RECyT
Year 25 / Nº 40 / 2023 / 38–49
DOI: https://doi.org/10.36995/j.recyt.2023.40.005

Evaluations of Design and User Experience in Virtual Reality: A Systematized Bibliographic Review

Evaluaciones de Diseño y Experiencia de Usuario en Realidad Virtual: Una Revisión Bibliográfica Sistematizada

Avaliações da Experiência do Usuário em Realidade Virtual: Uma RevisãoBibliográfica Sistematizada sob a ótica do Design

Rodolfo Nucci Porsani[1, *]; Ana Beatriz Constâncio Trindade[2]; André Demaison[3]; Claudia Renata Mont'Alvão[2]; Luis Carlos Paschoarelli[1]

1- Universidade Estadual Paulista UNESP. Brasil.
2- Pontifícia Universidade Católica do Rio de Janeiro. Brasil.
3- Universidade Federal do Maranhão – UFMA. Brasil.
* E-mail: rodolfo.n.porsani@unesp.br

Received: 10/10/2022; Accepted: 06/02/2023

Abstract

Virtual Reality (VR) technology provides the sensation of immersion in virtual digital spaces, through interactions that occur in different dimensions of perceptions. Considering the lack of research involving VR in evaluations of Human Computer Interaction (HCI), Emotional Design, and User Experience, the present study aimed to investigate the state-of-the-art in this subject. For this, a systematic literature review was carried out. The question to be answered is: How do users change behavior in visual interaction with different artifacts in real and virtual environments and how that influences the perception (emotional, semantic, and usability) of individuals? Structured analyzes were applied to scientific articles that address the experience of healthy adult participants and their interaction relationship with environments and artifacts immersed in VR. After screening and in-depth reading steps, 27 articles were selected for meta-analysis discussions. The results point to the existence of a scientific gap since the works found and analyzed only partially answered the research question, which, because of this, may indicate an open field for studies involving VR This technology can be a viable tool with potential of assisting and complementing the methodological processes already consolidated in the Design and Human Factors areas.

Keywords: Virtual Reality; Design; Interaction; Perception; User Experience.

Resumen

Las tecnologías de Realidad Virtual (VR) proporcionam la inmersión en espacios virtuales e interacciones en diferentes dimensiones de percepción. Visto la falta de estudios sobre la RV en la evaluación de la interacción humano-computadora y la experiencia del usuario, el presente estudio investigó el estado del arte en este tema. Para ello, se realizó una revisión sistemática de la literatura, cuya pregunta fue: ¿Cómo modifican los usuarios su comportamiento en la interacción visual con diferentes artefactos en entornos reales y virtuales y cómo influye esto en la percepción (emocional, semántica y de usabilidad) de los individuos? Se aplicaron análisis estructurados a artículos científicos que abordan la experiencia de participantes adultos sanos y su interacción con entornos y artefactos en la RV. Finalmente, después de la selección y lectura, se seleccionaron 27 artículos para metanálisis. Los resultados apuntan a la existencia de un vacío científico, ya que los trabajos encontrados y analizados respondieron solo parcialmente a la pregunta de investigación, lo que puede indicar un campo abierto para estudios que involucren RV. Esta tecnología puede ser una herramienta viable con potencial para ayudar y complementar los procesos metodológicos ya consolidados en las áreas de Diseño y Factores Humanos.

Palabras claves: Realidad virtual; Diseño; Interacción; Percepción; Experiencia del Usuario.

Resumo

As tecnologias da Realidade Virtual (RV) proporcionam a sensação de imersão em espaços digitais virtuais, através de interações que ocorrem em diferentes dimensões de percepções. Considerando a carência de estudos envolvendo RV nas avaliações da Interação Humano-computador, Design Emocional e Experiência do Usuário, o presente estudo teve como objetivo investigar o estado da arte neste assunto. Para isso, foi realizada uma revisão sistemática da literatura, cuja pergunta foi: Como os usuários mudam o comportamento na interação visual com diferentes artefatos em ambientes reais e virtuais e como isso influencia a percepção (emocional, semântica e de usabilidade) dos indivíduos? Análises estruturadas foram aplicadas a artigos científicos que abordam a experiência de participantes adultos saudáveis e sua relação de interação com ambientes e artefatos imersos em RV. Finalmente, após triagem e leitura, 27 artigos foram selecionados para discussões de meta-análise. Os resultados apontam para a existência de uma lacuna científica, pois os trabalhos encontrados e analisados responderam apenas parcialmente à questão da pesquisa, o que pode indicar um campo aberto para estudos envolvendo RV. Esta tecnologia pode ser uma ferramenta viável com potencial de auxiliar e complementar os processos metodológicos já consolidados nas áreas de Design e Fatores Humanos.

Palavras-Chave: Realidade Virtual: Design, Interação, Percepção; Experiência do Usuário.

Introduction

Design, as a project area, offers methods, strategies, and metrics for developing products, whether they are real/physical, or digital/virtual. Therefore, it aims at the adequacy of these products to their users, to meet the needs of practical, aesthetic, and symbolic use, the desires and specific capabilities of those who use the object. Design is also responsible for understanding the user's relationship with the artifact.It seeks to verify whether the ergonomic, hedonic, emotional, semantic, symbolic, and social demands of people have been properly met by the products.

For this, qualitative and quantitative information collection methods are used. These metrics help and guide important strategic decision-making for the development and improvement of products that are increasingly suited to human needs. Within the Design and Human Factors areas, there are lines of research such as Human-Computer Interaction (HCI), User-Centered Design, and Design for Emotion.

When it comes to Product Design Development, users' cognitive, psychological, and emotional factors can go unnoticed and interfere with the quality of the user experience. As suggested by Chapman (2005), any object (no matter how complex) can generate intense experiences for users and each project/design decision(no matter how small) can influence the perception of these experiences.

As for sensations, the perceptions, aesthetics, and experience in the use of artifacts can be shaped by various aspects of product design. The factors of materiality and aesthetics of objects, such as shape, color, texture, size, and weight can influence the interaction of human and artifact, and consequently, the experiences derived from its use (LOBACH, 2001). Usability factors such as HCI, comfort, safety, efficiency, and effectiveness also have the potential to influence usability (IIDA E GUIMARÃES, 2016); in addition to subjective factors, such as semiotics, values, and added symbols of status or stigmas (BURDEK, 2010).

Therefore, it is necessary to observe that the configurative elements that make up the artifacts are grouped into macroelements (shape, material, surface, color, etc.), through which their configuration is determined, and microelements that also participate in the general impression of the configuration (such as screws, rivets,nuts, fittings, among others) (LÖBACH, 2001). For the author, a good project also has, at its core, the task of meeting the demands of users through relationships established during use. Thus, artifacts carry with them and perform practical, aesthetic, and symbolic functions.

