cognitive overload (Huisinga, 2017, p. 12). Dyslexia is in the focus of this paper.

The traditional approach is that dyslexia represents an unexplained reading difficulty that exists despite normal intelligence, appropriate sensory and motor functioning, and adequate conditions for learning. It is a quite frequent disorder which is identified in about 5-11% of school children, depending on the environment (Birsh, 2005, as cited in Obradović, Bjekić, & Zlatić, 2015, pp. 292).

According to the International Dyslexia Association, "Dyslexia is a specific learning disability, neurological in its origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede the growth of vocabulary and background knowledge" (AID, 2017, p. 3). Summarizing this description, dyslexia can be defined as "a specific learning disability which affects a person's ability to read, spell and understand language while reading or writing" (Gupta et al., 2019). Manifestations of dyslexia vary from person to person. Each person overcomes dyslexia differently depending on their way of learning and other cognitive abilities.

According to Dyslexia International, at least one of ten people is a person with dyslexia. It is around the world more than 700 million persons with dyslexia (Sisodia, 2018). According to the Italian Dyslexia Association (AID), in 2014 there are 3.5% of students with dyslexia in the Italian population between 6 and 18 – it is around 90.000 students aged 6-18. The situation was very problematic in some European countries. In English-speaking countries, the percentage of persons with dyslexia is around 10%. On average, there are at least two students with dyslexia in each class and each teacher has to deal with this problem every day. It would be very useful for teachers to access effective technology. In India, approximately 35 million schoolchildren are children with dyslexia. At the HEIs level, researches show an increasing number of students with dyslexia, "including a high percentage of art and design students" (Huisinga, 2017, p. 13). According to the European Dyslexia Association, "the group of European Citizens with dyslexia and specific learning disorders encompasses between 9 and 12 percent of the population, navigating through life in a largely non-"dys" friendly world" (EDA).

It is known that amended, atypical processing of information is the basis for difficulties of people with dyslexia (Obradović et al., 2015). Among the different perspectives of cognitive specificity of dyslexia, the dominant view is that this developmental disorder is characterized by deficient linguistic processing, based on degraded phonological representations (Gillon, 2004; Snowling, 2000; Carroll et al., 2003; Hudson, 2007, Walley et al., 2003; as cited in Obradović et al., 2015). The phonological deficit hypothesis is a prevalent explanation for the cause of difficulties of dyslexic individuals (the assumption is that specific reading difficulties are the consequence of cognitive deficits connected with the phonological processing and representation of the units of the speech sounds) (Elbro & Jensen, 2005; Snowling, 2000; Share & Stanovich, 1995). The biological basis of dyslexia is the assumed congenital anomalies of the cortical structures participating in phonological processing and reading process, located in perisylvian regions and affecting predominantly the left hemisphere (Galaburda et al., 1985; Temple et al., 2001; as cited in Obradović, 2013).

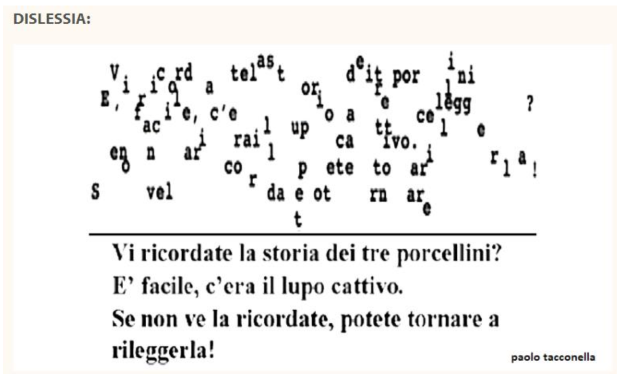

Figure 1. *Persons with dyslexia recognition of text (AID, retrieved from https://www.aiditalia.org/it/la-dislessia*

The effects of dyslexia also vary from language to language. Mastering reading skills in all languages and scripts implies learning the connections of graphemes with phonemes, i.e. learning orthography. In alphabetic scripts, the correspondence between phonemes and graphemes is not always complete, i.e. the scripts differ in the degree of f this connection complexity (Seymour, Aro, & Erskine, 2003).

