5G TECHNOLOGY AND ITS IMPACT ON THE USE OF ONLINE VIDEOGAMES: A COMPREHENSIVE SYSTEMATIC REVIEW

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ABSTRACT

5G technology has received a lot of attention lately thanks to increased connections, synchronization between devices, better speed and higher bandwidth. But it still presents challenges, such as infrastructure and data security. On the other hand, we live in an era where being connected to the Internet seems intrinsic in our lives, the future says that "the Internet of things" will be present even in devices that we would never have imagined, and in the use of video games there are fewer and fewer titles that do not make use of the network in one way or another. This research aims to determine the state of the art on recent studies and provides an overview that relates 5G technology and Online Videogames, and will help to close existing gaps and direct future research. The Systematic Literature Review (SLR) located 9032 papers from major digital libraries such as: Scopus, Wiley Online Library, ARDI, Taylor & Francis Online, ERIC, ProQuest, ACM, Google Scholar and Springer. The research has allowed us to identify clusters of papers whose Conclusions and Discussions are Objective, Bibliometric Networks of Keywords, named entities (NER) that are most frequently presented in the Abstracts and the most cited topics in the experimental research reviewed on the subject. After a detailed review process, only 70 papers were considered according to the defined inclusion and exclusion criteria.

Keywords: *Game, Online video games, 5G technology, Systematic Literature Review*

1.   INTRODUCTION

A.   5G Technology

5G Technology is the fifth generation of wireless network technology, which enables a new type of network designed to provide higher network speeds, lower latency, and support for more users, devices, and services, while improving network efficiency [12]. 5G technology ensures data traffic management through a significant reduction in cost per bit.

The improvements in terms of speed and latency brought by 5G technology constitute an obvious and important advantage over 4G technology, as well as all the standards prior to it. This technology brings with it increased device compatibility due to the smaller size and more accurate transmission of directional signals from MIMO (multiple input, multiple output) antenna systems that come hand in hand with 5G technology [23].

From the literature review process, we believe that 5G technology will be one of the next technological revolutions [38]. There are several reviews related to 5G, different application areas such as in internet of things (Iot), health, education, government, security aspects, gaming [41].

In the advanced digital world to speed up every process, we use electronic means for every work. Currently, 5G technology has seen widespread growth as a result of the use of the Internet [2]. 5G technology is part of an even bigger revolution that also includes artificial intelligence (AI) and cloud technologies to drive a more robust and sustainable platform [48].

B.   Videogames

On the other hand, 5G connectivity brings improvements in the use of video games, such as reduced latency, the most important feature, since the time it takes for data to travel from one device to another location will be much lower; another one is the higher network speed, allowing game downloads to take a few seconds and also is a better bandwidth, allowing a greater volume of data and network capacity [20].

Therefore, today in a technological world, this type of technology is essential. Also, future research is needed to develop new techniques and tools, to support other phases or activities of SLR.

In this paper, the objective is to perform an in-depth analysis of current research on the impact of 5G technology on Online Video Games. The structure of this paper is organized as follows: Section II describes the Review Method. The findings and discussions are presented in Section III. Section IV reports the research conclusions and offers some recommendations for future research.

2.   RESEARCH METHODOLOGY

The research method and its corresponding research design used are based on B. A. Kitchenham and S. Charters [84] guidelines for systematic literature review. The review method processes the research questions, data sources, search procedure, exclusion criteria, quality assessment, data extraction and data synthesis.

The research design consists of nine steps to carry it out, as shown in Figure 1.
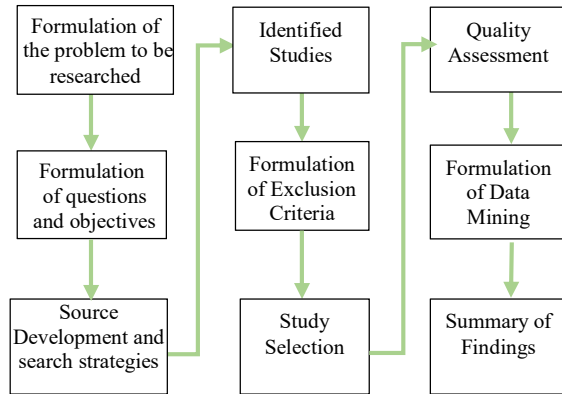

Figure 1: Stages for the SLR

2.1 Research Problems and Objectives

When conducting a systematic literature review, research questions (RQ) play an important role in the data search and analysis strategy. In identifying the research questions, we also identified the objectives, which are shown in Table 1 below.

