DIFFERENTIAL EQUATIONS AND MATHEMATICAL MODELS: AN EDUCATIONAL APPROACH

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Abstract

A documentary review was carried out on producing and publishing research papers on studying differential equations, mathematical models, and education. The bibliometric analysis proposed in this paper was to know the main characteristics of the volume of publications registered in the Scopus database during 2017-2021, identifying 90 publications. The information provided by the said platform was organized employing tables and figures categorizing the information by Year of Publication, Country of Origin, Area of Knowledge and Type of Publication. Once these characteristics were described, a qualitative analysis was used to refer to the position of different authors on the proposed topic. Among the main findings of this research, it is found that the United States, with 13 publications, was the country with the highest scientific production registered in the name of authors affiliated with institutions of that nation. The area of knowledge that made the greatest contribution to the construction of bibliographic material referring to the study of differential equations, mathematical models, and education was Mathematics, with 37 published documents, and the type of publication that was most used during the period mentioned above was the conference article, which represents 47% of the total scientific production.

Keywords: Differential Equations, Mathematical Models, Education.

1. Introduction

The importance of differential equations, mathematical models for both basic and social sciences, is a great challenge for teachers of mathematics and physics to find alternative methods to improve their teaching, finding pedagogical learning models that allow the motivation of students to achieve the acquisition of new skills, taking advantage of the resources available to achieve better acceptance and understanding, despite its level of complexity. In this context, Rocha (2021) states:

Higher education has faced different changes and challenges throughout its history as a product of social needs and demands, which incite in some way to adapt to the new realities of the 21st century (p. 65).

Indeed, differential equations offer several challenges, the conception of a hypothesis for the proper approach of a model, the collection of all the acquired results, and verifying, validating and comparing the possible solutions to the real data to check the efficiency of the implemented method. As can be seen, for the solution of a problem, it is necessary to propose one or several hypotheses, with which several examples must be made in order to verify, ratify, and reformulate as the case may be.

Consequently, in recent years, advances in technology, particularly in computers, have led to the teaching of mathematical sciences in courses of differential equations and mathematical models, with a methodology of experimental sciences so that the results obtained can be experimented with and checked (Hernández-Suarez et al., 2016). For this reason, this article seeks to describe the main characteristics of the compendium of publications indexed in the Scopus database related to the variables differential equations, mathematical models, and education, as well as the description of the position of certain affiliated authors during the period between 2017 and 2021.

2. General Objective

To analyze from a bibliometric and bibliographic perspective, the production of research papers on the variables Differential Equations, Mathematical Models, and Education, registered in Scopus during the period 2017-2021.

3. Methodology

Quantitative analysis of the information provided by Scopus is performed under a bibliometric approach on the scientific production related to the study of Differential Equations, Mathematical Models and Education. Also, from a qualitative perspective, examples of some research papers published in the area of the study mentioned above are analyzed from a bibliographic approach to describe the position of different authors on the proposed topic.

The search is performed through the tool provided by Scopus, and the parameters referenced in Figure 1 are established.
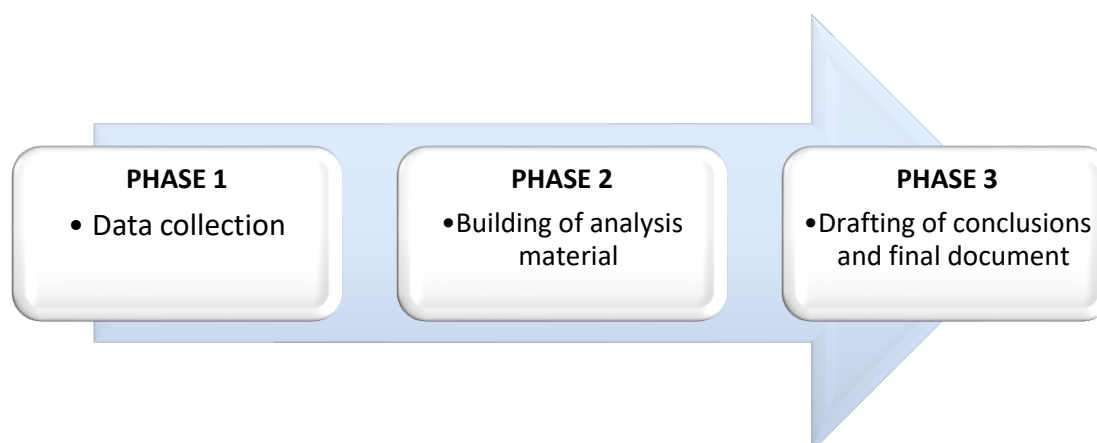
3.1 Methodological design

