

Digital Curriculum: a bibliometric analysis

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Abstract: *The paper represents a bibliometric analysis of the studies indexed in the Web of Science database, utilising the "Digital Curriculum" keyword in order to generate explanatory graphical models through the use of the VosViewer software. The purpose of the analysis is to determine the keywords having the highest frequency of use in studies regarding the topic of "Digital Curriculum", while also individuating the countries having the biggest impact and the largest number of publications in the mentioned domain of interest. The study reveals the quantitative relevance of "curriculum", "design", "education" and "students" keywords, highlighting the influential nature of digital curricula on the performative results of students during the educational process, due to the possibility of redesigning pedagogical materials, exercises and problems to be solved interactively. A relevant result may be observed in the relatively high total link strength for the "mathematics" keyword, suggesting the intricate connection between the two domains of study and the suitability of mathematics to be taught through digital means.*

Keywords: Digital Curriculum, Bibliometric Analysis, Mathematics, Education.

1. Introduction

The implementation of digital curricula in the psycho-pedagogical process of educational institutions represents admittedly one of the frontlines' subjects in the development of teaching practices.

Utilising technological means adequately designed for facilitating the learning experience could not only increase efficiency and offer teachers, tutors and professors' innovative ways of displaying and structuring their courses, but also improve students' academic performance.

Although its presence may have a positive impact, using digital curricula implies the necessity of having trained teachers with a high level of technical and pedagogical readiness (Al-Awidi et al., 2017) that, once properly trained, may benefit from a large variety of facilities, such as monitoring the number of attempts

made by students while solving interactive exercises, or adjusting to the students' individual learning paces (Pepin et al., 2017).

Offering students the possibility of choosing their own customizable learning paths when possible (Edson, 2017) and accessing various online programs available on the internet (Darragh, 2021) highlights the utilitarian value of the implementation of digital curricula in the pedagogical experience.

A particular study-case in the literature is represented by the advantages digital curricula bring to mathematics teachers' design of exercises and problems to be solved, as broadly discussed in (Araujo et al., 2017; Choppin, 2016; Pepin, Gueudet & Trouche, 2017; Pepin et al., 2017; Pepin & Gueudet, 2020; Pepin, 2021), due to the compatibility of the mathematical domain with digital pedagogical tools' capabilities.

The rest of this paper is structured as follows: Section 2 will present the methodology we used in our research, while Section 3 is offering the findings. Section 4 is devoted to discussions based on our findings and in the end we present the conclusions of our study.

2. Method

The aim of our research is to understand which are the most relevant papers addressing the topic of digital curriculum, based on several criteria. The purpose of this analysis is to determine the most frequently used keywords in the studies on "Digital Curriculum" and which countries the distributions of the publications belong to.

Therefore, our approach was to address the keyword "Digital Curriculum" in the Web of Science database, by selecting "all fields" in the search criteria. Certain limitations were made while analyzing the studies. The relevant limitation is to Citation of authors, Co-occurrence-all keywords, Bibliographic coupling of documents, Bibliographic coupling of sources, Bibliographic coupling of countries.

Once the results are obtained from Web of Science, we used this information as an input to VosViewer (VosViewer Tool, 2023) in order to analyze the data obtained in the previously described step. The study took place on July 12, 2023. As a result, 90 studies were found and the data were analyzed with VosViewer.

3. Findings

3.1 Citation of authors

The criteria selected in VosViewer when analyzing the citation of authors required the number of published documents of an author to be at least 2, while the minimum number of citations of an author could also be 0. Out of 130 authors, 4 meet the imposed thresholds. In Figure 1, it can be observed the graph obtained in

VosViewer in relation to the citation of authors, while Table 1 highlights the most important authors from this domain and their citations.

