Tendencias y características de la realidad virtual: Una revisión de la literatura entre los años 2017 y 2018

Trends and features of virtual reality: A literature review between 2017 and 2018

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Resumen— La realidad virtual ha tenido una gran evolución desde la década de 1960 hasta el día de hoy. Se ha implementado en múltiples áreas, tanto de la investigación como del conocimiento, siendo más reconocida en la industria del entretenimiento. Con el propósito de establecer el estado de la realidad virtual y obtener una idea de su futuro, 537 documentos científicos han sido revisados aplicando criterios de búsqueda específicos, como realidad virtual aplicada a la educación. Un análisis bibliométrico fue realizado, teniendo como base un resumen y descripción de cada artículo, así como sus palabras claves y tendencias, procediendo a categorizar cada documento de acuerdo con su campo de aplicación. Se encontró que la realidad virtual tiene una gran relevancia en la medicina, industria militar y en el entrenamiento de personas, debido a su capacidad de simular situaciones difíciles y, sobre todo, condiciones específicas requeridas por instructores. El futuro de la realidad virtual como herramienta de entrenamiento para los profesionales de múltiples áreas es promisorio

Palabras clave— Análisis bibliométrico; educación; evolución de la realidad virtual; tendencias; realidad virtual

Abstract— Virtual Reality has greatly evolved since the 1960´s to the present. It has been implemented in multiple research and knowledge areas, the most recognized being the entertainment industry. In order to establish the state of Virtual Reality and get an idea of its prospects, 537 scientific documents have been reviewed, applying search criteria, more specifically, Virtual Reality applied to education. A bibliometric analysis was realized based on summarizing each document, as well as its keywords and trends, then proceeding to categorize each one, according to the field of application. It was found that Virtual Reality is having relevance in medicine and training area, due to the ability to simulate difficult situations and above all, specific conditions raised by instructors. The future of Virtual Reality as a tool to train professionals in multiples areas is promising.

Keywords— Bibliometric Analysis; education; trends Virtual reality; virtual Reality Evolution

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I. Introducción

La *Realidad Virtual* o RV ha experimentado un gran avance, desde que Iván Sutherland propuso experimentar las sensaciones del mundo real a través de un mundo virtual [1]. Se ha recorrido un largo camino desde aquellos dispositivos montados en la cabeza de un usuario con base en CRT (Tubo de Rayos Catódicos) [2], hasta la complejidad y precisión de los últimos lanzamientos para que un usuario disfrute un ambiente virtual como son el Oculus Rift o HTC VIVE (Visores de realidad virtual), que actualmente han salido del ámbito del entretenimiento y han incursionado en múltiples áreas, como múltiples revisiones de literatura han constatado [22], [40].

El primer sistema computarizado usado para realizar una simulación fue la computadora Whirlwind [3], [4], un trabajo conjunto entre el MIT (Massachusetts Institute of Technology) y la Fuerza Aérea de los Estados Unidos (USAF), el cual se inició en 1945 y se prolongó hasta 1959 [5], con el fin de simular las rutas de las aeronaves.

Se puede atribuir a Morton Heilig el desarrollo de los primeros dispositivos simuladores multisensoriales, llamados *Sensoramas*, los cuales eran cabinas con películas pregrabadas, las cuales iban acompañadas de elementos (como aromas y vibraciones) que incrementaban la experiencia del espectador [6].

Para 1961, fue desarrollado por la corporación PHILCO (Philadelfia Storage Battery Company) un Dispositivo Montado en la Cabeza o HMD, llamado "Headsight", el cual podía seguir los movimientos de la cabeza de un usuario, utilizando unas pantallas pequeñas para cada ojo, y conectado a un circuito cerrado de televisión [2]. Sin embargo, fue Sutherland quien propuso el concepto de un *mundo virtual computarizado* que pudiera simular todas las características del mundo real y además pudiera ser interactivo para el usuario: "The Ultimate Display". El mismo Sutherland en 1968 desarrollo un dispositivo ubicado en la cabeza de un espectador, con el cual podía ver imágenes, el cual llamaría "The Sword of Damocles" y se podía acoplar a los movimientos realizados por quien lo usara, para así mantener la inmersión [2], [7].

El siguiente avance se produjo de la mano de la Universidad de Carolina del Norte (UNC), la cual empezó a desarrollar en 1967 un sistema que pudiera recibir retroalimentación, el cual se llamó "Proyect Grope", y consista en una interfaz o pantalla que mostraba cambios al recibir una manipulación de un usuario mediante un Joystick (palanca de mando) [8].

Myron Krueger creo en 1975, un sistema que reflejaba las siluetas de los usuarios, que eran capturadas mediante cámaras, para luego ser reflejadas mediante un proyector en una pantalla como una imagen 2D. Este sistema conocido como "Videoplace" también permitía la interacción de las imágenes reflejadas por la interfaz, así como la interacción con objetos virtuales [9], [10].

En 1977, Dean Kocian, ingeniero del Laboratorio de Investigaciones Médicas Amstrong de la USAF, presento un modelo de dispositivo vestible para la cabeza de un usuario, llamado "VCASS", cuya fabricación inició en 1982, para ayudar al entrenamiento de los pilotos, posibilitando la visualización de objetivos y optimizando sus rutas de vuelo, mediante un sistema muy similar a lo que se conoce el día de hoy como *Realidad Aumentada* [11]. A finales de la década de 1980, la base de la Fuerza Aérea estadounidense Wright-Patterson siguió el mismo patrón que había iniciado Kocia, y empezó a entrenar a sus pilotos usando la RV, bajo el proyecto denominado "Super Cockpit" [2]

En 1984, el Centro de Investigaciones Ames de la NASA (Administración Nacional de Aeronáutica y el Espacio), observo el potencial de la RV e imagino múltiples beneficios como el poder experimentar los planetas y sus características mediante el uso de la RV, y diseño un dispositivo montado en la cabeza o HMD, junto con una silla especial para incrementar el nivel de inmersión del usuario [12]. Además, el Centro Espacial Johnson de la NASA también empezó a entrenar a sus astronautas usando la RV a finales de la década de 1980 [2].

