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*Article*

# Cloud Gamification: Bibliometric Analysis and Research Advances

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**Abstract:** Research on gamification in the cloud has been increasing in recent years. The main objective of this work was to analyse the advances and progress reported in the scientific literature published internationally in cloud gamification from a bibliometric perspective. The scientific production in this field was identified using the Web of Science (WoS) database. The analysis was carried out with the support of the VOSviewer software, version 1.6.18, developed by van Eck and Waltman, for the graphical visualisation of bibliometric networks. The study period covered the time from the first publication on the subject in 2012 to 31 July 2022, with 108 documents detected. The most prolific author was Jacub Swacha from the University of Szczecin, Poland. Forty-seven countries published on Cloud Gamification, with Spain and Italy being the countries with the highest scientific production. The most productive organisations were Bucharest University of Economic Studies, Complutense University of Madrid, Liverpool John Moores University and the University of Szczecin. The journal with the highest output was *Information*. The groups in the producing countries, the authors, the organisations to which they belonged and the thematic areas of the studies were identified, as well as their evolution over time.

**Keywords:** cloud; gamification; bibliometric analysis; research trends; database WoS; VOSviewer



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## 1. Introduction

There is no simple definition of Cloud computing. Clouds do not have a clear and complete definition in the literature yet [1]. The Cloud concept is still changing. Vaquero et al. [1] offered a global definition of the Cloud, stating that Clouds "are a large pool of easily usable and accessible virtualized resources (such as hardware, development platforms and/or services)". According to the 2011 definition by the National Institute of Standards and Technology "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction". The cloud definition is vague [2] and subjective and depends on the purposes and targets of the research, which highlights the "subjectivity" of the definition of the clouds [3]. For Razzaq and Zia [4], the "Cloud definition says everything is available everywhere at any time". Gamification is one of the great technological advances of the last decades [5] and a term that gained recognition in 2010. Deterding et al. [6] defined gamification as "the use of game design elements in non-game contexts". Cloud Gamification is the introduction of gamification in cloud services. Cloud computing can be employed for gamification by exploring all potential configurable resources and utilizing those resources for designing and developing games, for the proper and efficient application of gamification.

It is a novel topic, highly relevant and with great potential for future development. It has entered a powerful phase for online learning [7] and has become a cutting-edge technology in research [8]. Other authors [9] consider that gamification and cloud computing

present fertile grounds for relevant research in information technology service management (ITSM) and information systems (IS).

The use of cloud services for gamification allows accessibility anytime and anywhere on mobile devices [10] which, with wide access to the mobile internet and reduced bandwidth restrictions, has enabled the removal of previous limitations or barriers [11].

Cloud gamification has many applications in various fields and sectors, such as in the tourism sector [12,13], education [14–18], programming subjects [7], physics [19], cybersecurity subjects [14], language teaching [20]; health applications have also been developed to monitor brain health at home [21].

Cloud computing can be used for gamification to develop games for learning. Marchiori [22] has found it necessary to encourage students to change their mental habits to become familiar with the basic notions of distributed storage and cloud computing. Some authors [23,24] developed MyMOOCSpace, a mobile system based on gamification in the cloud that combines key aspects of collaborative machine learning.

There is a multitude of applications for transport and a reduction in energy consumption, among others; David et al. [25] developed an advanced transportation metering tool with vehicle information to enable enterprise reporting and cloud-based service development. The purpose of cloud gamification is to motivate building users to collect data to reduce energy consumption [26]. Research by Jia et al. [2] focused on crowd detection with privacy incentives.

The implementation of gamification in the cloud would reduce the costs incurred by educational institutions [5]. The operational cost of data centres has been an issue exposed in the scientific literature. For this purpose, Yin et al. [27] designed and built a new cloud data centre management system based on the concept of 3D gamification.

The scientific production on Cloud Gamification, being quite recent, is somewhat scarce; however, it has increased significantly over time, as a result of the interest that it has awakened and generated.

This article provides an analysis of the scientific literature on Cloud Gamification from a bibliometric perspective, which has not been performed in previous articles. The main objective of this work was to analyse the advances of and progress in cloud gamification published internationally in the scientific literature, from the first publication (2012) until 31 July 2022.

