

Article

Scientific Performance and Mapping of the Term STEM in Education on the Web of Science

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Received: 13 February 2020; Accepted: 11 March 2020; Published: 14 March 2020



Abstract: Technological progress is causing terms such as “STEM”, an acronym for Science, Technology, Engineering and Mathematics, to burst into the educational arena, marking a new era in the application of innovative and motivating teaching and learning processes. The objective of this research is to analyze the trajectory and the transcendence of the “STEM” concept in the educational field, having as reference the reported literature of Web of Science. The methodology applied in this research is based on bibliometrics, analyzing both the performance and the structural and dynamic development of the concept through a co-word analysis. The total number of documents analyzed is 4390. The results show that the scientific community mainly uses English and research papers to present their results. From 2015 onwards, the main lines of research are beginning to be established, which focus on “women” and “science”. It can be concluded that the term “STEM” in education is beginning to have a greater incidence and impact on the processes of teaching and learning, especially in the field of science, although there are currently discrepancies between men and women in its use.

Keywords: STEM; education; bibliometric analysis; co-words; scientific mapping; Web of Science

1. Introduction

The characteristics of today’s society have meant that the use of information and communication technologies (ICT) has become a common practice in everyday life [1]. The technological impact has generated important changes, both in the way of interacting with the environment and in people’s behaviour [2]. In the educational field, the inclusion of ICTs in society has had a full influence on teaching and learning processes [3], encouraging teachers to benefit increasingly from their potential [4], reported from the perspective of teachers and students themselves [5]. Specifically, educational technology promotes improved motivation, access to a variety of educational resources [6], as well as a greater attitude among students [7] who value and welcome active methodologies with an innovative character [8]. In this sense, it can be determined that ICTs have gone from being a simple support tool in learning spaces [9] to becoming an inseparable part of today’s pedagogical processes [10], generating the appearance of new training environments [11] and new learning experiences [12].

Among the new pedagogical actions, we find the term STEM, an acronym for the terms Science, Technology, Engineering and Mathematics. This term has had an increasing impact in the educational field, especially in recent years. It is defined as an interdisciplinary pedagogical application of the disciplines of Science, Technology, Engineering and Mathematics, through the integration of all curricular elements [13–17], being used at various educational stages, by integrating content in a

practical way, from a holistic and meaningful approach, with the intention of being applied in a practical way in one's own society [18–20].

The term of STEM education has its beginnings from a non-educational perspective. It is in recent times, where due to social and economic reasons, the term STEM has been introduced in the educational field. For this reason, the term of STEM education should be taken with caution, since for some authors it is represented as a pedagogical action that prepares students for university engineering courses; others value it as a career path for an engineering profession, while others value it as a component of general education, when trying to improve STEM knowledge in the population [21]. The use of STEM in education involves students working as a team, to focus on problem solving, to increase decision making and creativity, to improve critical thinking and self-esteem, to acquire significant learning, to develop interaction between peers, to enhance self-efficacy, scientific identity and an attitude towards mathematics and science, to develop active learning, to improve reasoning skills, collaboration and the self-regulation of learning [22–38].

The processes of teaching and learning through the STEM teaching method require an adequate development of teaching professionals [39–41], where years of experience, level of education and subject matter expertise have a direct influence on whether the teaching method is applied with assurance, as well as increased involvement of families who support STEM learning at home [42,43].

The methodological approach on teaching STEM has recently evolved in education from using traditional media to more advanced technological media [44,45]. Moreover, more and more studies are associated with other teaching methods considered innovative, such as online learning, gamification, learning communities, design-based science education or augmented reality [46–51]. This methodology brings to the educational field another active teaching method, which allows to develop the competences of the students towards the society [28].

One of the main problems associated with the STEM teaching method is the existing gender gap in certain countries in South America, Central America and Europe, as reflected in the studies of [52], due to the greater use of this pedagogical technique by men than by women [53–55]. This has generated the emergence of new projects such as W-STEM to reduce this gap [56,57]. In addition, there are other factors, such as socioeconomic and cultural level, that affect the development of educational practices with STEM, where students with low socioeconomic and cultural levels have less possibilities to develop this teaching method [58–60].

2. Justification and Research Objectives

This research tries to analyze the term “STEM” in the educational field, from the scientific literature collected in the Web of Science (WoS), following a methodological procedure based on scientific mapping; that is, graphic representation of science through the use of information of a relational nature, taking into account various bibliometric indicators, such as h-index, g-index, hg-index and q2-index; the performance of the scientific production, being considered as the analysis of production, activity, quality and impact measures; and the structural development of the generated terms, with the intention of knowing the trajectory and the importance of this topic in the scientific community. The reason for using bibliometrics is to try to analyze, at a statistical and sociometric level, the scientific literature, through the use of mathematical models, analyzing the size, growth and distribution of the scientific literature in the study of the structure and social dynamics of the selected subject of study, in this case being the term of STEM in education [61]. In addition, to find out if sustainability is present in STEM studies in the educational field, after the analysis of the generated database, no bibliometric studies have been found on the use of STEM in the field of education. Therefore, this study tries to guide the scientific community that wants to study and develop their research on the term “STEM” in the educational field. The objectives established in this research are:

- Determining the scientific performance and production of literature concerning “STEM” in the educational field (year of publication, language, type of documents, organizations, authors, sources of origin, countries and citation).

- Specifying the scientific evolution of this term according to the key words in the different scientific documents.
- Delimiting the most influential topics in the conceptual association, obtained from the analysis of the key words established by the authors in the different documents.

3. Materials and Methods

3.1. Research Design

The research method developed in this study is based on bibliometrics [62], coming from the branch of scientometrics [63], to quantify, analyze and identify the quality, productivity and scientific evolution of a certain subject of study [64], being in this case, "STEM". To this end, firstly, analytical tracking and documentary quantification techniques have been used to evaluate research performance in the field of study [65] specified in the section on Procedure and Data Analysis. Secondly, scientific mapping has been carried out [66] to find out the particular and general themes of the research, as well as their thematic evolution [67]. This scientific mapping takes as main references, the h index and the number of citations [68], and as secondary indicators, the g, hg and q2 indexes [69], trying to offer as much information as possible about the metrics of the field of study [70]. Throughout this procedure, a PRISMA protocol has been applied to collect scientific output [71], and various criteria for inclusion in the control variables to show the results obtained [72].