El avance en RV continuo, y así, en 1985, la compañía VPL Research, fundada por antiguos empleados de Atari, entre ellos Jason Lanier, a quien se le atribuye el término "Realidad Virtual", fabrico y puso a la venta los primeros dispositivos de RV, disponibles comercialmente como el Dataglove y Eyephone HMD. Sin embargo, estos dispositivos no consiguieron las ventas suficientes, razón por lo cual la compañía se declaró en quiebra en 1990 [10]. Pronto le siguió la compañía Fake Space Labs, comercializando para 1989 un dispositivo llamado BOOM (Binocular Omni-Oriented Monitor), el cual consistía en un dispositivo parecido a unos binoculares con pantallas CRT para cada ojo, unidos a un soporte mecánico, y permitía al usuario poder manipularse de forma simple [13]. El Centro Ames de la NASA empleo dos de los dispositivos antes mencionados, específicamente el BOOM y el VPL Dataglove a fin de realizar una simulación en RV de un túnel de viento, obteniendo resultados

que demostraban algunos aspectos a mejorar desde la parte técnica del hardware, pero vaticinaban el potencial que tenía las aplicaciones en RV para los científicos e ingenieros [14].

Mientras tanto la UNC, inicio el llamado "Walktrought Project" en 1986, el cual pretendía hacer que un espectador experimentara la arquitectura de ciertas edificaciones en RV. El proyecto tardó 6 años y demostró resultados prometedores, además de un análisis de las limitaciones técnicas de la fecha [15].

Por 1992, sale a la luz el Ambiente Virtual Automatizado — CAVE — (tiene su nombre en alegoría al escrito de Platón "La Cueva"), y consiste en un cuarto cerrado parecido a un cubo, el cual posee entre 3 y 6 proyectores, cada uno de estos ubicado detrás de una pared. Un usuario se ubica en la mitad del cuarto usando unas gafas de LCD (no confundir con HMD) para poder experimentar lo que ofrece CAVE [6], [16].

No tardó mucho en surgir un concepto derivado de la RV, y es la conocida Realidad Aumentada o RA, presentada para 1993 (aunque ya se habían dado casos de usos básicos como se mencionó antes), y consistía en una tecnología diseñada para ayudar, mediante la superposición de objetivos virtuales tridimensionales en el mundo real, a acrecentar el campo de visión de un usuario, sin reemplazarlo, como ocurre con la RV. Esto se logra a través de diferentes tipos de dispositivos como gafas y HMD´s [17], [18].

Se resaltan los aportes de la industria de videojuegos al avance y masificación de los dispositivos de RV. Por ejemplo, la compañía Sega empezó en 1991 el desarrollo de unos HMD para el negocio de consolas caseras (Sega VR Headset) y para arcades o máquinas recreativas. Se esperaba que vieran la luz en 1993, sin embargo, Sega canceló el proyecto.

La compañía que logró lanzar una consola basadada en RV, fue Nintendo en 1995, denominada el Virtual Boy. Esta consola constaba de un dispositivo parecido a un HMD, pero apoyado sobre un soporte unido a un control. La consola no duro mucho tiempo, debido a sus bajas ventas, considerada un fracaso. Sin embargo, la compañía nipona volvió a lanzarlo basándose en efectos estereoscópicos en 3D, la conocida consola portátil Nintendo 3DS, con la ventaja que no requería gafas para estos efectos y además contaba con funciones de RA.

Desde 2009, el empresario Palmer Luckey fue trabajando en el desarrollo de un dispositivo para RV que tuviera mejores capacidades técnicas y mejores precios, dando como resultado el desarrollo y posterior lanzamiento del Oculus Rift. Es correcto decir entonces que, desde este punto se inició la carrera de masificación de los dispositivos de RV, a la que también se unieron el conglomerado japonés Sony al lanzar la PlayStation VR en 2014, la compañía taiwanesa HTC con HTC VIVE en 2015 y múltiples otros dispositivos. En 2019 se lanzó el dispositivo Oculus Rift´S que presentaba ventajas técnicas sobre su predecesor y para 2020 se anunció el Oculus Quest 2, el cual seria lanzado en el año 2021.

Actualmente, la RV se encuentra en múltiples campos, no solo en el entretenimiento, siendo algunos otros campos como la medicina, la ingeniería y la educación [19], [20], así como el área militar [2]; y es de esperarse que la tendencia de la RV como herramienta didáctica o de entretenimiento no se detenga. Lo anterior se sustenta en los comprobados beneficios del uso de entornos basados en RV para la enseñanza en diferentes áreas [21]-[23]. Se destaca su aplicación y relevancia en ambientes y espacios de difícil acceso o donde los niveles de riesgo en la realidad sean elevados. De esta forma la RV permite la capacitación del recurso humano ante escenarios adversos donde el individuo requiera una preparación especial [24], destacando como relevantes los ambientes de alto riesgo y los campos de acción de la medicina [25].

Al hacer posible practicas más constantes, y más inmersivas, se puede solucionar así, uno de los problemas que aqueja a varias naciones, y es la falta de una correcta preparación de profesionales y estudiantes. Este es un problema que afecta a las naciones, y se ha relacionado el bajo nivel de entrenamiento para la vida laboral de las personas con un Bajo Índice de Innovación (GII), el cual es un indicador de la capacidad de un país para innovar [26].

