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Bibliometric Analysis of Scopus Publications Related to STEM and STEAM Research in the Context of Mathematics Education

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Abstract: This article presents a bibliometric analysis of publications in Scopus with the keyword "STEM Mathematics" or "STEAM Mathematics" in the abstract or title. Scientific documents on a global scale, as well as specifically for Bulgaria, are analyzed according to: their types (conference proceedings, articles, book chapters, etc.); the subject areas they cover; their distribution by country; and the top ten most frequently cited publications. The period analyzed in this study spans from 2000 to 2024, encompassing all available publications globally (14,592 documents) and in Bulgaria (38 documents). Additionally, a cluster analysis was performed using the VOSviewer program, which created network maps of the most frequently used keywords and their connections. A strong increase in the number of publications on the subject in Scopus is observed internationally after 2011. In contrast, in Bulgaria, the

number of publications remains small, with the first results appearing after 2015. For Bulgaria, the largest share of publications is in the field of "Computer Science", unlike the overall result, which shows the highest share in the field of "Social Sciences". In Bulgaria, cooperation between researchers from different fields in STEM and STEAM research, in the context of mathematics, is still not sufficiently realized. The goal is to track the development of interest in the topic, the main educational elements with which it is related, to show the current state within the selected scientific portal and to help orient researchers in communities, applications, connections, problems, perspectives and other elements related to STEM and STEAM in the context of mathematics education.

Keywords: bibliometric analysis, STEAM, STEM, Mathematics, VOSviewer

Introduction

Tools like VOSviewer, Bibliometrix, HistCite, and SciMAT are commonly used for visualizing and analyzing bibliometric data over the past few years (Abdi et al., 2024; Karampelas, 2023; Marín-Marín et al., 2021). The VOSviewer program, for example, helps in identifying keyword co-occurrences, country-level collaboration mapping patterns, and thematic clusters (Bhatt et al., 2020; Gillani et al., 2022). Recent bibliometric analyses also include a review of top scientific journals in which similar works are published, as well as the quartiles (from Q1 to Q4) in which they are located (Ha et al., 2020).

Scientific databases, such as Scopus and Web of Science, continue to expand the tools offered in their portals – including export file formats, maximum numbers of exported documents, catalogs for choosing between partial or full presentations of data from scientific publications, and the use of artificial intelligence, among others. These additions allow for fast and accurate extraction of a database. A major drawback of scientific systems that support a large volume of documents by authors from all over the world is the inconsistency in terminology dictionaries across individual fields, as well as the presence of similarity in author names. A similar overlap emerged in the present study when searching for “STEM” due to its use in the fields of biology and medicine.

In the field of mathematics education, bibliometric analyses regarding STEM focus on students' interdisciplinary skills, critical thinking, problem-solving, the integration of new technologies in the classroom, and creativity (Aguilera & Ortiz-Revilla, 2021; Sun & Saleh, 2024; Wardat et al., 2025).

Here, we will not consider different understandings of the essence of STEM and STEAM. Nor will we analyze opinions and research results on the problems, challenges, benefits or harms that some practices of implementing STEM or STEAM education may cause to students' mathematical preparation.

Research Problem

One of the goals within the framework of Bulgarian education in recent years has been the creation of STEM centers in every Bulgarian school, along with trained teachers who can work with the technical devices installed in them. To equip the new spaces, each school chooses from five modules, which can be combined. The “Mathematics and Informatics” module is the second most frequently chosen module, requested by 36% of the schools (National STEM Center, 2024). It is appropriate to analyze the current state of STEM and STEAM implementation in the country. In this regard, the distribution of documents in Scopus affiliated with Bulgaria, by period, subject area, and authors with the highest number of papers, as well as those with the highest number of citations in various fields, will be examined. The results will be compared with those at a global level when searching the same Scopus database for future recommendations using a STEM approach in Bulgarian, specifically in the context of mathematics education.

Research Focus and Aim

In this article, we present a bibliometric analysis of Scopus publications related to research on STEM and STEAM in the context of mathematics education. The aim is to track the development of interest in the topic, the main educational elements with which it is related, to show the current state and to assist researchers in orienting themselves in concepts, communities, applications, connections, problems, perspectives and other elements related to STEM and STEAM education in the context of mathematics education. The aim is also to compare the results for Bulgaria and provide guidance on opportunities to facilitate activities and improve outcomes in Bulgaria in the implementation of STEM and STEAM in the context of mathematics education, as well as enhance the visibility of publication activity on the topic.

Literature Review

Interest in bibliometric analyses is increasing (Bychuk et al, 2025; Hruzevskyi, 2023; Zhu, 2025). One of the reasons is the improvement of technological tools for processing data from large scientific databases, such as Scopus, Web of Science (WoS), Google Scholar, and OpenAlex (Mongeon & Paul-Hus, 2016; Sokolova et al., 2025). Such analyses are conducted in various STEM and STEAM contexts (Gonzales, 2025; Nasiruddin et al., 2025; Rakhimov & Mukhamediev, 2022). There are also bibliometric analyses related to specific technologies relevant to STEM and STEAM, such as 3D printing (Chehlarova, 2025). Augmented reality (AR) and virtual reality (VR) technologies also stand out (Dogru et al, 2025; Giang et al, 2025).

