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Virtual reality and motivation in the educational context: Bibliometric study of the last twenty years from Scopus

Realidad virtual y motivación en el contexto educativo: Estudio bibliométrico de los últimos veinte años de Scopus

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Abstract

Information and communication technologies have undergone great changes in all sectors of today's society, but especially in the field of education, promoting the development of new methodologies. Among these new teaching methods is Virtual Reality, which in recent years has been of great importance as it has been shown to have a positive influence on the motivation of students and, at the same time, on the improvement of their attention. Hence the interest in carrying out this study, with the aim of analysing the current situation of the existing research in the Scopus database on the use of Virtual Reality in education to improve motivation in teaching-learning processes. The results reveal that in the last twenty years (1998-2018) the scientific production on the subject in question has grown exponentially, going from 0.27% in 1998 to 14.48% in 2018. We conclude the study by proposing to continue researching on this subject in order to continue verifying to what extent it is possible to improve the quality of education thanks to the use of new methodologies such as Virtual Reality.

Keywords: Virtual Reality, education, motivation, active methodologies, bibliometric.

Resumen

Las tecnologías de la información y comunicación han acontecido grandes cambios en todos los sectores de la sociedad actual, pero, especialmente en el ámbito educativo, promoviendo el desarrollo de nuevas metodologías. Dentro de estos nuevos métodos de enseñanza se encuentra la Realidad Virtual que en los últimos años ha tenido una gran transcendencia ya que se ha demostrado que influye de forma positiva en la motivación del alumnado y, a la vez, en la mejora de su atención. De aquí surge el interés por realizar este estudio, con el objetivo de analizar en qué situación actual se encuentran las investigaciones existentes en la base de datos Scopus sobre el uso de la Realidad Virtual en educación para la mejora de la motivación en los procesos de enseñanza-aprendizaje. Los resultados revelan que en los últimos veinte años (1998-2018) la producción científica sobre el tema en cuestión ha crecido de forma exponencial, pasando de publicar un 0.27% en 1998, a un 14,48% en 2018. Terminamos el estudio proponiendo seguir investigando sobre este tema con la finalidad de seguir comprobando hasta qué punto es posible mejorar la calidad educativa gracias al uso de nuevas metodologías como la Realidad Virtual.

Descriptores: Realidad Virtual, educación, motivación, metodologías activas, bibliometría.

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1. Introduction

Society is immersed in an age when information and communication technologies (ICTs), have acquired great importance in all social sectors, especially in the educational field (Rodríguez, Cáceres & Alonso, 2018), promoting the development of new teaching methods (Viñals & Cuenca, 2016). Among the main features that stand out from ICT and which are influenced in the educational field, are ubiquity —since it can be used from anywhere and at any time — and ergonomics —since it adapts to the specificities of the teaching and learning processes — (Fombona & Pascual, 2017).

The entry of ICT into the pedagogical actions developed today in schools, which is present in all educational stages (Larionova, Brown, Bystrova & Sinitsyn, 2018), has promoted new connections in the students, since ICT allow them to be connected with their peers, teachers, the educational content and material resources (Radu, 2014), stimulating their interest in the task (Villalustre & Del Moral, 2017), and allowing them to increase motivation and participation in educational dynamics (Marín & Muñoz, 2018).

Among the innovative practices in the educational field is the use of Virtual Reality (Dyer, Swartzlander & Gugliucci, 2018), which is defined as various multimedia sequences that simulate reality almost reliably, generated by human beings using information and communication technologies, being a requirement for their use of specific hardware (Díaz, Díaz & Arango, 2018; Samaniego, 2016).

Currently, the use of Virtual Reality in the pedagogical field is booming (Dos Santos & Dos Santos, 2019; Sural, 2018), since it is being included in different curricula (Huttar & Brintzenhofeszoc, 2019), being considered as an effective pedagogical resource that supports the learning of students (Jamil *et al.,* 2019), as well as innovative (Slater et al., 2019). Augmented Reality is accessible by various means, including the mobile phone (Degli *et al.,* 2019), which makes it customizable, accessible and interactive (Nijman *et al.,* 2019).