Es por estos aspectos que el objetivo de este artículo es entonces, el brindar una idea sobre las áreas del conocimiento que están ofreciendo las mayores posibilidades de desarrollo para esta tecnología o cuales están aprovechando la Realidad Virtual (RV) como herramienta didáctica, así como cuales son los países que dedican más recursos a la investigación de los beneficios de la RV.

A. *El concepto moderno de realidad virtual*

El concepto de RV ha evolucionado desde su incepción en 1965, cuando Iván Sutherland declaro las bases de un mundo virtual, donde sistemas electrónicos pudieran simular en cierto grado la realidad [1]. Gracias a los avances tecnológicos el concepto de RV empieza a agregar conceptos más técnicos (Fig. 1). En la década de 1990, empiezan a aparecer conceptos más técnicos y como ejemplo es la definición de Fuchs y Bishops, al describir la VR con términos como "Interacción en tiempo real", "modelos 3D" y "tecnología de pantalla" [27].

Si bien diferentes autores expresan diferentes conceptos de RV, se puede destacar 3 elementos que caracterizan la definición de esta: *Inmersión* o la capacidad de recrear fidedignamente un ambiente y en algunos casos, a nosotros mismos, *Percepción* o la capacidad de lleva a un usuario a ese ambiente, e *Interacción*, o la capacidad de poder manipular ese mundo simulado por parte de un usuario y obtener retroalimentación de ello, o bien, que el mundo simulado actué sobre el usuario y este obtenga retroalimentación por ello [28]–[30].

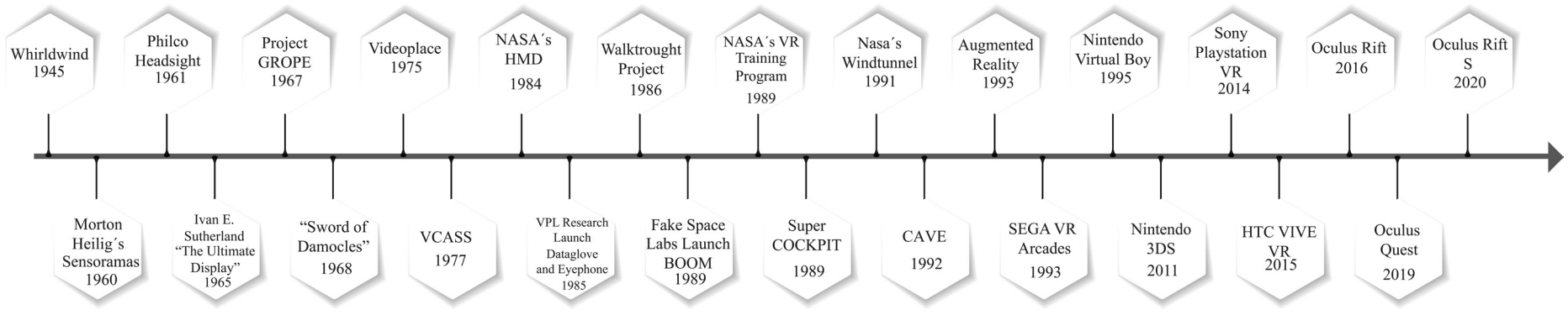

Fig. 1. Línea de tiempo Realidad Virtual
Fuente: Autores.

B. *Diferencia entre realidad virtual y realidad aumentada*

Si bien el avance de la RA ha ido de la mano con la RV, podemos remontarnos al año 1993 donde la RA es mostrada como una tecnología diferente a la RV, la cual consistía, no en reemplazar el mundo de un usuario, sino de incrementar el mundo real de un usuario. Este hecho se dio mediante el uso de unas gafas y HMD´s [17], [18], el cual se puede considerar la gran diferencia entre RV y RA. Es entonces que la RA trata de enriquecer el mundo alrededor de nosotros mediante la combinación del mundo real y de imágenes generadas por maquinas [31].

Un definición reciente de Klopfer & Squire sugiere que la AR puede ser considerada como una situación que entremezcla mundos reales, siendo el mundo real, sobrepuesto de forma dinámica por un mundo virtual o información virtual [32]. Estas situaciones pueden ser generadas mediante múltiples tipos de tecnologías, tales como HMD´s, ordenadores y dispositivos móviles, entre otros [33].

II. Aplicaciones de Realidad Virtual en Escenarios de Alto Riesgo (Nuclear, Salud Humana, Exploración Submarina)

La RV, junto con otras tecnologías afines, ha generado un impacto positivo a los métodos de enseñanza tradicionales [34], observando y documentando beneficios en el aprendizaje [35]. Un caso en específico es un estudio realizado en el 2002 [36], donde quedo demostrado que los estudiantes al utilizar la RV como herramienta de entrenamiento, tuvieron significativos beneficios sobre aquellos estudiantes que no la emplearon. La RV ayuda a los estudiantes el poder practicar complejos procedimientos médicos sin riesgo alguno para el paciente [25]. Otro ejemplo en la medicina es el uso de RV para el estudio y análisis en un ambiente virtual de un tipo de cáncer a un paciente, con el fin de determinar las medidas correctas para un tratamiento eficiente [37].

La RV también ha mostrado ser una herramienta eficiente para ayudar a los estudiantes a instruirse en el manejo de objetos o situaciones peligrosas. Un ejemplo de esto es la utilización de la RV para enseñar a personas el manejo de desperdicios nucleares en instalaciones nucleares [38], evitando exponer con este tipo de procedimiento a personas sin practicas previas. Así mismo, también se ha propuesto el uso de la RV para el estudio de la seguridad en las instalaciones nucleares a fin de hacer más eficientes estos procesos [39].

III. Análisis Bibliométrico

A. *Método de recolección de información*

Al aplicar métodos matemáticos y estadísticos a cierta recopilación de material científico y a autores, es posible encontrar ciertos patrones que nos pueden indicar la tendencia de cierta área, el avance de un campo o cuales autores son los más citados. A esto lo podemos llamar *Análisis Bibliográfico*, y existen múltiples técnicas y herramientas tecnológicas cuyo fin es ayudar a conseguir poder analizar la información y encontrar cualquier fenómeno que consideremos relevante [40]-[43].