Some of the bibliometric analyses conducted when searching for the phrase “STEM ...” are based on interdisciplinary studies and their impact in social sciences, economics, and other fields (Abdi et al., 2024; Prahani et al., 2023). Bibliometric analyses regarding STEM, in the field of education, are based on global studies and, in particular, specific regions or countries and their contribution to global trends are examined (Aboudahr et al, 2024; Cai et al, 2023; Pabuçcu, 2024).

Here, we will conduct a bibliometric analysis of publications in Scopus that include the keywords "STEM Mathematics" or "STEAM Mathematics" in the abstract or title, both on a global level and specifically for Bulgaria.

Materials and Methods

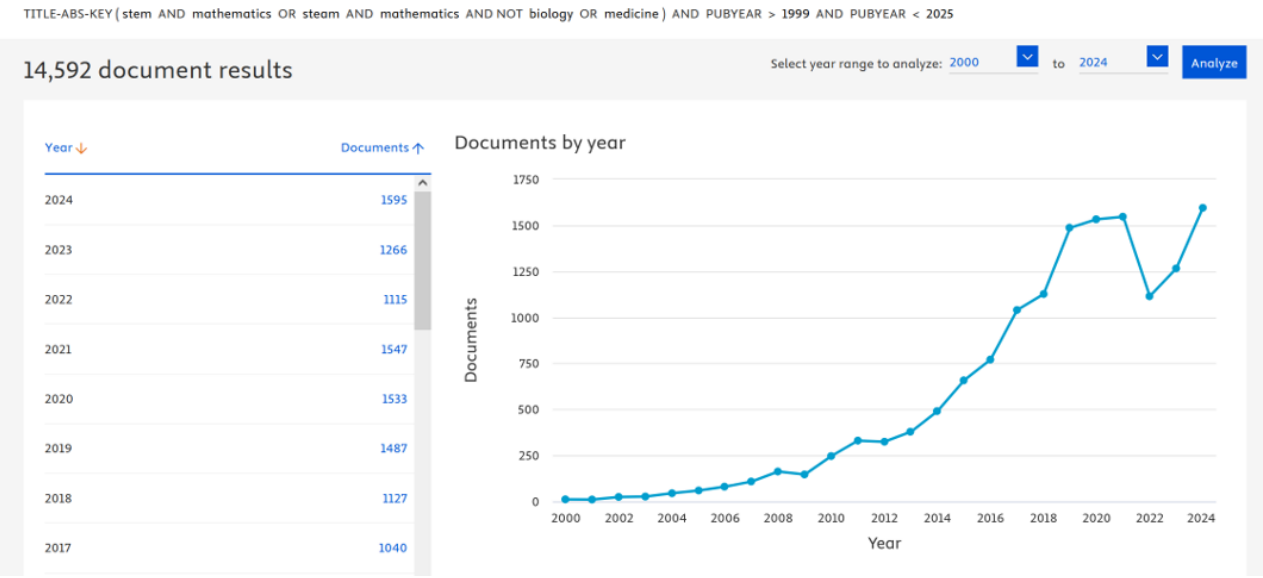
For the bibliometric analysis, data from Scopus, available as of January 2025, are used. Publications with a keyword or text in the abstract or title “STEM and Mathematics” or “STEAM and Mathematics” are examined. The chosen keywords are based on the second most frequently chosen module, “Mathematics and Informatics” by Bulgarian schools for their newly made STEM centers. We are excluding biology or medicine as subject areas for the period from 2000 to 2024. The reason for excluding biology and medicine is the use of the term “stem” in medicine, as well as the presence of the semantic meaning of these two acronyms. Quantitative comparisons were made using indicators, based on automatically generated statistical results from Scopus. Some of the data were processed using the VOSviewer program, and a network map was created with the first 100 items, ordered by their frequency of occurrence. The map coloring is based on the cluster division automatically made by the software. The VOSviewer software allows for the analysis of up to 20,000 documents simultaneously, which can be more challenging to use in other general and extensive research. In this study, the total number of documents viewed globally and for Bulgaria did not exceed the limit, and the software proved to be a useful tool for analysis.

Results

Here, we will examine the ready-made statistical data provided by Scopus based on the specified search. Fig. 1 presents the number of publications with a keyword or text in the abstract or title "STEM and Mathematics" or "STEAM and Mathematics" by year, excluding biology or medicine, for the period from 2000 to 2024. The total number of documents in this search is 14,592. There was a weak development of interest in the topic until 2010, followed by a strong increase in the number of publications from 2011 to 2019, with retention of interest in the latter period. However, a decrease was observed in 2022.