Orthographies vary in the continuum from a highly irregular relationship, which is characterized by a complex and inconsistent grapheme-phoneme correspondence (the same sound can be spelled in several ways, and the rules of using graphemes are not clearly defined) to those where the degrees of correspondence between grapheme and phoneme is consistent, and the rules are clear and transparent. The example of highly irregular orthography is English orthography, where the correspondence between graphemes and phonemes is highly complex and inconsistent. English has 26 graphemes, and 46 phonemes, which can be spelled in 1,120 ways (Coulmas, 2003). On the other hand, there are so-called "shallow orthographies" (e.g. Russian, Spanish, Finnish, Serbo-Croatian) where the correspondence between spelling and pronunciation are more regular and consistent, and the spelling rules are clear, although the correspondence is still not equivalent (Borgwaldt, Hellwig, & De Groot, 2005, as cited in Obradović, 2013).

What we today know about dyslexia relies heavily on the findings obtained in the non-transparent orthography of the English language. A review of literature in this field has determined that in the period from 1998 to 2012, as many as two-thirds of the published articles on dyslexia originate from the English language area (Ziegler et al., 2003). However, due to the considerable inconsistency of English script in relation to the others, the question is how appropriate generilizations, drawn from one language writing system and applied to another, can be (Obradović, 2013; Share, 2008). Such challenges have shifted the research focus towards cross-linguistic studies on reading.

According to many findings, such interference of phonological processing (degraded representations of words, phonological working memory deficits or difficulties of recalling verbal stored materials) is not accompanied by analogous difficulties in processing visual material (Spaulding et al., 2008; Archibald & Gathercole, 2006, 2007, as cited in Obradović et al., 2015). Asymmetry in the quality of processing visual and verbal information in people with dyslexia might contribute to the visual preferences in relation to verbal information in various stages of automated data processing, but also to gaining access to the data in the learning process, or in the style of learning. In recent years, there are opinions (Davis, 2010, as cited in Obradović, 2013) that dyslexia itself carries a particular learning style, which is characterized by global perception, thinking in images, intuitive and multi-dimensional thought and curiosity, and which significantly affects the frequent occurrence of innovative and creative solutions in all scientific and artistic fields, and top achievements in different professions than in the general population.

The classic way of teaching is not helpful for students with dyslexia/specific learning disabilities (SLD). This is the reason why there are many multisensory programs for students with dyslexia in the last decades and a space for the creative use of ICT in their education.

The bases of multisensory approach in learning and training students with dyslexia have been an integral part of many programmes for remedying and overcoming reading difficulties (e.g. Palinscar & Brown, 1984; Temple et al., 2003; Trei, 2003; Joyce, 2004, as cited in Obradović et al. 2015). The multisensory approach refers to any learning activity that provides simultaneous input or output through two or more sensory channels. The material taught in this way is easier to remember. This approach is considered suitable for people with dyslexia and bilingual persons who may have difficulty in understanding verbal instructions. That is, by assumption, due to a failure in people with specific learning disabilities, a sensory channel may have restrictions, so it is sometimes very difficult for them to receive information from only one sensory modality properly.

At the end of the 1990s, this notion that students with dyslexia have different patterns of hemispheric processing of data has led to the expiration of their presumed preferences for visual-spatial learning strategies (Obradović, 2013). This idea is further developed by West, and perhaps it could be said that the examination of modal preferences of people with dyslexia was best initiated by West's highlighting (West, 1997, as cited in Obradović et al., 2015, p. 292); the positive aspects of dyslexia that can be used in the process of learning in small groups, and contributing to the achievement of more efficient results in the whole group, and especially the students who have reading difficulties. West has used the Galburda's research to show that persons with dyslexia who rely on data processing in the right hemisphere have practical advantages over the typical population in certain learning situations, pointing out the positive aspects of dyslexia and underlining that people with dyslexia have developed the ability to visualize creative thinking, developed visual-spatial skills, a holistic rather than an analytical approach, and developed skills of practical problem-solving (Obradović et al., 2015: pp. 292-293).

One of the most important problems in teaching students with disabilities is the problem or difficulties in communication. The development of adequate communication is an important, perhaps crucial step, in teaching students with disabilities. Therefore, various forms and means of technological supports are sought and developed -

such as augmented reality technology, augmented reality communication, alternative communication, etc. (Alant, Bornman, & Lloyd, 2006; Mirenda, 1999; Obradović & Bjekić, 2018). E-learning as an educational technology simultaneously uses different sensory channels (visual, auditory, tactile perception channels).

