Virtual Reality for Special Educational Needs

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ABSTRACT
Virtual Reality (VR) can be viewed as an assistive technology, due to its potential to minimize or offset the effects of a disability and provide an alternative mean for an individual to accomplish a particular task [12]. It is a promising avenue to provide children with Special Educational Needs (SENs) opportunities that they otherwise would never experience. VR learning environments can be personalized to allow a child to focus on their unique strengths and abilities, rather than limit their interactive capabilities, and work toward mastery of a task. VR can provide a safe and supportive simulated environment that allows a child to practice or enhance various skills which can be transferred to the real world.

VR encourage interactive learning and provide a variety of opportunities for the learner to have control over the learning process. In fact the flexibility and controllability of VR provides a vehicle for interactive, ecological and valid assessment tools in formal, informal or continuing education. Some advantages of these technologies are the repetition, the control over the learning process and, in addition, VR systems have the capability to increase the complexity of the tasks and measure performance [8].

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ACM Classification Keywords
H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities; K.3.0 [General]; H.5.2 [User Interfaces]: Theory and methods;

INTRODUCTION
Howard Rheingold [17] defines Virtual Reality as an experience in which a person is “surrounded by a three-dimensional computer-generated representation, and is able to move around in the virtual world and see it from different angles, to reach into it, grab it, and reshape it.”

In this position paper will briefly introduce what SENs means and the reason of using VR in educational sector. After the introduction the paper is organized in two different macro-sectors. The first one categorizes VR devices and contents and explains the relationship of this technology with the learning ecosystem. The second main point investigate the SENs impacts on individuals and society and what cognitive and psychological dimensions can be empowered through the use of technologies.

What ‘Special Educational Needs’ refers to?
The term Special Educational Needs (SENs) is a way to refer to students with learning disabilities [6,15]. They require specialized learning strategies to meet their potential and avoid self-esteem and behavioural difficulties. These learning disabilities are classified by The World Health Organization (WHO), a specialized agency of the United Nations (UN) concerned with international public health, into the disorder F81 included in the block “Disorders of psychological development” of the document “ICD-10 International Statistical Classification of Diseases and Related Health Problems, 10th Revision” [20]. Briefly, there are three main types of learning difficulties which appear in primary school: dyslexia (specific reading disorder), dysgraphia (specific writing disorder), and dyscalculia (specific disorder of arithmetical skills).

Why Virtual Reality?
VR can enable several student-centered learning opportunities, from immersive environments for field trips, to simulated experiences relevant to course contents, to explore otherwise inaccessible locations like outer space or distant world landmarks, to virtual laboratories to supplement course curriculum to help students better understand some experimental science concepts [18].

Several research results and projects [9,19] have shown that the use of VR and gaming could improve the cognitive abilities of children with SENs via a more constructionist learning approach supported by self-directed exploration of the virtual environment [3].

The literature emphasizes the manifest advantages of VR in raising the degree of awareness of experiences which are difficult to convey verbally, and which otherwise demand considerable time resources [14]. In fact “VR offers lots of advantages in terms of generalisation, intuitiveness and a lower level of abstraction required to participate with the tool and to gain access to the benefits, which it is fundamental when creating solutions for special education” [19]. Moreover various studies [4,5,7] have pointed out that children using VR enjoy it and want to learn more.

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VIRTUAL REALITY FOR EDUCATION

VR devices and contents

Virtual Reality headsets between the 1950s and 1990s didn't make a commercial breakthrough, but today VR devices have enjoyed an unexpected renaissance. Oculus Rift, HTC Vive, Sony PlayStation VR, Razer OSVR, Samsung Gear VR, Google Cardboard have all made virtual more of a reality for a new generation of users, businesses and applications. From the economic point of view in 2016 globally VR equipment revenues are projected to reach $895 million. 77% of that value consists of newly launched devices from Oculus, HTC, and Sony [16].

The VR headsets can be technically divided into two main categories: the first ones are the devices that use an external equipment like smartphone as computational resource and display, the second ones use an hardware that needs to be connected to a console or pc. Example of the first category is the Google Cardboard an essential and cheap (less than 10 Euro) gadget to make use of VR contents; it can fit many different types of smartphone but the ergonomics and interaction input are poor. Other example is Samsung Gear VR that is more comfortable and integrates different sensors and input interfaces, but it is more expensive (about 100 Euro) and it is compatible only with few Samsung series smartphones. With the use of mobile devices the VR experience becomes much more accessible to everyone, anytime and anywhere, mostly the exploitation of this portable technology allows the improvement of the usage and attempts to delete the physical constraints. In this way the VR devices could become a very important tool for ubiquitous learning applications. The other important category of VR headset is represented by the popular Oculus Rift, HTC Vive and PlayStation VR. In addition, an appreciable device is the Razer OSVR (Open Source Virtual Reality) because it is an open source platform where the VR community and industry are unified, collaborating, and innovating to empower the VR system. These devices have a cost between 400 Euro and 1000 Euro but they need to be integrated with a PC for gaming, on the other hand there is a better quality and stability of the VR system.