PHASE 1	PHASE 2	PHASE 3
• Data collection	•Building of analysis material	•Drafting of conclusions and final document

Figure 1. Methodological design
Source: Own elaboration

3.1.1 Phase 1: Data Collection

The data collection was carried out using the Scopus web page search tool, through which a total of 90 publications were identified. For this purpose, search filters were established consisting of:

TITLE-ABS-KEY (differential AND equations, AND mathematical AND models, AND education) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017)))

✓ Published papers whose variables are related to the study of Differential Equations, Mathematical Models, Education.
✓ Without distinction of country of origin.
✓ Without distinction of area of knowledge.
✓ Without distinction of type of publication.

3.1.2 Phase 2: Construction of analysis material

The information identified in the previous phase is organized. The classification will be made through graphs, figures and tables based on data provided by Scopus.

- ✓ Word Co-occurrence.
- ✓ Year of publication
- ✓ Country of origin of the publication.
- ✓ Knowledge area.
- ✓ Type of Publication

3.1.3 Phase 3: Drafting conclusions and final document

After the analysis carried out in the previous phase, the study proceeds to draft the conclusions and prepareof the final document.

4. Results

4.1 Co-occurrence of words
Figure 2 shows the co-occurrence of keywords within the publications identified in the Scopus database.
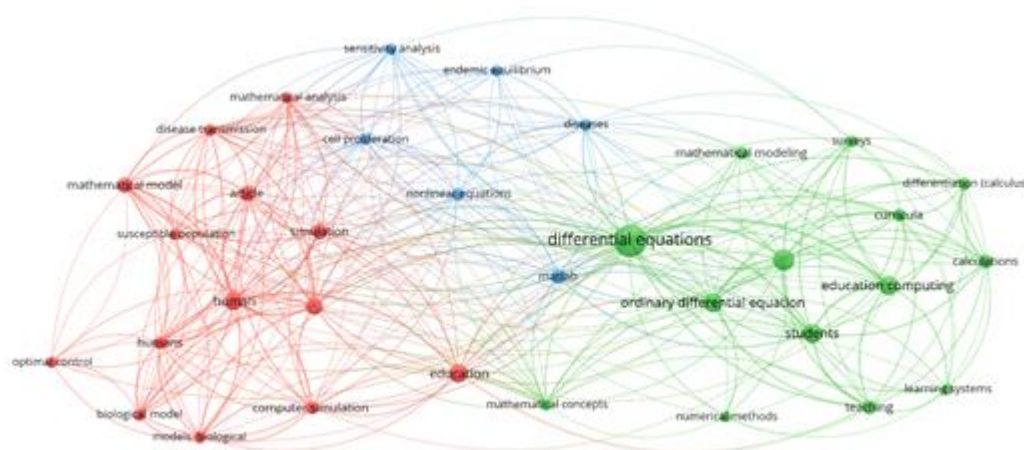

Figure 2. Co-occurrence of words
Source: Own elaboration (2022); based on data provided by Scopus.