3.2. Procedure and Data Analysis

The study has followed several phases. Firstly, the database for the bibliometric study was determined, in this case, the Web of Science (WoS) (<https://bit.ly/2TujHlw>), by Thomson Reuters, in its main collection (Science Citation Index, Social Science Citation Index, Art & Humanities Citation Index, Conference Proceedings Citation Index Sciences / Social Science & Humanities and Emerging Sources Citation Index), given that it is a repository, within the branch of social sciences that houses a large number of high-impact scientific productions. Then, the keyword was selected to develop the search in WoS. In this case, bearing in mind those indicated in the special issue of Sustainability, called "Integration of ICT in STEM Education", the term "STEM" was used in the subject in the category "Education Educational Research", locating the word established in the title, or the abstract and or the key words of the various scientific texts. The total number of documents collected in the first place was 4458. Later, through the application of the PRISMA protocol (Figure 1), with the intention of providing a more detailed explanation of the various steps and processes followed, in order to select the documents used in this research, the inclusion and exclusion criteria are specified in this protocol. The final number of documents was 4390. The search for documentation began in January 2020, locating the texts from 2010 to 2019, inclusive.

A number of inclusion criteria have been established to analyze the performance of scientific production. The intention is to present the most relevant data related to year of publication, language, type of documents, organizations, authors, sources of origin, countries and citation (Table 1).

Table 1. Production indicators and inclusion criteria.

Indicators	Criteria
Year of publication	2010-2019
Language	$x \geq 6$
Type of documents	$x \geq 100$
Organizations	$x \geq 100$
Authors	$x \geq 12$
Sources of origin	$x \geq 100$
Countries	$x \geq 100$
Citation	The four most cited documents

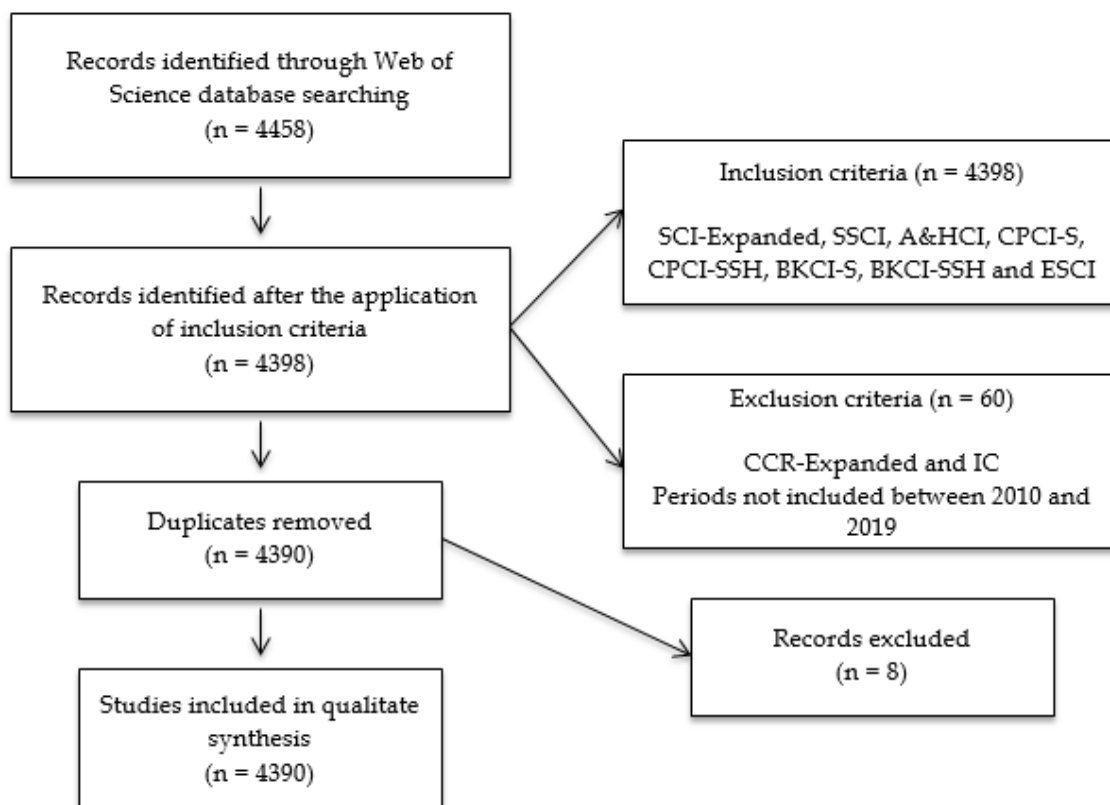


Figure 1. Flowchart according to the PRISMA Declaration.

The structural and dynamic development, from a longitudinal axis, has been carried out with the SciMAT tool [73] (Figure 2), following the steps marked by the experts in the use of it [74]:

- **Detection:** In this phase, we proceed to the analysis of the keywords of all the scientific production ($n = 9146$) and create a map of co-occurrence through nodes, thus generating a standardized network of co-words. In this way, the most relevant keywords ($n = 8333$) are obtained, which, by means of a clustering algorithm, the topics are configured, as well as the connection established between them.
- **Representation:** The creation of strategic diagrams and thematic networks continues, under the principles of centrality and density. The graphic representation is structured in four sectors: (1) Top-right = motor and relevant themes; (2) Top-left = consolidated but isolated themes; (3) Bottom-left = developing or disappearing themes; and (4) Bottom-right = cross-cutting themes and with little development.
- **Location:** The configuration of the time intervals continues. Try to collect the documents by time periods. In this case, ten intervals have been created ($I1 = 2010$; $I2 = 2011$; $I3 = 2012$; $I4 = 2013$; $I5 = 2014$; $I6 = 2015$; $I7 = 2016$; $I8 = 2017$; $I9 = 2018$; $I10 = 2019$), following the criteria of document equity in all established periods.
- **Performance analysis:** Finally we proceed with the analysis of the data, obtaining the connections given between the key words or themes. For this purpose, the unit of analysis specified by the assessment unit was determined, in this case, the keywords set by the authors in the documents and the keywords set by WoS. The frequency threshold sets the minimum frequency of the intervals. The network type elaborates a multiple connection of co-occurrence of keywords and authors. The value of coincidence binding articulates the established intervals. The normalization measure determines the binding threshold, revealing the minimum connection of the occurrence. The normalization of connections is based on the equivalence index $e_{ij} = c_{ij} / \sqrt{(c_i - c_j)}$. The clustering algorithm, by means of simple centers, makes the map of subjects and related

subnetworks. The evolutionary measure, through the Jaccard Index, shows the similarity measure that elaborates the evolutionary map and the transition map through the inclusion rate. All this is collected, with its corresponding indicators in Table 2.