Figure 1

Distribution of publications in Scopus, when searching for "STEM and Mathematics" or "STEAM and Mathematics", in 2000-2024

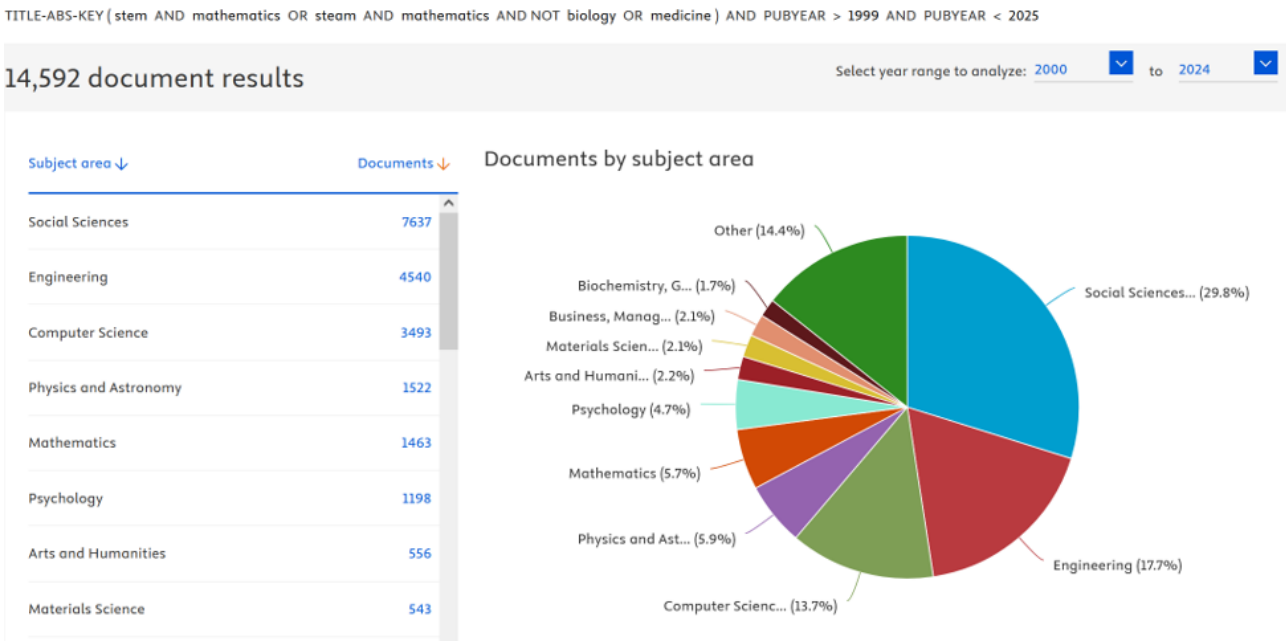


Source: Scopus.

Publications from the field of Social Sciences (29.8%) predominate, followed by Engineering (17.7%), Computer science (13.7%) (Fig. 2). The following fields are Physics and Mathematics, with close values, respectively 5.9% and 5.7%. We will specify that some of the publications span multiple subject areas. That is, the publications related to mathematics are 1463, which, compared to the total number of 15,592, represents 9.4%.

Figure 2

Distribution of documents in Scopus, by subject area, when searching for "STEM and Mathematics" or "STEAM and Mathematics", in 2000-2024