The use of Virtual Reality in education has gained remarkable recognition (Panerai, Catania, Rundo & Ferri, 2018) by being an effective form of training and evaluation (Abi-Rafeh *et al.*, 2019), which generates advantages in students (Klippel *et al.,* 2019), including the understanding of the contents (Hanson, Andersen & Dunn, 2019), improving creativity (Yang *et al.,* 2019) participation (Lorenzo-Álvarez, Rudolphi-Soler, Ruiz-Gómez & Sendra-Portero, 2019) and students' commitment to content and learning (Makransky & Lilleholt, 2018), as well as making education more accessible to everyone (Sood & Singh, 2018), thus increasing the specific competences of the students in their field of knowledge (Wu *et al.*, 2019).

Currently there are several studies that analyze the use of Virtual Reality and its influence on motivation, among which are those of Kim and Hall (2019), which determined that there is a highly significant effect of perceived enjoyment in those using Augmented Reality; Sattar *et al.* (2019), who found that Virtual Reality was best for medical students, both in learning motivation and learning competence; Ho, Sun and Tsai (2019), established that students in the digital media department improve their motivation and interest in learning 3D animation; Rockstroh, Blum and Goritz (2019), determined that when implementing Virtual Reality to teaching and learning processes, it improved motivation and helped users keep their attention.

Due to the transcendence that Virtual Reality has acquired in the field of education, especially from 2017 onwards (Gómez-García, Rodríguez-Jiménez & Navas-Parejo, 2019), and its influence on motivation, the aim of this study is to analyze the existing research in the Scopus database on the use of Virtual Reality in education for the improvement of motivation in teaching-learning processes, which is specified in the following specific objectives:

- To know the diachronic productivity of the last 20 years and if the Price Law is complied
- To analyze if there are authors and sources specialized in this topic and therefore if the Laws of Lotka and Bradford are complied.
- To determine which countries produce the most scientific documents on the subject, which are the main areas of publication, and which types of documents are most commonly used for their dissemination.
- To analyze the connections between the different descriptors related to the Virtual Reality used in education.

2. Methodology

The methodology of the bibliometric studies has been followed (Moreno, 2019), with the intention of quantifying the scientific production of one of the most relevant databases; Scopus, about Virtual Reality used in education and its relationship with motivation in teaching-learning situations over the last 20 years.

Previously, a series of descriptors related to the subject to be studied contained in the ERIC Thesaurus were stablished, resulting in the following keywords with which the search was carried out: "Virtual Reality", "Education " (Education) and "Motivation". All these descriptors address the fundamental concepts of this study.

The search for the data and its analysis took place during the month of September 2019. The premises of other studies of the same type have been followed (Aznar, Romero, Rodríguez & Rodríguez, 2018; Rodríguez, Trujillo & Sánchez, 2015) analyzing the following elements:

- Production indicators: diachronic and personal productivity, which have led to verification of Price's and Lotka's law.
- Scatter indicators: to which Bradford's law has been verified.
- Impact indicators, depending on: the area of publication, typology of the documents, country of publication.

On the other hand, connections have been established between the different descriptors related to virtual reality used in education, configuring a network map from the VOSviewer software.

For the preparation of the final sample (n = 1.112) different inclusion criteria were applied, depending on the different variables and the type of analysis performed (Table 1). The entire population has been analyzed, therefore it is equivalent in number to the sample.

Table 1. Inclusion criteria based on variables

Variables	Inclusion criteria
Year of Publication	Years from 1998 to 2018 (2019 is excluded because it is not completed)
Type of Documents	Only scientific articles were taken into account to make the network map. For the rest of the study, all documents have been used
Publishing Areas	The most relevant six have been included
Country	Those which published from 2% of the total documents
Language	In the analysis of the documents, no exclusion criteria by publication language have been used. Because the keywords used for the search were in English, all articles written in any language are covered, since they have descriptors (keywords) translated into English in addition to those of the publishing language
Bibliometric Map	It has been done with all the articles found in Scopus

Own elaboration

Data collection was organized in Excel. For the analysis of personal production and that of the scattering indicators, the SPSS statistical program has been used in version 22, analyzing percentages of occurrence and linear regression of variables, and Excel, finding the scatter plots for the comparison of values and analysis of trend lines. Different statistics have been used for the data analysis such as: percentages, Pearson correlation coefficient, regression coefficient, and prediction coefficient.