The scientific production in this field was identified from the Clarivate Analytics Web of Science (WoS) database, as implemented in other articles [28–30]. All databases and all collections were used. As one of the most comprehensive, the WoS database supports the reliability of the bibliometric analysis. The analysis was carried out with the support of the VOSviewer software, version 1.6.18, developed by van Eck and Waltman [31], which is a software tool that allows the graphical visualisation of bibliometric networks. It uses the proximity index as a measure of similarity. This research had the following objectives:

- To analyse the existing academic networks in the research field of Cloud Gamification.
- To identify the most productive countries, authors and organisations.
- To study the most relevant topics and trends in Cloud gamification research.

This paper proposes the following research questions:

RQ1: What is the evolution of knowledge about Cloud Gamification?
RQ2: What is the geographical distribution of the production on Cloud Gamification?
RQ3: Which publications, authors and papers have influenced research on Cloud Gamification?
RQ4: What is the conceptual and thematic structure of the scientific literature on Cloud Gamification?

Following this introductory section, we present the research methodology, research results, discussion and our conclusions.

## 2. Materials and Methods

Bibliometric research uses a quantitative analysis of statistical data from the published literature to study publication patterns within a scientific field [32]. Bibliometric analysis involves the use of a set of quantitative metrics, techniques and tools to analyse bibliographic data in the scientific literature [33]. Bibliometric studies are based mainly on the quantitative analysis of publications related to a specific phenomenon [34]. This analysis is widely recognised and used as a legitimate method to examine the scientific discourse [35] and is an effective procedure to understand how a research field emerges and develops [36,37].

With the development and coverage of bibliographic databases, bibliometrics has become a useful tool to address the current knowledge structure of a research area or topic [38]. The methods implemented in bibliometrics are based on the statistical analyses of quantitative data provided by the scientific literature and increase the rigour of literature reviews by minimising the subjective component of the researcher [39].

The use of VOSviewer as a bibliometric tool for systematic literature analysis provides several advantages, including a comprehensive bibliographic analysis that allows us to conduct research of unprecedented scope [40]. These tools allow us to extract reliable data from a variety of analysis units [41].

This work was carried out to understand the academic scope of the examined subject and the content that is being debated and to identify the countries with the greatest scientific production, the most prolific authors and the most cutting-edge organisations. This study is novel in that no systematic review or bibliometric analysis of cloud gamification has ever been carried out.

The bibliometric study was carried out in several phases: the first phase consisted of a search for documents investigating the subject. All types of documents were included: Proceding Papers, Articles, Early-Access Articles, Review Articles, Book Chapters, etc. In Table 1, we present the research design, where the inclusion criteria, exclusion criteria and bibliometric indicators are indicated, following the PRISMA 2020 guidelines.

**Table 1.** Research design.

| Inclusion Criteria | Exclusion Criteria | Bibliometric Indicator |
|---|---|---|
| CI1: Period: From the first published document until 31 July 2022 | EX1: Documents published after 31 July 2022 | Number of documents per year of publication |
| CI2: All categories in WoS | EX2: None | Number of citations per year |
| CI3: Type of documents: all. Proceeding Papers, Articles, Early-Access Articles, Review Articles, Book Chapters | EX3: None | Number of documents by typology |
| CI4: Language | EX4: None | Number of documents by typology |
| CI5: Topics "Cloud" AND topics "Gamification". | EX5: Filtering of documents containing the subject matter | Most prolific countries<br>Most productive organisations/institutions<br>Most productive authors |

The selection of papers was performed in a broad sense; in the search, if we considered the term "Cloud Gamification", the result was only one paper, whose author is Ricardo Queiros [1].

The diagram of the paper selection and search process is showed in Figure 1.


**Figure 1.** Diagram of the selection and search process.

## 3. Results

The results of the citation and publication analysis are shown in Figure 2 and Table 2.