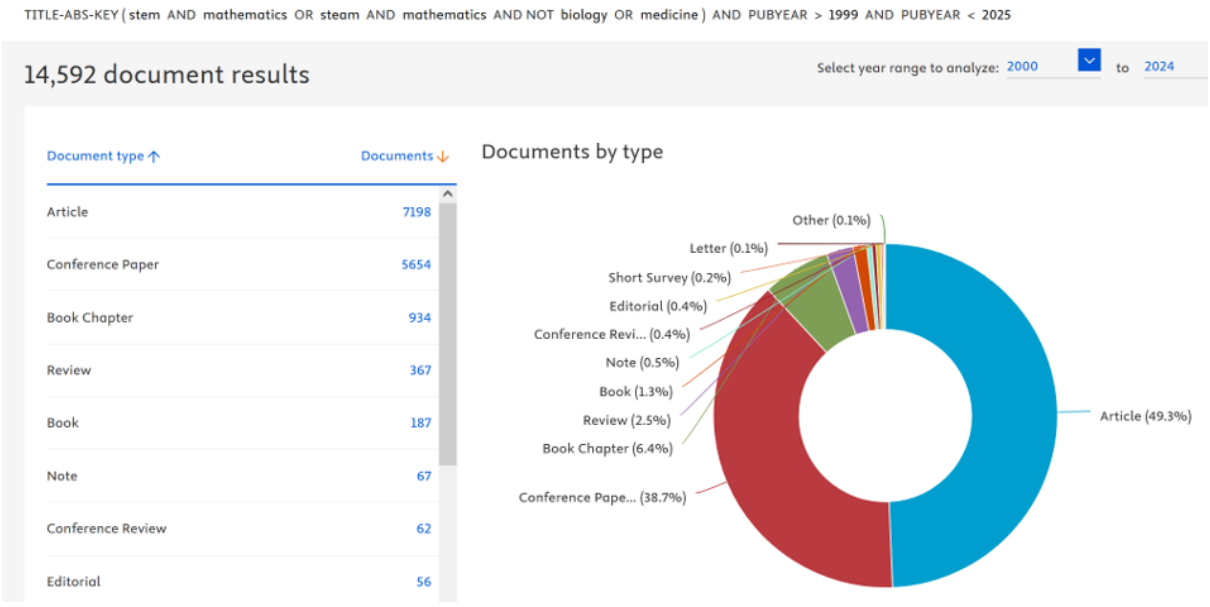


Source: Scopus

Almost half of the publications are journal articles, and 38.7% are publications in conference proceedings, which we associate with a significant number of conferences dedicated to STEM and STEAM education (Fig. 3).

Figure 3

Distribution of documents in Scopus, by type of publication, when searching for "STEM and Mathematics" or "STEAM and Mathematics", in 2000-2024

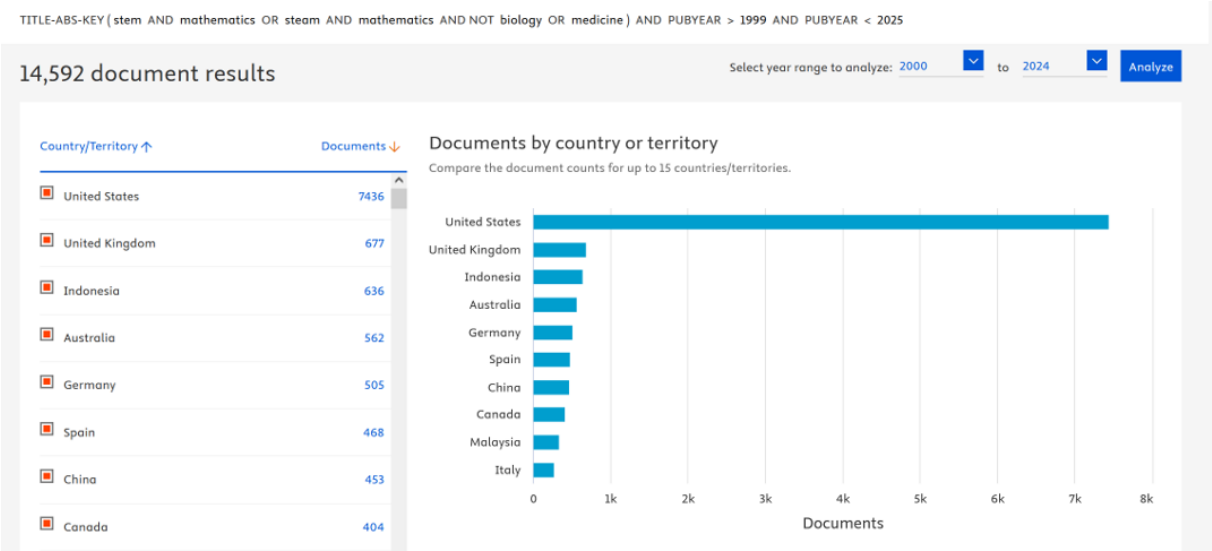


Source: Scopus.

The largest number of publications on the topic is in the USA, significantly outstripping those from the following countries (Fig. 4). Bulgaria ranks 52nd, with 38 documents out of a total of 152 countries.

Figure 4

Distribution of documents in Scopus, when searching for "STEM and Mathematics" or "STEAM and Mathematics", by country/territory in 2000-2024



Source: Scopus.

Table 1 presents the 10 most cited publications in the considered Scopus search.

Table 1.

The 10 most cited publications in Scopus, when searching for "STEM and Mathematics" or "STEAM and Mathematics"

№	Author, year	Cited		№	Author, year	Cited
1	(Freeman et al., 2004)	5867		6	(Jispeert et al., 2007)	1010
2	(Grover & Pea, 2013)	1600		7	(Weintrop et al., 2016)	958
3	(Wai et al.,2009)	1357		8	(Kelly & Knowles, 2016)	923
4	(Uttal et al., 2013)	1285		9	(Su et al., 2009)	804
5	(Blickenstaff, 2005)	1152		10	(Katehi et al., 2009)	799

Source: Scopus.