Table 1: Research Questions and Objectives.

Research Question	Objetive
RQ1: What are the clusters of Papers whose Conclusions and Discussions are characterized by high Objectivity and low Polarity in the research on 5g Technology and its impact on the use of Online Video Games?	To determine clusters of Papers whose Conclusions and Discussions are characterized by high Objectivity and low Polarity in the research on 5g Technology and its impact on the use of Online Video Games
RQ2: What are the Co-Occurring Keywords in 5G Technology research and their impact on the use of Online Video Games?	Identify the Keywords that present Cooccurrence in 5G Technology research and their impact on the use of Online Video Games
RQ3: What are the named entities (NERs): people, organizations, places, expressions of time and quantities that are most frequently presented in the Abstracts of research on 5G Technology and its impact on the use of Online Video Games	Identify named entities (NERs): people, organizations, places, expressions of time and quantities that occur most frequently in Abstracts of research on 5G Technology and its impact on the use of Online Video Games
RQ4: What are the most cited concepts (topics) in research on 5G Technology and its	Determine the concepts (topics) most cited in research on 5G Technology and its

impact on the use of Online Video Games?	impact on the use of Online Video Games

2.2 Search Sources and Search Strategies

The digital libraries used to find the publications used are: Scopus, Springer, ACM Digital Library, IEEE Xplore, ProQuest, Taylor & Francis Online, Wiley Online Library and Google Scholar.

The search strategy included the search for keywords relevant to the study (Table 2).

Table 2: Search Descriptors and their Synonyms.

Descriptor	Variable
5G/5G Technology/ 5G Networks	Independent
Online Videogames	
Computer Games	Dependent
Electronic Game	
Console Game	

The search procedure has been carried out using search equations for each source, as shown in Table 3.

Table 3: Information sources and search equations.

Source	Search equation
Scopus	(ALL (("5G technology" OR 5g OR "5G networks")) AND ALL (("video game" OR "computer game" OR "electronic game" OR "game console")) AND ALL ((online OR on-line OR connected)))
Wiley Online Library	("5G technology" OR 5G OR "5G networks") anywhere and "("video game" OR "computer game" OR "electronic game" OR "game console")" anywhere and "(online OR on-line OR connected)" anywhere
ARDI	(("5G technology" OR 5G OR "5G networks")) AND (("video game" OR "computer game" OR "electronic game" OR "game console")) AND ((online OR on-line OR connected))
Taylor & Francis Online	[[All: "5g technology"] OR [All: 5g] OR [All: "5g networks"]] AND [[All: "video game"] OR [All: "computer game"] OR [All: "electronic game"] OR [All: "game console"]] AND [[All: online] OR [All: on-line] OR [All: connected]]
ERIC	("5G technology" OR 5G OR "5G networks") AND (methodology OR method OR model) AND ("video game" OR "computer game" OR "electronic game"
ProQuest	("5G technology" OR 5G OR "5G networks") AND ("video game" OR "computer game" OR "electronic game" OR "game console") AND (online OR on-line OR connected)
ACM Digital Library	[[All: "5g technology"] OR [All: 5g] OR [All: "5g networks"]] AND [[All: "video game"] OR [All: "computer game"] OR [All: "electronic game"] OR [All: "game console"]] AND [[All: online] OR [All: on-line] OR [All: connected]]
Google Scholar	"5G technology" OR 5G OR "5G networks") AND (methodology OR method OR model) AND ("video game" OR "computer game" OR "electronic game" OR "game console") AND (online OR on-line OR connected)
Springer Link	("5G technology" OR 5G OR "5G networks") AND (methodology OR method OR model) AND ("video game" OR "computer game" OR "electronic game" OR "game console") AND (online OR on-line OR connected)