El *factor de impacto* (o índice de impacto) demuestra la importancia que tiene una publicación en la comunidad científica. Entre mayor es el número de citaciones de una revista o artículo, mayor es el impacto que este ha obtenido en el área pertinente [43]-[45]. La idea del *factor de impacto* fue concebida en 1955, por Eugene Garfield [43],

[44]. Para calcular el impacto de una publicación, se debe realizar después de 2 años de establecer una fecha, es decir, se calcula mediante la siguiente formula (1):

$$Impacto\ en\ el\ a\ \ o\ Z \quad \frac{A+B}{C \quad D} \tag{1}$$

Donde:

Z: es el año que se desea medir.
A: son las veces en el que los artículos publicados por una determinada revista en el año X han sido citados.
B: son las veces en que los artículos de una determinada revista han sido citados.
C: es el número de artículos publicados por la revista en el año *X*.
D: es el número de artículos publicados por la revista en el año *Y*.
X: es el número que se obtiene al restar el año que se desea medir menos 2.
Y: es el número que se obtiene al restar el año que se desea medir menos 1.

Si se desea medir el impacto de una publicación en el año 2015, se debe tener el número de citaciones que ha tenido una revista en el 2015, de los artículos publicados en el 2013 y 2014, y dividirlo entre el número de artículos publicados por la misma revista en los años 2013 y 2014.

El *índice h* presenta otra manera para medir el impacto que ha tenido alguna persona en la comunidad científica mediante un cálculo, entre el número de citaciones que ha obtenido un determinado autor y el número de publicaciones que ha realizado el mismo [42]-[45]. Este sistema fue propuesto por Jorge Hirsch en el año 2005 [45] como método de medición, tanto de calidad como de cantidad de publicaciones de un autor.

Se siguieron una serie de pasos básicos para la selección de artículos científicos:

Primero se estableció cuales palabras claves cumplían los criterios necesarios. Para poder proceder a realizar un algoritmo debían contener al menos dos factores claves para ser elegidos: RV (temas sobre ambientes virtuales) y Educación (o relacionados con enseñanza).

Se analizaron los motores de búsqueda especializados a fin de determinar cuál o cuáles podrían brindar una línea de resultados acorde con lo que se desea. Y se determino que por sus contenidos se usaría el motor de búsqueda digital Web of Science (WoS).

Una vez determinadas las palabras claves y las bases de datos especializadas a emplear, se procedió a la búsqueda de la información dando preferencia a aquellos artículos que estuvieran relacionados con el tema y cumplieran con tener las palabras claves. Si bien se dio preferencia a la palabra clave *Virtual Reality*, se observaron y se tuvieron en cuenta aquellos artículos que tuvieran en su haber la palabra clave *Virtual Enviroment*, ya que estas podrían brindar información suficiente e importante.

B. *Colección de datos y tratamientos*

Para la recolección de datos, se realizó una búsqueda con los criterios de búsqueda correspondiente a la Fig. 2. Esta búsqueda se llevó a cabo en noviembre de 2018 y se obtuvieron 1.688 resultados en el compendio científico en línea WoS utilizando la cadena de búsqueda en el idioma inglés. Se procedieron a elegir artículos que hubieran sido publicados en el periodo comprendido entre enero 2017 y noviembre 2018, es decir, un periodo de 23 meses. Esto arrojo como resultado 279 documentos científicos elegibles, los cuales fueron sido publicados en 2017 y 258 documentos científicos publicados en los 11 primeros meses de 2018, lo que da un total de 537 elementos utilizables.

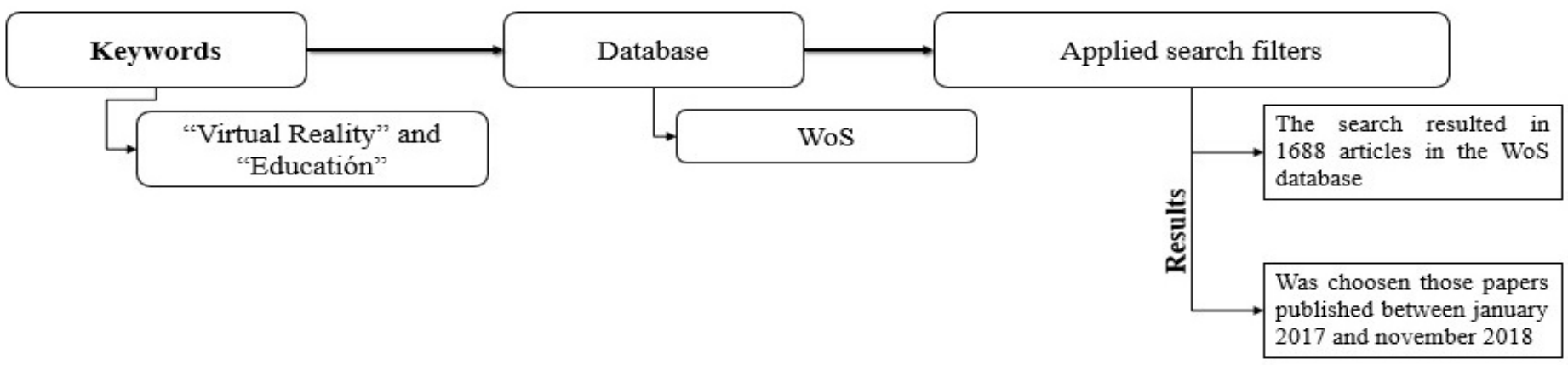

Fig. 2. Diagrama de bloques con criterios de búsqueda (Inglés)
Fuente: Autores.