In Freeman et al. (2014), a meta-analysis was conducted based on 255 studies that examined data from the exam results of students in STEM (science, technology, engineering, and mathematics) courses at the undergraduate level in the USA. The authors focus on teaching methods, testing, and the classroom environment, and how these factors relate to increasing students' overall exam scores. According to the data in the article, active learning helps to improve performance, and lectures increase the overall failure rate of taken exams. In Kelly and Knowles (2016), a theoretical conceptual framework is proposed to support the integration of STEM content within the US education framework. The guidelines in the framework are "intended for secondary education, specifically high school level educators and learners". In Jispeert et al. (2007), a method for switching from swimming to walking mode in an amphibious robot salamander has been proposed. The authors show a variant of the evolutionary development from aquatic to terrestrial life through a robotic system that mimics animal movements. In Grover and Pea

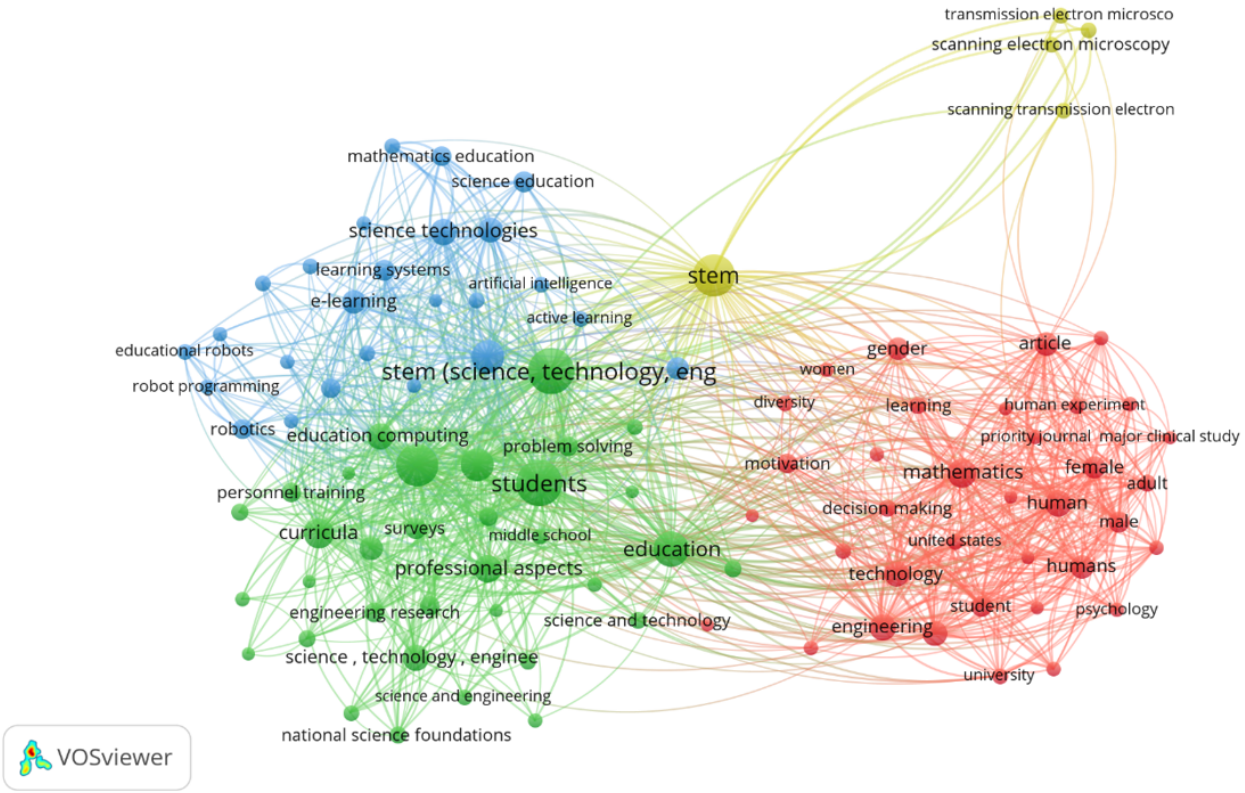
(2013), a review of publications examining computational thinking in K–12 education was conducted. According to the authors, the most common discussions in the analyzed publications concern the different interpretations of the term and the methods and tools by which computational thinking can be implemented in the educational process. (Weintrop et al, 2016) also discusses computational thinking, but more specifically in Mathematics and Science classrooms in the USA. The authors described the approach they took to compile a taxonomy that articulates a definition of ‘‘computational thinking in mathematics and science. From the abstracts of the other closed-access documents, key factors influencing the spread of the STEM concept are analyzed. The gender distribution of researchers relevant to the development of STEM careers, based on literature from the past 30 years, is the focus of (Blickenstaff, 2005). The spatial ability of over 400,000 students in the USA was tracked over 11 years (Wai et al., 2009). The authors concluded that Spatial ability in adolescents plays a key role in identifying potential future specialists in the STEM field. Similar conclusions were reached by Uttal et al. (2013) in their study, which was based on a review of 217 documents examining spatial skills.

Cluster Analysis

For the bibliometric analysis, data from Scopus are used. Data for publications in Scopus, available in January 2025, with a keyword or text in the abstract or the title “STEM and Mathematics” or “STEAM and Mathematics”, excluding biology or medicine, for the period 2000 to 2024, were also processed with the VOSviewer program (VOSviewer).