Table 2. Production indicators and inclusion criteria.

Configuration	Values
Analysis unit	Keywords authors, keywords WoS
Frequency threshold	Keywords: $I_1 = (2)$, $I_2 = (2)$, $I_3 = (3)$, $I_4 = (3)$, $I_5 = (4)$, $I_6 = (4)$, $I_7 = (5)$, $I_8 = (6)$, $I_9 = (5)$, $I_{10} = (5)$
Network type	Co-occurrence
Co-occurrence union value threshold	Keywords: $I_1 = (1)$, $I_2 = (1)$, $I_3 = (1)$, $I_4 = (1)$, $I_5 = (1)$, $I_6 = (1)$, $I_7 = (2)$, $I_8 = (2)$, $I_9 = (2)$, $I_{10} = (2)$
Normalization measure	Equivalence index
Clustering algorithm	Maximum size: 9; Minimum size: 3
Evolutionary measure	Jaccard index
Overlapping measure	Inclusion Rate

Note: $I_1 = (2010)$, $I_2 = (2011)$, $I_3 = (2012)$, $I_4 = (2013)$, $I_5 = (2014)$, $I_6 = (2015)$, $I_7 = (2016)$, $I_8 = (2017)$, $I_9 = (2018)$, $I_{10} = (2019)$.

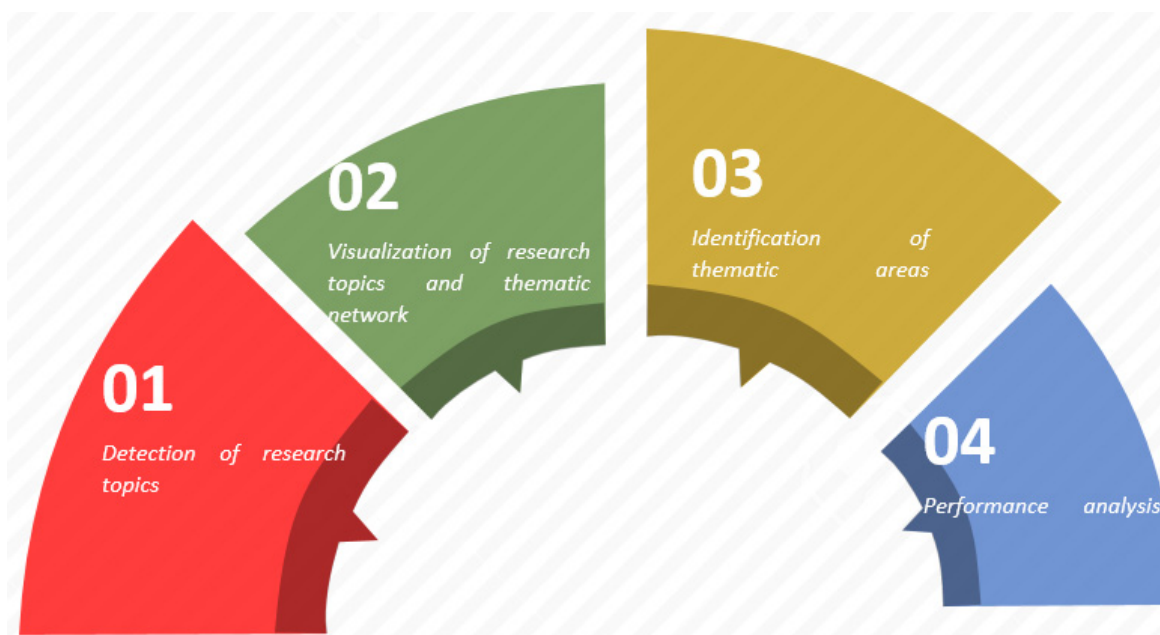


Figure 2. Phases of longitudinal co-word analysis using SciMAT.

4. Results

4.1. Performance and Scientific Production

The temporal evolution of the 4390 scientific texts analyzed in the years between 2010 and 2019, offers an ascending evolution from 2010 onwards, although this evolution is not constant, given that there are small decreases in production in the years 2012, 2015 and 2018. The year in which the highest production was recorded is 2017 (Figure 3).

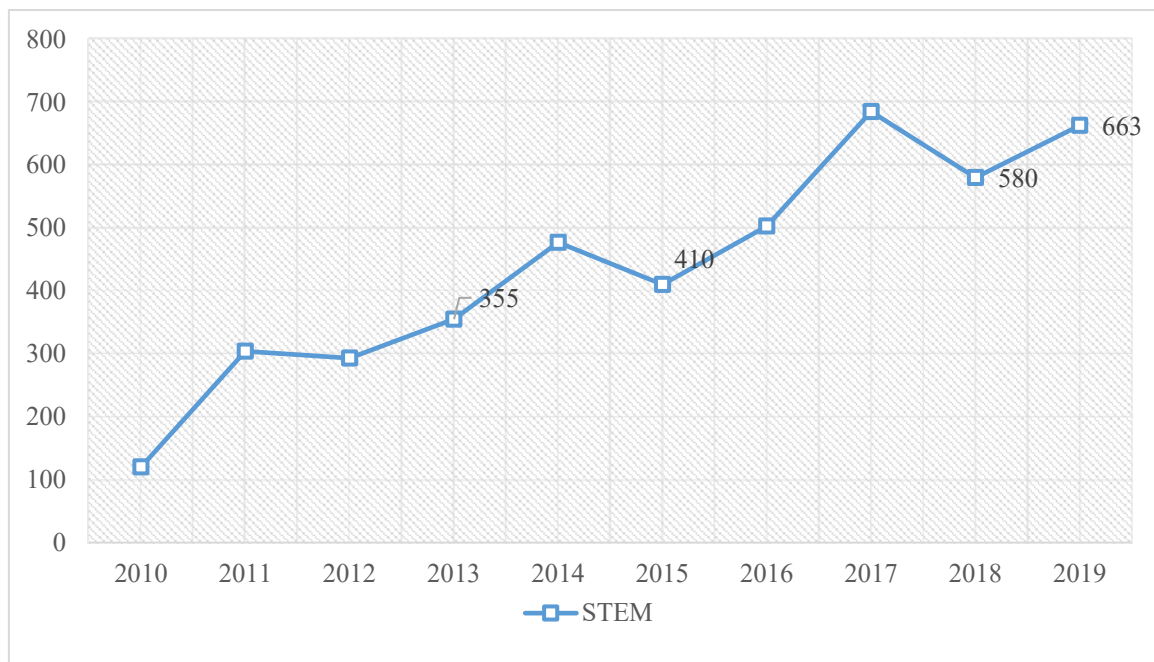


Figure 3. Evolution of scientific production of diet in education in the Web of Science (WoS).