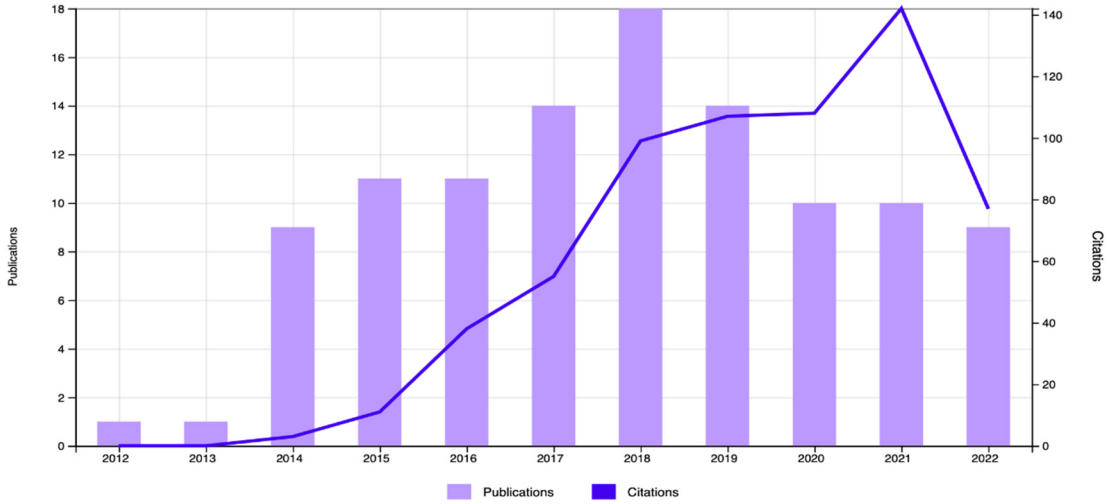


**Figure 2.** Number of publications and citations per year (2012–2022).

**Table 2.** Document typology *.

| Document Types | N° |
|---|---|
| Meeting | 66 |
| Article | 39 |
| Review article | 3 |
| Total | 108 |

* Note: Article: "Reports of research on new and original works that are considered citable. Includes research papers, brief communications, technical notes, chronologies, full papers, and case reports (presented as full papers) that were published in a journal and/or presented at a symposium or conference". Review article: "Detailed, critical surveys of published research. A review article may summarize previously published studies and draw some conclusions but will not present new information on the subject. Includes Reviews, Reviews of the Literature, Mini-reviews, and Systematic reviews. If an article is listed under the review section in a journal and/or the term *Review of the Literature* appears in the title, it will be considered a review".

In the study period (since the first publication in 2012 to 31 July 2022,) the highest peak of scientific production on the subject was 2018. Since 2020, there has been a decrease in the scientific production. This is consistent with other recent bibliographic studies [42,43]. We will have to wait longer to see if this trend is confirmed.

The scientific production on cloud gamification involved different types of documents. Among the different documents, Proceeding papers were the most numerous (66), followed by articles (39), representing 97.22% of the production analysed (Table 2).

Descriptions of the document types available when searching the Web of Science Core Collection can be found at https://webofscience.help.clarivate.com/en-us/Content/document-types.html (accessed on 12 October 2022).

Table 3 shows the top 10 WoS categories that published most of the papers on the subject. The first in the ranking was "Computer Science Theory Methods" with 29 papers, followed by "Computer Science Information Systems" with 24 papers, and, in third place, with 20 papers, "Engineering Electrical Electronic". The next-highest-ranked journals had fewer than 20 documents.

**Table 3.** Number of publications and categories from the WoS database.

| Web of Science Categories (10) | Number of Publications | Percentage |
|---|---|---|
| Computer Science Theory Methods | 29 | 26.852 |
| Computer Science Information Systems | 24 | 22.222 |
| Engineering Electrical Electronics | 20 | 18.519 |
| Education Educational Research | 19 | 17.593 |
| Computer Science Interdisciplinary Applications | 14 | 12.963 |
| Computer Science Artificial Intelligence | 12 | 11.111 |
| Education Scientific Disciplines | 10 | 9.259 |
| Telecommunications | 10 | 9.259 |
| Computer Science Cybernetics | 9 | 8.333 |
| Computer Science Hardware Architecture | 7 | 6.481 |

Table 4 shows the Titles of the ten journals or meetings that published the most documents on the subject.

**Table 4.** Titles of Journals or Meetings.

| Titles of Journals or Meetings (10) | Number of Publications | % of 108 |
|---|---|---|
| Information | 4 | 3.704 |
| 2014 IEEE ACM 7th International Conference on Utility and Cloud Computing UCC | 3 | 2.778 |
| Lecture Notes in Computer Science | 3 | 2.778 |
| 2018 IEEE 6th International Conference on Future Internet of Things and Cloud Workshops W Ficloud 2018 | 2 | 1.852 |
| Advances in Intelligent Systems and Computing | 2 | 1.852 |
| Applied Sciences Basel | 2 | 1.852 |
| Communications in Computer and Information Science | 2 | 1.852 |
| Computer Applications in Engineering Education | 2 | 1.852 |
| Edulearn15, 7th International Conference on Education and New Learning Technologies | 2 | 1.852 |
| Elearning and Software for Education | 2 | 1.852 |

They represent 22.22% of the total production analysed (108 documents). The journal *Information* ranked number one in the top ten, with four articles; in second place, we found two meetings titles, all of them with three papers, i.e., the *7th International Conference on Utility and Cloud Computing UCC* held in 2014 and *Lecture Notes in Computer Science*. The other publication titles had a number of less than three papers.