Observation technique is understood as a complex practice, which involves psychic functions of cognition, intellect, memory, and desire. During the process, the observer is inserted within a social, institutional, technical, and ideological context, based on emotional stimuli, previous experiences, perspectives, and their own points of view. Due to this, the design oriented towards cognitive and emotional aspects is a great challenge for the design practice because emotions are strictly personal (DESMET, 2002; DESMET, 2003).

Desmet and Hekkert (2000) propose, in their work, the idea of a model of product emotions, generally describing the rules through which products arouse emotions involving **Operational Interests** (utilitarian, social, affective, andcognitive artifacts. Prior to their use, they are either seen as desirable or undesirable). **Normative Interests** (standards and norms, according to which we believe that artifacts should be based on, products that meet these requirements generate pleasant emotions; when opposed to these principles, they generate displeasure). The **Appreciative Interests**, in turn, depend on personal dispositions of either liking something or not. Jordan (1999) also investigated different sources of pleasure related to objects. He proposed that they

can be physiological (bodily sensations), psychological ('self-related gains'), sociological (social interaction), and ideological (sensory stimulation).

Virtual Reality technology and its potentials

Virtual Reality (V.R.) is described by Braga (2001) as an advanced interface technique, in which the user performs immersion, navigation, and interaction in a three-dimensional artificial environment, digitally modeled and computer generated, through multi-sensory pathways. The author adds that these V.R. based interfaces have as their main characteristics being immersive, intensive, interactive, illustrative,and informative.

V.R. can be briefly understood from the concepts proposed by Jerald (2015), to whom the technology is defined as a digital computing environment that can be interactively experimented with as if it were a real environment. For Tori (2020), this technology makes it possible to create alternative realities capable of simulating real environments and systems, as well as creating experiences that are only possible in the virtual environment. The author also adds that the potential for applications of this technology is wide, as it allows to witness real-world experiences and others that can be imagined, at low cost and practically without risk to the user. V.R. can also influence users' emotions: Caldas et al. (2020) suggest that scenario strategies can be used to separately influence the dimensions of emotion and presence, and can infer emotional and arousal engagement.

Using metrics from the field of User Experience, Design for Experience and Emotional Design, combined with Virtual Reality Technology as an auxiliary tool, could provide greater dynamism and methodological flexibility in Design research.In this scenario, V.R. emerges as an alternative that can contribute to the improvement of environments and artifacts, facilitating the process of development, design, and evaluation of products, in the dimensions of satisfaction, apparent usability, pleasantness, emotional perception, and semantic perception, which especially involve visual interaction.

It is based on the methodological potential of the fields of Design, on the technological potential of V.R. and in the current scientific scenario, where health measures of social isolation were imposed as a result of the COVID-19 pandemic, caused by the new Coronavirus, which justifies the relevance of this research. Studies on the use of V.R. as an auxiliary tool for researchers at the time of data collection, outline a new way of using protocols without having direct contact with users, a situation that would allow the continuity of research even in cases of lockdown. It is necessary to search for existing studies in the area, understanding their methods and techniques for an understanding of the theme.

Therefore, considering the scope of the present study, the elaboration of a Systematic Literature Review (SLR) about state-of-the-art V.R. and its applications as an auxiliary tool for data collection in the area of Design, seeking to understand the feasibility of the method and technology, its potential and applications in research protocols, was defined as its purpose.

Methodological procedures

The methodological procedures proposed by Crossan and Apaydin (2009)were adopted as a basis for this bibliographic review, which guide the collection, analysis and synthesis of information. The defined steps were according to the flowchart in Figure 1.

We worked here with the systematic literature review (SLR) of integrative, mixed, sequential exploratory and explanatory classification, of a quantitative and qualitative nature, according to the PICO methodology, structured in: (P) Person - (I)Intervention - (C) Comparison - (O) Outputs (METHLEY, et al. 2014). This way, the research question was structured in: How do users change behavior in visual interaction with different artifacts in real and virtual environments and how that influences the perception (emotional, semantic, and usability) of individuals?

Therefore, we identify as (P) people "users", (I) interaction "behavioral change", (C) comparison between real and virtual environments, and (O) "outputs" the perceptionof individuals. In addition to the question, the recommendations of the PRISMA checklist (Preferred Reporting Items for Systematic Reviews and Meta-analyses Prisma Checklist - 2015) are followed, among which is proposed a group of three researchers to the development of the study.

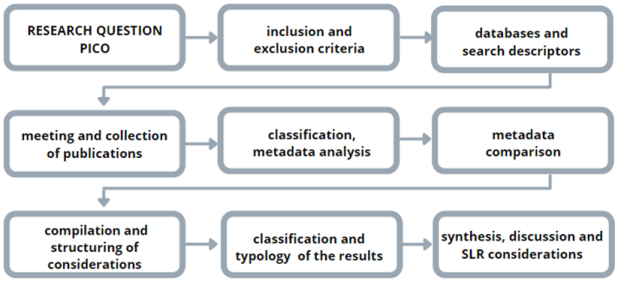

Figure 1: Research Flow diagram. Source: Adapted + from Crossan and Apaydin (2009) performed by the authors, 2022.

Systematic review criteria

After the research question was structured, the planning and delimitation of thesearch parameters for the construction of the protocol criteria to be applied were defined: 1) Studies published in the time period from 2017 to 2021 were included. 2) The studies were searched in the Web of Science, Scopus, and ACM Library databases, considered safe and reliable. 3) Only English

Language. 4) Inclusion criteria: a) original articles, b) written in English, c) published in scientific journals indexed to defined databases, d) from April 2017 (launch of rift technology) to May 2021, e) which presents qualitative and/or quantitative results on the user's visual interaction with the object in a real and virtual environment, f) healthy participants, without visual impairments, aged between 18 and 60. 5) Exclusion criteria: a) non-original or duplicate works, b) not written in English, c) published in books, events, dissertations, course conclusion works, reports, expanded abstracts, d) not indexed to defined databases, e) out of timelines, f) theoretical article that does not present quantitative and/or qualitative results, g) participants who are unhealthy, visually impaired, or younger than 18 and older than 60, h) does not meet eligibility criteria PICO, i) does not respond to search strings in title, abstract or keyword.

2017 was chosen as the beginning year because, according to Facin (2016), from this year on, a new aspect of V.R. would be commercialized and that would revolutionize the market, with products such as the PlayStation V.R., the HTC Vive, the Microsoft HoloLens, and the Oculus Rift II., designed to support scientific and academic research with coverage in the areas of science, social sciences, arts, humanities, computing, and technology (RIBEIRO, 2018).

In the next step, the search strings that guided the procedures for tracking articles on the aforementioned platforms were elaborated. Therefore, the search was implemented following the PICO process again (METHLEY, et al. 2014), as seen in Table 1.

Table 1: Search Strings Source: The authors, 2022.

