SOCIAL SUSTAINABILITY AND VIRTUAL REALITY HEAD-MOUNTED DISPLAYS: A REVIEW OF THE USE OF IMMERSIVE SYSTEMS IN THE AID OF WELL-BEING

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ABSTRACT

This review seeks to update our knowledge about the positive effects in the use of VR head-mounted displays (HMDs) for immersive systems in the aid of human well-being and quality of life. Through a systematic Literature review which includes all peer-reviewed research documents that are relevant to the objective to ensure a comprehensive search. Four research databases were identified: (I) web of Science, (II) IEEEExplore, (III) ScienceDirect and (IV) PubMed. Only primary empirical studies on the use of HMDs were included. The review identified a number of situations where HMDs are useful for aid and improvements of the human well-being, rehabilitation, and improvement in the quality of life, thus, contributing in the field of sustainability study. Although there are several studies, more research is needed on the use of this technology within settings to ensure recommendations that can implement the improvement of use for social sustainability and sustainable development.
Key Words: Virtual reality, sustainability, sustainable development, well-being

1. INTRODUCTION

Technological advancement brought enormous possibilities, mainly in the field of design, for the development of new techniques and devices that are linked to the potential of visuality, interaction, human factors, perception, cognition and user experience. This progress brought about profound consequences in the many fields of the sciences, be it on the intellectual field or the practical. Consequently, with the advent of globalization, concerning technological globalization, new technologies with developments in computing, communication and transports were highlighted, in detriment to social inequalities. Questions involving innovation and sustainability have brought new challenges to the new business models, incorporating not only the technological factor, but also strategies to achieve sustainable development, which, through technology, promote new possibilities to create user experience for human well-being and quality of life. In the theoretical referential of Positive Psychology, Seligman; Csikszentmihalyi (2000) approach the idea that Positive Technology provides the increase of emotional, psychological and social well-being. As such, positive technologies can influence individual experiences by promoting positive emotions, engagement, social integration and connectivity.

Sustainable development has been walking in parallel with the technological innovations that provide new devices, techniques and processes. The term "sustainable development" has been widely discussed and has many definitions. The ideology was discussed in the report entitled "Our Common Future". Sustainable development is that which "answers the needs of the present without compromising the capacity of future generations of satisfying their own needs" (Brundtland, 1987; Olakitan, 2018).

With technological development, design supports itself more and more on strategic tools to give support in the many fields of knowledge, in search, analysis and representation of information. Because of this great amount of information, visualization techniques have a fundamental role in the achievement of this task. Until recently, this information was provided through written word and visual screens, which are now replaced by computerized devices that include from daily objects, such as radios, watches and smartphones, to controls in a nuclear power plant where an inadequate project can have disastrous consequences. Among the sensorial organs, vision has stood out as the main organ for the reception of this new human-machine relationship, followed by hearing – which, generally, is used in a complementary way to visual information in some specific situations (IIDA, 2016).

On the other hand, virtual environments amplify the user's capacity in their evaluation with the use of multimodal interactions, with the aid of 3D software technology that allow photorealistic images that complicate the distinction between real and digital. Many products, such as: smartphones and social media websites that need the user's interaction were projected having mainly the user in mind. Others were not projected taking the user experience into consideration, being conceived as systems that execute defined functions. Even though they work efficiently, this changes when we analyze these processes of interaction in the real world. This way, new forms of projecting interfaces, together with the technological convergence, are pointing toward the new generation of computation systems based on immersive VR for use in many areas: from entertainment, such as games, to collective scientific experiments, collaborative environments, medical applications and architectural and product design, constituting true research laboratories.

2. RESEARCH METHODS

2.1. Systematic Literature Review

The Systematic Literature Review (SLR) seeks to establish a rigorous procedure to bring about a revision of literature, to identify the available literature and analyze data so as to obtain evidence of a certain phenomenon with a rigorous process in identification, evaluation, interpretation and relevance conducted in revision. It will be made according to the simplified model proposed by Conforto et al. (2011), which can be described in 15 steps and divided in 3 phases: Entry, Processing and Exit.

Research Question (RQ) 1 – How can VR technology contribute to help human well-being?

VR immersion has been studied in many domains, but its correlation with well-being has not yet generated explicitly addressed interventions. Examining the case studies to identify the possible relation between VR technology and sustainable development.

Research Question (RQ) 2 – To which aspects of VR were attributed questions related to the contribution to sustainable development?

New ways of interactivity and development in the fields of: social and economic and environmental associated to VR, taking into consideration triple bottom line (TBL). These are the research questions that will be addressed by this revision through the following steps.

2.2. Method and Tools

Also, to definition inclusion and exclusion criteria was used to search string definition was defined using the terminology identified for PICOC framework (table 2) – which stands for population, intervention, comparison, outcomes, and context can be useful to ensure that one decides on all key components prior to starting the review. During the planning phase, we used Parsifal tool to document the whole process, keywords and synonyms, and selecting the sources.