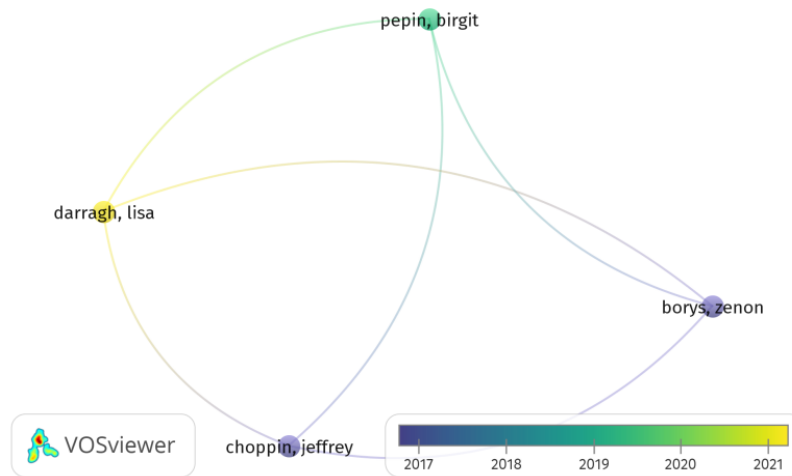


Figure 1. Graph generated with VosViewer for citation of authors

Table 1. Table of citations of authors

Author	Documents	Citations	Total link strength
borys, zenon	2	13	3
choppin, jeffrey	4	64	7
darragh, lisa	2	6	6
pepin, birgit	3	50	6

3.2 Co-occurrence-all keywords

The criteria selected in VosViewer when analyzing the "Co-occurrence-all" connections between different keywords imposed the minimum number of occurrences of a keyword to be 5, resulting in the shrinking of the initial data pool of 223 keywords to 8. The graph generated in VosViewer for co-occurrence-all keywords is presented in Figure 2, while the associated Table 2 presents the number of occurrences for the keywords.

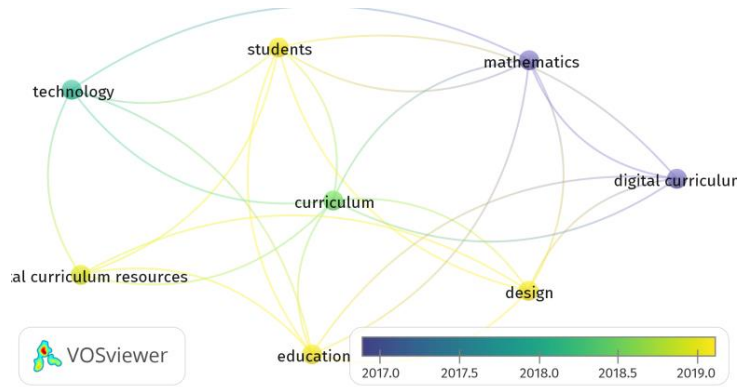


Figure 2. Graph generated with VosViewer for co-occurrence-all keywords

Table 2. Table for co-occurrence-all keywords

Keyword	Occurrences	Total link strength
curriculum	9	15
design	6	14
digital curriculum	12	9
digital curriculum resources	8	10
education	7	16
mathematics	5	13
students	5	16
technology	5	7

3.3 Bibliographic coupling of documents

The selected criteria for the bibliographic coupling of documents imposed the minimum number of citations of a document to be 5, filtering out 15 of the 50 initial documents. In Figure 3 and Table 3 it can be noted the name of the authors and the number of citations regarding bibliographic coupling of documents.

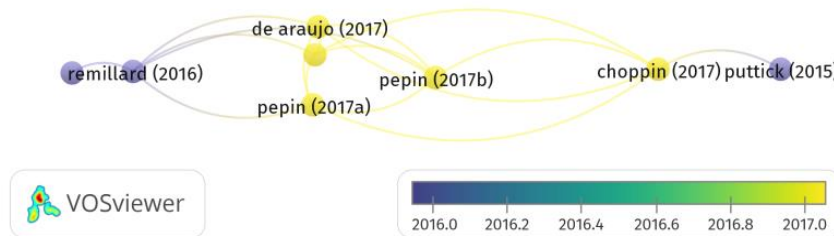


Figure 3. Graph generated with VosViewer for bibliographic coupling of documents

Table 3. Table for bibliographic coupling of documents

Document	Citations	Total link strength
al-awidi (2017)	15	0
puttick (2015)	8	1
pepin (2017a)	45	16
pepin (2017b)	47	37
choppin (2017)	13	22
de araujo (2017)	11	11
remillard (2016)	18	11
leary (2016)	17	1
rangel (2015)	13	0
ciccione (2019)	5	0
edson (2017)	7	17
abell (2005)	11	0
norman (2014)	5	0
wijngaards-de meij (2018)	32	0
memon (2019)	5	0