Database	Strings	Results
Web of Science	(Virtual Reality) AND (Interaction) OR (Evaluation) AND (Perception) AND (Emotion) AND (Semantic) AND (Usability) AND (User) - Title - 2017-2021	92
Scopus	(Virtual) AND (Reality) AND (Interaction) OR (Evaluation) AND (Perception) AND (Emotion) OR (Semantic) AND (User) - Title Abstract and Keywords - 2017-2021	12
ACM Library	(Virtual Reality) AND (Interaction) OR (Evaluation) AND (Perception) AND (Emotion) OR (Semantic) AND (User) - Title Abstract and Keywords - 2017-2021	07

The strings were standardized for the 3 platforms (Web of Science, Scopus and ACM Library) and the search was performed on June 2, 2021, following the previously established protocol. After a total of 111 articles obtained through these strings on the 3 platforms, the filtering steps were established to refine the search process, following the previously defined inclusion and exclusion criteria:

- 1st Filter - The title, abstract, and keywords of all 111 articles were read, with an average forecast stipulated by the researchers of approving 50~100 articles. Result: 72 articles approved and 39 articles excluded.
- 2nd Filter - The introduction and conclusion of the 72 articles approved in the first stage were read, with an average forecast stipulated by the researchers of approving 30~50 articles. Result: 29 articles approved and 43 articles excluded
- 3rd Filter - The 29 complete texts approved were read. From a general critical analysis and records, questions were raised such as the place of research and the place of publication, in addition to the coherence regarding the subject addressed, themethodological quality, the analyzed dimensions (semantics, emotional, usability, among others), the nature of the approach (qualitative, quantitative or both), the sample number (n), the protocols used, the results, conclusions, and possible limitations. Thus, the authors stipulated the maximum approval forecast for the 29 articles. Result: 27 articles were approved, 2 of which were removed because they were considered completely theoretical.

For the selection and organization of the records obtained, Google Drive platform in its cloud version was used. After being downloaded, the articles were indexed for analysis and sorted into folders according to each filter. Spreadsheets were also used for records and filings. All the procedures described in the SRL process were recorded within the PRISMA flow diagram (PAGE et. al., 2020) (Figure 2), following the order and criteria indicated in the tool.

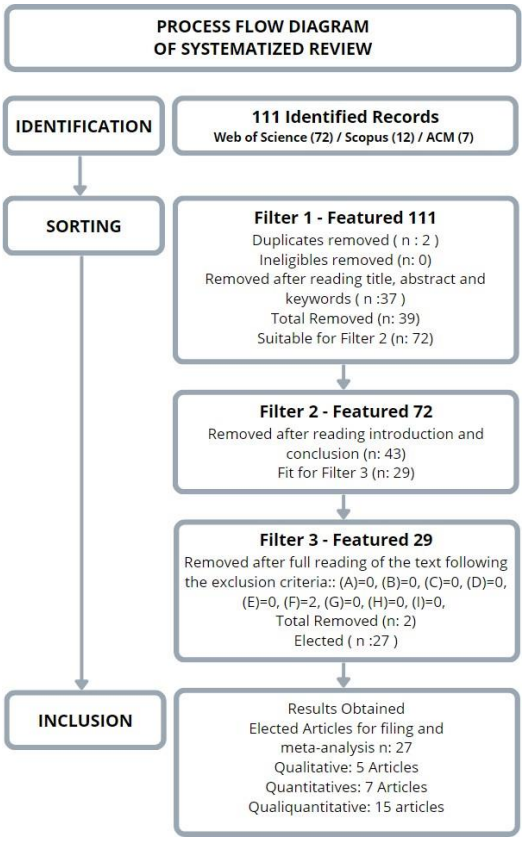

Figure 2: Flow diagram of the Systematized Review based on the PRISMA 2020 model, proposed by Page et al (2020). Source: The authors, 2022.

Finally, 27 articles were selected for filing, and meta-analysis investigations were carried out, according to the 7 steps proposed by Cooper (2010) - [1] Identification/ formulation of the research problem; [2] literature collection; [3] collection of information from each study; [4] evaluation of the quality of studies; [5] analysis and synthesis of study results; [6] interpretation of collected data; and [7] presentation of search results.

These data are presented in Table 2 in descending chronological order (from the most recent to the oldest - from 2021 to 2017) and by the number of citations.

Table 3 presents authors, titles, and university (abbreviated to Uni.),year/journal, DOI and the number of citations, based on Google Scholar data on June2, 2021.

Table 2: Selected works and citation numbers. Source: The authors, 2022.

Selected Works			Nº of cit.
1	Authors and Year	Ebnali, M. et al. (2021)	7
	Title	Virtual reality tour for first-time users of highly automated cars: Comparing the effects of virtual environments with different levels of interaction fidelity	
	DOI	ttps://doi.org/10.1016/j.apergo.2020.103226	
	University	University at Buffalo, Buffalo, USA	
2	Authors and Year	Nezami, FN. et al. (2021)	1
	Title	Westdrive X LoopAR: An Open-Access Virtual Reality Project in Unity for Evaluating User Interaction Methods during Takeover Requests.	
	DOI	https://doi.org/10.3390/s21	
	University	Universität Osnabrück, Germany	
3	Authors and Year	Li, JY. et al. (2021)	1
	Title	Rear-Seat Productivity in Virtual Reality: Investigating VR Interaction in the Confined Space of a Car	
	DOI	https://doi.org/10.3390/mti5040015	
	University	Media Informatics, Germany	
4	Authors and Year	Lou, XL. et al. (2021)	0
	Title	Hand-adaptive user interface: improved gestural interaction in virtual reality.	
	DOI	https://doi.org/10.1007/s10055-020-00461-7	
	University	College of Digital Media and Design, Hangzhou Dianzi University – CHINA	
5	Authors and Year	Chinazzo, G. et al. (2020)	5
	Title	Temperature-Color Interaction: Subjective Indoor Environmental Perception and Physiological Responses in Virtual Reality.	
	DOI	DOI: 10. 1177/ 0018 7208 19892383	
	University	Ecole Polytechnique Federale de Lausanne (EPFL), Switzerland	
6	Authors and Year	Pallavicini, F. et al. (2020)	8
	Title	What Is the Relationship Among Positive Emotions, Sense of Presence, and Ease of Interaction in Virtual Reality Systems? An On-Site Evaluation of a Commercial Virtual Experience	
	DOI	https://doi.org/10.1162/PRES_a_00325	
	University	University of Milano Bicocca, Italy	
7	Authors and Year	Felip, F. et al. (2020)	4
	Title	Influence of presentation means on industrial product evaluations with potential users: a first study by comparing tangible virtual reality and presenting a product in a real setting.	
	DOI	https://doi.org/10.1007/s10055-019-00406-9	
	University	Universitat Jaume I, Spain	
8	Authors and Year	Cho,Y. et al. (2020)	3
	Title	X-person asymmetric interaction in virtual and augmented realities	
	DOI	https://doi.org/10.1002/cav.1985	
	University	Korea Foundation for the Advancement of Science and Creativity	
9	Authors and Year	Springer, A. et al. (2020)	3
	Title	Progressive Disclosure: When, Why, and How Do Users Want Algorithmic Transparency Information?	
	DOI	https://doi.org/10.1145/3374218	
	University	University of California at Santa Cruz, USA	
10	Authors and Year	Li, ZX. et al. (2020)	1
	Title	Gaze-based Kinaesthetic Interaction for Virtual Reality.	
	DOI	doi: 10.1093/iwc/iwaa002	
	University	Faculty of Information Technology and Communication Sciences, Finland	
11	Authors and Year	La Scaleia, B. et al. (2020)	0
	Title	Visuomotor Interactions and Perceptual Judgments in Virtual Reality Simulating Different Levels of Gravity	
	DOI	doi: 10.3389/fbioe.2020.00076	
	University	University of Rome Tor Vergata, Italy	
12	Authors and Year	Oprea, S. et al. (2019)	17
	Title	A visually realistic grasping system for object manipulation and interaction in virtual reality environments.	
	DOI	DOI: 10.1016/j.cag.2019.07.003	
	University	Universidade de Alicante, Spain	
13	Authors and Year	Agullo, B. et al. (2019)	16
	Title	Making interaction with virtual reality accessible: rendering and guiding methods for subtitles	
	DOI	https://doi.org/10.1017/	
	University	Universitat Autònoma de Barcelona, Spain	
14	Authors and Year	Zibrek, K. et al. (2019)	14
	Title	Is Photorealism Important for Perception of Expressive Virtual Humans in Virtual Reality?	
	DOI	https://doi.org/10.1145/3349609	
	University	Trinity College Dublin, Ireland	
15	Authors and Year	Sun, LY et al. (2019)	10
	Title	Cross-objects user interfaces for video interaction in virtual reality museum context	
	DOI	http://doi.org/10.1007/s11042-018-6091-5	
	University	Zhejiang University, China	