### *3.1. Network Analysis*

This section presents the analysis results of the data and their interpretation and visualization with VOSviewer.

First, the evolution and geographical distribution of the publications, authors and organisations to which the researchers belonged and the most influential papers were analysed. The intellectual structure of this literature was described using an author co-citation network constructed with VOSviewer. Second, we performed a keyword co-occurrence analysis to identify the main themes and trends.

The results also point to the most recent topics of interest that deserve attention for future research. The results of each analysis are presented in Tables for a quicker understanding and then illustrated in Figures for their visualisation.

### *3.2. Analysis of the Authors' Influence*

The authors ordered by the number of citations, as an indicator of quality, are showed in Table 5.

**Table 5.** Top 10 most prolific authors, ordered by the number of citations.

| Authors | Number of Publications | Citations | Organization |
|---|---|---|---|
| Ali, Raian | 2 | 28 | Bournemouth University, United Kingdom |
| Dalpiaz, Fabiano | 2 | 28 | Utrecht University. Utrecht, Netherlands |
| Hosseini, Mahmood | 2 | 28 | Eastern Mediterranean University Fac Engn Famagusta, North Cyprus, Turkey |
| Shahri, Alimohammad | 2 | 28 | Leyton UK London, England |
| Neyem, Andres | 2 | 22 | Pontificia Universidad Catolica de Chile Ciencias Computac Santiago, Chile |
| Perez-Sanagustin, Mar | 2 | 22 | Universite Toulouse 1 Capitole Inst Rech Informat Toulouse Toulouse, France |
| Ramirez-Donoso, Luis | 2 | 22 | Pontificia Catolica Univ Chile Ciencias Computac Macul, Chile |
| Swacha, Jacub | 3 | 10 | Univ Szczecin, Szczecin, Poland |
| Abdullahi, Hamit | 2 | 9 | Abu Dhabi University Coll Engn Abu Dhabi, U Arab Emirates |
| Ahmed, Masud | 2 | 9 | Abu Dhabi University Coll Engn Abu Dhabi, U Arab Emirates |

The most prolific authors was Jacub Swacha, University of Szczecin, Szczecin, Poland (Table 5). Of the rest of the authors in the top ten, nine published two papers each and belonged to organisations from Europe, UK, South America and the Arab Emirates.

The most cited paper published in 2014 was a paper in the *Proceedings of the 45th ACM Technical Symposium on Computer Science Education* (SIGCSE '14) with a total of 113 citations, and an average number of citations per year of 12.56, by the authors Alexandru Iosup

and Dick Epema, entitled "An Experience Report on Using Gamification in Technical Higher Education".

The document co-citation analysis identified the following papers as key contributions to the study of Cloud Gamification:

- Juho Hamari, Jonna Koivisto, and Harri Sarsa, 2014. "Does Gamification Work?—A Review of the Literature on Gamification", in *Proceedings of the 2014 47th Hawaii International Conference on System Sciences* (HICSS '14). IEEE Computer Society, USA, 3025–3034. https://doi.org/10.1109/HICSS.2014.377 (accessed on 15 September 2022).
- Gabe Zichermann y Christopher Cunningham, 2011. "The Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps", O'Reilly Media.
- Sebastian Deterding, Dan Dixon, Rilla Khaled, and Lennart Nacke, 2011. "From game design elements to gamefulness: defining "gamification", in *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments* (MindTrek '11), Association for Computing Machinery, New York, NY, USA, 9–15. https://doi.org/10.1145/2181037.2181040 (accessed on 15 September 2022).

The author co-citation analysis identified, as the most outstanding authors, Hamari, J., Deterding, S., Zichermann, G. and Nacke.

In total, 372 authors were found to have published on the subject. With a minimum threshold of 2 publications, the number of authors decreased to 40 authors, forming 14 clusters, very dispersed and not very collaborative. In the 14 clusters, 9 authors were connected (red cluster): Anadon N.J., Capo, M.A.; Del Pino, J., Diaz, M.J., Frejo, M.T.; García, J., Lobo, M., Mourin, F.J. and Moyano, P. The visualisation showed little connection and collaboration between the authors researching the subject (Figure 3).