The language primarily used by the educational community to present their results is English (Table 3).

Table 3. Scientific language used in EDIE.

Language	n
English	4317
Spanish	32
Turkish	11
Portuguese	6

The type of documents used are articles and the number of communications is relevant, since it is another means used to show the scientific evidence (Table 4).

Table 4. Document types.

Document Types	n
Article	2736
Proceedings paper	1395
Book Chapter	448
Editorial Material	147
Early Access	103

At the institutional level, Purdue University is the institution of reference for this type of study, followed by the University of North Carolina (Table 5).

Table 5. Institution.

Institution	n
Purdue University	144
University of North Carolina	127
State University System of Florida	104
University of California System	104
University of Texas System	103

The most prolific authors on the subject are T.J. Moore and C.C. Johnson. The rest of the authors following, have, in this case, a great diversity of scientists working on the same field of knowledge (Table 6).

Table 6. Authors.

Authors	n
Moore, T.J.	25
Johnson, C.C.	22
Grandgenett, N.	19
Nugent, G.	16
Barlex, D.	15
Henderson, C.	15
Osman, K.	14
Banks, F.	14
Capraro, R.M.	14
Osman, K.	13
Guzey, S.S.	13
Roehrig, G.H.	13

The main sources of exposure of scientific work are the documents generated from the conferences. The first journal that deals with this topic is the Journal of Science Education and Technology (Table 7).

Table 7. Source titles.

Source titles	n
ASEE Annual Conference Exposition	606
2014 ASEE Annual Conference	168
2011 ASEE Annual Conference Exposition	151
2012 ASEE Annual Conference	136
INTED Proceedings	122
Edulearn Proceedings	117
Journal of Science Education and Technology	117
International Journal of STEM Education	106

The country with the highest production is the United States, but it is closely followed by England and Australia, which shows the international character of the subject (Table 8).

Table 8. Countries.

Country	n
United States	247
England	226
Australia	195
Spain	128
Canada	124
Germany	103

Grover and Pea (2013) are the scientific community's reference publications for developing studies on "STEM" in the educational field, with a total of 326 citations (Table 9).

Table 9. Most cited articles.

Reference	Citations
[75]	326
[76]	241
[77]	226
[78]	192

4.2. Structural and Thematic Development

The keyword continuity between intervals shows information about outgoing, incoming and matching keywords in the set periods. The ascending arrow indicates the keywords leaving the period. The down arrow indicates the keywords entered in the period. The horizontal arrow provides keyword matching between periods. In this case, bearing in mind the information shown in Figure 4, it can be seen that there is a before and after in the year 2015, given that before that date, the coincidence between most of the periods was less than 30%, which marks a settlement of the subject matter by the scientific community. On the other hand, from 2015 onwards, the coincidence of key words between the periods studied shows a settlement and delimitation of the field of study, given that the level of coincidence between periods is higher than 30% in all cases.

**Figure 4.** Continuity of keywords between contiguous intervals.

The academic performance of the different topics generated by SciMAT is shown below. These themes are represented by the periods established above. This shows the topics with various bibliometric indicators, presenting in this case the h index [79], g index [80], hg index [81] and q^2 index [82], thus offering information on the most relevant topics in each of the intervals marked. According to the data revealed in Table 10, there has not been a theme that, due to its bibliometric indicators, is a reference year after year, except in the years 2017 and 2018, where "science" presents the highest bibliometric values. In the remaining years, there has been an evolution in the field of research, with "knowledge" in 2010 being the largest bibliometric indicator; "students and women" in 2011; "science" in 2012; "choice" in 2013; "mathematics" in 2014; "instructions" in 2015; "achievement" and "women" in 2016; and "women", "gender differences", "mathematics", "STEM education" and "motivation" in 2019. As can be seen, the main research has been oriented towards "women" and "science".

Table 10. Thematic performance.

Interval 2010						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Stem-Cell-Research	3	3	3	3	4.58	27
Knowledge	5	5	5	5	10.49	99
Women	4	4	4	4	20.3	329
Beliefs	5	3	4	3.46	10.25	158
Persistence	5	3	3	3	7.35	60
STEM	9	2	2	2	11.58	79
Students	5	2	4	2.83	7.75	36
Completion-rate	2	2	2	2	3.46	12
Interval 2011						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Faculty	4	3	3	3	11.49	155
Career-Development	3	1	1	1	8.37	70
Teacher-change	3	1	1	1	15.36	236
Academic-success	5	3	5	3.87	11.49	248
Students	14	7	8	7.48	17.35	464
Gender-Differences	5	4	4	4	16.73	175
Women	8	7	7	7	14.49	417
Stem	8	3	5	3.87	12	133
Science	9	5	8	6.32	12.65	299
STEM-Education	4	1	1	1	1.73	3
Achievement	5	3	3	3	4.24	38
Interval 2012						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Science	22	9	17	12.37	19.44	632
Perspective	6	4	4	4	6.63	59
African-American	6	5	5	5	5.48	90
Performance	17	8	12	9.8	17.66	404
Knowledge	6	4	5	4.47	10.2	101
Curriculum	3	2	2	2	16.97	160
Interval 2013						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Choice	17	9	16	12	13.75	459
Gender-Differences	8	4	6	4.9	10.2	93
Professional-Development	7	4	4	4	8.94	72
Beliefs	19	8	13	10.2	12	197
Attitudes	11	6	9	7.35	8.49	99
Diversity	9	6	7	6.48	10.39	184
Knowledge	11	5	10	7.07	9.22	109
STEM	8	5	7	5.92	9.49	230
Persistence	8	4	4	4	4.47	22
Educational-Choice	3	3	3	3	5.74	39
Interval 2014						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Women	31	12	18	14.7	17.32	349
Mathematics	27	13	21	16.52	21.02	480
Motivation	12	9	10	9.49	11.62	177
Perceptions	17	9	15	11.62	12.73	231
Race	8	4	5	4.47	12.49	125
Teachers	13	6	8	6.93	10.95	135
Socialization	5	4	4	4	7.48	77
Assessment	2	1	1	1	3.61	13

Table 10. Cont.