Selected Works			Nº of cit.
16	Authors and Year	Krompiec, P. et al. (2019)	7
	Title	Enhanced Player Interaction Using Motion Controllers for First-Person Shooting Games in Virtual Reality	
	DOI	http://10.1109/ACCESS.2019.2937937	
	University	Chung-Ang University, South Korea	
17	Authors and Year	Kalarat, K. et al. (2019)	0
	Title	Real-Time volume rendering interaction in virtual reality	
	DOI	ttps://doi.org/10.14716/ijtech.v10i7.3259	
	University	Walailak University, Thailand	
18	Authors and Year	Yang, Y. et al. (2019)	3
	Title	A Human-Computer Interaction System for Agricultural Tools Museum Based on Virtual Reality Technology.	
	DOI	https://doi.org/10.1155/2019/2659313	
	University	College of Information and Electrical Engineering, China	
19	Authors and Year	WeiB, Y. et al. (2018))	5
	Title	2D, 3D or speech? A case study on which user interface is preferable for what kind of object interaction in immersive virtual reality.	
	DOI	DOI:10.1109/CW.2018.00021	
	University	Karlsruhe University of Applied Sciences e Ludwig Maximilian University of Munich, Germany	
20	Authors and Year	Hudson, S. et al. (2018)	95
	Title	With or without you? Interaction and immersion in a virtual reality experience	
	DOI	https://doi.org/10.1016/j.jbusres.2018.10.062	
	University	Rennes School of Business e Institut de Recherche Technologique - France	
21	Authors and Year	Han, D.T .et al. (2018)	36
	Title	Evaluating Remapped Physical Reach for Hand Interactions with Passive Haptics in Virtual Reality	
	DOI	DOI: 10.1109/TVCG.2018.2794659	
	University	University Texas, EUA	
22	Authors and Year	Nanjappan, V. et al. (2018)	14
	Title	User-elicited dual-hand interactions for manipulating 3D objects in virtual reality environments.	
	DOI	https://doi.org/10.1186/s13673-018-0154-5	
	University	Xi'an Jiaotong-Liverpool University, China	
23	Authors and Year	Debarba, H.G. et al. (2017)	74
	Title	Characterizing first and third person viewpoints and their alternation for embodied interaction in virtual reality.	
	DOI	https://doi.org/10.1371/journal.pone.0190109	
	University	Université de Bretagne Occidentale, France	
24	Authors and Year	Han, S. et al. (2017)	39
	Title	A Study on Immersion of Hand Interaction for Mobile Platform Virtual Reality Contents.	
	DOI	doi:10.3390/sym9020022	
	University	Catholic University of Pusan, South Korea	
25	Authors and Year	Tcha-Tokey, K.et al. (2017)	12
	Title	Effects on user experience in an edutainment virtual environment: Comparison between CAVE and HMD.	
	DOI	DOI: 10.1145, 3121253.3121254	
	University	Arts et Métiers ParisTech, France	
26	Authors and Year	Kang, J.et al. (2017)	8
	Title	Effect of Interaction Based on Augmented Context in Immersive Virtual Reality Environment	
	DOI	https://doi.org/10.1007/s11277-017-4954-0	
	University	Dankook University, South Korea	
27	Authors and Year	Ray, A.B. et al. (2017)	2
	Title	Creating an interaction interface to improve user engagement in virtual reality systems.	
	DOI	http://dx.doi.org/10.1080/09720510.2017.1395179	
	University	Department of Computer Science and Engineering National Institute of Technology Agartala, India	

Following the same order proposed in Table 2, the metadata table is presented below (Table 3), compiling information related to the authors and their respective titles, in addition to the analyzed dimensions, the nature of the research(qualitative, quantitative or quali/quanti approaches), sampling and protocols used for data collection.

Table 3: Metadata. Source: The authors, 2022.

Metadata Table		
1	Authors and Titles	Ebnali, M. et al. (2021)- Virtual reality tour for first-time users of highly automated cars: Comparing the effects of virtual environments with different levels of interaction fidelity
	Dimension	Rehabilitation and emotional dimension
	Nature	Qualitative/ Quantitative
	Sampling	97 participants
	Protocols	The Igroup Presence Questionnaire (IPQ), Escala Likert e Simulator Sickness Question-naire (SSQ).
2	Authors and Titles	Nezami, FN et al. (2021)- Westdrive X LoopAR: An Open-Access Virtual Reality Project in Unity for Evaluating User Interaction Methods during Takeover Requests
	Dimension	Usability
	Nature	Qualitative
	Sampling	11 participants
	Protocols	System Usability Score (SUS)
3	Authors and Titles	Li, JY et al. (2021). Rear-Seat Productivity in Virtual Reality: Investigating VR Interaction in the Confined Space of a Car
	Dimension	Usability and emotional dimension
	Nature	Qualitative/ Quantitative
	Sampling	33 participants
	Protocols	Escala Likert, Task Load Index (NASA-TLX) e The Igroup Presence Questionnaire (IPQ).