Within the study of the research reported by the Scopus platform, referring to the variables differential equations, mathematical models, and education, the object of this scientific debt is considered exposing the variable of differential equations and mathematical models as a global approach in education involves some interpretations not only in the educational field but a broad orientation of mathematical models and the various sciences that arise from this. It is for this reason that through the interpretation of Figure 2, it is possible to determine how keywords of the publications reported in Scopus, Differential Equation, Education, Integral Calculus, and Mathematical Concepts, in attention with the correlation of mathematical terminology make common denominator the didactic area of mathematics, mostly using technology since the few pedagogical strategies at the time of learning are frequent. Moreover, with technological resources, the student makes the class more attractive, thus awakening a deep interest in the subject.

4.2 Distribution of scientific production by year of publication
Figure 3 shows how the scientific production is distributed according to the year of publication, considering the period from 2017 to 2021.
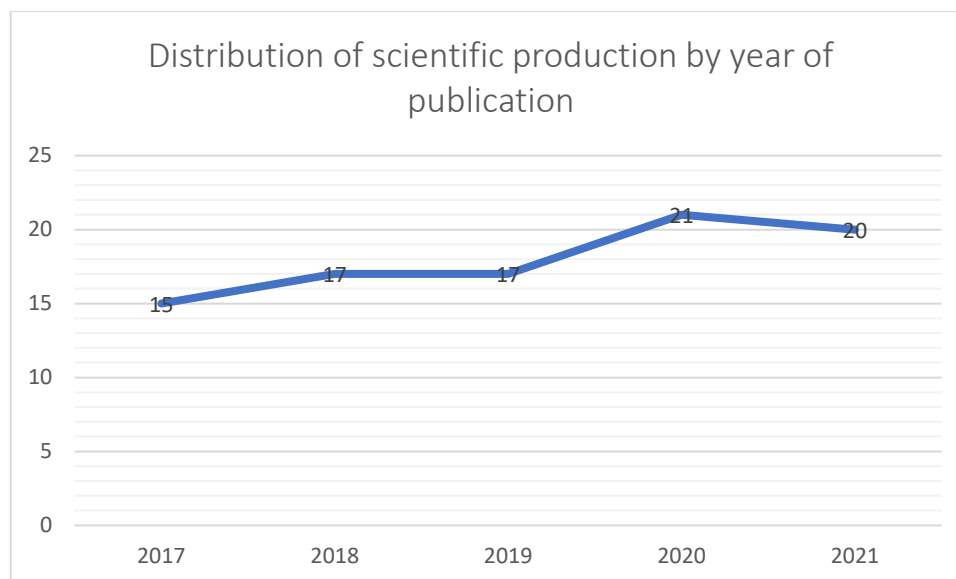
Figure 3. Distribution of scientific production by year of publication.
Source: Own elaboration (2022); based on data provided by Scopus.

The article entitled "Adoption of drone technology in mathematics education" stands out in this period (Duraj et al., 2021), whose objective was to describe a theoretical framework describing the use of drone technology in mathematics education to enhance engagement and learning with experiential learning method. In particular, that study discusses the pedagogical aspect where drones can be used in combination with various learning techniques and methods. The role of drones in mathematics education can be reflected from two aspects, the mathematical terms that make the drone work and the drone as a mathematical object and as an interceptor that can build mathematical objects. In the end, the study can be used by educators and researchers interested in drone-based mathematics learning.