3.4 Bibliographic coupling of sources

The criteria selected in VosViewer when analyzing the bibliographic coupling of sources included the minimum number of documents of a source to be 2 and the minimum number of citations of a source to be 0. Out of the 41 sources, 3 meet the thresholds, as it can be noted in Figure 4. In Table 4 are presented the most important sources addressing the research topic and the number of documents for each source.

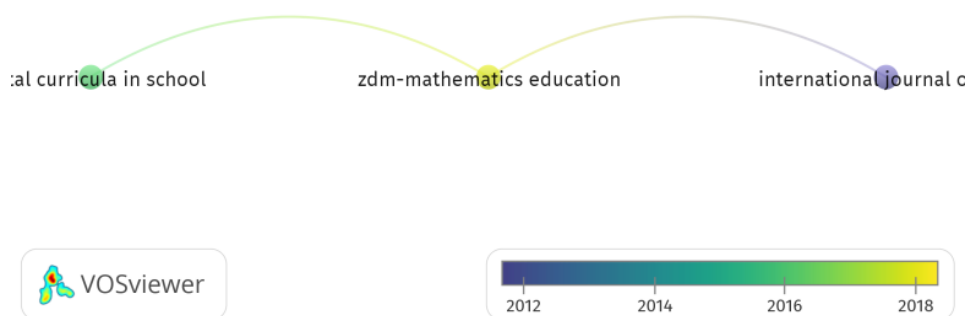
**Figure 4.** Graph generated with VosViewer for bibliographic coupling of sources

Table 4. Table for bibliographic coupling of sources

Source	Documents	Citations	Total link strength
digital curricula in school mathematics	3	25	41
international journal of emerging technologies in learning	2	8	1
zdm-mathematics education	7	124	42

3.5 Bibliographic coupling of countries

The criteria selected in VosViewer when analyzing the bibliographic coupling of countries imposed the minimum number of published documents in a country to be 2, while asking for the minimum number of citations of a country to be at least 1. 10 countries out of 20 meet the thresholds and are presented graphically in Figure 5 and detailed in Table 5.

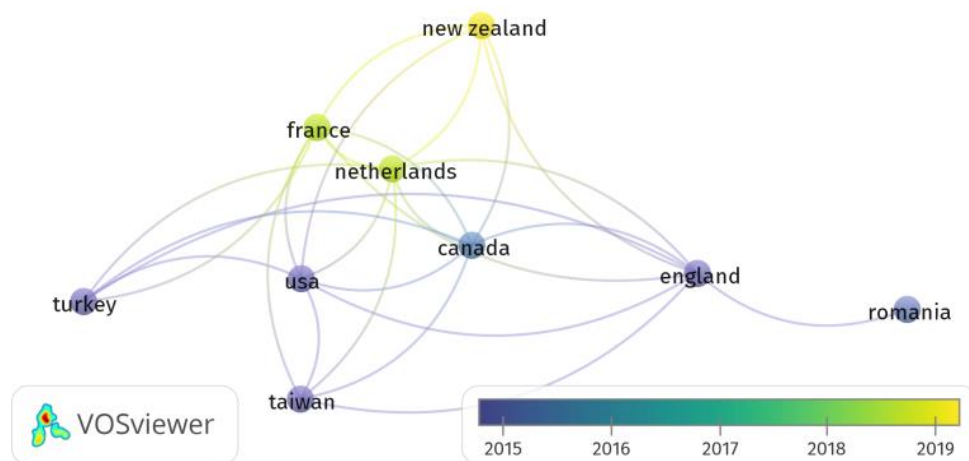
**Figure 5.** Graph generated with VosViewer for bibliographic coupling of countries