C. *De las publicaciones seleccionadas*

Para el análisis de la procedencia de los artículos, se decidio estudiar el origen de cada artículo, así como la nacionalidad de cada autor, y si es un artículo desarrollado por más de una nación (es decir, documentos científicos como resultado del trabajo de autores o instituciones de diferentes). Se encontró que, de las 537 publicaciones recolectadas, 510 son publicaciones en el idioma inglés (94.98 %), mientras que hay 9 publicación en español (1.68 %),7 publicación en portugués (1.30 %), 4 publicaciones en alemán (0.74 %), 2 publicaciones en húngaro (0.37 %), 2 publicaciones en ruso (0.37 %), 2 publicaciones en chino (0.37 %) y como último, 1 publicación en francés (0.19 %). Estos datos se pueden observar en la Tabla I.

TABLA I.
IDIOMA DE LAS PUBLICACIONES.

Idioma	Numero de Publicaciones	Porcentaje
Inglés	510	94.98 %
Español	9	1.68 %
Portugués	7	1.30 %
Alemán	4	0.74 %
Húngaro	2	0.37 %
Ruso	2	0.37 %
Chino	2	0.37 %
Francés	1	0.19 %

Fuente: Autores.

Además, de las 537 publicaciones mencionadas, 431 corresponden a *articles* (80.26 %), 68 corresponden a *reviews* (12.67 %), 21 corresponden a *proceedings papers* (3.91 %), 7 a *editorial reviews* (1.30 %), 7 a *meeting abstracts* (1.30 %), 2 corresponden a *early access papers* (0.37 %) y finalmente 1 es un *letter* (0.19 %).

D. *Países, regiones, autores e instituciones*

Para el análisis de la procedencia de los artículos, se decido estudiar el origen de cada artículo, así como la nacionalidad de cada autor, y si es un artículo desarrollado por más de una nación (es decir, documentos científicos como resultado del trabajo de autores o instituciones de diferentes naciones).

TABLA II.
PROCEDENCIA DE LAS PUBLICACIONES.

País	Numero de Publicaciones	Porcentaje
Estados Unidos	144	26.82 %
Reino Unido	62	11.55 %
China	50	9.31 %
Canada	46	8.57 %
Australia	40	7.45 %
Alemania	30	5.59 %
España	27	5.03 %
Francia	20	3.72 %
Italia	19	3.54 %
Brasil	18	3.34 %
Otros	81	15.08 %

Fuente: Autores.

El análisis da cuenta, sobre la mención de 62 naciones del mundo en el periodo antes mencionado. Estados Unidos se encuentra a la cabeza de la producción científica sobre RV enfocada o con usos educativo con 144 documentos (26.82 %). En segundo lugar, se encuentra Reino Unido con 62 (11.55 %) documentos, seguido de China con 50 (9.31 %), Canadá con 46 (8.57 %), Australia con 40 (7.45 %), Alemania con 30 (5.59 %), España con 27 (5.03 %), Francia con 20 (3.72 %), Italia con 19 (3.54 %) y Brasil con 18 (3.34 %). Este listado corresponde a los primeros 10 países con mayor producción en el tema ya mencionado. Estos diez países tienen en su total 456 documentos

publicados, lo que representa 84.92 %, mientras que los 52 países restantes comprenden las 81 publicaciones restantes, o el 15.08 % (análisis disponible en la Tabla II). En la base de datos de los documentos elegidos para su análisis, se encontró que existen 2197 autores mencionados, lo cual es normal al haber generalmente múltiples autores por cada artículo. La lista de los primeros diez autores está encabezada por Lars Konge con 10 autorías, seguida por Karl Kowalewski con 9 autorías, Beat Muller-Stich con 9 autorías, Felix Nickel con 9 autorías, y Kamran Ahmed con 6 autorías. Estos son los autores con más de 5 autorías, y la información con los primeros diez puestos se pueden encontrar en la Tabla III.

Tabla III.
Autores con mayor número de menciones.

Autor	Numero de Menciones
Konge, L.	10
Kowalewski, K. F.	9
Muller-Stich, B. P.	9
Nickel, F.	9
Ahmed, K.	6
Friedrich, M.	5
Kenngott, H. G.	5
Schmidt, M. W.	5
Bjerrum, F.	4
Dasgupta, P.	4

Fuente: Autores.

Sobre las instituciones, se encontraron 846 instituciones publicantes. El número de instituciones que publicaron es mayor al número total de artículos (537) debido a que, en varios documentos, hubo participación de dos o más instituciones. La Universidad de Toronto se encuentra a la cabeza de instituciones con más participación en la muestra tomada, al tener participación en 13 documentos científicos. En segundo lugar, se encuentra Rigshosp con 10 participaciones, seguido de la Universidad de Washington con 10 participaciones, la Universidad de Heidelberg con 9 participaciones; y en quinto lugar la Kings Collegue con 9 participaciones. En la Tabla IV se presentan las diez primeras instituciones con mayor número de participaciones.

Se encontró en el análisis de los documentos que hubo una gran participación de empresas o instituciones, de hecho, hay registradas 437 entidades a las cuales se les atribuye participación o ayuda al momento de elaborar la documentación recopilada; entidades tanto públicas como privadas. La entidad más nombrada como fuente de auspicio fue la *National Natural Science Foundation of China*, instituto chino que promueve y financia investigaciones, con alrededor de 7 menciones. En segundo lugar, se encuentra la *National Science Foundation*, agencia gubernamental estadounidense dedicada a promover investigaciones, con 4 menciones. En tercer lugar, se encuentra la *European Social Fund of the State Baden Wuerttemberg*, fondo alemán dedicado a promover e integrar investigadores, posee 3 menciones. Después se encuentra la organización alemana *German Research Foundation DFG*, considerada la más grande de Europa, con 3 menciones; y en quinto lugar la *Nanyang Technological University*, universidad malaya con 3 menciones. La Tabla V muestra las diez primeras entidades con más menciones.