The availability of VR experiences requires not only the availability of hardware interfaces but also of proper contents. They can be divided into two main categories: real world contents (somehow extending the original definition of VR) and digital virtual environments. The first ones consist of 360° videos often created by 360° camera consumer devices like Samsung Gear 360, or professional like Nokia OZO. These contents represent the real world and can be useful also for real-time streaming through online platform like Youtube or Facebook. The second ones consist of digital virtual environments created in computer graphics, for simulating scenarios and/or phenomena, like in virtual labs experiments or in historical, remote or futuristic adventures. Some popular tools to design virtual spaces are Unity 3D or Unreal Engine or the most easy to use CoSpaces that aims to make VR available for everyone, and not only developers or designers.

The democratization of VR devices and tools combined with high level contents can create the bases for useful interface and smart solutions in educational area too.

VR and the learning sector

VR can have clear applications in the educational field if it will be part of a school challenge solutions to increase quality learning materials and to create more authentic learning opportunities. Effectively, in a survey at the Consumer Electronics Show (January 2016), 36 percent of attendees (1,567 people) indicated that VR would find its most significant impact in the educational sector and that VR would translate well into areas such as "virtual classrooms and AR/VR-enabled textbooks" [13]. Moreover Samsung Electronics America, Inc. and GfK research, released at International Society for Technology in Education (ISTE June 2016) [18], explains that only two percent of U.S. K-12 teachers have used VR in the classroom, but 60 percent are interested in making it part of the learning experience, and 85 percent of teachers agree that VR would have a positive effect on their students.

According with NMC/CoSN Horizon Report: 2016 K-12 Edition [1] VR can be indicated as an important technology that is very likely to impact changes in education across the world over the next years. Certainly the adoption or abandonment of immersive VR system by educational sector will be determined by the responses taken across the consumer technology world and obstacles to develop useful innovative contents. VR technologies can make formal and informal learning more personalized and accessible, even if not developed expressly for the educational sector; moreover, they may include tools adapted from other domain and for other objectives, that can became strategically useful for learning, like consumer and visualization technologies [1].

The most exploited use of VR technologies in classrooms is virtual field trips for students to allow the experiences that they might not be able to visit physically, whether that be due to proximity or cost. Interesting example of this possibility is Nearpod VR[1] that developed an inexpensive way to get a basic 3D experience into classrooms: it easily provides a set of panoramic "tours" of famous places and VR lessons explorable through the Google Cardboard. Another representative case of VR immersive fieldtrips is Google Expeditions[2] that shows, through Google Cardboard, particular 360° panoramas with some interactive points of interest.

In addition to 360°video field trips, VR applications in learning can be also a complete virtual environment that

[1] https://nearpod.com/nearpod-vr

[2] https://www.google.com/edu/expeditions

allows users to create personalized lesson plans and immersive experiences. Examples of this solutions are Lifeliqe[3] and Edmersiv[4] as virtual environments designed for single-user interaction (SVEs) [3], in which a user controls navigation and interaction with the objects into a VR educational lab; and Engage[5] a collaborative virtual environments (CVEs) [3] for education which simulates a lecture hall in VR, while adding special effects which can't be utilized in a traditional classroom setting.

A common solution, to empower learning process, in VR 360°video and virtual environment is the use of gamification techniques. The application of elements and game design techniques to not-leisure contexts through VR interfaces is showed in videogame House of Languages[6], Developed by the Estonian company Fox3D. This VR app to learn new language puts players/students in a cartoon house with a cute raccoon that explains the games goals, basically find an object into virtual space and when players look at objects, they are able to see their names and hear the pronunciation. Generally gamification could enable VR technologies to be useful for a large variety of users with disabilities and/or SENs, to develop their motivation, self-esteem, and improve their skills.