Interval 2015						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Achievement	26	9	15	11.62	12.73	245
Gender	24	10	14	11.83	12.25	220
Instruction	28	12	18	14.7	16.25	341
Outcomes	5	3	3	3	6.71	41
Framework	9	6	9	7.35	10.39	109
Perceptions	10	6	9	7.35	8.83	85
Higher-Education	8	5	7	5.92	7.07	54
Project-Based-Learning	3	2	2	2	10.39	57
Diversity	3	1	1	1	4.24	18
Environment	2	1	1	1	1	1
Classroom	2	1	1	1	1.73	3
Interval 2016						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Achievement	28	9	13	10.82	11.22	213
Women	50	9	12	10.39	11.62	238
Students	24	8	13	10.2	11.66	191
Teachers	11	5	9	6.71	5.48	92
STEM	51	7	10	8.37	9.17	151
STEM-Education	18	7	14	9.9	9.9	211
Experience	12	4	9	6	6.63	235
Robotics	5	3	3	3	7.14	69
Interval 2017						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Science	183	11	14	12.41	13.27	633
Race	17	5	8	6.32	7.75	79
Gender-differences	22	7	11	8.77	10.58	137
Engagement	15	5	7	5.92	6.71	67
Inquiry	9	2	4	2.83	4.69	21
Performance	21	5	7	5.92	6.71	79
STEM-Education	19	6	9	7.35	7.75	105
Physics	9	3	5	3.87	4.24	26
Knowledge	13	4	5	4.47	5.29	36
Experience	6	3	3	3	4.24	16
Interval 2018						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Science	147	7	9	7.94	7.94	301
Persistence	27	5	7	5.92	6.32	74
Race	25	4	7	5.29	6.93	63
Instruction	11	4	6	4.9	4.47	36
Choice	27	4	6	4.9	4.9	64
Impact	29	3	4	3.46	4.24	37
Mathematics	46	5	6	5.48	5.94	90
Classroom	10	2	3	2.45	3.74	15
Sex-differences	9	3	4	3.46	3.46	20
Design	8	3	4	3.46	3.87	20
Community	5	1	1	1	1.41	4
Policy	4	2	2	2	2.83	9
Interval 2019						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Women	73	3	3	3	3	50
Gender-Differences	34	3	4	3.46	3.46	32
Persistence	20	2	2	2	2.45	15
Mathematics	96	3	4	3.46	3.46	60
Professional-development	17	1	2	1.41	1.73	5
STEM-Education	39	3	3	3	3	26
Motivation	32	3	3	3	3	21

Table 10. Cont.

Interval 2019						
Denomination	Works	Index-h	Index-g	Index-hg	Index-q ²	Citations
Higher-Education	19	2	2	2	2	7
Computational-Thinking	9	2	2	2	2.83	6
Model	7	1	1	1	1.41	4
Design	5	2	2	2	2.83	6
Intervention	5	2	2	2	2	4
Equity	5	2	2	2	2.45	5
High-School	6	1	1	1	1.41	4
Outcomes	4	1	1	1	1	1
Skills	6	1	1	1	1.41	3

The diagrams of the established intervals provide information on the relevance of each of the themes, through a process of grouping, bearing in mind Callon's indicators, which analyze the degree of interaction of a network with respect to other networks, from two perspectives: centrality, which measures the strength of external links with other topics, being the measure of the importance of a topic in the development of a certain field of research; and density, which analyzes the internal strength of the network, identifying the internal links between all the key words that are grouped around a specific topic, thus offering the degree of development of the field of study analyzed. The study of all the established diagrams shows how, in 2010, the driving themes were "Stem-cell-research", whose studies focus on "internet", "learn", "qualitative-research", "undergraduate", "misconceptions", "science education", "argumentation" and "evaluation"; "women", whose studies focus on "achievement", "faculty", "ethnicity", "impact", "role models", "inequality", "equity" and "recruitment"; and "knowledge" whose studies focus on "work", "undergraduate education", "science", "skills", "representation", "STEM cells" and "performance". In 2011, it was "faculty" whose studies focus on "research productivity", "men", "identity", "program", "graduate", "career", "mentors" and "job satisfaction"; "gender differences" whose studies focus on "participation", "educational choice", "teachers", "attitudes", "classroom", "question", "curriculum" and "sex differences"; "academic-success" whose studies focus on "color", "qualitative research", "African- American", "underrepresented minorities", "persistence", "undergraduate research" and "predominantly white"; and "students" whose studies focus on "gender", "success", "personality", "mathematics", "model", "interest", "environment" and "performance". In 2012, it was "science" whose studies focus on "math", "gender", "self-efficacy", "technology", "choice", "women", "career", and "interests"; and "perspective" whose studies focus on "outcomes", "color", "minority students", "perceptions", "professional development", "recruitment", "diversity" and "faculty". In 2013, it was "gender differences" whose studies focus on "problem solving", "early childhood", "sex differences", "school", "assessment", "Americans", "performance" and "validity"; "attitudes" whose studies focus on "achievement", "school science", "STEM studies", "mathematics", "identity", "perceptions", "STEM careers" and "meta-analysis"; and "choice" whose studies focus on "gender", "academic achievement", "social cognitive", "students", "women", "model", "career" and "science major". In 2014, it was "women" whose studies focus on "gender", "persistence", "stereotype threat", "science", "experiences", "African-American", "career" and "minorities"; "mathematics" whose studies focus on "achievement", "self-efficacy", "success", "beliefs", "gender differences", "high school", "college" and "majors"; and "motivation" whose studies focus on "diversity", "performance", "participation", "technology", "design", "classroom", "math" and "STEM education". In 2015, it was "achievement" whose studies focus on "math", "persistence", "performance", "students", "motivation", "high school" and "career"; "instruction" whose studies focus on "professional development", "inquiry", "integration", "science", "technology", "impact" and "STEM education"; "gender" whose studies focus on "race", "middle school", "online learning", "STEM", "experiences", "choice", "women" and "interests"; "outcomes" whose studies focus on "validity", "mentoring", "quality", "retention", "college", "meta-analysis", "undergraduate research" and "self-efficacy"; "framework"