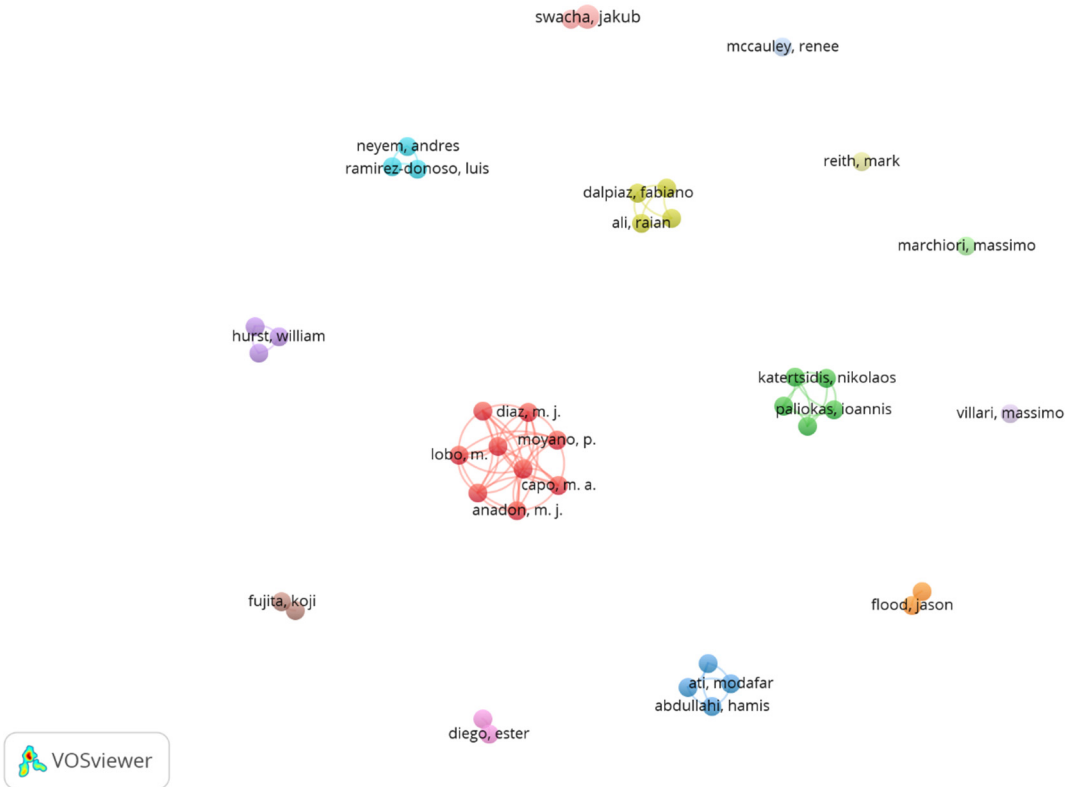


**Figure 3.** Mapping the scientific collaborations.

### *3.3. Analysis of Organisations and Countries*

The total number of organisations publishing on cloud gamification was 166. Only three universities had three publications: Liverpool John Moores University (UK), Universidad Complutense de Madrid (Spain) and the University of Szczecin (Poland). The rest had

one or two publications, and there were no significant connections. Only 13 organisations of the involved 166 were connected, as can be seen in Figure 4.