Metadata Table		
4	Authors and Titles	Lou, XL. et al. (2021). Hand-adaptive user interface: improved gestural interaction in virtual reality.
	Dimension	Tecnology precision/accuracy
	Nature	Quantitative
	Sampling	First sample 10 participants, second sample 2 participants
	Protocols	Slater Usoh - Steed presence Questionário (SUS-PQ), System Usability Scale (SUS), Scale from Borg (1982) e NASA TLX.
5	Authors and Titles	Chinazzo, G. et al (2020). Temperature-Color Interaction: Subjective Indoor Environmental Perception and Physiological Responses in Virtual Reality
	Dimension	Perception of colors and temperature
	Nature	Quantitative
	Sampling	57 participants
	Protocols	Quiz AD-HOC
6	Authors and Titles	Pallavicini, F. et al. (2020). What Is the Relationship Among Positive Emotions, Sense of Presence, and Ease of Interaction in Virtual Reality Systems? An On-Site Evaluation of a Commercial Virtual Experience
	Dimension	Emotional and sense of presence
	Nature	Quantitative
	Sampling	61 participants
	Protocols	Visual Analógic Escale (VAS) e UCL Presence Questionnaire
7	Authors and Titles	Felip, F. et al. (2020) Influence of presentation means on industrial product evaluations with potential users: a first study by comparing tangible virtual reality and presenting a product in a real setting
	Dimension	Semantic Dimension
	Nature	Quantitative
	Sampling	77 participants
	Protocols	Semantic Differential (DS) and Likert Scale
8	Authors and Titles	Cho, Y. et al. (2020). X-person asymmetric interaction in virtual and augmented realities.
	Dimension	Sense of presence and immersion
	Nature	Quantitative
	Sampling	20 participants
	Protocols	Game Experience Questionnaire (GEQ)
9	Authors and Titles	Springer, A. et al. (2020). Progressive Disclosure: When, Why, and How Do Users Want Algorithmic Transparency Information?
	Dimension	Emotional and usability
	Nature	Qualitative/Quantitative
	Sampling	Test 1 - 74 participants / Test 2 - 42 participants / Test 3 - 53 participants / Test 4 - 10 participants
	Protocols	E-meter, by Springer and Escala Likert.
10	Authors and Titles	Li, ZX et al. (2020). Gaze-based Kinaesthetic Interaction for Virtual Reality.
	Dimension	Interaction, usability and control
	Nature	Quantitative
	Sampling	32 participants
	Protocols	HandGaze – Touch
11	Authors and Titles	La Scaleia, B. et al. (2020). Visuomotor Interactions and Perceptual Judgments in Virtual Reality Simulating Different Levels of Gravity
	Dimension	Spatial and temporal perception
	Nature	Quantitative
	Sampling	16
	Protocols	AD-HOC questionnaire

Metadata Table		
12	Authors and Titles	Oprea, S. et al. (2019). A visually realistic grasping system for object manipulation and interaction in virtual reality environments.
	Dimension	Interaction and Usability
	Nature	Qualitative/Quantitative
	Sampling	10 participants
	Protocols	Qualitative questionnaire with 14 randomized questions, Likert Scale, Quantitative analysis conflicts and errors using proprietary software
13	Authors and Titles	Agullo, B et al. (2019). Making interaction with virtual reality accessible: rendering and guiding methods for subtitles
	Dimension	Accessibillity, usability and immersion
	Nature	Qualitative/Quantitative
	Sampling	8 participants
	Protocols	Igroup Presence Questionnaire (IPQ) and Ad Hoc Questionnaire
14	Authors and Titles	Zibrek, K et al. (2019). Is Photorealism Important for Perception of Expressive Virtual Humans in Virtual Reality?
	Dimension	Emotional
	Nature	Quantitative
	Sampling	797 participants
	Protocols	Likert Scale
15	Authors and Titles	Sun, LY et al. (2019). Cross-objects user interfaces for video interaction in virtual reality museum context
	Dimension	Apparent usability
	Nature	Qualitative
	Sampling	45 participants
	Protocols	Semi-structured interview e System Usability Scales
16	Authors and Titles	Krompiec, P. et al. (2019). Enhanced Player Interaction Using Motion Controllers for First-Person Shooting Games in Virtual Reality
	Dimension	Usability
	Nature	Qualitative/Quantitative
	Sampling	10 participants
	Protocols	Likert Scale
17	Authors and Titles	Kalarat, K. et al. (2019). Real-time volume rendering interaction in virtual reality
	Dimension	Usability
	Nature	Qualitative/Quantitative
	Sampling	20 participants
	Protocols	Execution of 17 tasks in 3 predefined interfaces and Likert Scale
18	Authors and Titles	Yang, Y et al. (2019). A Human-Computer Interaction System for Agricultural Tools Museum Based on Virtual Reality Technology
	Dimension	Emotional and apparent usability
	Nature	Qualitative
	Sampling	10 participants
	Protocols	AD-HOC questionnaire
19	Authors and Titles	WeiB, Y. et al. (2018). 2D, 3D or speech? A case study on which user interface is preferable for what kind of object interaction in immersive virtual reality
	Dimension	Usability
	Nature	Qualitative/Quantitative
	Sampling	30 participants
	Protocols	Predefined tasks and Likert Scale

Metadata Table		
20	Authors and Titles	Hudson, S. et al. (2018). With or without you? Interaction and immersion in a virtual reality experience
	Dimension	Apparent usability and emotional dimension
	Nature	Qualitative/Quantitative
	Sampling	Focus group: two sessions with 8 participants each Test: 234 participants
	Protocols	Focus group and questionnaire with Likert Scale
21	Authors and Titles	Han, D.T. et al. (2018). Evaluating Remapped Physical Reach for Hand Interactions with Passive Haptics in Virtual Reality
	Dimension	Apparent Usability
	Nature	Qualitative/Quantitative
	Sampling	First stage: 16 participants Second stage: 12 participants
	Protocols	AD-HOC questionnaire
22	Authors and Titles	Nanjappan, V. et al. (2018). User-elicited dual-hand interactions for manipulating 3D objects in virtual reality environments.
	Dimension	Apparent Usability
	Nature	Qualitative
	Sampling	12 participants
	Protocols	AD-HOC questionnaire
23	Authors and Titles	Debarba, HG et al. (2017). Characterizing first and third person viewpoints and their alternation for embodied interaction in virtual reality.
	Dimension	Apparent Usability
	Nature	Qualitative/Quantitative
	Sampling	48 participants
	Protocols	Galvanic Skin Response (GSR) and Mental Ball Drop (MBD).
24	Authors and Titles	Han, S. et al. (2017). A Study on Immersion of Hand Interaction for Mobile Platform Virtual Reality Contents.
	Dimension	Apparent Usability
	Nature	Qualitative/Quantitative
	Sampling	50 participants
	Protocols	Likert Scale
25	Authors and Titles	Tcha-Tokey, K. et al. (2017). Effects on user experience in an edutainment virtual environment: Comparison between CAVE and HMD.
	Dimension	User Experience
	Nature	Qualitative/Quantitative
	Sampling	21 participants
	Protocols	Presence Questionnaire (PQ), Immersive Tendencies Questionnaire (ITQ), Flow in education (Flow4D16 atual EduFlow2), Computer Self-Efficacy (CSE), Achievement Emotions Questionnaire (AEQ), System Usability Scale (SUS), Unified Theory of Acceptance and Use of Technology (UTAUT) and Perceived hedonic and pragmatic quality (AttracDift), Simulator Sickness Questionnaire (SSQ).
26	Authors and Titles	Kang, J. et al. (2017). Effect of Interaction Based on Augmented Context in Immersive Virtual Reality Environment
	Dimension	Apparent usability and emotional dimension
	Nature	Qualitative/Quantitative
	Sampling	30 participants
	Protocols	Evaluation questionnaire with 10 point scales
27	Authors and Titles	Ray, AB et al. (2017). Creating an interaction interface to improve user engagement in virtual reality systems
	Dimension	Apparent Usability
	Nature	Qualitative
	Sampling	34 participants
	Protocols	AD-HOC questionnaire