SPECIAL EDUCATIONAL NEEDS IMPACTS ON INDIVIDUALS AND ON SOCIETY

While learning disabilities and difficulties may vary, they usually affect a well defined set of skills and functions, that can be structured around two main dimensions: a cognitive dimension and a psychological dimension. Typically, each child with SENs presents a unique set of weaknesses and difficulties. The degree of the problem may vary, and many of them, taken individually, can go from light to mild difficulties. To support children with SENs in both dimensions, psychologist, educators, teachers and families work with them, to empower the corresponding and specific functions and skills. For example, a child could manifest some difficulties - within the cognitive dimension - about attention and logic reasoning, or - within the psychological dimension - about lack of self- esteem.

According to the UK Educational System's definition, SENs can compromise a child or a young person's ability to learn. SENs could mean that a student has:

- learning difficulties in acquiring basic competences in early school years
- social, emotional or psychological difficulties
- specific learning difficulties - with reading (eg dyslexia), writing, number work or understanding information
- sensory or physical impairment
- communication difficulties
- medical or health conditions

Some children with SENs need help with everything they do at school and at home, while others only need help in certain areas. Children have different ways in which they learn best; sometimes they don't easily succeed or make progress slower than their peers, as children with SENs. Teachers have to refer to an inclusive kind of education, that can give a chance to learn to all the children. One of the categories of SENs that had much attention in last years was Specific Learning Difficulties (SpLDs). SpLDs comprehends different type of condition that often can co-occur, that are: Dyslexia, Discalculia, Dysgraphia and Dysortography, Dispraxia. In these disorders the normal patterns of skill acquisition are disturbed from the early stages of development. This is not simply a consequence of a lack of opportunity to learn, it is not a result of mental retardation, and it is not due to any form of acquired brain trauma or disease. These disorders have a neurobiological origin, and are not tied in any way to the intelligence. May cause differences and difficulties in reading (dyslexia, precisely), writing (dysgraphia and dysorthography), in the calculation of the numbers (dyscalculia), the coordination of movements (dyspraxia). They can have significant impact on education and learning and on the acquisition of literacy skills.

VR and SENs cognitive/psychological functions

The SENs learning difficulties can compromise scholastic performances and social-communication relationship with classmates and teachers and it could be cause of early school leaving. To avoid these difficulties the use of technologies like VR can provide educational multimedia contents that help children to gradually achieve the autonomy in the study and to empower their cognitive and psychological functions, and their learning abilities. For example, it is well established that children and adolescents with SENs often have also an impaired working memory (WM) [11]. The ability of technologies to repeat audio-visual inputs can be a useful action to reach increasing memory goals [9]. Kalyvioti has reported that, in test and subtests for the working memory within VR environments, students with dyslexia had similar overall performances to students without dyslexia [9]. In fact VR environments let an effective use of compensatory memory strategies. These are methods of processing information that allow individuals to achieve goals using alternative means, as story creation (recall information through storytelling) and item grouping based on common characteristics (e.g. initial phonemes, semantically, utilitarian) [9].

As another example, the use of visual and auditory way of learning improves writing performance in children with developmental dyslexia [10]. Therefore VR educational contents have to provide strong multimodal stimuli to enhance multisensorial learning. VR can also better the

[3] https://www.lifeliqe.com/

[4] http://www.edmersiv.com/

[5] http://immersivevreducation.com/engage/

[6] http://fox3d.com/vr

ability to process and understand visual information (also called cognitive visuospatial skills) thanks to the ability to personalize and manipulate the virtual environment at will (changing the inner objects' properties, locations and quantity) [19]. These VR characteristics well match with the superior visuospatial strengths of dyslexics in a virtual environment [2].

Moreover, for the psychological functions, VR immersive environments could also increase motivation, curiosity and autonomy for students with SENs, and therefore improve their learning performances, empower academic self-esteem and self-efficacy, promote well-being (psychological dimension), social competence and behaviour.

CONCLUSION

Within new learning situations and by the use of realistic, intuitive, interactive, adaptable and multisensory VR technologies and environments, individuals with Special Education Needs can be confident about their own learning strengths, their visuospatial abilities and learning preferences, and their compensatory memory strategies, fulfilling the required tasks and the expected outcomes. The use of VR-related new learning methods and technologies can be focused on the capabilities and qualities of SENs to compensate and minimize their learning difficulties, and improve cognitive abilities. Nevertheless, there is still much more to investigate and explore. The first step is the definition of best practices to design useful VR learning contents for SENs. These guidelines should be created by a multidisciplinary community of technologists and SENs education experts, and tested within school environments, with both students and teachers, and for specific subjects and/or learning abilities.

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