- Search databases: IEEE Xplore, ScienceDirect, Web of Science, PlubMed
- Search string: ("virtual reality") AND ("head-mounted display" OR "immersive systems" OR "virtual environment") AND ("economic" OR "environmental" OR "social") AND ("quality of life" OR "social well-being" OR "sustainability" OR "sustainable development" OR "well-being")

2.3. Eligibility Criteria

- Inclusion Criteria: IC 1: primary study that presents evidence of the use of VR systems for sustainable development; IC 2: primary study that presents evidence of the contributions of VR for the well-being. IC 3: primary study that presents evidence of the use the VR technology to enhance the quality of life.
- Exclusion Criteria: EC 1: Papers not written in English; EC 2: Papers that were published before 2014; EC 3: Papers that are duplicated within the search documents; EC4: Study that is not full paper EC5: Papers that do not meet any of the inclusion criteria EC6: Papers that are not primary research. EC7: Primary study that not use HMDs for VR.

[Table 1] SLR search: search string delivery results classified by database.

Database	Search string	Total	Included	Results
IEEE Xplore	("virtual reality") AND ("well-being" OR "sustainability" OR "sustainable development")	81	32	3
ScienceDirect	("virtual reality") AND ("head-mounted display" OR "immersive systems" OR "virtual environment") AND ("economic" OR "environmental" OR "social") AND ("quality of life" OR "social well-being" OR "sustainability" OR "sustainable development")	318	154	3
Web of Science	(("virtual reality") AND ("well-being" OR "social well-being" OR "sustainability" OR "sustainable development"))	171	93	5
PlubMed	("virtual reality") AND ("head-mounted display" OR "immersive systems" OR "virtual environment") AND ("economic" OR "environmental" OR "social") AND ("quality of life" OR "social well-being" OR "sustainability" OR "sustainable development" OR "well-being")	405	310	5

[Table 2] Research scope: obtained through the application of the PICOC framework to the SLR. (Font: FERNÁNDEZ DEL AMO et al., 2018)

Concept	Definition	SLR application
Population	The problem or situation the research is dealing with.	Virtual Reality for maintenance applications research: well-being, social well-being, welfare
Intervention	Existing techniques utilised to address the problem identified.	Methods, tools and techniques for VR technology: head-mounted display, immersive systems, virtual environment
Comparison	Techniques to contrast the intervention against.	Contrast between intervention techniques.
Outcome(s)	The measure to assess the effect of the techniques in the population.	Sustainability, sustainable development, social well-being, well-being, quality of life
Context	The particular settings or areas of the population.	Maintenance of medium-long life complex assets. triple bottom line – social, economic, environment.

3. DISCUSSION AND RESULTS

The aim of this paper is to discuss the challenges immersive VR technologies posit to human well-being. Through of the search string definition with the aid the PICOC framework our search strategies retrieved a set of 975 papers out of which 16 were selected as primary studies after qualitative assessment criteria. techniques; and Improve safety.

[Table 3] Empirical papers relating to the use of VR-HMDs.

Reference	Benefits found	Target group | Context
Meneses et al. (2017)	Social impacts; well-being	Senior citizens in an adult day care centre

Tashjian et al. (2017)	Reduces pain; well-being; therapy for pain	Hospitalized patients with pain
Suhaimi et al. (2015)	Rehabilitation of the arm movement	Stroke patient
Crespo et al. (2016)	Entertainment, physical activity; quality of life	VR based on drones for older people
Quesnel et al. (2018)	Transformative experience, well-being	VR to elicit feelings of awe and wonder
Román-Ibáñez et al. (2018)	Sustainability; e-learning;	Students in robotics technology courses
Battisto et al. (2018)	Therapeutic; promoting health; quality of life	Increase nature contact for older adult
Salisbury et al. (2016)	Neurorehabilitation	Spinal cord injury; brain injury
Wiederhold et al. (2014)	Distraction techniques; treat chronic pain	Chronic Pain Patients
Didehbani et al. (2016)	Social skills; promoting social-cognitive	Children with Autism (ASD)
Fralish et al. (2018)	Improved Physiology; psychosocial well-Being	Individuals with Physical Disabilities
Shi et al. (2016)	Sustainable development; communication	Building sustainability; (BIM)
Tang et al. (2016)	Health; well-being; quality of life	Busy working people
Yoo et al. (2016)	Health; well-being; quality of life	Promoting health through exercise
Yu et al. (2018)	Access nature environments for restoration	Positive impacts on psychological health
Käthner et al. (2015)	Visual stimuli; effectiveness of HMDs	A person in the locked (LIS)

With recent advances, the use of immersive virtual reality devices is becoming more and more popular. According to Schmidt et al. (2018), they present the results of a subjective experiment carried out with the aim to compare different kinds of virtual environments with each other, such as HMDs[1] and CAVE[2], the present results were demonstrated that the majority of participants showed a superior feeling of presence with using the HMDs. Therefore, the non-use of HMDs were not included in this study. These devices vary by their relationship to the user's eyes, the field of view, illumination, resolution, color, stereopsis, effect on head motion and user interface (Ehrlich et al., 2017).