Result and Discussion

Initially, some articles with a significant rate of citations stand out: Hudson et al. (2018), with 95 citations; Debarba et al. (2017), with 74 citations; Han et al. (2017), with 39 citations; and Han et al. (2018), with 36 citations. This, within a short period of time (2017-2021), may suggest a growth in research interest in the area. Among these articles, 2 of them were developed in American universities, another 2 in France and another 2 in South Korea, evidencing the popularization of this research in different continents.

All institutions or research centers appeared only once in terms of number of published articles. This fact may suggest that research involving UX, HCI, Emotional Design and User-Centered Design, correlated to Virtual Reality, may be inearly stages or be a recent/new topic for these centers/institutions.

In addition, the frequency of publication by continent was identified. European countries appeared more frequently, being present in 14 articles. Asian countries appeared in 11 articles, and North American in 2 articles, while South American, African and Oceanian countries do not appear in the results. This fact may corroborate the idea presented by Ribeiro et al. (2020), regarding the possible research gap with exploration potential at the intersection between V.R. and Ergonomics.

It was observed that the distribution of research results found includes the countries of the northern hemisphere, which may also suggest a lack of research of this type in nations of the southern hemisphere, especially developing countries, such as Brazil and Argentina. Globally, the data presented indicate that the research interest in this technology is led by the countries present at the top of the World Innovation Index of 2021, an index that evaluates the registration of patents, investment in education, and productivity (Global Innovation Index, 2021).

Analyzing the metadata, a significant number of articles of Quantitative (7), Qualitative (5), and Qualitative and Quantitative (15) nature can be observed, which may indicate the need for a greater cross-referencing of the data. Most of the researchers sought not only to explain the reason behind the phenomena, but also to indicate statistical results to complement their work.

As for sampling, there is a large variation in the number of participants,varying according to the nature

of the research, ranging from compact samples (n = 8 participants for the qualitative method) to larger samples (n = 797 participants for the quantitative method). The article by Springer et al. (2020) worked with 4 hypotheses, tested in stages with four different samples (test 1 with 74 participants, test 2 with 42participants, test 3 with 53 participants and test 4 with 10 participants).

Regarding the dimensions evaluated, the ones that appear most frequently and prominently among the selected works are the emotional dimension, the usability of technology, and the apparent usability of the digital interface, involving the sense of presence, which may indicate a direction of focus of the research on these themes. The dimensions with the lowest frequency are user experience, spatial and temporal perception, and color and temperature perception. Among the protocols used in the selected articles, those that appear most frequently are the Likert Scale, The Igroup Presence Questionnaire (IPQ), and specific questionnaires developed on a case-by-case basis (AD-HOC).

Based on all the data collected in this review, there clearly is a research gap in the area, especially in the so-called developing countries. This technology could be better explored and used, especially in this new post-social isolation perspective, in which the hybrid system is becoming a constant in the teaching environment, at work and even in personal relationships.

The application of V.R. in research can provide a better understanding and analysis of the sensation of immersion and interaction with objects and virtualspaces, serving as an instrument for analysis of artifacts, environments, and projected situational conditions in which there is a desire to conduct studies. As an example, simulations of work activities, daily activities, leisure, social relationships, and even risk situations can be cited, which otherwise outside the V.R. could put the participant's life in danger (Ribeiro et al. 2020).

Possibilities are opening up here, such as the search for alternatives for data collection protocols without direct contact with the user, through the use of V.R. to emulate the interaction between human, product, and environment. For research in the field of UX and Design for Experience, V.R. can emerge as a viable tool, capable of assisting and complementing the methodological processes and qualitative and quantitative assessments already consolidated in physical laboratories.

Study limitations and Final Considerations

According to the elements presented in the tables and descriptions of theresults, it was possible to identify the dimensions of greatest research interest during this time frame, as well as the works that resulted in the highest number of citations, the most frequently used protocols and the identification of the main research centers in this area.

In addition, the development of an SLR contributed to the objective of ascertaining the state-of-the-art of this research topic. From this analysis, it was possible to observe that the researchers who study the relationship between human interaction and artifacts or environments, both real and virtual, are still in their early stages. The works found usually address dimensions of immersion and sense of presence, apparent usability, visuo-motor response, pleasantness and emotional dimension, applied separately in V.R.

No results were found that make direct comparisons of interactions between real and virtual environments in V.R. and that answer the research question stipulatedfor this review. Therefore, it was possible to partially answer the proposed question, thus listing new possibilities for research in the area that deepen studies on the theme.

Among the responses observed, it can be concluded that no studies were found that holistically address user interaction and artifacts, in a real and virtual laboratory environment (V.R.), within the emotional, semantic, and usability dimensions. It is proposed, with the points listed from this review, the possibility of studies that explore, in a deeper way, this research gap that permeates the fields of Design, Virtual Reality, and User Experience, in addition to their respective intersections (Figure 3).

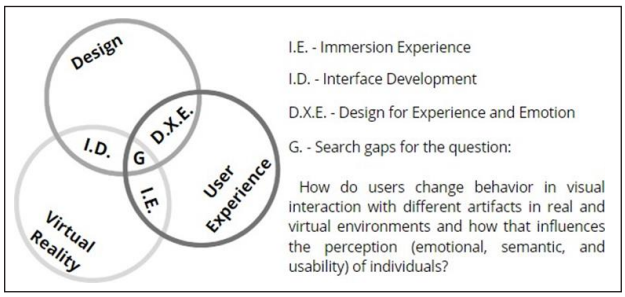

Figure 3: Gap and Tensions observed from the Systematized Bibliographic Review - SLR. Source: The authors, 2022.

The present research also has limitations such as the restricted time period (2021-2017), considering this cut from the year of launch of new V.R technologies. In addition, the study was limited to original articles, written in English, published in scientific journals indexed to the defined databases, with qualitative and quantitative results and with a sample of users considered healthy, aged between 18 and 60.