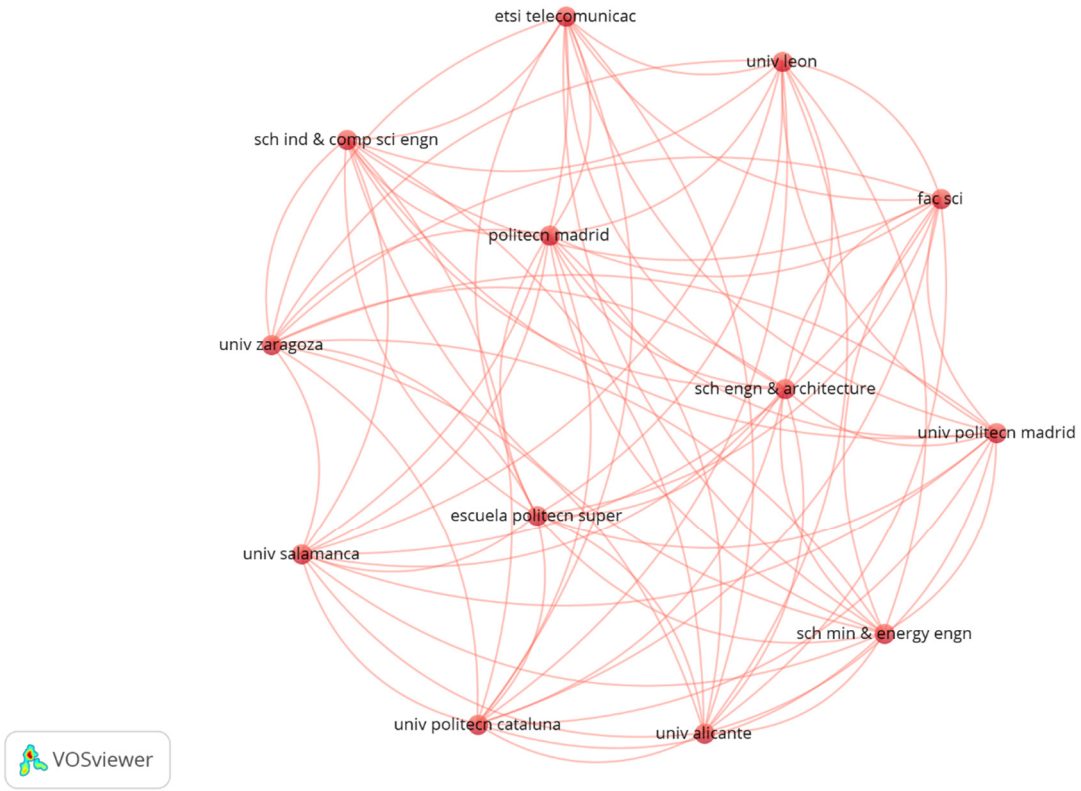


**Figure 4.** Networked organisations.

In total, there were 47 countries that published about cloud Gamification. We visually represented those countries that were connected with a minimum threshold of two documents. With this threshold, we found 20 producing countries, of which only 14 were connected (Figure 5).

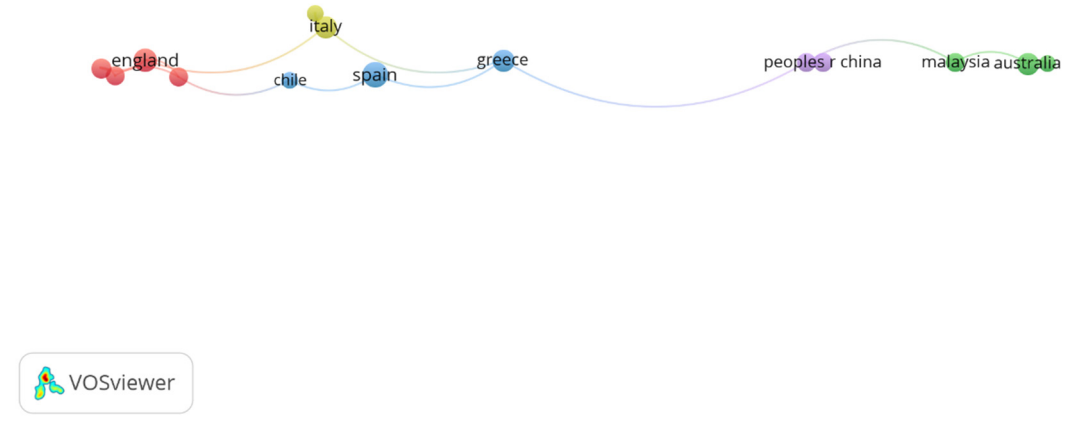


**Figure 5.** Country clusters.

We identified five clusters: the red cluster, including England, France, Germany and the Netherlands; the green cluster, with Australia, Austria and Malaysia; the blue cluster, with Chile, Greece and Spain; the yellow cluster, with Belgium and Italy; and the purple cluster, with China and Saudi Arabia.

### *3.4. Co-Word Analysis*

In this part of the paper, through the identification of the clusters, the most prominent issues in the scientific literature in this field are detailed.

There are controversies when implementing co-word analysis. Different units of analysis can be used: authors' own keywords ("author KeyWords") or keywords automatically extracted from the frequency of occurrence of words in the titles of references of the cited publications (KeyWords plus, KW+). These are standardised with vocabularies derived from Elsevier thesauri. According to Cantos-Mateos et al. [44], the most appropriate units are KW+. However, other studies [37,45] considered the key words provided by the authors. Zhang et al. [37] stated that they are less exhaustive than KW+ to represent the content of a publication.

As a consequence, we analysed and compared the visualisations generated by VOSviewer by both author KeyWord descriptors and Keyword plus and revealed that the author KeyWord descriptors are more suitable in this scientific domain. Therefore, we created bibliometric maps with the authors' keywords by applying the methodology based on co-word analysis, clustering techniques and visualisation techniques. The co-word analysis reflects the semantic structure of the research field being addressed.