whose studies focus on “family”, “thinking”, “information”, “mathematics”, “knowledge”, “identity”, “design” and “university”; and “perceptions” whose studies focus on “benefits”, “culture”, “success”, “teacher”, “attitudes”, “beliefs”, “scientists” and “education”. In 2016, it was “women” whose studies focus on “engineering”, “gender”, “success”, “science”, “technology”, “majors”, “career” and “persistence”; and “achievement” whose studies focus on “career choice”, “meta-analysis”, “physics”, “mathematics”, “attitudes”, “identity”, “motivation” and “classroom”. In 2017, it was “science” whose studies focus on “gender”, “achievement”, “mathematics”, “STEM”, “students”, “technology”, “school” and “education”; and “gender differences” whose studies focus on “academic achievement”, “self-efficacy”, “sex differences”, “choice”, “women”, “high school”, “career” and “competence”. In 2018, it was “race” whose studies focus on “mentoring”, “intersectionality”, “color”, “African-American”, “doctoral students”, “socialization”, “equity”, and “faculty”; “choice” whose studies focus on “gender gap”, “career”, “self-efficacy”, “attitudes”, “school”, “motivation”, “model” and “secondary school”; “persistence” whose studies focus on “graduate education”, “success”, “experiences”, “retention”, “college”, “diversity” and “academic achievement”; and “science” whose studies focus on “math”, “gender”, “achievement”, “STEM”, “students”, “technology”, “beliefs” and “women”. In 2019, it was “women” whose studies focus on “minorities”, “gender”, “girls”, “science”, “experiences”, “choice”, “identity” and “majors”; “gender difference” whose studies focus on “sex differences”, “stereotype threat”, “ability”, “math”, “meta-analysis”, “performance” and “achievement”; “mathematics” whose studies focus on “beliefs”, “science education”, “mathematics education”, “teachers”, “STEM”, “knowledge”, “attitudes” and “technology”; “persistence” whose studies focus on “graduate education”, “success”, “predictors”, “schools”, “African-American”, “college”, “association” and “socialization”; “motivation” whose studies focus on “goals”, “fit-indexes”, “mixed methods”, “students”, “innovation”, “interests”, “adolescents” and “self-efficacy”; and “higher education” whose studies focus on “color”, “critical thinking”, “strategies”, “support”, “diversity” and “transition”. In this last period, the themes of “equity”, “design”, “high school” and “mode” should also be taken into account, given that, in the coming years, these may be the new trends in this field of study (Figure 5).

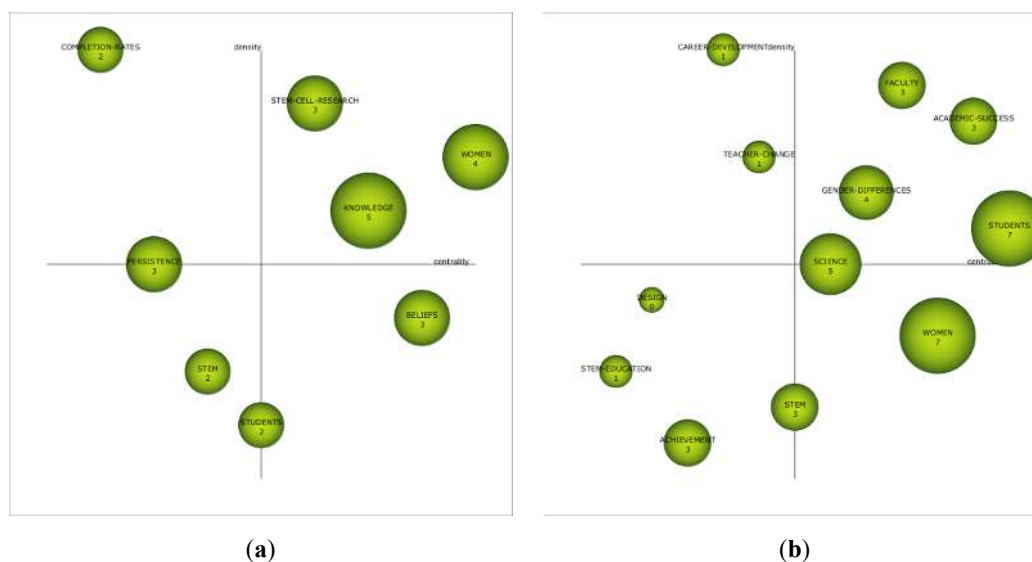


Figure 5. Cont.