3. EDUCATIONAL DIMENSIONS OF AUGMENTED REALITY

Most of the researchers considered augmented reality (AR) as "a new technology medium that is still very early in its development but is likely to become common educational technology as researchers and educators address the opportunities and challenges it creates (Walker, 2017, p. 1). Milgram (according to Kahn, Johnston & Ophoff, 2019) recognized AR on the dimension of mixed reality (Figure 2).

AR can support and engage students to learn by allowing them to experience content through multiple mediums (Huisinga, 2017). For the students with dyslexia, AR can add digital support and aids for struggling readers to use with non-digital printed text and books (Huisinga, 2017).

Walker mentioned the history of AR (Walker, 2017, p. 2): The term "augmented reality" was used in 1992 to describe a platform used by Boeing as a manufacturing innovation which allowed workers to see digital prompts over real-time imagery to support the completion of assembly tasks. Now, at the end of the twenty-first century, AR is a feature of many applications on a variety of devices, including traditional computers, mobile phones, and, increasingly, wearable devices. AR platforms and applications display digital information on a live view of the real physical world.

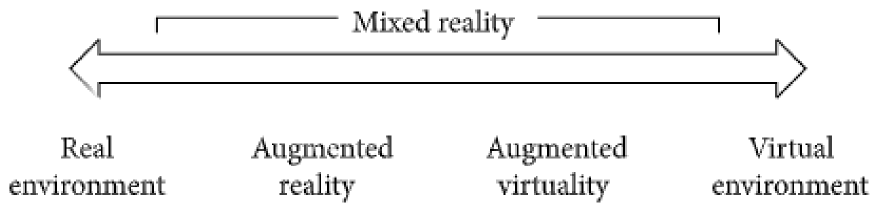

Figure 2. *Milgram's mixed reality continuum (according to Kahn, Johnston &Ophoff, 2019, p. 2)*

3.1. Basics of Augmented Reality

Augmented reality as a kind of virtual reality is defined from different approaches:

- "as a Medium wherein digital information overlays the physical world; dependent on the perspective of the individual interacting with and experiencing the AR Medium" (Caudell, 1992; Azuma, 1997; Kaufmann, 2003; Zhou, Dah & Billinghurst, 2008; and Craig, 2013; as cited in Huisinga, 2017, p. 2);
- "as the kind of reality which integrates virtual object or virtual view in the real object or real environment; it is a technique that augments virtual view into the real world and doesn't break the user connection/interaction with a real world unlike virtual reality" (Khan et al. 2017, p. 500);
- as a system which allows for combining or "supplementing" real world objects with virtual objects or superimposed information, and which is resulted with the coexistence of the virtual objects in the same space with the real world" (Bacca et al., 2014, p. 133);
- as technologies that project digital materials onto real world objects (Cuendet, Bonnard, Do-Lenh, & Dillenbourg, 2013, as cited in Bacca et al., 2014, p. 134);
- as a supplement of the reality (Bacca et al., 2014);
- "as an extension of virtual reality with some advantages over virtual reality" (Wojciechowski & Cellary, 2013, as cited in Bacca et al., 2014, p. 134);
- as a mixed reality in which the virtual objects are located in the physical, outer world (Serin, 2017, p. 5);
- as a technology in which the virtual data and the real environment are brought together in a simultaneous interaction (Azuma, 1997; Milgram & Kishino, 1994; as cited in Serin, 2017, p. 5);
- AR strengthens and augments the physical reality, which can be obtained through the sense organs, with the virtual objects.

One of the illustrative descriptions of the AR is the following (Dunleavy, Dede, & Mitchell, 2009, as cited in Huisinga, 2017): "Digital handheld devices (smartphones, tablets) provide one way to experience AR by overlaying digital content with the physical environment. The camera of the device can recognize physical content using natural feature tracking or GPS coordinates to trigger the augmented content. By looking through the handheld digital device, a viewer sees the digital content overlaid with the real-time image pulled in through the camera. AR allows for digital resources to infuse the world of non-digitally connected items."

The three main characteristics of AR are: (a) combination of a real and virtual world, (b) real-time user interaction ability, (c) realization in 3D space (Khan et al. 2017, p. 500).

Key aspects of AR are the following (Craig, 2013, as cited in Huisinga, 2017,p. 27):

- The physical world is augmented by digital information superimposed on a view of the physical world.
- The information is displayed in registration with the physical world.
- The information displayed is dependent on the location of the real world and the physical perspective of the person in the physical world.
- The AR experience is interactive, that is, a person can sense the information and make changes to that information if desired. The level of interactivity can range from simply changing the physical perspective (e.g., seeing it from a different point of view) to manipulating and even creating new information.