The authors' co-occurrence analysis of keywords produces a network of themes and their relationships that represent the conceptual space of a research field. In the graphical visualisation, the size of the circles denotes the relevance of an element, and the network connections identify the most closely linked elements. The placement of the circles, colours, and delimitation are used to group the elements. The distance between two nodes is proportional to the number of matches between the keywords. Therefore, shorter distances suggest a higher match between keywords.

Of the 108 documents, 380 keywords were obtained from the authors; limiting the search to keywords with a minimum of three occurrences, reduced the keyword number to 15, of which 14 were connected (Figure 6).

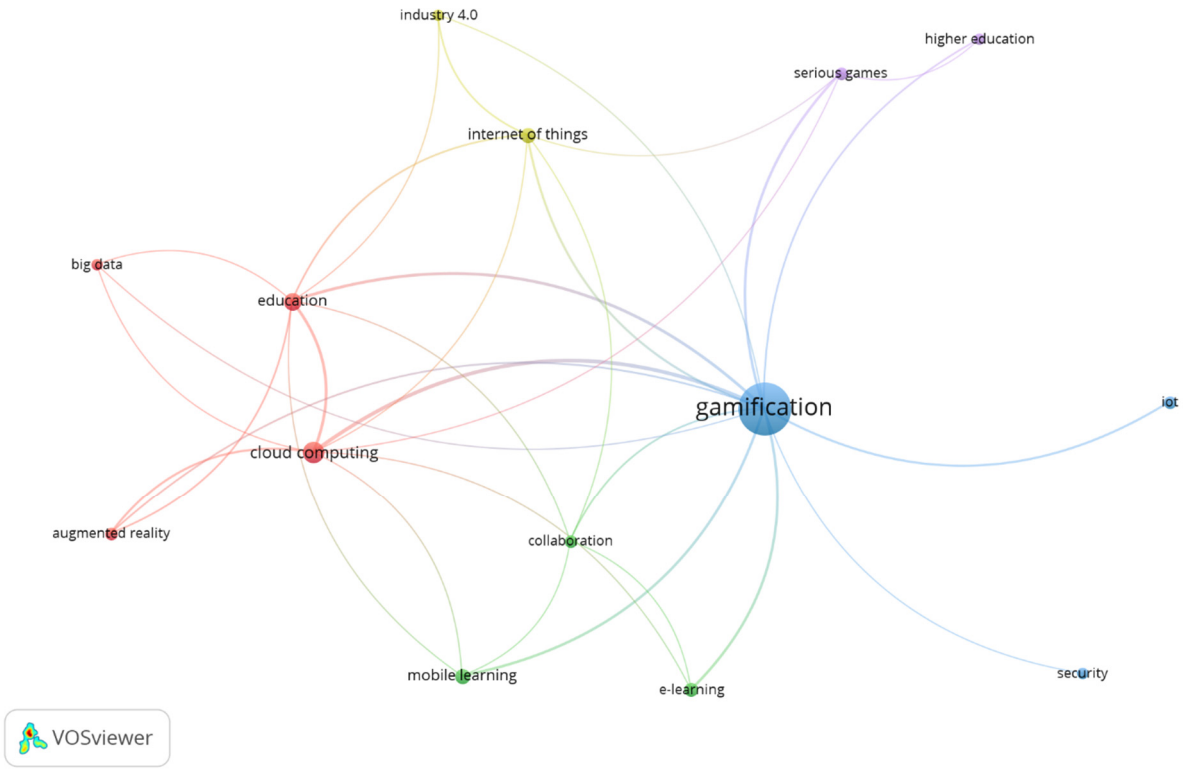


**Figure 6.** Labelled bibliometric map.

The resulting maps showed five thematic clusters or main research fronts. The red cluster encompassed cloud computing, education, augmented reality and big data; the

green cluster included collaboration, e-learning and mobile learning; the blue cluster comprised gamification, IoT and security; the purple cluster analysed serious games in higher education with the keywords higher education and serious games.

In terms of the evolution and modification of research topics, the initial focus was on topics related to the so-called "serious games". In more recent years, researchers have focused on the analysis of augmented reality, mobile learning and higher education.