4.3 Distribution of scientific production by country of origin.

Figure 4 shows the distribution of scientific production according to the nationality of the authors.
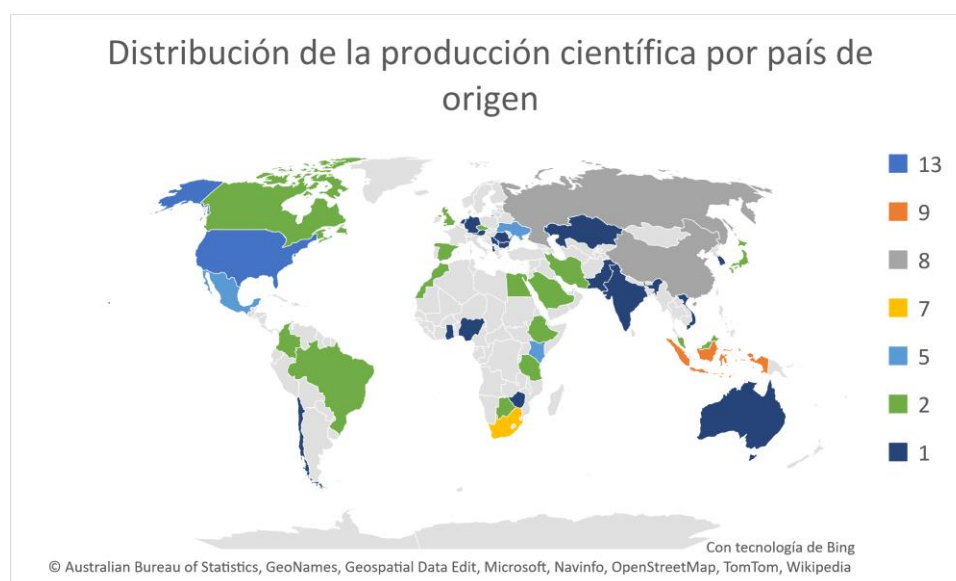

Figure 4. Distribution of scientific production by country of origin.
Source: Own elaboration (2022); based on data provided by Scopus.

The United States was the country with the highest number of publications registered in Scopus referring to the variable Differential equation and mathematical models, education, during the period 2017-2021 with a total of 13 publications, followed by Indonesia with 9 registrations and Porcelain with 8. Of the latter, the article entitled "MATLAB-based physics calculator: an alternative for learning means for the concept of work and energy" stands out (RA et al. Journal of Physics: Conference SeriesOpen AccessVolume 1806, Issue 131 March 2021 Article Number0120222020202020 International Conference on Mathematics and Science Education, ICMScE 2020BandungJuly 14, 2020July 15), whose objective is the development (R&D) with 4Dmodel development (Definition, Design, Development and Dissemination). The Matlab-based physics calculator is created using Matlab software through a multimedia development format that formulates, simulates and theorizes. The above research helps future generations further learn and understand their work in a simulated formula.

At this point, it should be noted that the production of scientific publications, when classified by country of origin, presents a special characteristic and that is the collaboration between authors with different affiliations to public and private institutions, and these institutions can be from the same country or different nationalities so that the production of an article co-authored by different authors from different countries of origin allows each of the countries to add up as a unit in the overall publications. This is best explained in Figure 5, which shows collaborative workflow from different countries.
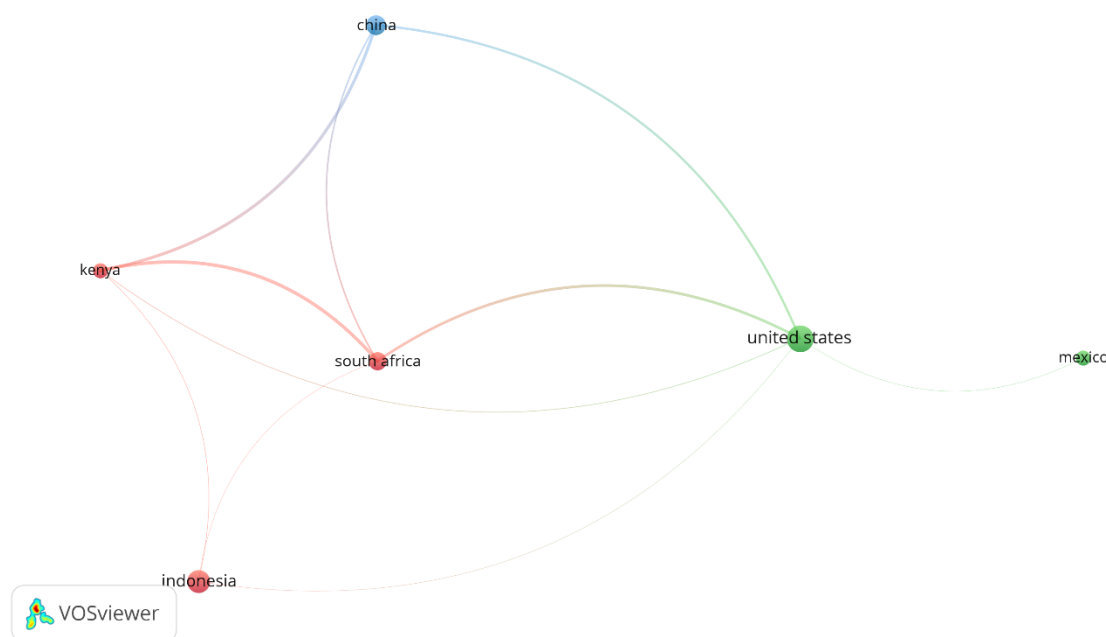