AR can be applied in the multisensory context (as a combination of all senses - hearing, touch, smell) (Bacca et al., 2014). AR strengthens and augments the physical reality, which can be obtained through the sense organs, with the virtual objects (Serin, 2017, p. 6).

3.2. AR Implication in Education

As a blending of virtual and physical worlds in real time, AR can be used in the classroom to supplement physical materials and add new dimensions to classroom learning (Husinga, 2017, p.12).

The AR applications, that are very popular in many fields, have been started to be used in the educational environment easily by the usage of mobile devices (Serin, 2017, p. 5).

According to Serin, the attitudes of the educators and learners have a key role in enabling AR applications to be used smoothly in educational settings (Serin, 2017, p. 4)

Although there are many systematic literature reviews of technology use in education, there are only a few systematic reviews on researches on the effectiveness of educational AR. Bujak et al. (2013, as cited in Serin, 2017, p. 6) have categorized the advantages of using the AR in the educational areas under three titles: physical, cognitive, and contextual. In the review of advantages of the use of AR for educational purposes, some advantages are following (Aziz et al., 2012; Bacca et al., 2014; Quintero et al., 2019; Sirakaya & Sirakaya, 2018):

- increases achievement,
- facilitates learning
- enhances motivation,
- enhances attention,
- ensures permanent learning,
- improves immediate memory (short-term memory),
- improves understanding and memory,
- increases interest in lessons,
- develops positive attitudes,
- enhances spatial skills,
- ensures cooperative learning,
- ensures learning by having fun,
- heighten the excitement of the learning experience,
- enhances engagement,
- increases confidence,
- increases the level of commitment and interest,
- improves satisfaction,
- provides opportunities for self-learning,
- facilitating interaction,
- enhances collaborative learning,
- decreases cognitive load,
- realization of the experiment in a safe environment…

There are also some limitations in using AR for educational purposes (Quintero et al., 2019, p. 61):

- technical problems experienced while using AR is the leading and most important limitation;
- technical problems experienced about GPS, technical problems experienced about perceiving the marker;
- teachers' lack of sufficient information to develop AR materials;
- AR assisted lessons require more time compared to traditional lessons.

A most important aspect of AR for education is the interactivity of the AR (AR requires interaction). The AR as an effective tool to teach abstract concepts since they provide a sense of reality through 3D visualization.

Huisinga makes a review of the examples of uses AR in the classroom (Husinga, 2017, p. 28):

- adding audio and definitions to a word wall;
- augmented posters with images, video, audio, 3D models, text, links to websites; quizzes to engage students;
- connecting videos of project presentations or lectures to an overview bulletin-board/poster or summary hand out;
- showing 3D visual representations of chemical reactions, where students get to push different elements together;
- showing interactive 3D models of items difficult to access (organ dissection, cellular systems or functions);
- gamifying learning and allowing everyday spaces to be transformed with an overlay of information;
- using AR to "travel" on class field trips not only too difficult to reach locations but different times as well;
- allowing students to access digital resources while interacting outside;

- showing real-time translations of printed text to different languages (Google Translate app)
- engaging students in mathematics by connecting real world experiences to mathematic equations.

Considering the attitudes of students towards the AR applications in education, Serin (2017) emphasized positive attitudes.

Considering teachers' views on the augmented reality applications, Serin (2017) summarizes the views of the teachers on AR applications:

- Visualization of the 3D course contents increases the creativity skills of the learners.
- AR apps are more efficient on those students who are reluctant and not active during the classes. They become more active and interested.
- These apps are convenient tools for learners to learn in their speed and styles.
- These apps increase the in-class communication amongst the learners.
- The AR apps provide a suitable atmosphere for student-centred and experience-based learning.
- These applications provide time-saving, especially while teaching 3-dimensional concepts because there is no need for methods like drawing, describing, and imagining.
- It can be easily utilized in the classroom settings on the condition that the amount of light is accurate, and the pointer is pointed decently (Serin, 2017: 10)

Based on the systematic literature review of the AR applications in education, Bacca et al. (2014, p. 146), summarized results in the following way:

- The number of published studies about AR in education has progressively increased, especially in the period from 2010.
- Science and Humanities & Arts are the fields of education where AR has been applied the most. Health & welfare, Educational (teacher training), and Agriculture are the research fields that were the least explored.
- AR has been mostly applied in higher education settings and compulsory levels of education for motivating students. Target groups like early childhood education and Vocational educational Training (VET) are potential groups for exploring the uses of AR in the future.
- Marker-based AR is the most used type of AR. In addition, location-based AR is being widely applied. This can be due to the availability of sensors in mobile devices like the accelerometer, gyroscope, digital compass, and the possibility of using GPS. Marker-less AR needs some improvement in algorithms for tracking objects but the use of Microsoft Kinect is becoming more and more popular.
- The main purpose of using AR has been for explaining a topic of interest as well as providing additional information. AR educational games and AR for lab experiments are also growing fields.
- The main advantages of AR are learning gains, motivation, interaction, and collaboration.
- Limitations of AR are mainly: difficulties maintaining superimposed information, paying too much attention to virtual information, and the consideration of AR as intrusive technology.
- AR has been effective for: a better learning performance, learning motivation, student engagement, and positive attitudes.
- Very few systems have considered the special needs of students in AR. Here there is a potential field for further research.

3.3. AR and Educational Inclusion

According to Walker (2017, p. 1), the potential of AR is only limited to the user's imagination, and is, therefore, one of the more innovative, exciting technologies that special educators can use in their classroom.

The augmented information may be applied to all senses; this makes AR a promising strategy to favour processes of educational inclusion (Sheehy et al., 2014, as cited in Quintero et al., 2019) since it favours multiple means of representation, of action, and multiple ways of engaging students in the learning process (Meyer et al., 2014, as cited in Quintero et al., 2019).

In a detailed review of some studies and researches (widely available literature) that address the use of AR for the creation of inclusive learning scenarios. Quintero et al. (2019) concluded that the use of AR to achieve educational inclusion has been not deeply explored. They emphasized some evidence of the effectiveness of AR with students with disabilities support:

- AR makes it possible for children with disabilities to understand concepts faster and better;
- AR offers exciting and fun teaching aids for students with special needs as it catches their attention.

Walker, also, confirmed that "AR is a particularly powerful tool for individuals with disabilities due to the tools' capabilities of displaying context-relevant digital information that can support the needs of the individual at that moment and provide just-in-time learning (Walker, 2017, p. 3).

Quintero et al. (2019) considered the implementation of AR with different groups of students with disabilities:

- For the individual with hearing impairments, the AR allows the use of mobile devices and the visual channel is often preferred for perceiving information; the applications developed for this population combine videos with other visual tools or interactive multimedia, also promoting the use of glasses for AR and QR codes (Parton, 2010, 2017, as cited in Quintero et al., 2019); the effects are: eliminating or diminishing the hearing barrier, improving communication.

- For individuals with Autism Spectrum Disorder, AR facilitates the creation of applications recognizing facial emotions; AR helps teachers to reduce their workload and supports better concentration and motivation in children with Autism (Escobedo & Tentori, 2014, as cited in Quintero et al., 2019).
- For individuals with intellectual disabilities, AR has influenced the treatment due to its low cost and the use of gamification, created an interactive textbook for children with learning disabilities due to neurobiological disorder, using AR, video, and images to enrich learning by interacting with the exhibits; the effect is: improving the level of understanding.

According to Quintiero et al. (2019), types of technology, including assistive ones, developed to support using AR for educational inclusion, are different. Technologies used with AR in inclusive education are mainly mobile AR (44%). The "based on the vision" significance (16%) multimedia tools with AR. The next subcategory in importance, based on sensors (6%), refers to those sensors used to search and record the movements of students with some physical or motor disability. Kinetic devices (6%) also help to control movements in combination with AR. Next, 3D (6%), may have been included by more studies in their applications, but only 3 studies mentioned it."

Based on the review of researches, Quintero et al. (2019) concluded that research confirmed the effects of AR in inclusive education are the following:

- Improves communication in students with disabilities;
- Raises interest, attention, motivation, and school performance in students with SEN;
- The teacher can create personalized content for the child;
- Increases knowledge of the subject in students with SEN;
- Improves the teaching of work and employment skills;
- Motivates physical activity in students with disabilities;
- Improves navigation through digital maps;
- Increases access to distance education;
- Reduces the burden of teachers of students with disabilities;
- Improves the physical and mental health of the elderly;
- Improves knowledge of indigenous culture and traditions.