Tabla IV.
Instituciones

Institución	Numero de Menciones
Universidad de Toronto	13
Rigshop	10
Universidad de Washington	10
Universidad Heidelberg	9
King´s College de Londres	9
Universidad de Copenhagen	9
Escuela Medica de Harvard	7
Universidad de Melbourne	6
Universidad de Pittsburgh	6
Universidad de Sydney	6

Fuente: Autores.

TABLA V.
ENTIDADES CON MAYOR NÚMERO DE MENCIONES

Entidad	Numero de Menciones
National Natural Science Foundation Of China	7
National Science Foundation	4
European Social Fund Of The State Baden Wuerttemberg	3
German Research Foundation Dfg	3
Nanyang Technological University	3
Nasa	2
University Of North Carolina	3
Vattikuti Foundation	3
Agency For Healthcare Research And Quality	2
Bond University	2

Fuente: Autores.

E. *Palabras claves*

Se hallaron 1548 palabras claves en toda la base de datos. Estas pueden ser de palabras compuestas, como el caso de Virtual Reality, o por palabras simples, como Virtual o Reality. En este orden de ideas, la palabra más mencionada fue *Virtual* con 239 veces (15.4 %), seguida de *Reality* con 218 veces (14.08 %). Esto se encuentra alineado con los parámetros establecidos en el algoritmo de búsqueda. En tercer lugar, se encuentra la palabra *Training* con 111 menciones (7.17 %) y delante de la palabra *Education* con 108 veces (6.98 %). La palabra clave *Simulation* completa las primeras cinco posiciones siendo nombrada 97 veces (6.27 %). La Tabla VI muestra las primeras diez posiciones.

TABLA VI.
PALABRAS CLAVES

Palabra Clave	Numero de Menciones	Porcentaje
Virtual	239	15.44 %
Reality	218	14.08 %
Training	111	7.17 %
Education	108	6.98 %
Simulation	97	6.27 %
Based	85	5.49 %
Learning	65	4.20 %
Using	46	2.97 %
Review	45	2.91 %
Surgical	43	2.78 %

Fuente: Autores.

Al analizar la muestra de 537 artículos, se encontró que estos fueron publicados en 334 revistas en total. La revista con más publicaciones acerca del tema de la educación asociado a la RV fue la revista *Surgical Endoscopy And Other Interventional Techniques*, revista del campo de las ciencias de la salud, con 21 artículos publicados (3.91 %). En segundo lugar, se encuentra la publicación *Journal of Surgical Education*, otra revista enfocada a las ciencias de la salud, con 15 publicaciones (2.79 %). En tercer lugar, se encuentra la publicación *Computers & Education* con 11 publicaciones hechas (2.05 %). En cuarta posición se encuentra la publicación *Eurasia Journal of Mathematics Science and Technology Education* con 8 publicaciones (1.49 %) y en quinta posición, la publicación *Agro Food Industry Hi-Tech* con 7 documentos científicos publicados (1.30 %).

Una vez realizada la base de datos con los 537 artículos, se procedió al análisis básico de cada uno de estos, en lo que se incluye el resumen y las palabras claves. Esto con el fin de poder realizar una categorización de los documentos científicos descargados y así establecer mejor cuales áreas de estudio están aprovechando más esta tecnología. La Tabla VII muestra cómo se agrupan los artículos según el campo al que se enfocó. En

concordancia con la Tabla VI o tabla de palabras claves, se puede observar que la mayoría de estos artículos están enfocados a fin de ser utilizados como un medio de educación o entrenamiento, así como también un medio para la rehabilitación de las personas.

Es necesario recalcar, que los artículos pueden no solo estar en una categoría, sino que pueden pertenecer a 2 o más. En el análisis correspondiente se encontró que la mayoría de los artículos estaban localizados en 2 o más categorías según su área de estudio o enfoque.

IV. Analisis De Articulos Según Su Categotizacion

Habiendo leído las palabras claves y el resumen de cada artículo recolectado, se procedió a realizar una categorización, a agruparlos según el campo de uso y el objetivo por el cual el artículo fue realizado. Con esta información se conformó la Tabla VII. Se puede observar entonces, la gran apuesta que están haciendo los diferentes campos asociados a la salud, utilizando la RV, ya sea como sustituto de los medios tradicionales de enseñanza, o como complemento de estos mismos. Y esto es bastante comprensible, debido a que los profesionales de las diferentes áreas de la salud deben enfrentar muchos problemas para poder realizar sus prácticas aplicadas a los humanos, teniendo como principal riesgo, el daño que pueden sufrir los pacientes.

La cirugía es el campo que más le está apostando a entrenar utilizando la RV como sustituto de los medios tradicionales. Inclusive, los artículos dedicados principalmente al estudio de casos sobre RV en el entrenamiento en el campo de la cirugía, es el que presente en la mayor numero de casos de estudio. Se puede observar que un procedimiento médico, llamado *Laparoscopia*, ha despertado el interés de muchos investigadores a fin de estudiar los beneficios del entrenamiento en un mundo virtual y así hacer mejores y más preparados profesionales. La *laparoscopia* que es una exploración de una parte del cuerpo a través de un instrumento óptico llamado laparoscopio ha tenido un gran aliado en la RV. Al poder simular este procedimiento en un ambiente virtual, y poder combinarlo con otros métodos didácticos, se han podido entrenar las habilidades de los futuros profesionales, asimismo, la *endoscopia*, que es otro tipo de exploración corporal mediante un dispositivo denominado *endoscopio*, también se ha beneficiado de la tecnología antes mencionada.