2.3 Identified Studies

At the end of the search, a number of papers were obtained for each source, shown in Figure 2.
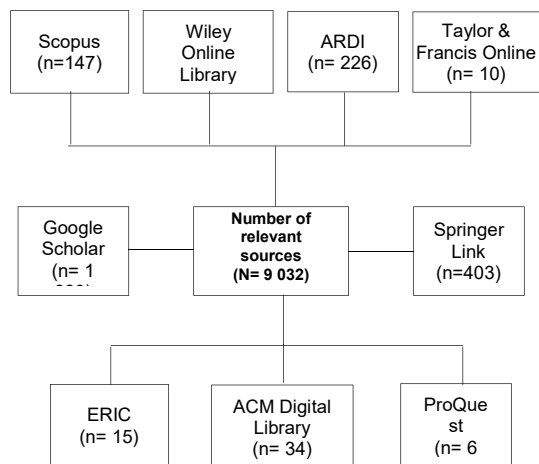

Figure 2: Number of Relevant Sources

2.4 Exclusion Criteria

Exclusion criteria have been defined to accurately assess the quality of the literature. The papers were reviewed for the following criteria. CE1: The papers are older than 5 years.

CE2: The papers are not written in the English language.

CE3: The papers were not published in Conferences OR peer-reviewed journals.

CE4: The titles and keywords of the papers are not very appropriate.

CE5: The papers do not mention a methodology or model or method.

CE6: The abstract of the papers is not very relevant.

CE7: The papers are not unique.

CE8: The full text of the paper is not available.

2.5 Study Selection

Originally, 9032 papers were obtained based on the search performed using keywords relevant to the study.

The selection and filtering steps used are listed below:

Step1: Apply exclusion criteria to ensure that only relevant papers are included in this review.

Step 2: Apply quality assessment to include papers that give the best answers to the research questions posed.

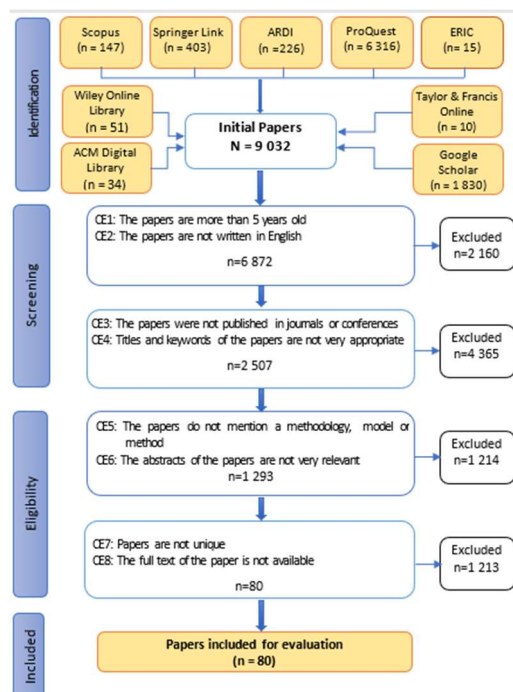The result of this step is 80 papers, as shown in Figure 3.

Figure 3: PRISMA flow chart

2.6 Quality Assessment

The application of quality assessment rules was the final step used to identify the final list of papers included in this review paper. Quality Assurance Criteria (QAs) were applied to assess the quality of the research papers according to the established research questions. Seven QAs were identified. The QAs that were used to assess the quality of the selected papers are:

QA1: Is the paper well organized?

QA2: Are the collection instruments referenced?

QA3: Does the research have clearly described instructions?

QA4: Is the purpose of the research clearly explained?

QA5: Is the full text of the document available?

QA6: Is there sufficient background information in the document?

QA7: In general, is the paper considered useful?

During this stage, the quality of the 80 studies that had met the exclusion criteria was assessed. To analyze the rigor, credibility and relevance of the studies, each study was evaluated independently according to the 7 criteria. For each paper, the full text was read and the evaluation criteria were applied to assess its quality.

The primary studies as a whole (80) met each of the QAs.

