Research Trends of Serious Games: Bibliometric Analysis

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Abstract. One of the alternatives offers to enhance the improvement of learning process is by adopting a game which is known as serious game. The using of serious game in various studies published by leading journals has gradually increased. This increase is also reflected in various fields of research. The purpose of this research is therefore to define the current trends in serious game. The research performed a bibliometric analysis based on the Scopus database. Based on the keywords, the research was able to collect 5,375 documents in further review. Various methods have been used, such as frequency analysis, VOSviewer for data visualization, citation and metrics analysis. This study reports research results using standard bibliometric measures such as publication year, document type, source type, subject area, keyword analysis, geographic distribution, authorship, affiliation and citation analysis. Based on these results, serious game publications have increased significantly since 1984 in recent years. The increasing number of serious game research underlines the importance of serious game for learning.

1. Introduction
The serious game is now becoming popular and widely studied. The serious game has also grown rapidly in their use as educational tools \cite{1}. The purpose of serious games is that game must be fun, entertaining, and educational \cite{2}. Serious games can attract attention, increase engagement, provide a positive attitude towards learning and change behaviour when compared to conventional media formats \cite{3}. Even though there are many benefits of a serious game, it is also a very complicated game that requires mastering various skills in the game. Serious games also require many hours of practice before someone can become proficient at playing them \cite{4} \cite{5} \cite{6}.

Through the development of information technology related to statistical data analysis, visual analysis technology plays a very important role in presenting and describing the results of research that has been done. VOSviewer can be used to create author maps or journals based on cocitation data or to build keyword maps based on shared incident data. The VOSviewer program can generate detailed bibliometric maps, display maps in various ways, and each emphasizes a different aspect of the map \cite{7}. Analysis in this regard includes indicators such as parameters of scientific activity,
identifying research groups and authors, citations of published articles, information consumption, impact factors, h-index, among others [8].

This article is organized as follows: Section 2 outlines the process of gathering data and the techniques used in this article. The results of a thorough bibliometric analysis are summarized in section 3. The final part of the article ends by highlighting the findings. The main objective of this research is to better understand the quantitative and visual aspects of current literature and to obtain reliable results for the advancement of serious game research and future trends in research. This study analyzed a comprehensive study focused on bibliometric analysis and information mapping assisted by the Scopus and VOSviewer databases.

2. Methods
For this study, we have obtained bibliometric information from Scopus, one of the most widely used databases. Scopus is an abstract and quotation database for peer-reviewed literature and is also part of SciVerse provided by Elsevier as described in the previous section and is also based on the same database as Science Direct [9]. The results of the study were evaluated in terms of experience of the growth of the journal. The following keywords have been used to scan the related article relating to serious game. We concentrate on the title of the articles, as it is a particular subject that is important for the study area and for the purpose of the report. The search was carried out in September 2020. We take a few tags from Scopus, such as author, title, abstracts, countries, citation, author affiliations, and references. Based on our search, we have obtained 5,735 documents that matched our keywords. Documents collected from Scopus, classified in Conference Paper (4,327), Article (1,110), Book Chapter (166), Review (96), Editorial (11), Book (10), Conference Review (6), Short Survey (3), Note (2), Erratum (1), and Undefined (3).

Various output metrics for bibliometric analysis have been derived in this paper. Comprehensive records for the total number of publications originating from the source. Comprehensive citation for the total number of citations earned by publication. Documents by citation to assess the total number of publications. The bibliometric approach used in this study uses modern technologies in information engineering, database management and statistics. The bibliometric approach will determine possible technology patterns or research orientations using the author's keywords, title keywords, and keywords plus [10]. In combination with VOSviewer software, the bibliometric approach is used to empirically and visually analyze serious game research from 1984 to 2019. Bibliometric or Scientometric analysis is a research field that aims to examine the current developments in literature. It provides guidance and motivation for future research work [11]. The scientific field is to study science, technology, and innovation from a quantitative point of view. Scientometric outlook adds a quantitative focus on text and communication to interdisciplinary science and technology [12].