Tabla VII.
Categorización de los artículos según su campo

Categorías	Subcategorias	Referencias
Salud y actividad	Calidad de vida	430, 498, 521, 551
	Ejercitación	47, 61, 62, 82, 260, 271, 290, 338, 343, 541
Educación/Entrenamiento/ Rehabilitación/ Tratamiento	Adrenalectomía	136
	Anatomía	85, 107, 123, 142, 160, 179, 180, 190, 268, 291, 292, 318, 331, 383, 390, 555, 573
	Apendicectomía	324
	Arquitectura/Urbanismo	196, 211, 563, 564, 576
	Arte marcial	104
	Artrología	174, 212, 289, 376, 381, 468
	Astronomía	455, 543
	Autoestereoscopia	573
	Autismo	69, 209, 353, 506
	Aviación	48
	BED	314
	Biotecnología/Biología molecular/Biología	198, 325, 559, 560, 572
	Broncoscopia	96, 415, 484, 490, 514
	Cateterismo	300, 389, 414, 533
	Cirugía	76, 110, 113, 146, 148, 155, 161, 162, 166, 169, 170, 173, 176, 181, 182, 190, 192, 197, 203, 205, 207, 218, 224, 235, 244, 252, 259, 265, 273, 277, 286, 293, 300, 317, 326, 328, 334, 337, 360, 365, 369, 371, 397, 399, 405, 409, 410, 411, 420, 424, 427, 428, 432, 434, 441, 452, 460, 461, 462, 463, 466, 473, 491, 496, 500, 511, 512, 513, 524, 528, 532, 561, 562, 569, 571, 575, 578

Categorías	Subcategorias	Referencias
Educación/Entrenamiento/ Rehabilitación/ Tratamiento	Cirugía bariátrica	151
	Cirugía maxilofacial	571
	Cirugía ortognática	524
	Colecistectomía	135, 299, 535
	Construcción	329, 348, 356, 387, 472, 497
	Cuidados aplicados a la salud/Medicina	108, 122, 127, 129, 158, 245, 300, 344, 359, 370, 380, 384, 385, 394, 395, 406, 418, 431, 435, 459, 481, 493, 505, 518, 538, 550, 551
	Cultura/Arte	66, 219, 270, 279, 280, 281, 282, 368, 469, 519, 534, 549, 570, 580
	Déficit de atención/ Hiperactividad	440
	Desórdenes en el desarrollo de la coordinación (DCD)	302
	Diseño gráfico	72
	Dislexia	60
	Educación ambiental	249, 297, 581
	Educación física/Deportes y afines	102, 269, 352, 354
	Educación/Educación remota	56, 92, 139, 152, 153, 164, 171, 200, 208, 233, 238, 243, 247, 251, 254, 267, 272, 333, 336, 341, 342, 347, 357, 361, 362, 367, 373, 406, 408, 416, 437, 444, 446, 449, 489, 494, 498, 501, 504, 507, 510, 517, 534, 542, 550, 565, 566
	Endodoncia	371
	Endoscopia	96, 124, 132, 133, 148, 154, 174, 289, 303, 324, 335, 376, 381, 405, 415, 426, 468, 476, 486, 547, 552
	Energía alternativa	471
	Enfermedad de Parkinson	503
	Enfermería	120, 151, 263, 264, 308, 344, 355, 388, 414, 425
	Espectroscopia	520
	Estrés postraumático	451
	EVAR	218
	Física	358, 479, 520
	Fluoroscopia	328, 386
	Genética/Genómica	46
	Geografía/Geología	143, 185
	Hemofilia	459
	Historia	68, 270, 364
	Idiomas	103, 105, 315, 436
	IKACTA	289
	Industria automotriz	49
	Industria manufacturera	242, 319
	Industria minera	99
	Industria textil	74, 448
	Ingeniería	121, 134, 188, 213, 217, 304, 340, 350, 351, 400, 417, 456, 472, 486
	Inyectología	91
	Juegos educativos	122, 149, 170, 172, 202, 226, 227, 232, 245, 250, 253, 255, 319, 364, 368, 435, 518, 521, 541, 544, 579, 580
	Laparoscopia	77, 87, 88, 135, 136, 152, 161, 165, 170, 171, 193, 194, 195, 206, 220, 222, 224, 230, 241, 262, 275, 285, 294, 299, 301, 320, 324, 375, 396, 410, 419, 422, 423, 463, 467, 475, 492, 535, 556
	Mamoplastia	502
	Matemáticas	101, 115, 201
	Nanotecnología	443

Categorías	Subcategorias	Referencias
Educación/Entrenamiento/ Rehabilitación/ Tratamiento	Nefrología	157
	Neonatología	493, 508
	Neumología	207, 552
	Neurología/Neurocirugía/ Otoneurología/ Endoneurocirugía/ Neuroimagen	50, 90, 116, 117, 132, 140, 144, 205, 221, 227, 256, 259, 268, 274, 287, 288, 303, 324, 365, 366, 402, 447, 482, 554, 574
	Nutrición	407
	Obstetricia/Ginecología/ Histeroscopía	154, 321, 337, 476, 529, 530, 531
	Odontología	58, 109, 167, 168, 231, 240, 284, 295, 307, 313, 327, 371, 392, 442, 457, 465, 568
	Oftalmología	112, 160, 166, 177, 283, 309, 334, 409, 499
	Oncología	509, 536, 557, 561
	Ortopedia	224, 397, 428, 454, 500, 528
	Osteología	383, 569
	Osteotomía	569
	Otorrinolaringología/ Otología	138, 204, 205, 225, 276, 278, 391, 439, 558
	Patología	130, 131, 453, 562
	Pediatría	175, 441, 493, 516
	Planificación/Planeación familiar	310
	Psicosis	413
	Psicología	95, 236, 246, 344, 372, 482, 516
	Psiquiatría	94, 413
	Química	106, 183
	Radiología	51, 141, 314, 346, 429, 499, 527
	Radioterapia	421, 477, 478, 509, 557
	Rehabilitación cardiaca/ Cardiología	111, 124, 145, 147, 218, 285, 338, 547
	Rehabilitación/ Estimulación cerebral	64, 125, 260, 431, 485, 503, 505
	Sialoendoscopia	114
	Simulación de fluidos/ Hidrodinámica	305
	Terapia ocupacional	234
	Tiroidectomía	85
	Tomografía	499
	Trastornos del desarrollo/ Trastornos intelectuales	521, 539
	Turismo	378, 570
	Urología	97, 158, 214, 215, 248, 296, 379, 403, 441, 464, 515, 525
	Ultrasonido	147, 189, 316, 474, 483
	Uso de tecnología	54, 55, 57, 59, 71, 89, 98, 187, 188, 190, 213, 214, 217, 228, 232, 238, 256, 258, 282, 336, 347, 393, 398, 430, 434, 445, 481, 495, 501
	UVA	379, 464
	VATS	207
	Ventriculostomía	133
	VR-CPES	363