2.7 Data Mining Strategies

At this stage, the final list of papers was used to extract the information needed to answer the set of research questions.

The information extracted from each paper included the following: ID of the paper, title of the paper, URL, source, year, country, number of pages, language, type of publication, authors, affiliation, number of citations, abstract, keywords, sample size.

It is also important to note that not all the papers answered all the research questions.

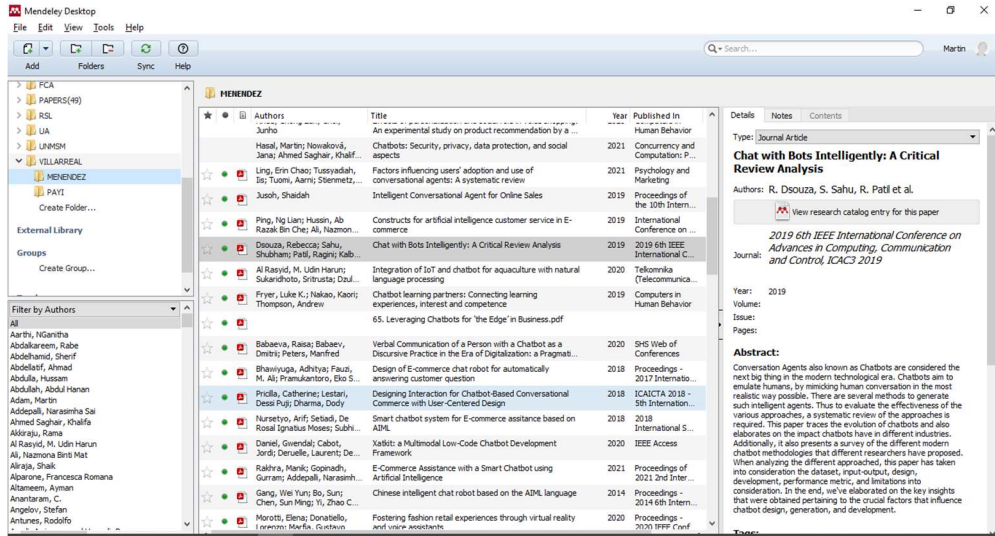The Mendeley tool was used to perform the data extraction as shown in Figure 4.

Figure 4: Mendeley Reports

2.8 Synthesis of Findings or Synthesis of the Data

The information extracted for research questions RQ1-RQ4 was tabulated and presented as quantitative data that were used to develop a descriptive and inferential statistical analysis of the different findings for each research question. These developed statistics helped to answer the research questions RQs.

3. RESULTS AND CRITICAL DISCUSSION

3.1 General description of the studies

Figure 5 shows the chronological distribution of the research carried out over the years, showing the number of papers found in the SLR from 2009 to 2022. The results show that in 2021 the greatest amount of research in the area was published, followed by 2020 and 2022.
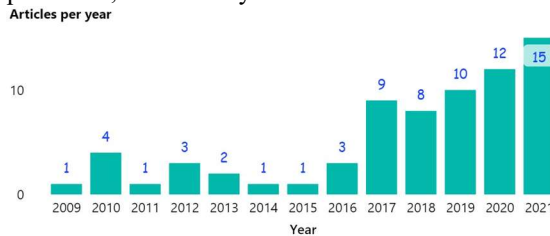

Figure 5: Chronological distribution of the research

The number of investigations identified in the years 2021 and 2020 are significantly higher. Between the years 2009 to 2019, research was also identified, but with a lower percentage compared to the years 2020 and 2021.

Another focus of this Figure 6 shows that in 2021 there was the highest number of publications about 5G Technology and its impact on Video Games, obtaining 21.43% of the total papers.
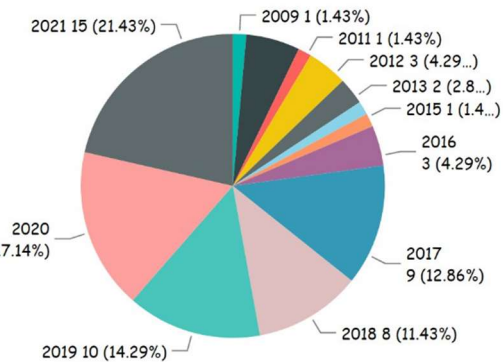

Figure 6: Number of papers per year

On the other hand, H. Al Fatta, Z. Maksom, and M. Hafiz in their paper "Game-based learning and gamification: Searching for definitions" [3], mention that 2019 was one of the most productive years, which provided papers with information that is more in line with the current reality.