Figure 5

Network map of keywords from documents in Scopus, when searching for ”STEM and Mathematics” or ”STEAM and Mathematics”



Source: Scopus data processed with the VOSviewer program.

From a total of 43096 keywords, we separate those that occur at least 100 times. There are 128 of them. Fig. 5 presents a network map of the first 100 elements, ordered by their frequency of occurrence. STEM research in the context of mathematics is closely tied to technologies such as augmented reality and virtual reality, and artificial intelligence is also not overlooked. There is also a focus on learning methods, such as project-based learning. We note the different spelling of the keywords STEM and STEM (science, technology, engineering and mathematics).

Table 2 presents the 100 most frequently used keywords from the network map in Fig. 5, organized by their cluster distribution.

Table 2

The 100 most frequently used keywords from the analyzed documents in Scopus, when searching for "STEM and Mathematics" or "STEAM and Mathematics"

Cluster	Keywords
Cluster 1 (36 items)	academic achievement; academic achievement; achievement; adolescent; adult; article; career; career choice; child; controlled study; curriculum; decision making; diversity; engineering; female; gender; human experiment; humans; learning; major; clinical study; male; mathematics; mentoring; motivation; priority journal; psychology; research; science; self efficacy; student; technology; united states; universities; university; women
Cluster 2 (34 items)	application programs; curricula; design; education computing; employment; engineering design; engineering design process; engineering education; engineering research; high school; high school students; middle school; middle school students; national science foundations; personnel training; problem based learning, problem solving; professional aspects; professional development; project based learning; science, technology, engineering, and mathematics; science, technology, engineering, and maths; science, technology, engineering and mathematics; science and engineering; science and technology; stem (science, technology, engineering and mathematics); stem fields; students; surveys; teaching; undergraduate students; underrepresented minorities
Cluster 3 (25 items)	active learning; artificial intelligence; augmented reality; computational thinking; computational thinkings; computer aided instruction; e-learning; educational robotics; educational robots; educational technology; engineering and mathematics; higher education; learning environments; learning systems; mathematics education; robot programming; robotics; science education; science technologies; secondary schools; stem education; teachers'; teaching and learning; technology education; virtual reality
Cluster 4 (5 items)	high resolution transmission electron microscopy; scanning electron microscopy; scanning transmission electron microscopy; stem; transmission electron

Source: Scopus data processed with the VOSviewer program.

Although initially limited to the fields of medicine and biology, Cluster 4 includes examples of specialized techniques for visualizing the structure of materials, likely due to the interdisciplinary scope of some of the documents. According to the keywords included in the other clusters, we can summarize that:

Cluster 1 describes the life cycle of professional development in the STEM field. The keywords encompass a range of age groups, genders, motivations, and mentoring styles. We note that the United States is present as a standalone keyword.

Cluster 2 provides a general overview of the ways STEM is applied across different educational levels. These include methods for training learners and trainers, curricula, and, more specifically, the training of engineering personnel. Variants of the spelling of the term occur in this section.

Cluster 3 includes examples of specific disciplines (engineering, mathematics, robotics) contributing to the development of key competencies through STEM technologies. This cluster also includes examples of learning methods (active learning, computational thinking, technology education)

and the types of methods through which information reaches students (computer-aided instruction, e-learning, learning environments, learning systems).

Due to the similarity in the names of some authors and their abbreviations, attempts to visualize a network map yielded inconsistent results, as they automatically grouped several different authors under a single name. Accordingly, the total number of connections between them and their other co-authors was not accurate.