3.1 Designing for Social Sustainability and Human Well-being

In this line of thought in which design walks towards a model of sustainable development in the environmental, social and economical fields, the traditional methodology of industrial design production has been giving space to the production of a new paradigm, based on the sustainable development that seeks the human well-being, which, through environmentally harmonic solutions, seeks the satisfaction of human needs and desires, bringing a strategic and systemic approach of innovation applied to the emergent product-service systems of this new social context to reach solutions that are harmonic with the limits of the environment, through a long and healthy life (Vezzoli et al., 2018). According to Bolier et al. (2013) "It is possible to define 'subjective well-being' as the cognitive and/or affective appraisal of one's own life as a whole, while the term 'psychological well-being' refers to the optimal functioning of the individual and includes concepts such as flow, hope, and resilience". Additionally, World Health Organization, "Mental Health" is defined as "a state of well-being in which the individual realizes her or his own abilities, can cope with the normal stresses of life, can work productively, and is able to make a contribution to his or her community."

Design is oriented towards the resolution of problems, which go from simple daily cases to complex questions, such as: the use of immersive systems that aid in the neurorehabilitation of patients through VR systems – providing a significant improvement to the quality of life and well-being of the patients after the use of these devices, which were made based on user experience, as well as an improvement in the assistance of medical procedures, entertainment and even simulations for military training. According to Battisto (2018) scientists generally, recognize five factors or determinants of health. (I) Genes and biological factors such as sex and age; (II) Health behaviors such as physical activity, eating habits, smoking, and alcohol use; (III) Social environment or social characteristics such as income, gender, and family composition, which influence an individual's health; (IV) Total ecology or physical environments that an individual inhabits, such as where a person lives and works, community characteristics and natural resources; (V) access to medical care and quality healthcare services.

With the paths that may be addressed by the designer and the diversity of use scenarios, considering users that utilize immersive computing systems, design requires a new way of thinking. Interaction and environmental devices

[1] A Head Mounted Display (HMDS) is a display system worn on the head that presents views to one or both eyes. In immersive virtual reality this is both eyes, often using stereoscopic displays to create the illusion of depth through the use of parallax. Font: Brooks, A. L., Brahnam, S., & Jain, L. C. (Eds.). (2014).

[2] The Cave Automatic Virtual Environment (CAVE) projects computer images onto the walls of a room and the participant wears tracked shutter glasses to view the scene three-dimensionally. Font: (CRUZ-NEIRA et al., 1993).

lead to the necessity of flexible systems that can adequate themselves to different requirements of interaction, collaborating for the inclusion and social well-being.

3.2 VR Technology for Sustainable Development

VR technology can provide tools that aid in creating a more profound comprehension of the addressed subjects on the educational field – through training and simulations that diminish the risk of accidents in medical procedures or the training of pilots, for instance. Currently, the dimensions of sustainability have been highlighted around the world in eight aspects: economic, social, environmental, cultural, ecologic, territorial, national politics and international politics, as listed by Ignacy Sachs, one of the foremost scientists to contribute to the subject. In the 90s, we were presented with the triple bottom line (TLB), which highlights three dimensions and was originated by the observation of the social and economic dimensions of the agenda proposed by the Brundtland Report, 1987 (Elkington, 2004; Vellozi, 2018; Sanchs, 1997; Wced, 1987).

Aside from inspiring users, virtual reality systems can improve empathy through the impact generated by immersive systems, as reported by the United Nations Virtual Reality (UNVR) – (visit: http://unvr.sdgactioncampaign.org/).– which seeks to use immersive narrative to raise awareness of various global issues, by means of Agenda 2030, adopted by all member-states of the United Nations in 2015 that aim for the 17 Sustainable Development Goals (SDGs) (UNVR, 2019).

[Figure 1] Sustainable Development Goals (Font: United Nations)

According to Makarova et al. (2019), technologies become inherent to human beings and, in 5 to 10 years, will change the world. These technologies are incorporated to this new generation of people in the use of cellphones, computers and internet, and the most promising ones are linked to the fourth industrial revolution (industry 4.0). Known as smart technologies, they aim to provide better life conditions, generating social well-being through sustainable development. The author highlights that, to increase the quality of the projected systems and products, a new approach to education is necessary, one that guarantees ways to improve the education process through virtual reality simulators in the automotive area. Questions about the sustainable development and minimization of environmental impacts most be taken into consideration as well, if we are to have an intelligent education.

4. CONCLUSION

In this revision, we evaluated the current state of the 5 last years of research in VR-HMDs on what concerns sustainability, sustainable development, and human well-being. The research found that immersive virtual reality systems can bring benefits through the technological potential in rehabilitation, intervention in quality of life, psychological evaluation, education and promotion of health and well-being. Therefore, researchers must keep up with technological advancement so as to develop new methods and devices that amplify the limits and potential for more effective interventions through user-centered design (UCD). This study approach how the VR technology can provide the improvement in health and wellness as well as showcasing a wide range of the results in contexts that aim social and life skills, training in safe, controllable virtual environments.

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