Figure 5. Co-citations between countries.
Source: Own elaboration (2022); based on data provided by Scopus.

Figure 5 shows how research is grouped according to international participation among affiliated authors. Outstanding participation is evident among authors affiliated with institutions in the United States, China and Kenya, South Africa, with authors from Kenya and collaboration with researchers from the United States and China.

4.4 Distribution of scientific production by area of knowledge

Figure 5 shows how the production of scientific publications is distributed according to the area of knowledge through which the different research methodologies are executed.
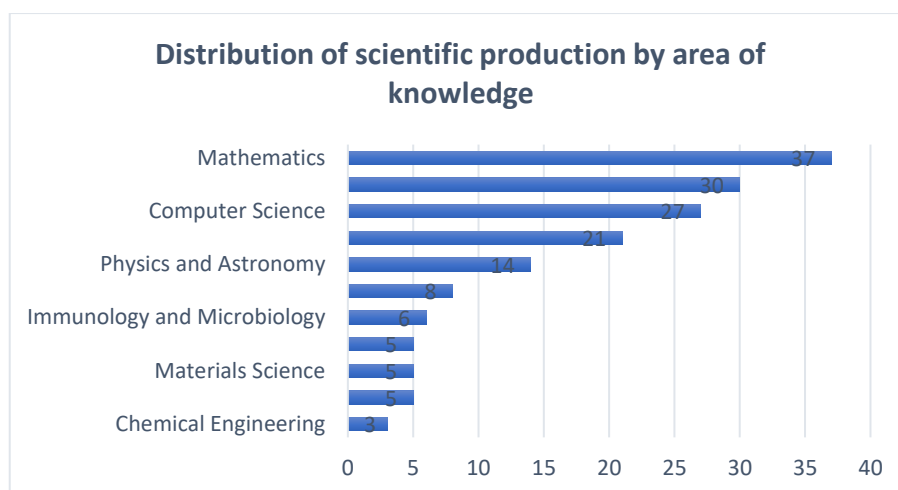
Figure 6. Distribution of scientific production by area of knowledge.
Source: Own elaboration (2022); based on data provided by Scopus.

Mathematics was the knowledge area with the highest number of publications registered in Scopus, with 37 papers that have based their methodologies on the variables Differential equations and mathematical models, education. In second place, Engineering with 30 documents. The above can be explained thanks to the study to improve academic performance in mathematical skills in undergraduate education. The impact analysis in higher education is reflected in an article registered in the area of Engineering entitled "Mathematical content of an undergraduate course on deep learning" (Shiberu, ASEE Annual Conference and Exhibition, Conference ProceedingsVolume 2020-June22 June 2020 Article number10012020 ASEE Virtual Annual Conference, ASEE 2020Virtual, online22 June 2020to26 June 2020Code164392), in which the author explains the empirical models which are based on solving challenging problems, such as autonomous driving in unstructured environments or allowing robots to grasp arbitrary objects. With the invention and widespread use of computers, the applied mathematics curriculum has evolved to include courses such as numerical analysis that complement analytical modeling with simulation and numerical solutions to complex problems. Even introductory STEM courses such as calculus, differential equations, matrix algebra, and statistics turn to simulation and computer-based solutions.