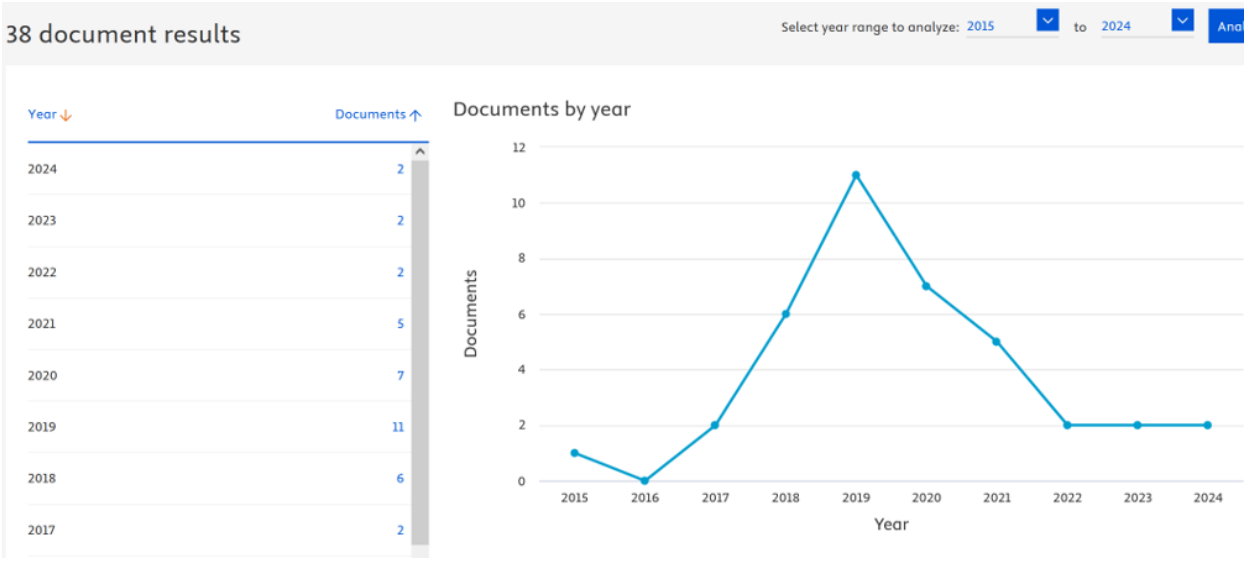
Results for Bulgaria

In the curricula for school education in Bulgaria, the structure included the following cultural and educational areas for a long period: Bulgarian language and literature; foreign languages; mathematics, informatics and information technologies; social sciences and civic education; natural sciences and ecology; arts; life and technologies; physical culture and sports. The implementation of cross-curricular connections was included in the relevant curricula of individual subjects. Despite the efforts within the framework of several European projects, in which teams from Bulgaria worked, to spread the idea of STEM and STEAM education (for example, the Fibonacci, Scientix, Mascil, STEMPDNet projects), wide dissemination was realized only after the Ministry of Education and Science of the Republic of Bulgaria adopted several decisions and launched a project related to the construction of STEM centers in every Bulgarian school. Currently, a National STEM Center has also been established, which coordinates activities related to several projects and provides support for work within these centers, as well as prepares teachers for upcoming initiatives. Over the past decade, some of the publications by Bulgarian authors have been related to European and international educational projects. There are publications from Bulgaria related to the development of common models for STEM and STEAM (Chehlarova, 2024). Currently, in connection with activities at some of the STEM centers launched in schools, several publications related to practices have been published (Chehlarova et al., 2024; Chehlarova, 2021; Kozhuharova, 2022). In some studies, the focus is on information technology, its impact on students with educational needs, and the simultaneous development of mathematical and digital competence (Karashtranova et al., 2024; Nikolova et al., 2024; Todorov et al., 2024). However, a large number of these publications are in editions not included in the database considered.

In the already described Scopus search, but with an additional restriction for affiliation from Bulgaria, 38 documents were identified. In practice, results from 2015 show a peak in 2019 (Fig. 6 and Fig. 7). Unlike the overall result, for Bulgaria, the largest share of publications is in the field of "Computer Science". One reason is that in Bulgaria, many researchers in the field of computer science are also involved in education. The various procedural requirements in the Act on the Development of Academic Staff in the Republic of Bulgaria, related to referencing in specific databases, including Scopus, are also likely to be important. For example, in the scientific field of Computer Science, to obtain the educational and scientific degree of doctor or doctor of science, as well as to qualify for assistant, assistant professor, and professor positions, only publications referenced in Scopus or Web of Science are valid. In contrast, for the field of Pedagogical Sciences, publications referenced in other databases are also important.

Figure 6

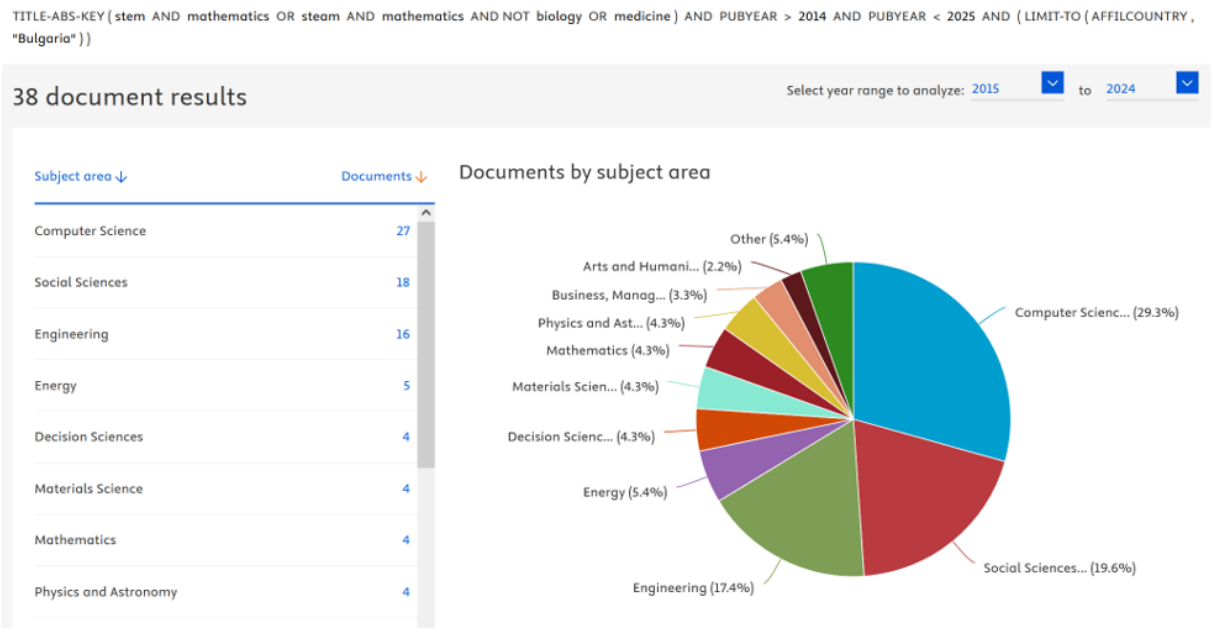
Distribution of documents from Scopus, with affiliation from Bulgaria, when searching for "STEM and Mathematics" or "STEAM and Mathematics"