In the research of the impact of different technological trends on inclusive education (Aziz et al., 2012), analyzed cloud computing and augmented reality in education.

The main results supported that "augmented reality offers significant benefits to the learning process". Two potential issues that may inhibit effective implementation of AR (and mobile technology) in the learning of the learners with disabilities, or with the special educational needs, are (a) teachers' lack of training on how to use the technology and (b) the lack of a pedagogical framework on how to include the technology to meet the needs of diverse learners (Walker, 2017).

4. AUGMENTED REALITY AS SUPPORT FOR STUDENTS WITH DYSLEXIA

ART (Augmented reality tool or technology) as an ICT tool enables users to see and experience the real world mixed with various virtual objects, without losing the sense of reality. ART take benefit both for the students with dyslexia and for their educators "since it can transform the learning procedure into more stimulating and entertaining" (Persefoni & Tsinakos, 2016).

Augmented reality technology (ART) can be widely used in working with persons with dyslexia. AR supports all domains of work with persons with dyslexia:

- AR (or ART) in diagnoses dyslexia (Tenemaza, Navarrete, Jaramillo, & Rodriguez, 2019),
- AR (or ART) for treating persons with dyslexia,
- AR (or ART) in educating students with dyslexia.

Laura Anne Huisinga (2017) considered how AR support struggling readers in higher education, especially art/design students in higher education. Her results show that most students, including self-identified struggling and typical readers, would use AR support for other text if provided. Results highlight the potential for using AR on text to provide reading support and the need for additional research on its implementation and impact. The basic conclusion of this research is the following: augmented reading supports for academic text increase motivation, engagement, and confidence in understanding as perceived in struggling readers as well as typical readers (Huisinga, 2017, p. 98)

How students with dyslexia (a specific reading disorder in general) use AR for reading support?

AR supports struggling readers, including scaffolding for vocabulary acquisition and comprehension, which could be overlaid on the static text. Husinga describes AR as educational technology for students with dyslexia:

> "The design of the augmented scaffolding could be based on common core literacy standards, particularly looking at improving synthesis and analysis of reading material and vocabulary acquisition. Research supports explicit instruction practice, particularly when used for struggling learners Yet, direct teacher involvement is not always possible. Developing scaffolding for struggling readers through the use of AR could provide the needed support independently, to be used in a classroom or at home. Direct instruction through the use of scaffolding has been proven to help struggling readers achieve above the level they could on their Scaffolding could be built into an AR experience to provide direct instruction for vocabulary acquisition and comprehension. AR also would bring many affordances of digital text to static print text, which can aid struggling readers" (p. 100).

Huisinga (2017) provides clarity of four main areas of AR applications: (1) the uses for AR in the classroom, (2) the affordances and challenges of using AR for education, (3) how AR experiences are designed, and (4) insights and lessons that can be pulled from studies for both AR research and instruction.

Augmentative and Alternative Communication (ACC), based on the augmented reality and alternative communication, is a specific type of communication intended for people with complex communication needs. ACC supports different AR technology. To implement AAC communication in inclusive educational systems, there is a need to establish national policies in Balkan countries (Obradović & Bjekić, 2018). It is necessary to organize a specific teaching staff education (including student–teachers and practicing teachers) for implementing AAC systems and AR in the educational system.

Walker (2017) described the following mechanisms of AR support for students with dyslexia:

> "Teachers can introduce words in context by labelling physical objects with text labels that AR application can read. AR application can read aloud difficult words, display additional information on an academic topic, provide video instructions and provide details about upcoming procedures when attempting a multistep activity, or deliver prompts to individuals to support independent living. AR can provide a myriad of solutions if we consider practical applications for AR in education in addition to more consumer-friendly entertainment value designs" (p. 3).

Three examples of implementation of AR as support for people with dyslexia are presented: Augmenta11y (Sisodia, 2019), AURISMA (Husinga, 2017), and "I love dyslexia" (Papa, 2016).