According to authors S. Katsigiannis, W. Ahmad, and N. Ramzan [25] the two most productive years were 2020 and 2021, with 15 and 12 papers published respectively, related to 5G technology.

According to the author B. Wu in his paper "Influence of MOOC learners discussion forum social interactions on online reviews of MOOC" [77] the most productive year was 2020, where the impact of the use of Online Video Games was higher, compared to the other years.

Figure 7 shows the number of papers by country where it is shown that the US and China have the highest number of papers, with 13.75% and 12.5% respectively.

Figure 7. Number of papers per country.

Reviewing the study of authors P. Subedi et al., in their paper "Network slicing: a next generation 5G perspective" [67], they agreed that ProQuest and Google Scholar are placed in the first places of productive sources to answer research questions, due to the numerous amount of papers that can be found.

According to [3], they ratify that the research by China was the most productive, allowing to have greater scope on the application of 5G technology and its impact on Online Video Games.

According to the authors, S. M. C. Loureiro, R. G. Bilro, and F. J. de A. Angelino [34], mention that the country of Canada did not contribute considerably in answering the questions posed.

On the other hand, the authors B. Klimova and J. Kacet [17] point out that more papers on the use of online video games were published in the USA.

3.2 Answers to the Research Questions

RQ1: What are the clusters of Papers whose Conclusions and Discussions are characterized by high Objectivity and low Polarity in research on 5G Technology and its impact on the use of Online Video Games?

Cluster analysis is performed with the purpose of finding data that maintains a certain homogeneity with respect to the other data, to subsequently allow the analysis of a large volume of data, a natural grouping is sought based on its information, it should be said that the analysis is a statistical method oriented to classify by groups the individuals that are part of the sample.

Figure 8 shows the 4 clusters according to the polarity and objectivity of the discussions and conclusions present in each research paper, indicating that the papers are related to the papers in their identified cluster. Three clusters have been found that are characterized by their high objectivity and low polarity, which are clusters 4 and 3.
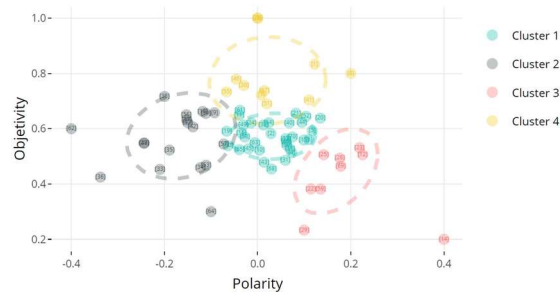

Figure 8. Clusters for Discussions and Conclusions.

According to authors Z. Ning et al., in their paper "Mobile Edge Computing Enabled 5G Health Monitoring for Internet of Medical Things: A Decentralized Game Theoretic Approach" [46], they mention that information exchange is vital for the good clustering of and correlation of variables taking into account the magnitude of polarity and objectivity.

On the other hand, authors S. Subedi, and J. Pyun in their paper "A survey of smartphone-based indoor positioning system using RF-based wireless technologies" [68], point out that the cluster with the lowest polarity is cluster 3 and the lowest objectivity cluster is cluster 2.

Likewise, the authors [17], consider that the K-means clusters divide the observations into K groupings according to the "distance" between the observations, which is similar to the multiple comparison and therefore has a low polarity in recent years.

RQ2: What are the Co-Occurring Keywords in 5G Technology research and their impact on the use of Online Video Games?