## 4. Discussion

Documents published on the research topic Cloud Gamification began to appear in 2012. The first document with impact was the Conference paper "Experiences in the Design and Implementation of a Social Cloud for Volunteer Computing" published by the *IEEE 8th International Conference on E-Science*, by the authors Ryan Chard, Kris Bubendorfer and Kyle Chard.

There was a clear upward trend in the scientific production and dissemination on this subject since the first publication in 2012, ten years ago. The scientific production has been increasing, with the highest peak in terms of the number of publications in 2018. However, it has decreased slightly in recent years (addressing RQ1).

The total number of authors publishing on cloud gaming was 372 authors. The most prolific author in terms of the number of papers was Jacub Swacha, with three papers. Papers on cloud gamification were published in more than 47 countries. Spain was at the top of the ranking in terms of the number of publications. Spain appeared very central, occupying the first place in the world ranking, with the production of 13% of the papers in this field, reporting 13 publications and 51 citations (addressing RQ2 and RQ3).

The most productive organisations were Bucharest University of Economic Studies, Complutense University of Madrid, Liverpool John Moores University and the University of Szczecin. The titles of the publications with the highest number of papers were *Information*, *IEEE ACM 7th International Conference on Utility and Cloud Computing UCC* and *Edulearn Proceedings*. The most cited working paper published in 2014 was a Proceedings paper in *Proceedings of the 45th ACM Technical Symposium on Computer Simulation Education* (SIGCSE '14), with a total of 113 citations and an average number of citations per year of 12.56, by the authors Alexandru Iosup and Dick Epema, entitled "An Experience Report on Using Gamification in Technical Higher Education".

The journals with the highest production on the subject were *Information*, *2014 IEEE ACM 7th International Conference on Utility and Cloud Computing UCC*, and *Edulearn Proceedings* out of the 128 titles in Publication Titles (Journals, Conferences).

The publication languages of the documents were English (107) and Ukrainian (1). Clusters of topics were identified using the authors' keywords. From a total of 380 authors' keywords, with a minimum number of occurrences of 3, 5 clusters with 15 items were obtained, of which 14 were connected. The resulting maps showed five thematic clusters or main research fronts (addressing RQ4). The red cluster encompassed the topics of cloud computing, education, augmented reality and big data; the green cluster investigated e-learning and collaboration, encompassing the words collaboration, e-learning and mobile learning; the blue cluster comprised gamification, IoT and security; the yellow cluster analysed the topic of interconnection and digital transformation, comprising industry 4. 0 and internet of things; the purple cluster analysed serious games in higher education with the keywords higher education and serious games. Pappas et al. ([46] p. 321) pointed out that "more recently, the idea of pairing existing gamification approaches with other emergent technologies such as the Internet of Things, XR, and easy-to-use game engines has started appearing in the industry with application to education. One example of such development is what PTC is doing for training, in using this methodology for worker training or remote worker supervision".

The central keyword was gamification. Over time, the key words of the authors changed and evolved. In earlier years, topics such as serious games were dealt with. However, in more recent years, the focus shifted to research and analysis of augmented

reality, mobile learning and higher education. It was possible to transform a complex, underlying, dynamic and multidimensional reality into visible representations that could help a better understanding of the evolution of the cloud gamification research field by experts in the field. The explanation may lie in a chronological reason: initially, the concept of serious game was developed, a term coined by Clark Abt in 1970 in his work *Serious Games* (Viking Press, 1970). However, as indicated by Bel et al. [47] "recently the term 'gamification' has gained popularity among researchers, and many gamification methods have been established in recent years due to the popularity of the concept".

Among the limitations of this study is the fact that only the WoS database was used. In future work, the search for documents could be extended to Scopus or other databases to complete the analysis.

## 5. Conclusions

Due to the multidisciplinary and multidimensional nature of this field of study, two-dimensional bibliometric maps are a suitable instrument for understanding the thematic structure of this scientific domain. Bibliometric analyses are becoming increasingly important because they quantify the scientific activity using mathematical and statistical methods to discover scientific gaps that provide opportunities for new research [48].

In this study, we quantified the scientific activity in this field of research through bibliometric analysis. An objective and logical summary of the existing knowledge about cloud gamification was offered. This bibliometric analysis allowed us to respond to the objective set by analysing the scientific production on Cloud Gamification reported in one of the most relevant databases (WoS). The bibliographic analysis carried out in this work allowed us to detect and indicate the development of research in cloud gamification and the future trends. This article provides the first bibliometric analysis of this topic, which is very useful for generating future research proposals in this field of study. With the help of bibliometric analysis, researchers can identify the current state of research on a topic and potential research hotspots.

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