3. Results

After placing the different descriptors in the Scopus search engine, selecting the "Article Title, Abstract and Keywords" option for "Virtual Reality" and "Education" and "All Fields" for "Motivation", and using the "y" connector to increase the rigor of the search, 1,241 results were obtained. Once the search has been refined excluding this year 2019 that has not been completed (123 documents) and those before 1998 (only 6 documents since 1993), the results are reduced to 1112 documents.

3.1. Production Indicators

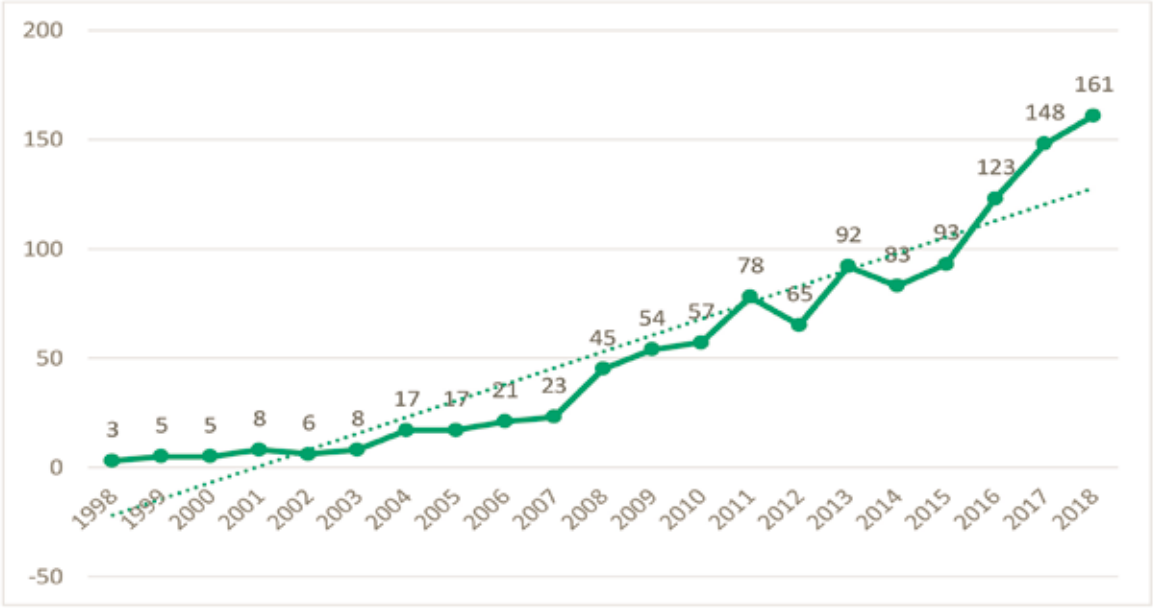
3.1.1. Diachronic production

Analyzing the 1122 indexed references in the Scopus database, which are obtained with the combination of the selected descriptors, detailing the search to the years between 1998 and 2018 and using as variable "year of publication", it can be observed the increase in the last 20 years of scientific production that deals with virtual reality used in education and is related to motivation.

Figure 1 contains the results per year of the production indexed in Scopus. An exponential production increase can be observed graphically.

In accordance with Price's law, it can be seen that the premise that scientific production is doubled every 10-15 years is fulfilled (Price, 1986). In this case, the proportion is even higher; 3 documents published in 1998 (0.27%), then it goes to 45 in 10 years (4.05%), corresponding to 2008. In the following ten years 2018, production amounted to 161 documents (14.48%).