4.5 Type of publication

Figure 7 shows how the bibliographic production is distributed according to the author's chosen publication type.
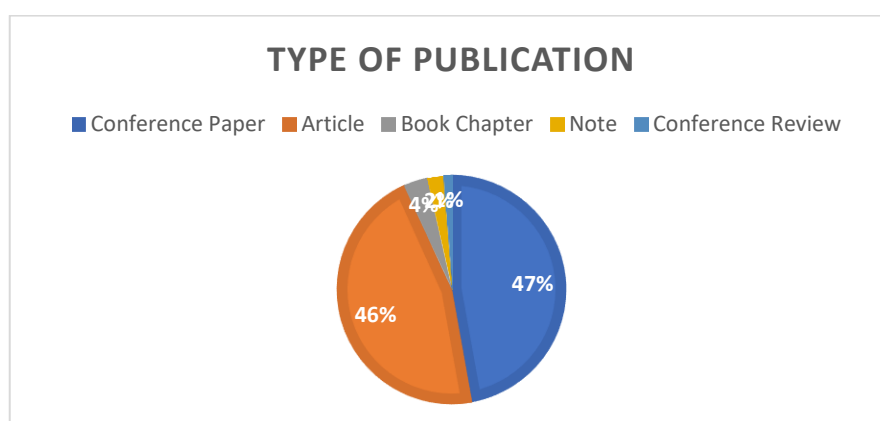

Figure 7. Type of publication
Source: Own elaboration (2022); based on data provided by Scopus.

The most frequently used type of publication by researchers was the Section Paper Article; 47% of the total scientific output corresponds to this document. In second place, articles with 46% and Book Chapters with 4%. In this last category, emphasis is placed on the article entitled "Analysis of the Educational Process System" (Ganicheva & Ganichev, Proceedings of the CEUR WorkshopVolume 3057, pages 161 - 1662021 6th International Scientific and Practical Conference "Distance Learning Technologies", DLT 2021Yalta, Crimea20 September 2021to22 September 2021Code175606). Its objective is the application of Markovian chains to analyze the educational process system. The structural scheme of the educational process is developed and the processes of the educational system are described using discrete and continuous Markovian chains and network modeling, a method for analyzing the stability of the Kolmogorov system of equations that corresponds to the considered model of the educational process.

5. Conclusions

Through the bibliometric analysis carried out in this research work, it was possible to establish that the United States was the country with the most significant number of published records on the variable of differential equations, mathematical models, and education, with a total of 13 publications in the Scopus database during the period 2017-2021. Similarly, it was possible to establish that applying theories framed in the area of Mathematical Sciences was the most frequently used in measuring the impact of differential equations and mathematical models based on education. It is important to emphasize that most of the authors help with the strengthening of new pedagogical ideas, the use of technological resources for the elaboration of new additional strategies to achieve, on the one hand, to motivate the student for experimentation, elaboration and simulation of interactive tools. Likewise, it is necessary to motivate methodological strategies related to applying differential equations to contribute to new learning and teaching processes at the undergraduate level. However, it can be concluded that research related to the study of the variables of differential equations, mathematical models, and education has strengthened the creation of new educational practices through the use of all the potential offered by technological tools, so it is expected that by identifying the main features in the total scientific production reported in Scopus, the scientific community is encouraged to intensify efforts in the search for the generation of new knowledge around these variables and thus achieve greater theoretical and pedagogical support at different educational levels.

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