3. Results
In this section, we have shown bibliometric results for different performance metrics, including documents by year, documents by author, documents by affiliation, documents by territory/country, documents by source title, documents by subject area, most productive authors, most common disciplines, and top journals.

3.1. Research growth and geographical distribution
The serious game publication in Scopus started in 1984 with one document and grew exponentially. The highest number of publications in 2019 is 950. The number of publications has grown significantly from year to year. A total of 101 countries contributed to the publications on serious game in which the top 10 publishing countries were colored in Figure 1. The country was determined on the basis of the affiliation of the authors. Figure 2 displays 10 of the most active countries. On Figure 2, the United States is the largest contributor, accounting for 13.43%. United Kingdom and the Germany have contributed 11.05% and 10.29% respectively to second and third positions. Spain and
Italy each contributed 8.58% and 7.74% respectively. Netherlands, Portugal, France, Canada and Brazil each contributed 6.99%, 6.36%, 6.24%, 4.76% and 4.57% respectively.

![Graph of number of documents per year](image1)

**Figure 1.** Total number of Scopus publications.

![Geographical distribution map](image2)

**Figure 2.** Geographical distribution.

3.2. **Subject area and affiliation**

The analysis next classifies the published documents on the basis of the subject area as displayed in figure 3. The delivery of serious game research derives predominantly from Computer Science (82.25%), Engineering (26.19%), Social Sciences (25.56%), Mathematics (21.03%) and Medicine (8.74%). However, other subjects have also published articles, such as Psychology (4.31%), Decision Sciences (4.25%), Business, Management and Accounting (2.93%), Arts and Humanities (2.39%), and Health Professions (1.97%).
We're also evaluating the 10 leading affiliations. The great majority of serious game study comes from Università degli Studi di Genova (1.78%), Coventry University (1.59%), Technische Universität Darmstadt (1.43%), Universidade do Porto (1.34%), and Universidad Complutense de Madrid (1.29%). Obviously, documents by affiliation are shown in Figure 4.

![Figure 3. Top 10 subject area.](image)

![Figure 4. Top 10 affiliate contribution.](image)

### 3.3. Source title

Serious game research has also been published in numerous journals, proceedings, and books. Table 1 below shows the top source title that the serious game articles have been published on the basis of a minimum of 40 publications provided by each source title. From the table you can conclude that Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligence And Lecture Notes in Bioinformatics is the most documents on serious game. Table 1 provides an overview of the analysis of the most commonly published sources or documents.

| Source Title                                                                 | Total Document | Percentage (N = 5,735) |
|------------------------------------------------------------------------------|----------------|------------------------|
| Lecture Notes In Computer Science Including Subseries                        | 779            | 13.58                  |
| Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics |                |                        |
| ACM International Conference Proceeding Series                              | 228            | 3.98                   |
| Communications In Computer And Information Science                          | 104            | 1.81                   |
| Ceur Workshop Proceedings                                                   | 88             | 1.53                   |
3.4. Most highly cited authors
The most cited authors of Scopus are extracted and sorted by a number of publications. Scopus' most prominent authors have been evaluated using VOSviewer tools. Table 2 shows the top ten most cited authors.

| Rank | Author                  | Citations | Total Link Strength |
|------|-------------------------|-----------|---------------------|
| 1    | De Freitas, S.          | 790       | 31051               |
| 2    | Hainey, T.              | 660       | 28844               |
| 3    | Bellotti, F.            | 696       | 26393               |
| 4    | Connolly, T. M.         | 583       | 25123               |
| 5    | Berta, R.               | 536       | 20173               |
| 6    | Fernandez-manjon, B.    | 501       | 19796               |
| 7    | Boyle, E. A.           | 465       | 19483               |
| 8    | Moreno-ger, P.          | 493       | 19172               |
| 9    | Prensky, M.             | 705       | 16788               |
| 10   | De Gloria, A.           | 406       | 16492               |