Figure 1. Diachronic Productivity on Virtual Reality



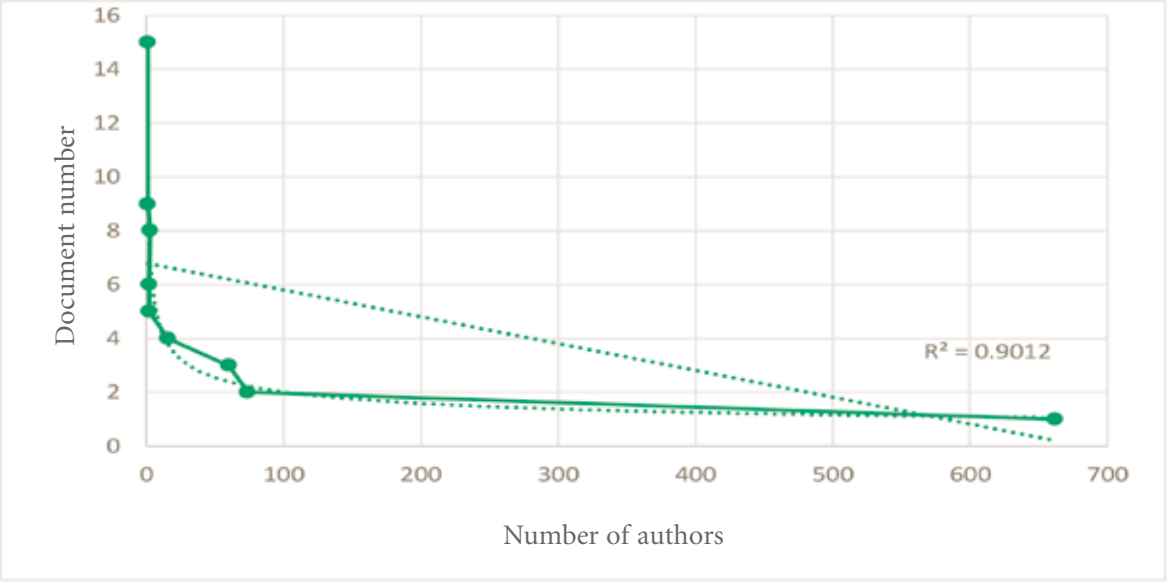
3.1.2. Personal productivity

With regard to personal productivity, it is proven that Lotka's law is complied, which states that biggest amount of the documents published on a given subject agree with a very small number of authors who are specialized in that area of knowledge.

Looking at Figure 2, it can be seen that the correlation between the fewest authors and the highest number of Scopus references is positive. Thus, it is observed at one end that a single author has published 15 documents and at the opposite end 662 authors have published one, showing the specialization of the author in this field.

When examining the linear relationship between the variables, a correlation coefficient of Pearson r = -0.498 is obtained, indicating that there is an average dependency between the variables and that they have a negative correlation, as they are affected inversely proportional. With respect to the coefficient of determination or multiple correlation, the result obtained is R2=0.9012, indicating that it has a very good fit.

Figure 1. Diachronic Productivity on Virtual Reality



Own elaboration

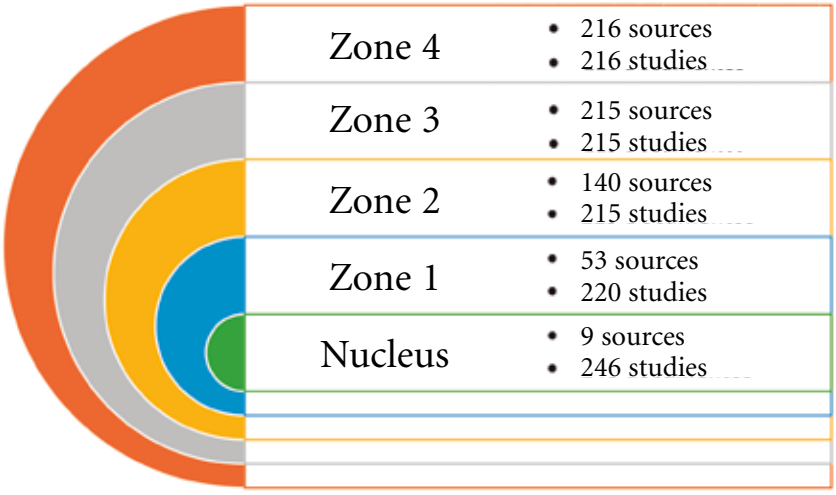
3.2. Scattering Indicators

Bradford's Law or The Law on the Scattering of the scientific literature of Bradford describes the quantitative relationship between journals and scientific articles contained in a literature on a given area, stating that a small number of journals, which make up the nucleus, concentrate a similar number of articles than a large number of journals, grouped into scattered areas (Miranda, 1990).