Table 5. Table for bibliographic coupling of countries

Country	Documents	Citations	Total link strength
Canada	2	52	334
England	2	51	336
France	2	47	188
Netherlands	6	127	514
New zealand	2	6	20
Peoples r china	6	2	0
Romania	4	3	1
Taiwan	2	1	10
Turkey	2	11	52
USA	16	132	513

4. Discussion

The paper represents a bibliometric analysis of the studies indexed in the Web of Science database, utilising the "Digital Curriculum" keyword in order to generate explanatory graphical models through the use of the VosViewer software.

When the graphs obtained with VosViewer are examined, a particular intensity in collaborations can be observed for Professor of Mathematics Education at University of Rochester Jeffrey Choppin, Lecturer at Faculty of Education at University of Auckland Lisa Darragh and Professor of Mathematics/STEM Education at Eindhoven University of Technology Birgit Pepin; the total link strengths for "choppin, jeffrey", "darragh, lisa" and "pepin, birgit" being 7, 6 and 6 respectively. From a quantitative analysis regarding the most individually cited authors in the literature, the present study highlights the scientific relevance in the "Digital Curriculum" domain of Professors Jeffrey Choppin and Birgit Pepin.

The analysis made on the "curriculum", "design", "education" and "students" keywords, reveals the influential nature of digital curricula on the performative results of students during the educational process, due to the possibility of redesigning pedagogical materials, exercises and problems to be solved interactively (Pepin, Gueudet, Trouche, 2017). The "mathematics" keyword resulted as one of the most utilised one, suggesting the intricate connection between the two domains of study and the suitability of mathematics to be taught through digital means (Reinhold, 2021).

The common source of citations' analysis highlights the importance of Professor of Mathematics/STEM Education at Eindhoven University of Technology Birgit Pepin, indicating also a close relationship between the study of

the utility of digital curricula and the domain of mathematics, as presented in the works: (Pepin, Gueudet, Trouche, 2017; Pepin, Choppin, Ruthven, Sinclair, 2017; Pepin, Gueudet, 2020; Pepin, 2021).

Another important detail resulted from the study would be the relevance of the “ZDM-Mathematics Education” journal, cited 124 times and having a constant and influential presence specifically through papers discussing the applicability of a digital curriculum in mathematics.

Examining the documentation of the studied domain, two countries come to the fore: the Netherlands, having 127 citations and a total link strength of 514, respectively the USA being cited 132 times and scoring a total link strength of 514. Canada, England and France have also scored relatively high total link strengths.

5. Conclusions

The paper represents a bibliometric analysis of the studies indexed in the Web of Science database, utilising the "Digital Curriculum" keyword in order to generate explanatory graphical models through the use of the VosViewer software. Our aim was to understand which are the most visible authors, the research with highest impact, as well as different collaborations that occur between researchers.

As a result of the analysis, noticeable impactful contributions have been brought in the specified literature by the works of Professor of Mathematics Education at University of Rochester, Jeffrey Choppin; Lecturer at Faculty of Education at University of Auckland, Lisa Darragh and Professor of Mathematics/STEM Education at Eindhoven University of Technology, Birgit Pepin; while the most cited countries in the field of study are the Netherlands and the United States of America.

In addition, the study shows that the “ZDM-Mathematics Education” journal is a fundamental scientific resource for pedagogical research, being cited 124 times in the studied Digital Curriculum domain.

Finally, the analysis shows the intertwining relevance of the “curriculum”, “design”, “education” and “students” keywords, revealing the influential nature of digital curricula on the performative results of students during the educational process, due to the possibility of redesigning pedagogical materials, exercises and problems to be solved interactively. A relevant result may be observed in the relatively high total link strength for the “mathematics” keyword, suggesting the intricate connection between the two domains of study and the suitability of mathematics to be taught through digital means.

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