3.5. Keyword co-occurrences analysis
We then analyze the author's keywords for the VOSviewer co-occurrences. Keywords co-occurrence can effectively reflect research hotspots in the field of discipline and provide auxiliary support for scientific research [13]. VOSviewer software built the co-occurrence keyword network of educational technology. VOSviewer software is used to extract data, map and group articles. The circle size is correlated positively with the appearance of the keywords in the title and abstract. The size of the product label and circle are therefore determined by the weight of the item. The larger the item's weight, the larger the label and the circle of the item [14]. The distance between the two nodes reflects the force of the two nodes. In general, shorter distances indicate stronger relationships. The line between the two keywords says they appear together [15]. The connecting strength between two nodes refers to the co-occurrence frequency. The relationship between two nodes can be shown as a quantitative index [16]. Following figure shows the visualization of the most influential keywords used by Scopus authors. We have 675 keywords at a time in all publications related to serious game. Relevant keywords, as shown in the same color, are commonly given together. The diagram shows that serious game, gamification, virtual reality, game design, and game-based learning are closely related and frequently co-occur.
Figure 5. Author keywords co-occurrences network visualization.

VOSviewer is able to display density visualizations (see Figure 6). Each node in the keyword density visualization plate has a color that depends on the density of the item at that node. In other words, the color of the node depends on the number of objects in the node environment. Keywords appear more frequently in the red area; on the other hand, keywords appear less frequently in green areas [17]. Figure 6 shows the focus of research studies intuitively. Serious game, gamification, virtual reality, game design, and game-based learning are the core keywords.

Figure 6. Author keywords co-occurrences density visualization.
3.6. Most highly cited sources
The most cited sources of Scopus are extracted and sorted by a number of publications. Scopus’ most prominent sources have been evaluated using VOSviewer tools. Table 3 shows the top ten most cited source.

| Rank | Source                                                                 | Citations | Total Link Strength |
|------|------------------------------------------------------------------------|-----------|---------------------|
| 1    | Computer Education                                                     | 1512      | 32674               |
| 2    | International Journal of Game-Based Learning                           | 129       | 20394               |
| 3    | Computers in Human Behavior                                            | 789       | 18466               |
| 4    | International Journal of Gaming and Computer Mediated Simulations     | 74        | 16176               |
| 5    | Simulation & Gaming                                                    | 860       | 15268               |
| 6    | British Journal of Educational Technology                             | 592       | 11838               |
| 7    | Journal of Medical Internet Research                                   | 223       | 8913                |
| 8    | Journal of Educational Psychology                                     | 318       | 8096                |
| 9    | Handbook of Research on Improving Learning and Motivation through Educational Games: Multidisciplinary Approaches | 99        | 7513                |
| 10   | Gaming and Simulations: Concepts, Methodology, Tools, and Applications | 26        | 7489                |

4. Conclusion
This research started an analysis of all sorts of academic articles published to date on serious game. The research demonstrates the pattern of previous studies using selected bibliometric indicators from the Scopus database. Overall, 5,735 record bibliometric information were extracted from the Scopus database. Results suggest that the serious game trend has started to become an evolving trend since 1984 and increased exponentially in 2019. Most of the papers have been written in the journal. The United States published the largest number of contributors, followed by United Kingdom and Germany. Serious game phenomena are primarily related to Computer Science, Engineering, Social Sciences, Mathematics and Medicine. However, other subjects have also published articles, such as Psychology, Decision Sciences, Business, Management and Accounting, Arts and Humanities, and Health Professions. The top five most cited source are Computer Education, International Journal of Game-Based Learning, Computers in Human Behavior, International Journal of Gaming and Computer Mediated Simulations, and Simulation & Gaming.
Despite the useful perspectives given in this article, a number of drawbacks should be taken into account by researcher. First of all, the study used specific keywords to find the initial list of scholarly articles published as indexed by Scopus. However, this method has been very common in previous bibliometric related studies. Although Scopus is one of the largest online databases that lists all scholarly papers, it does not fully cover all available sources. Any exclusions from this review are also very much awaited. In addition, no search query is 100% perfect for collecting all scholarly articles in this field. Despite these limitations, this work describes the panoramic knowledge of current trends in serious game science literature.

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