In this case, the total of the sources where the 1112 documents are indexed were distributed in 5 zones with an average of approximately 220 in each, where it can be observed that the nucleus consists of only 9 sources and it contains a similar number of documents as the other zones that have up to 216 sources in the areas farthest from the core, containing that same number of documents. This means that there are a lot of sources that contain only a reference of those found in Scopus on the subject matter and a considerably

smaller number of sources with a large number of documents, showing the specialization of some journals and books on Virtual Reality in education that refer to motivation (Fig. 3).

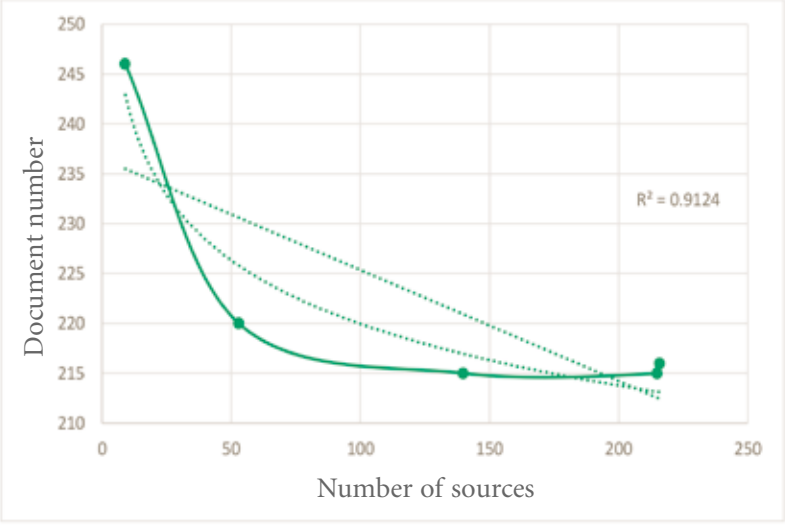
Figure 3. Bradford scattering area of scientific documents dealing with education-related Virtual Reality by mentioning motivation



Own elaboration

The linear regression analysis shows a high negative correlation between the number of sources and the accumulated documents (Fig. 4). It has a correlation coefficient of Pearson r = -0.783. And a multiple determination or correlation coefficient R2= 0.9124, indicating a very good fit.

Figure 4. Linear regression analysis between the number of sources and the number of studies



Own elaboration

3.3. Impact Indicators

Impact indicators have been analyzed according to different variables to know the influence of Virtual Reality studies on the scientific literature: publication area, type of documents and country of publication.

3.3.1. Publishing area

Different references are indexed in different publishing areas, including some that can be found in several categories.

Globally, it can be observed that most of the scientific production in this field is in the area of Computer Science (67.27%) followed by Social Sciences (39.21%). Out of the 26 areas of publication in which the 1,112 references are distributed, the six most representative references are presented in Table 2.

Table 2. Number of documents depending on the area of publication in the Scopus databases

Area of publication	Number of Scopus documents	Total percentage
Computer Sciences	748	67,27%
Social Sciences	436	39,21%
Engineering	274	24,64%
Medicine	142	12,77%
Mathematics	114	10,25%
Psychology	52	4,68%

Note: Percentages have been done on the total documents (1112) in each publication area. Since some documents can fall into several categories, the sum of the percentages does not match 100% of the items.

Own elaboration.

3.3.2. Type of document

Considering this variable that corresponds to the type of document found (Table 3), it is verified that most are session documents (51.80%), followed by articles (37.68%), in a low number there are book chapters and revisions, and with less than 1% the rest of the documents. Therefore, it can be stated that the preferred format for publishing research studies on Virtual Reality associated with motivation in education are the session paper and the scientific dissemination article.

Table 3. Number of documents depending on the type of documents in Scopus and WoS

Type of documents	Scopus Number	Percentage
Session Document	576	51,80%
Article	419	37,68%
Book chapter	69	6,20%
Revision	28	2,52%
Conference Revision	5	0,45%
Editorial	4	0,36%

Type of documents	Scopus Number	Percentage
Note	3	0.27%
Letter	1	0,09%
Retracted	1	0.09%
Indefinite	6	0,54%

Own elaboration

3.3.3. Country of publication

The countries with the highest scientific production on Virtual Reality in motivational education are the United States (27.52%) and Spain (8.63%), as can be seen in Table 4, which represents countries with more than 2% of the documents published on this topic in the last 20 years in Scopus. Thus, it can be observed the international scenario, geographically locating the institutions that investigate the most in this area. Fourteen countries containing 967 documents have been extracted from the 1112 analyzed, equivalent to 86.96% of the total. Spain ranks second with 96 publications, a long distance from the top position, but very close to the third position that is the United Kingdom.