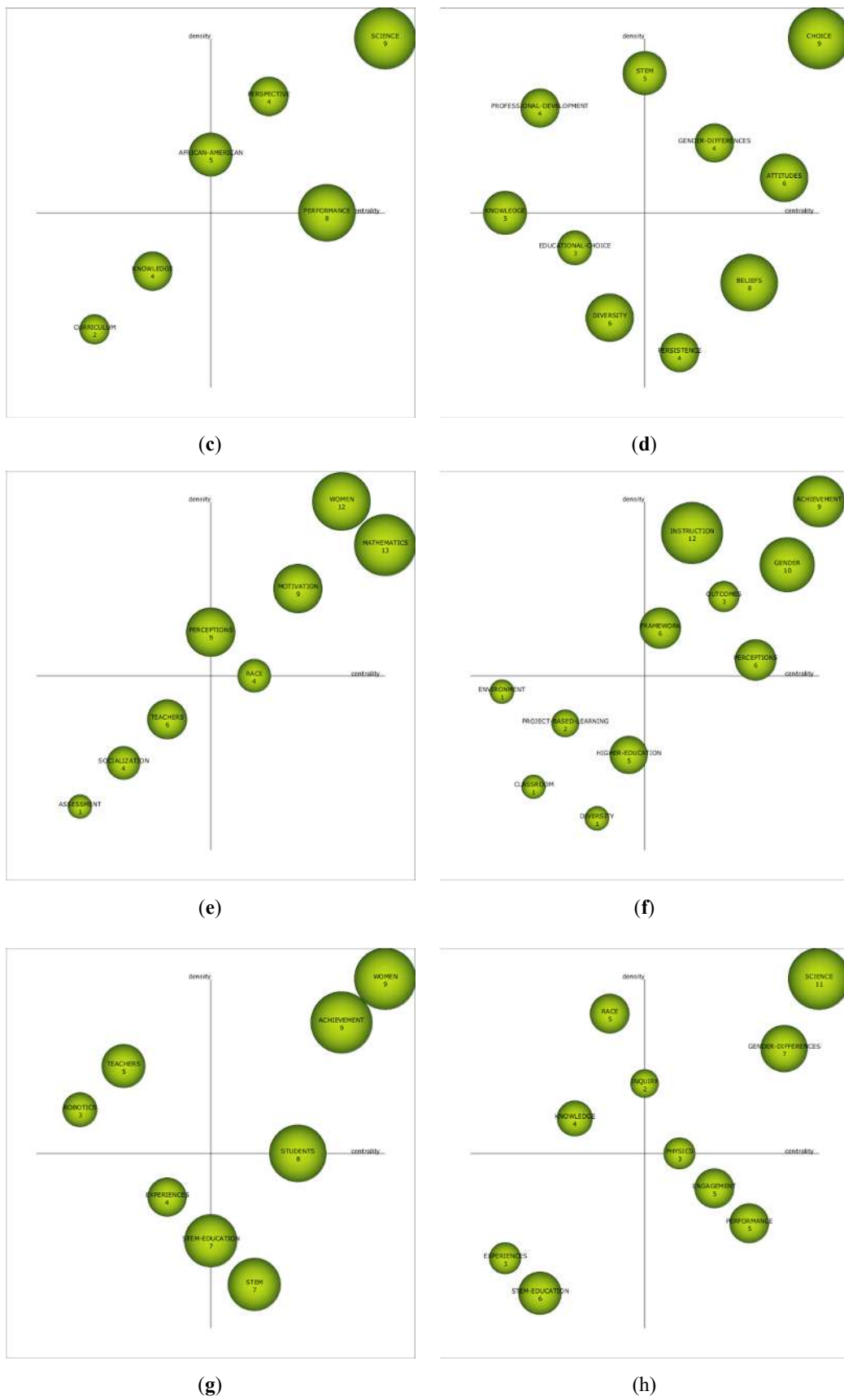


Figure 5. Cont.

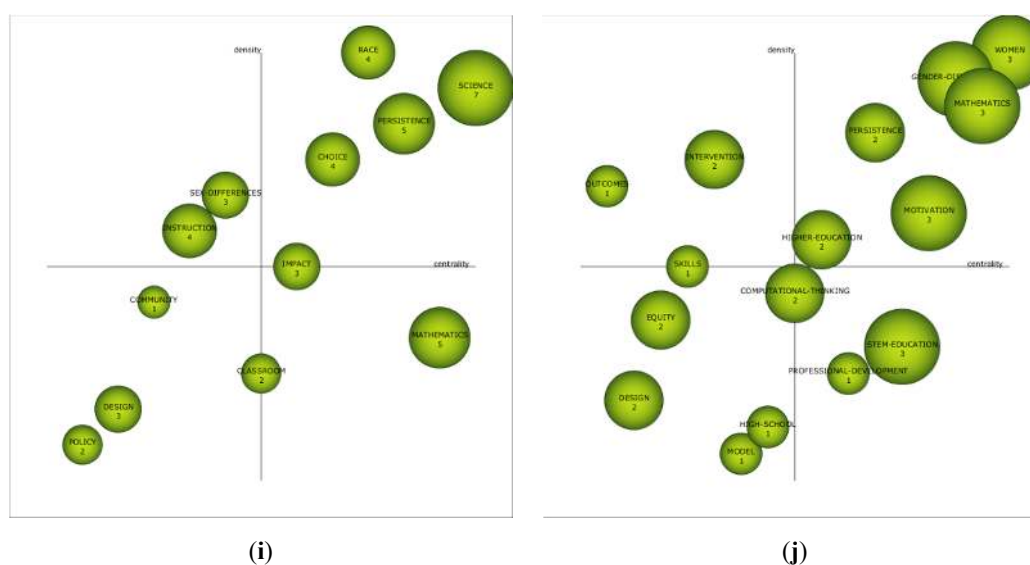


Figure 5. STEM's strategic diagram by h-index. Note: (a) 2010; (b) 2011; (c) 2012; (d) 2013; (e) 2014; (f) 2015; (g) 2016; (h) 2017; (i) 2018; (j) 2019.

4.3. Thematic Evolution of the Terms

The thematic evolution represents the strength of the relationship established between the themes of the various intervals generated, bearing in mind the Jaccard index. The evolution occurs if a theme of a certain interval shares keywords with the previous or contiguous intervals. The more keywords they have in relation to both themes of consecutive intervals, the more solid will be their evolution.

The two types of connections that can occur are represented in the figure with a continuous line or with a discontinuous line. The continuous line is used when the connection between themes is focused on the thematic of the different scientific literature. However, the discontinuous line is used when this connection is based simply in the matching of keywords. The thickness of both types of lines shows the strength of the relationship between the themes.

Bearing in mind the data shown in Figure 6, there is a conceptual gap in the evolution of the study of "STEM" in the educational field, given that there is no one theme that is repeated in all established periods, although it can be seen how the themes "STEM", "women", "science", "gender difference" and "achievement" are repeated several times in different periods. The connections established are mainly thematic, with a greater number of connections in the last period. It is also worth noting that the themes on which the studies are based are cyclical, given that "women" and "science" are important aspects for the scientific community in the years of production. Finally, it can be seen that in the last period, the use of STEM in higher education has become more important.

Another relevant aspect is the variety of research generated over time. This fact is shown by the variety of topics in the different established periods. This fact shows the needs and potentialities that have been produced throughout all of these years regarding the term STEM in education. Although, as we can see, due to the large number of continuous lines shown in the graph, there are common links in research generated in recent times. This shows us a base upon which most research is developed.