Figure 9 presents a dimension of the concurrences found in the keywords or thematic descriptors most frequently found in the 70 papers related to 5G Technology and its impact on the use of Online Video Games, during the years 2009 - 2021.
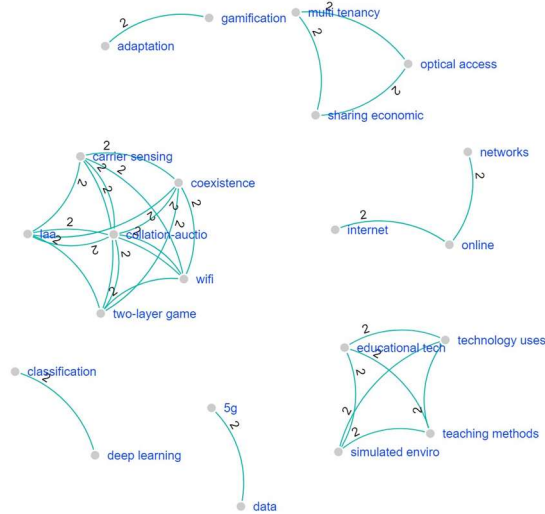

Figure 9. Keyword bibliometric network

According to the authors [34], mention that the degree of outdegree (Outdeg) of a keyword indicates the number of connections that the keyword has with other keywords in the set of articles.

As can be seen in Figure 10 that the words that are frequently represented in studies of 5G Technology and its impact on the use of Online Video Games are the following: "5G", "online", "video games", "service", "adaption", "gamification", among others.

Figure 10. Repeated Keyword Cloud

According to the author F. Banfi in his paper "The evolution of interactivity, immersion and interoperability in HBIM: Digital model uses, VR and AR for built cultural heritage" [5], they confirm that the most used keywords in the articles on video games were "gamification", "online gaming" and "video games".

Likewise, the authors [68], point out that the most used keywords referring to 5G technology in the papers presented were "5G", "online", "adaptation" and "addiction".

RQ3: What are the named entities (NERs): people, organizations, places, expressions of time and quantities that are most frequently presented in the Abstracts of research on 5G Technology and its impact on the use of Online Video Games?

As shown in Figure 11, the Abstracts of the research reviewed present 15 NERs type places (14.16%), 57 NERs type organizations (53.77%), 8 NERs type percentages (7.55%), 16 NERs type time (15.09%) and 10 NERs type people (9.43%).
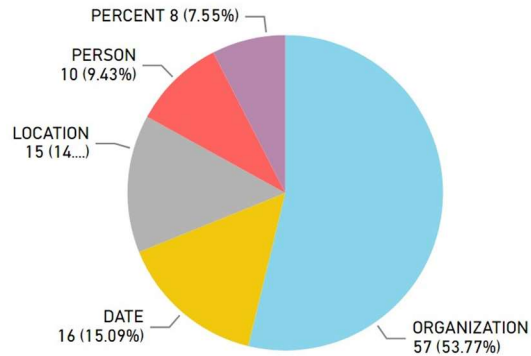

Figure 11. Types of NERs in Abstracts

On the other hand, Figure 12 shows 8 papers with their numbers of NERs, either with respect to people, organizations, places, time expressions and quantities.
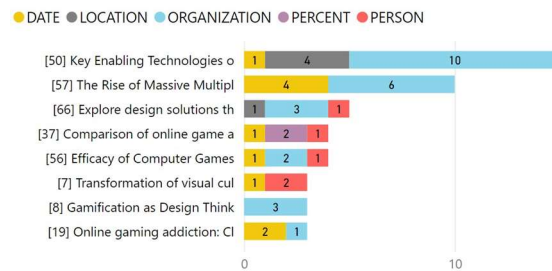

Figure 12. NERs distribution in abstracts

According to the authors J. Garcia-Arroyo and A. Osca Segovia [18], a large number of papers in their SLR mostly mention Organizations with regard to Named Entities (NERs).

For more detail, Table 4 shows the number of NERs found for each paper. The paper "Key Enabling Technologies of 5G Wireless Mobile Communication" [60] shows the highest number of NERs with a total of 15.

TABLE 4: NERs in Abstracts by Paper.