Table 4. Number of documents depending on the country of publication of the Scopus databases

Countries	Documents in Scopus	Percentage
United States	306	27,52%
Spain	96	8,63%
United Kingdom	89	8,00%
Taiwan	61	5,49%
China	60	5,40%
Australia	59	5,31%
Germany	53	4,77%
Greece	51	4,59%
Italy	41	3,69%
Canada	35	3,15%
France	30	2,70%
Brazil	29	2,61%
Portugal	29	2,61%
Netherlands	28	2,52%

Own elaboration

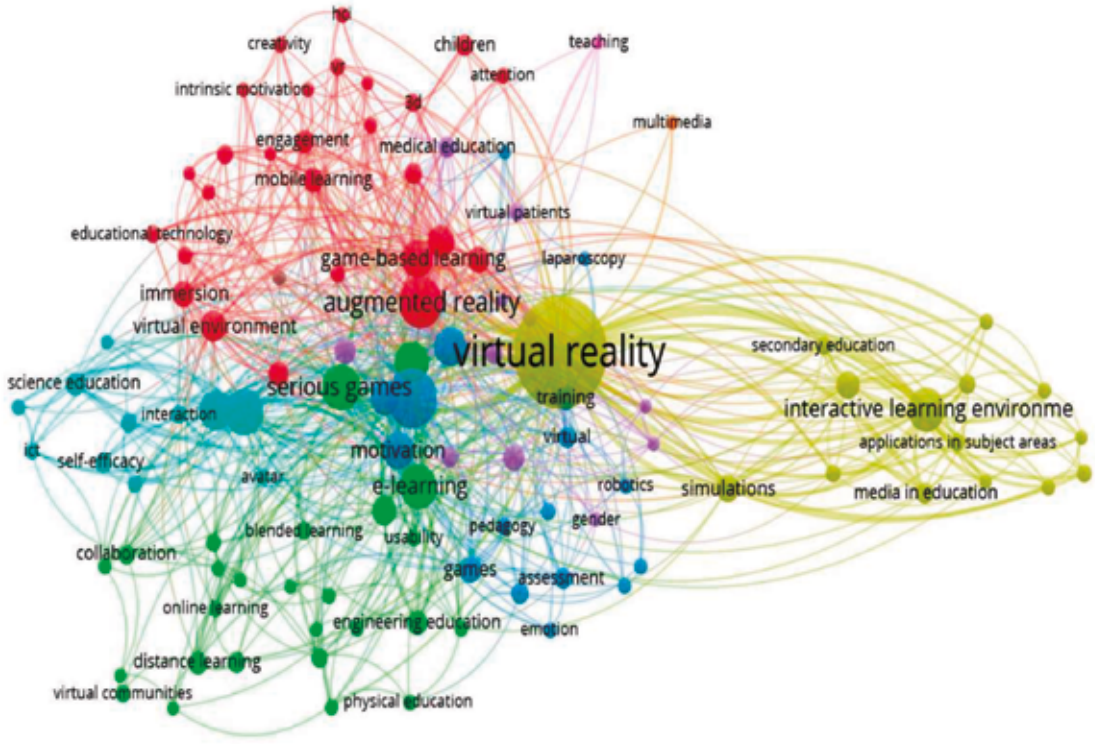
3.4. Bibliometric map

The network map between descriptors shown in Figure 5, presents the relationships that exist between the different keywords used in the analyzed articles that are indexed in Scopus (419).

Looking at the image, 6 groups of descriptors can be distinguished differentiated by different colors: yellow, blue, light blue, red, green and violet. The size of the concepts is directly proportional to the frequency of occurrence and the number of connections to other descriptors.

The largest concepts in the yellow clusters are: "Virtual Reality", "Interactive Learning Environment", "Simulation" and "Secondary Education". These descriptors are related to contextualized and active forms of teaching. The blue cluster features the descriptors "Motivation" and "Serious Games". This cluster relates to emotions and pedagogical games.