Works written in languages other than English, published as books or in annals of events, dissertations, course conclusion works, expanded reports or abstracts, not indexed in the defined databases, and outside the established time period were excluded, in addition to theoretical articles that do not present qualitative and/or quantitative results regarding user interaction with real and digital/virtual artifact/environment. Studies with participants belonging to children, the elderly or who have some level of physical disability or visual, cognitive,

intellectual and/or motor restriction, which do not meet the PICO eligibility criteria, were also excluded.

Finally, the possibilities derived from this research are highlighted. It isonsidered that the data presented here can help to encourage methodological proposals, helping the process of developing artifacts based on the principles and metrics of Design for Emotion and User Experience. It is also proposed that evaluations of services, environments, artifacts, and systems, still in the design phase, can be carried out in a laboratory environment developed in Virtual Reality.

Acknowledgements

This study was supported by: Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES (Processo 88887.603703/2021-00); Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq Brasil (Processo 304619/2018-3); Fundação de Amparo à Pesquisa e ao Desenvolvimento Científico eTecnológico do Maranhão - FAPEMA (Processo 012/2016-04206/2016); and Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio).

References

1. **Agulló, B.; Montagud, M.; Fraile, I**. Making interaction with virtual reality accessible: rendering and guiding methods for subtitles. Artificial Intelligence for Engineering Design, Analysis and Manufacturing 33, 416–428. DOI: https://doi.org/10.1017/S0890060419000362.
2. **Braga, Mariluci**. Realidade virtual e educação. Revista de biologia e ciências da terra, v. 1, n. 1, p. 0, 2001.
3. **Burdek, Bernhard E.**, Design. História, Teoria e Prática do Design de Produtos, Editora Blucher, 2 Edição, 2010.
4. **Caldas, Oscar I.; Aviles Oscar F.; Rodriguez-Guerrero, Carlos;** Effects of Presence and Challenge Variations on Emotional Engagement in Immersive Virtual Environments, Ieee Transactions on Neural Systems & Rehabilitation Engineering, Vol. XX, N°. X, November 2019, Authorized licensed use limited to: University of Exeter. Downloaded on May 03,2020.
5. **Chapman, J.** Emotionally Durable Design -Objects, Experiences and Empathy, First published by Earthscan in the UK and USA in 2005, Reprinted 2006, 2009, ISBN: 978- 1-84407-181-4
6. **Chinazzo, G.; Chamilothori, K.; Wienold, J.; Andersen, M.** Temperature-colorinteraction: subjective indoor environmental perception and physiological responses in virtual reality, Hum. Factors (2020), DOI: https://doi.org/10.1177/0018720819892383.
7. **Cho, Y.; Kim, J.** Production of Mobile English Language Teaching Application Based on Text Interface Using Deep Learning. Electronics 2021, 10, 1809. DOI: https://doi.org/10.3390/ electronics10151809
8. **Crossan, Mary; Apaydin, Marina.** A Multi-Dimensional Framework of Organizational Innovation: A Systematic Review of the Literature. Journal of Management Studies, v. 47, issue 6, p. 1154-1191, 30 set. 2009. Blackwell Publishing Ltd and Society for the Advancement of Management Studies doi: 10.1111/j.1467-6486.2009.00880.x. 2009.
9. **Cooper, H.** . Research synthesis and meta-analysis: A step-by-step approach (3. ed.). Thousand Oaks, CA: Sage. (2010).
10. **Debarba, H. G., Bovet, S., Salomon, R., Blanke, O., Herbelin, B., & Boulic, R. (2017).** Characterizing first and third person viewpoints and their alternation for embodied interaction in virtual reality. PLoS ONE 12(12): e0190109. DOI: https://doi.org/10.1371/journal.pone.0190109
11. **Desmet, P. M. A.; Hekkert, P.; Jacobs, J.** When a car makes you smile: development and application of an instrument to measure product emotions. In: HOCH & MEYER (eds.) Advances in consumer research, 27, 2000, p.111-117.
12. **Desmet, P.** Designing emotions. Delft, The Netherlands. Tese de Doutorado. Delft University of Technology, 225 p. 2002.
13. **Desmet, P.; Dijkhuis, E.** A Wheelchair can be Fun: A Case of Emotion-driven Design, Proceedings of the 2003 International conference on Designing pleasurable products and interfaces, ACM, Pittsburgh-Nova York, 2003, p. 22-27. 125
14. **Ebnali, M. et al.** Virtual reality tour for first-time users of highly automated cars: Comparing the effects of virtual environments with different levels of interaction fidelity. Applied Ergonomics 90 (2021) 103226, DOI: https://doi.org/10.1016/j.apergo.2020.103226
15. **Facin, Heloisa, 2016,** Saiba o que esperar dos óculos de realidade virtual nos próximos anos. acesso em 20/09/2021. Disponível em: https://www.techtudo.com.br/noticias/noticia/2016/10/saiba-o-que-esperar-dos-oculo s-de-realidade-virtual-nos-proximos-anos.html
16. **Felip, F. et al.** Influence of presentation means on industrial product evaluations with potential users: a first study by comparing tangible virtual reality and presenting a product in a real setting. Virtual Reality, 2019, p. 1-13 DOI: https://doi.org/10.1007/s10055-019-00406-9
17. **Global Innovation Index.** GII 2021 at a glance. Disponível em: <https://www.globalinnovationindex.org/userfiles/file/reportpdf/GII-2021/GII_at_a_ glance.pdf> Acesso em: 25 de outubro de 2021
18. **Han, D. T. et al.** Evaluating remapped physical reach for hand interactions with passive haptics in virtual reality. IEEE Transactions on Visualization & Computer Graphics, Vol. 24, Nº4, April, 2018. DOI: https://doi.