Categorías	Subcategorias	Referencias
Caso de estudio/Evaluación	Cirugía	110, 117, 162, 298, 326, 360, 365, 441, 454, 462, 466, 470, 475, 491, 500, 513, 532, 561, 571, 578
	Cuidados aplicados a la salud/Medicina	108, 118, 142, 150, 157, 179, 222, 307, 353, 355, 384, 385, 388, 407, 425, 433, 467, 468, 480, 503, 523, 538, 552, 557, 558
	Educación	52, 99, 139, 143, 163, 186, 237, 239, 316, 322, 342, 345, 359, 401, 403, 408, 487, 494, 540, 542, 576
	Filosofía	377
	Odontología	82, 465, 568
	Otorrinolaringología/ Otología	439
	Psicología	93, 181, 257, 338, 372, 516
	Rehabilitación cardiaca/ Cardiología	111, 547
	Tecnología/Técnicas	73, 80, 84, 86, 148, 224, 229, 261, 266, 311, 312, 313, 362, 382, 420, 438, 450, 458, 464, 506, 522, 533, 541, 545, 562, 567, 575, 576
	Tecnologías aplicadas a la arquitectura/Construcción/ Ingeniería/Historia/ Cultura	81, 211, 270, 329, 469, 472, 486, 549, 563, 564
	Tecnologías aplicadas a la educacíon	53, 65, 67, 75, 78, 79, 128, 137, 145, 156, 164, 184, 216, 284, 298, 306, 332, 333, 336, 339, 345, 357, 379, 393, 398, 401, 404, 412, 454, 480, 487, 488, 492, 495, 511, 515, 524, 529, 530, 531, 546, 548, 566, 572, 573, 579, 582
Tecnologías/Metodologías	Desarrollo tecnológico/ Técnicas con aplicaciones a la realidad virtual	63, 70, 100, 119, 126, 178, 185, 199, 252, 258, 261, 311, 312, 314, 349, 350, 361, 363, 369, 374, 400, 437, 438, 481, 498, 512, 516, 537, 553
Robótica	Aplicaciones a la cibernética/Cibernética	363
	Aplicaciones a la robótica/ Robótica	148, 191, 203, 214, 228, 282, 298, 300, 379, 399, 427, 445, 461, 464, 466, 470, 492, 515, 531, 561, 575

Fuente: Autores.

Establecido lo anterior, no se debe caer en el error que solo la medicina está estudiando los beneficios del uso de la tecnología de RV aplicada a la educación. Un ejemplo es la arquitectura, que también está utilizando los últimos beneficios de la tecnología aquí menciona, a fin de mejorar la educación de sus estudiantes y profesionales. Otro ejemplo que se encontró es como la RV se está aplicando en la educación de futuros ingenieros, y en campos que anteriormente no se hubieran pensado, como es el campo del turismo.

Sin embargo, el más claro beneficiado es el campo de la medicina. Desde el tratamiento de enfermedades como la dislexia y el autismo, hasta otros campos como radiología, se puede observar que los resultados de la búsqueda son mayoritariamente asociados al campo de la salud. Inclusive, los artículos científicos dedicados a estudios de casos son mayormente relacionados al campo médico.

Se encontró también, que la robótica, generalmente aplicada a la medicina, tiene una gran cabida en la RV como herramienta didáctica. Como se señaló anteriormente, esto es debido a las diferentes restricciones con las que se encuentran los futuros profesionales en su proceso de capacitación, y en la robótica aplicada a la medicina, aun mas, por lo caro y escaso de escenarios de practica disponible.

V. Conclusiones

Al poder simular situaciones de alto riesgo, así como escenarios con características específicas, la RV ha despertado del interés de múltiples investigadores. Los futuros profesionales enfrentan un dilema al momento de realizar prácticas para afianzar sus conocimientos, como la disponibilidad de lugares y herramientas necesarias para poder llevar a cabo sus prácticas, así como tener la situación que se plantea entrenar.

Basándose en los resultados obtenidos en este artículo, se encontró que la medicina es el campo que más le está apostando a la RV aplicada a situaciones de entrenamiento, rehabilitación y/ educación. Específicamente hablando, la cirugía y las prácticas en laparoscopia son las practicas que más se están simulando, debido a la complejidad de sus características, y, sobre todo, a capacidad de la RV de simular un ambiente quirúrgico y diferentes situaciones con pacientes.

Las conclusiones encontradas en la base de datos formada, muestra resultados promisorios para la educación en ambientes virtuales, mostrando a esta herramienta como un excelente complemento de las ayudas didácticas tradicionales, o inclusive como un futuro promisorio en donde estas ayudas puedan ser reemplazadas completamente.

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