Figure 5. Map of networks between the keywords of articles published in Scopus on Virtual Reality in motivational education



Own elaboration

The green group is closely related to education and the different forms of learning with ICT, highlighting concepts such as: "e-learning" (virtual learning space).

On the other hand, the red cluster refers to different educational methodologies with ICT, observing that the most outstanding concepts are: "Augmented reality" and "Game-based learning". Again, the motivation that is referred to in this case is intrinsic.

The light blue cluster includes "Interaction" and "Science Education". These are the most prominent descriptors that have been used in the 419 articles analyzed and that are closely related and connected to each other.

4. Discussion and Conclusions

Referring to the use of ICT in the educational context, Virtual Reality has had great significance in recent years as it has been demonstrated how this methodology influences the motivation of students by promoting the teaching process as mentioned by Marín and Muñoz (2018), Jamil *et al.* (2019), Cagiltay, Ozcelik, Berker and Menekse (2019), Jacobsen *et al.* (2019).

Additionally, the results of diachronic productivity over the past 20 years show that between 1998 and 2018 an increase in exponential scientific production has occurred, fact that agrees with studies carried out by Dos Santos and Dos Santos (2019), who claim that the use of Virtual Reality in the pedagogical field is increasing. In 1998, 3 documents were published, then 45 in 2008 and 161 in 2018, i.e., it goes from a production of 0.27% to 14.48%, which allows to verify that the Price Law is complied, although in this study the percentage has been higher than double. It should be noted that this first number in scientific production came two years after the publication of the Organic Law 2/2006 on Education (LOE), which is committed to the use of technologies to "create an open learning environment, make learning more attractive and promote active citizenship, equal opportunities and social cohesion" (p. 17160). In addition, the largest production occurs in 2018, five years after the entry into force of the Organic Law 8/2013 for the Improvement of Educational Quality (LOMCE), which supports the use of Information and Communication Technologies (ICT) in the educational field to "promote the conditions that allow the timely methodological change, so that students are an active element in the learning process" (p. 97860).

Regarding the personal productivity, it is observed that 662 authors have published only one article, while one author has published 15 on the topic, demonstrating that the Lotka Law is complied by stating that there are authors who specialize in a certain area of knowledge. Also, the Law of Bradford is complied since a large number of sources contain only a reference on the subject and a small number accumulate a high percentage of documents, allowing to understand that there are journals and books that demonstrate how Virtual Reality influences students' motivation. Out of the 1112 documents indexed in Scopus, distributed in 5 zones with an average of 220 each, it can be seen that the nucleus consists of 9 sources with a total of 246 documents.

In relation to the countries that have published more scientific documents on Virtual Reality, the results show that the United States is first, fact that is in agreement with what has been stated by Gómez-García, Rodríguez-Jiménez and Ramos-Navas-Parejo (2019), with 306 publications, followed by Spain (96), United Kingdom (89), Taiwan (61), China (60), Australia (59), Germany (53), Greece (51), Italy (41), Canada (35), France (30), Brazil (29), Portugal (29) and the Netherlands (28). These are based on six areas of publications: Computer Science, Social Sciences, Engineering, Medicine, Mathematics and Psychology.

In view of the type of documents, it is noted that most publications are session documents (576) followed by articles (419), and, in very low number, book chapters (69) and revisions (5), as mentioned by Gómez-García, Rodríguez-Jiménez and Ramos-Navas-Parejo (2019).

In short, and according to the results found, it is important to emphasize that the improvement of educational quality is possible by the use of new methodologies such as Virtual Reality. As can be seen, the scientific literature regarding the use of Virtual Reality as a methodology that encourages motivation in students and which is present in the Scopus database shows an increase in 2018 which allows predicting that it will increase in the coming years; thus, the aim is to investigate such increase with the idea of delving into the subject and continuing to see to what extent it is possible to improve educational quality due to the use of new methodologies such as Virtual Reality.

The limitations found in this research were based on the debugging of the database, since the various documents had to be analyzed one by one to verify that they met the requirements set out in the study. As a future line of research, it is planned to carry out a study with similar characteristics in the Web of Science database or on Google Academic.

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