org/10.1109/TVCG.2018.2794659

19. **Han, S.; Kim, J.** A Study on Immersion of Hand Interaction for Mobile Platform Virtual Reality Contents. Symmetry 2017, 9(2), 22; DOI: https://doi.org/10.3390/sym9020022
20. **Hudson, S. et al. (2019).** With or without you? Interaction and immersion in a virtual reality experience. Journal of BusinessResearch, Volume 100, July 2019, Pages 459-468, DOI: https://doi.org/10.1016/j.jbusres.2018.10.062
21. **Iida, I.; Guimarães, L. B. M.** Ergonomia: projeto e produção. 3. ed. São Paulo: Blucher, 2016.
22. **Jerald, Jason.** The VR book: human-centered design for virtual reality Morgan & Claypool, 2015.
23. **Jordan, P.** Pleasure with products: Human factors for body, mind and soul. In: W.S. GREEN; P.W. (eds.), Human factors in product design: Current practice and future trends. London, Taylor & Francis, p. 206-217, 1999.
24. **Jordan** (eds.), Human factors in product design: Current practice and future trends. London, Taylor & Francis, p. 206-217.1999.
25. **Kalarat, K.; Koomhin, P.** Real-time volume rendering interaction in virtual reality. International Journal of Technology 10(7): 1307-1314, ISSN 2086-9614, July 2019, Permalink, DOI: https://doi.org/10.14716/ijtech.v10i7.3259
26. **Kang, J.** Effect of interaction based on augmented context in immersive virtual reality environment. Wireless Personal Communications, 98(2), 1931–1940. DOI: https:// doi.org/10.1007/s11277-017-4954-0
27. **Krompiec, P.; Kyoungju, P. (2019).** Enhanced Player Interaction Using Motion Controllers for First-Person Shooting Games in Virtual Reality. IEEE Access 7 (2019), 124548–124557. DOI: http://dx.doi.org/10.1109/ACCESS.2019.2937937
28. **La Scaleia, B.; Ceccarelli, F.; Lacquaniti, F.; Zago, M. (2020)** Visuomotor Interactions and Perceptual Judgments in Virtual Reality Simulating Different Levels of Gravity. Front. Bioeng. Biotechnol. 8:76. DOI: http://doi.org/10.3389/fbioe.2020.00076
29. **Li, J.; George, C.; Ngao, A; Holländer, K.; Mayer, S.; Butz, A.** Rear-Seat Productivity in Virtual Reality: Investigating VR Interaction in the Confined Space of a Car. Multimodal Technol. Interact. 2021, 5, 15. DOI: https://doi.org/10.3390/ mti5040015
30. **Li, Z.; Akkil, D.; Raisamo, R.** Gaze-based kinaesthetic interaction for virtual reality. Interacting with Computers, Volume 32, Issue 1, January 2020, Pages 17–32, DOI: https://doi.org/10.1093/iwcomp/iwaa002.
31. **Lobach, B.** Design industrial: bases para a configuração dos produtos industriais. São Paulo: Edgard Blucher, 2001.
32. **Lou, X. et al.** Hand-adaptive user interface: improved gestural interaction in virtual reality. Virtual Reality 25, 367–382 (2021). DOI: https://doi.org/10.1007/s10055-020-00461-7
33. **Methley, Abgail M. et al.** PICO, PICOS and SPIDER: a comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. BMC health services research, v. 14, n. 1, p. 1-10, 2014.
34. **Nanjappan, V. et al.** User-elicited dual-hand interactions for manipulating 3D objects in virtual reality environments. Human-centric Computing and Information Sciences volume 8, Article number: 31, 2018. Published: 29 October 2018. DOI: https://doi.org/10.1186/s13673-018-0154-5
35. **Nezami, F.N. et al.** Westdrive X LoopAR: An Open-Access Virtual Reality Project in Unity for Evaluating User Interaction Methods during Takeover Requests. Sensors 2021, 21, 1879. DOI: https://doi.org/10.3390/s21051879
36. **Oprea, S. et al.** A review on deep learning techniques for video prediction. IEEE Transactions on Pattern Analysis and Machine Intelligence, 15 December 2020, pages 1 - 1, DOI: http://doi.org/10.1109/TPAMI.2020.3045007
37. **Page, Matthew. J. et al.** The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. MetaArXiv. 2020.
38. **Pallavicini, F.; Pepe, A.; Ferrari, A.; Garcea, G.; Zanacchi, A.; Mantovani, F. (2020).** What is the relationship among positive emotions, sense of presence, and ease of interaction in virtual reality systems? An on-site evaluation of a commercial virtual experience. Virtual and Augmented Reality, 27(2), 183–201. DOI: https://doi. org/10.1162/pres_a_00325.
39. **Ray, A.; Deb, S.; Devi, S.** Creating an interaction interface to improve user engagement in virtual reality systems. Journal of statistics & management systems, 2017, 20(4):593–600. DOI: 10.1080/09720510.2017.1395179 .
40. **Ribeiro, Daniel**, Dica para TCCs: 7 melhores sites de pesquisa acadêmica, Disponivel em: https://www.techtudo.com.br/listas/2018/03/dica-para-tccs-7-melhores-sites-de-pesq uisa-academica.ghtml, acesso em: 06/10/2021.
41. **Ribeiro, Luiz Ricardo Gonzaga; Menegon, Nilton Luiz; Camarotto, João Alberto.** Realidade Virtual aplicada à projetos em Ergonomia: revisão sistemática da literatura, XL Encontro Nacional De Engenharia De Produção "Contribuições da Engenharia de Produção para a Gestão de Operações Energéticas Sustentáveis" Foz do Iguaçu, Paraná, Brasil, 20 a 23 de outubro de 2020.
42. **Springer, A.; Whittaker, S.** Progressive Disclosure: When, Why, and How Do Users Want Algorithmic Transparency Information? ACM Trans. Interact. Intell. Syst. 10, 4, Article 29 (October 2020), 32 pages. DOI: https://doi.org/10.1145/3374218
43. **Sun, L.; Zhou, Y.; Hansen, P.; Geng, W.; Li, X. (2018).** Cross-

objects user interfaces for video interaction in virtual reality museum context. Multimedia Tools and Applications, 77(21), 29013–29041. DOI: hepperhttps://doi.org/10.1007/s11042-018-6091-5

44. **Tcha-Tokey, K.; Loup-Escande, O. Christmann, S. Richir.** Effects on user experience in an edutainment virtual environment Proceedings of the European conference on cognitive ergonomics. 2017—ECCE 2017, ACM, New York, NY, USA (2017), pp. 1-8, DOI: https://doi.org/10.1145/3121283.3121284
45. **Tonetto, Leandro Miletto; Costa, Filipe Campelo da Xavier.** Design emocional: conceitos, abordagens e perspectivas de pesquisa. Strategic Design Research Journal, v. 4, n. 3, p. 132-140, 2011.
46. **Tori, Romero; Hounsell, Marcelo da Silva; Kirner, Claudio.** Realidade Virtual; in : Introdução a Realidade Virtual e Aumentada. 3. ed. Porto Alegre: Editora SBC, 2020, Capítulo 1, pg 28.
47. **Weiß, Y.; Hepperle, D.; Sieß, A.; Wolfel, M.** What user interface to use for virtual reality? 2d, 3d or speech–a user study. In 2018 International Conference on Cyberworlds (CW), pp. 50–57. IEEE, 2018. DOI: https://doi.org/10.1109/CW.2018.00021
48. **Wu, M.; Ting, P.; Tang, Y.; Chou, E.; Fu, L.** Hand pose estimation in object-interaction based on deep learning forvirtual reality applications. Journal of Visual Communication and Image Representation, 2020, 70: 102802. DOI: https://doi.org/10.1016/j.jvcir.2020.102802
49. **YANG, Y.; FAN, Y.; SUN, R.** A Human-Computer Interaction System for Agricultural Tools Museum Based on Virtual Reality Technology. Adv. Multimed. 2019, Volume 2019, Paginas 1–15. DOI: https://doi.org/10.1155/2019/2659313
50. **Zibrek, K.; Martin, S.; Mcdonnell, R. (2019).** Is photorealism important for perception of expressive virtual humans in virtual reality? ACM Transactions on Applied Perception, 16(3). DOI: https://doi.org/10.1145/3349609