PAPER	DATE	LOCATION	ORGANIZATION	PERCENT	PERSON	Total
[60] Key Enabling Technologies of 5G Wireless…	1	4	10			15
[24] The Rise of Massive Multiplayer Online ….	4		6			10
[56] Explore design solutions throughth online…		1	3		1	5
[42] Comparison of online game addiction in…	1			2	1	4
[17] Efficacy of Computer Games on language…	1		2		1	4
[8] Transformation of visual culture in relation…	1				2	3
[9] Gamification as Design Thinking			3			3
[22] Online gaming addiction:Classification	2		1			3
[25] 5G :Disruption in Media and entertainment	1		1	1		3
[31] Traffic offloading in Unlicensed Spectrum			3			3
[54] University Students' perception toward the…		1	2			3
[57] Game theory-based smart mobile-data…			3		1	3
[69] An insight into the esport industry in China		1	2			3
[44] Massively multiplayer online games on…	1		2		1	2
…						
Total	**16**	**15**	**57**	**8**	**10**	**106**

Authors A. Sobodić, I. Balaban, and M. Tomašević in their paper "The Impact of Cultural Dimensions on Student's Use of E-Learning System" [65], assert that the highest number of NERs found in the studied papers is 15 NERs.

RQ4: What are the most cited concepts (topics) in research on 5G Technology and its impact on the use of Online Video Games?

According to the results shown in Table 5, the most used concepts are "alternative service providers", "game addiction scale", "lbt-based csat scheme" and others with two appearances in the papers; while concepts such as "abductive reasoning framing", "absen cinematic field", "access data rates", "archievable data rates" and others are present in only one paper.

TABLE 5: Trigrams of most used concepts by number of Citations.

Topic (Trigram)	<5	>=15	>=5 and <15	Total
alternative service providers		2		2
game addiction scale	2			2
lbt-based csat scheme	1		1	2
online game addiction	2			2
online games however	2			2
playing online games	2			2
send packets simultaneously	1		1	2
video game addiction	2			2

wifi backoff time	1		1	2
abductive reasoning framing		1		1
absent cinematic field		1		1
access data rates		1		1
access network sharing	1			1
achievable data rates			1	1
across multiple operators	1			1
…				
Total	**340**	**191**	**152**	**683**

According to the authors [3], the most used concepts in the research on 5G Technology and its impact on Online Video Games were "alternative service providers" and "abductive reasoning framing".

On the other hand, the authors [46], mentioned that the most used concepts in their systematic review were "active signal shaping" and "apple http live".

Likewise, the authors B. Klimova and J. Kacet [17], show in their research that the most recurrent and used concept is "activity-based IoT application".

Finally, it is appropriate to list some limitations that have manifested themselves in the research: only papers published in the last 5 years have been considered, and it has not been possible to locate a sufficient number of systematic review papers to make a better comparison of the bibliometric network, the cluster and the word cloud

generated with the natural language processing tool used.

4. CONCLUSIONS

In conclusion, this research utilizes Systematic Literature Review, which is an iterative process that combines a large amount of literature on a specific topic or research questions. The goal of SLR was to address the issues by identifying, critically appraising, and integrating the findings of all relevant individual high-quality studies that address one or more research questions. This method determines how far current studies have progressed in clarifying the use and impact of 5G technology in Online Video Games through evaluation. It identifies relationships, contradictions, gaps, and inconsistencies in the literature, and explores reasons for further study in the area. It also helps to formulate general statements, develop theories, and describe directions for future research.

A systematic literature review was conducted to collect, analyze, and synthesize data on measuring the reputation and influence of 5G technology on the use of Online Video Games. All the specific objectives formulated have been fulfilled, that is: to identify clusters of Papers whose Conclusions and Discussions are Objective, Bibliometric Networks of Keywords, named entities (NER) that are most frequently presented in the Abstracts and the most cited topics in the experimental research reviewed on the subject.

This research has some limitations that future research could address. First, it has a time limit for the papers that were reviewed, i.e., the papers were obtained between 2009 and 2021.

However, this topic is in its early stages and new publications will continue to appear. Therefore, future research should take into account more recent studies published on this topic. This will help increase awareness of the field among practitioners and researchers.

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