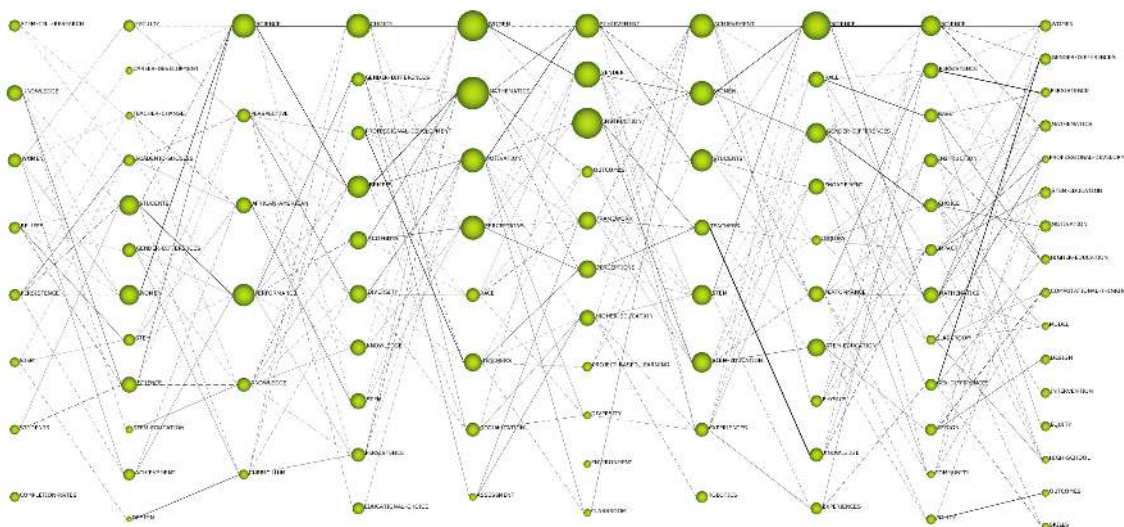


Figure 6. Thematic evolution by h-index.

5. Discussion and Conclusions

The term STEM (Science, Technology, Engineering and Mathematics) in the educational field is beginning to have relevance, especially with regard to teaching and learning processes, regardless of the educational stage. The term of STEM education has been introduced in the field of education in recent times. The term takes on different meanings, since for some authors, it is represented as a pedagogical action that prepares students for university engineering courses. Other authors see it as preparation for an engineering profession. For others, it is a component of general education, as it seeks to improve STEM knowledge in the population. The use of STEM in education involves students working in teams, focusing on problem solving, increasing decision-making and creativity, improving critical thinking and self-esteem, acquiring meaningful learning, developing peer interaction, improving self-efficacy, scientific identity and attitude towards mathematics and science, developing active learning, improving reasoning skills, collaboration and self-regulation of learning [21–38].

In this study, we have gone deeper into the dynamic and structural development of the “STEM” concept in the educational field, with the intention of offering relevant information for those researchers who intend to investigate this field. The results obtained allow us to respond to the objectives established previously.

The scientific production of “STEM” in the educational area had its beginnings in 2010, although its evolution has not been uniform, since it has suffered small recessions in the years 2012, 2015 and 2018. The largest production peaks occurred in 2017 and 2019 respectively.

The scientific community mainly uses the English language and, inside it, research articles in contrast to other types of papers, to present their results, although there is a high incidence of communications in the congresses. This fact is very revealing, because it shows and marks the recent development of this subject in this field of study, which is reflected in the sources of origin, where the communications of congresses occupy the first places of production.

The main institution in research on “STEM” in education is Purdue University, with the authors T.J. Moore and C.C. Johnson as the most prolific ones in this area, although not the most cited, given that Grover and Pea (2013) are benchmarks, with a high rate of citation. The United States, along with England and Australia, are the countries with the greatest interest in the subject.

A key moment in the evolution of the subject is in 2015, given that before that date, the field of study was not yet established, there being a great diversity of key words used by the scientific community when establishing the main lines of research. However, after that moment, the thematic begins to settle. It is remarkable how the topics “science” and “women” are the ones that have had the greatest relevance on the part of the scientific community, which have marked the main trends

in research in the use of “STEM” in the educational field. This shows how there are differences at the level of gender in its use in teaching and learning processes. This is an aspect that can generate controversy, given that, in the educational field, all discrepancies based on gender, race, culture or sexual identity must be avoided, as marked by [52–55].

In the background, topics such as “motivation”, “higher education” and “mathematics” are emerging as relevant and of great importance in the scientific literature, which makes us see new pedagogical actions, oriented to motivation, in subjects such as mathematics, and in educational stages such as higher education.

It can be concluded that the term STEM has a greater and growing incidence within the educational community, due to the boom in scientific production generated in recent years, especially in the United States, England and Australia, with articles in English being the medium used to present results by researchers. The main themes that focus the attention of researchers on the term STEM in the educational field are “science” and “women”, although new lines of research are beginning to appear, aimed at “motivation”, “higher education” and “mathematics”. In addition, sustainability is not among the most research-oriented aspects of research.

This study is important for educators, policy makers and STEM professionals because it offers a concrete and specific vision of the current situation of the term STEM in education, showing the most relevant aspects for the scientific community at this time. It also offers a concrete view of the evolution of this terminology over the last few years, thus showing the most relevant needs for the scientific community. Furthermore, it offers possible future lines of research in the coming years. With all this, the educational community can learn about the main virtues and difficulties associated with the term STEM in education.

The prospective of this research is to offer the scientific community the trends in the study of STEM in the educational field, as well as to show the competent educational administrations the needs to apply educational programs where the use of educational STEM is promoted among men and women.

The limitations of this research focus on the purification of the data presented in WoS, due to the fact that the database, on certain occasions, collects repeated documents or documents that are not within the established search field. Another aspect to bear in mind among the limitations are the parameters marked in this study, which have been established according to the criteria of the researchers. These were implemented trying to present results in accordance with the size and relevance; so, that is the reason why the data presented here must be analyzed with caution, due to the fact that the data are not always available. As future lines of research, we plan to carry out studies that analyze the impact of the practical application of the STEM teaching method with respect to the expository method.

Author Contributions: Conceptualization, M.R.N.-P, P.D.-T. and C.R.-J.; methodology, C.R.-J. and P.D.-T.; software, A.-J.M.-G.; formal analysis, A.-J.M.-G.; investigation, M.R.N.-P., P.D.-T., C.R.-J., A.-J.M.-G. and F.-J.H.-L.; data curation, C.R.-J. and A.-J.M.-G.; writing—original draft preparation, M.R.N.-P., C.R.-J., A.-J.M.-G., P.D.-T. and F.-J.H.-L.; writing—review and editing, M.R.N.-P., C.R.-J., A.-J.M.-G., P.D.-T. and F.-J.H.-L.; visualization, P.D.-T.; supervision, F.-J.H.-L. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Acknowledgments: We acknowledge the researchers of the research group AREA (HUM-672), which belongs to the Ministry of Education and Science of the Junta de Andalucía and is registered in the Department of Didactics and School Organization of the Faculty of Education Sciences of the University of Granada.

Conflicts of Interest: The authors declare no conflict of interest.

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