Example 1: Augmenta11y (Sisodia, 2018)

Augmenta11y is an application for Android and iOS devices, to help children with dyslexia learn easier. Mudita Sisodia discussed the process of Autmenta11y development (Augmenta11y as augmented reality tools) which was created for helping persons with dyslexia to read better real-world text. After analyzing of available products for supporting students, people with dyslexia, and analyzing comments of the people who work with persons/students with dyslexia, Oswald Labs' team developed some recommendations for preparation AR for students with dyslexia (Gupta et al., 2019; Sisodia, 2018):

- Sans-serif fonts such as Arial, Verdana, and Comic Sans are the least confusing for people with dyslexia. There are also fonts such as OpenDyslexic that are specifically designed to combat this disability.
- Text and background colour combination and contrast aided in making the text more legible to the users.
- Users often have a problem when moving from one line to the next; they tend to skip over lines; they allowed students with dyslexia to customize the text line-height.

Augmenta11y is an augmented reality application for helping people with learning disabilities like dyslexia to easily read the paper and other material in the real world. Augmenta11y helps users to scan text using their smartphone, which will then be superimposed with the same text but styled to suit the preferences of the user. Augmenta11y was developed in Oswald Labs XX.

This application has three features:

- Reader Mode: The user can read the text unaffected by external environmental factors by tapping on a text box and entering the Reader Mode. If required, the user can also have the text read aloud to them.
- Customizable Settings: Different users with dyslexia may have different requirements for styling the text that helps them read better. To facilitate customization, Augmenta11y allows them to adjust properties like fonts, text to background colour contrasts, and line-height. The application also provided a Major Object Detection mode that identifies the largest pieces of recognized text and displays only those, hence avoiding a cluttered reading experience.
- History: This application keeps track of previously detected text for future reference.

Example 2: AURASMA (Huisinga, 2017)

The application AURASMA for students with reading impairment, dyslexia, is developed by the Husinga and team. Huisinga described AURASMA in the following way:

"The three top-level components to an AR system include the sensor, processor, and display. When using AR through a mobile application such as Aurasma, the Tablet or smartphone fills the requirements of sensor, processor, and display, leaving the user free to focus on the virtual content, the interactions, and the physical world. This augmented reading study focuses on the creation of AR experiences through the mobile AR application Aurasma. Designing content for AR through mobile apps like Aurasma consists of creating overlays that can be seen/heard virtually over physical content. Overlays can consist of videos, images, audio, URL links, or 3D graphics. While some AR systems are capable of haptic feedback, olfactory, or gustation simulation, these abilities are not readily available currently for mobile AR technology. When creating video, audio, or photos for an Aura, a digital overlay in Aurasma, the simplest course is to use your smartphone or Tablet. Content can be directly uploaded to create an AR experience through the Aurasma App. Otherwise, content can be added to an AR experience through Aurasma's browser creator studio" (p. 40).

Example 3. "I love dyslexia" (Papa, 2016)

What are the specificities of AR implementation in students with dyslexia learning a foreign language? Aggeliki Pappa recognized that a major problem of today's education for students with dyslexia is education system constraints which prevent learners from being effectively included in the learning process of a foreign language (FL) depriving them of necessary life skill and a global voice. Papa described principles of "I love dyslexia" school:

"The award-winning 'I love dyslexia' (ILD) in Athens, Greece, is the first and only internationally, highly specialized school for holistic EFL-FL learning to students (children and adults) with dyslexia and SEN, introducing an innovative combination of authentic and complete FL tool collection and a pioneering multi-level program set to fill the big gap for effective EFL-FL access for millions of students with SEN worldwide, while its system could be implemented in settings where English is taught as a first language. ILD highly structured tool combination and holistic program of studies are designed based on brain targeted teaching, shelf awareness sessions, design thinking and mind mapping, smart multisensory mnemonics, synthetic and analytic teaching, drama and project passed differentiated activities, use of new technology and augmented reality tools in combination with activities in an outdoor natural environment, as well as mindfulness and Aikido as educational tools to develop inner harmony and meet challenges of living to thrive in life. Last but not least, ILD provides experiential training courses on EFL-FL and SEN, empowering educators worldwide with practical knowledge and effective tools to support all their students to succeed in EFL-FL learning" (p. 47).

5. CONCLUSION

In the new technology environment for teaching, the teachers meet different challenges and they are trying to involve in their educational practice. Augmented reality as educational technology is one of the challenges. Augmented reality enables virtual object involvement in real environments to support and facilitate real-time interaction. The research of educational applications of augmented reality is still in an early stage.

However, augmented reality technology can be considered as a technology for the diagnosis of dyslexia, for the treatment of students with dyslexia, and it is particularly important to research possibilities to use AR in education students with dyslexia.

Also, it is necessary to organize a specific teaching staff training for implementation of the augmented reality educational technology.

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