Source: Scopus.

Figure 7

Distribution of documents from Scopus, with affiliation from Bulgaria, based on years and subject area, when searching for "STEM and Mathematics" or "STEAM and Mathematics"



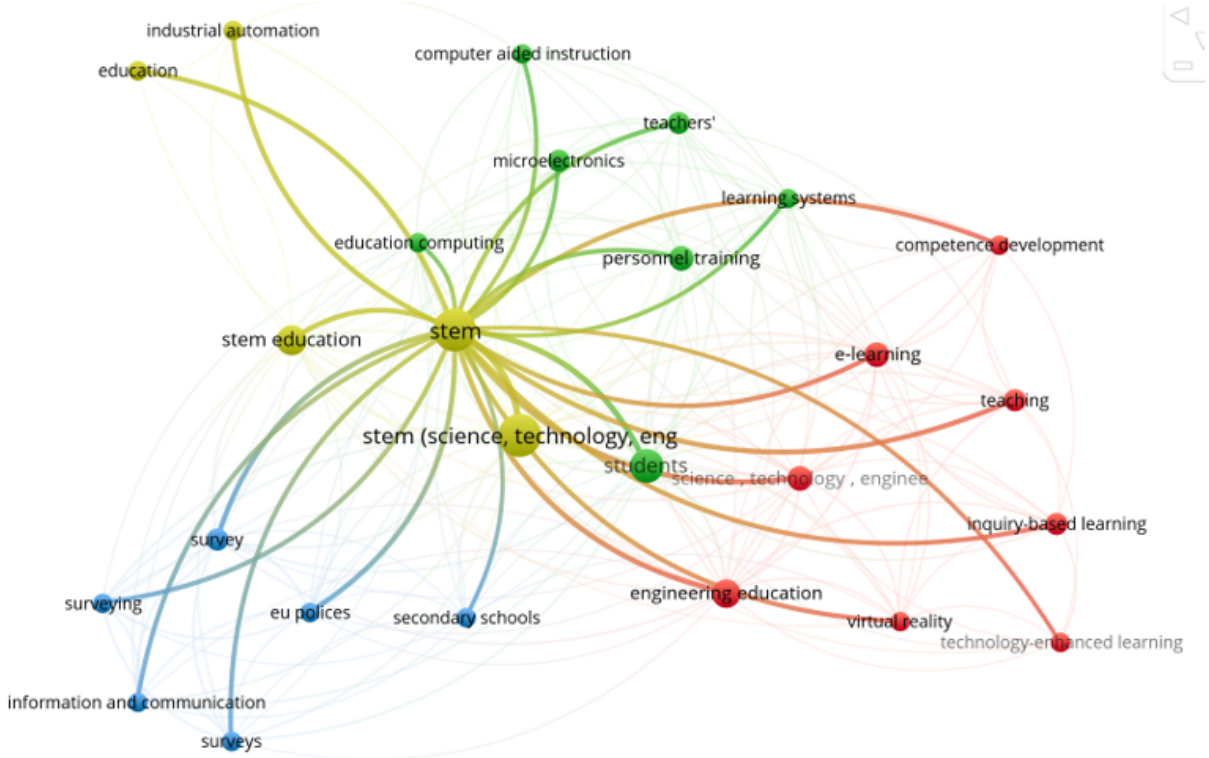
Source: Scopus.

Out of 295 keywords, we separate those that occur at least 3 times. There are 26 of them in total, and they are presented in Fig. 8. The network map provides sufficient visual information, and we will not separate them into tabular form by clusters. It is noted that the phrase "STEM" has available links to

all other keywords. Although they are smaller in number, the keywords are again divided into four clusters and reflect, by analogy, the clusters in Fig. 5.

Figure 8

Network map of the connections of the keyword STEM with all others from the analysis



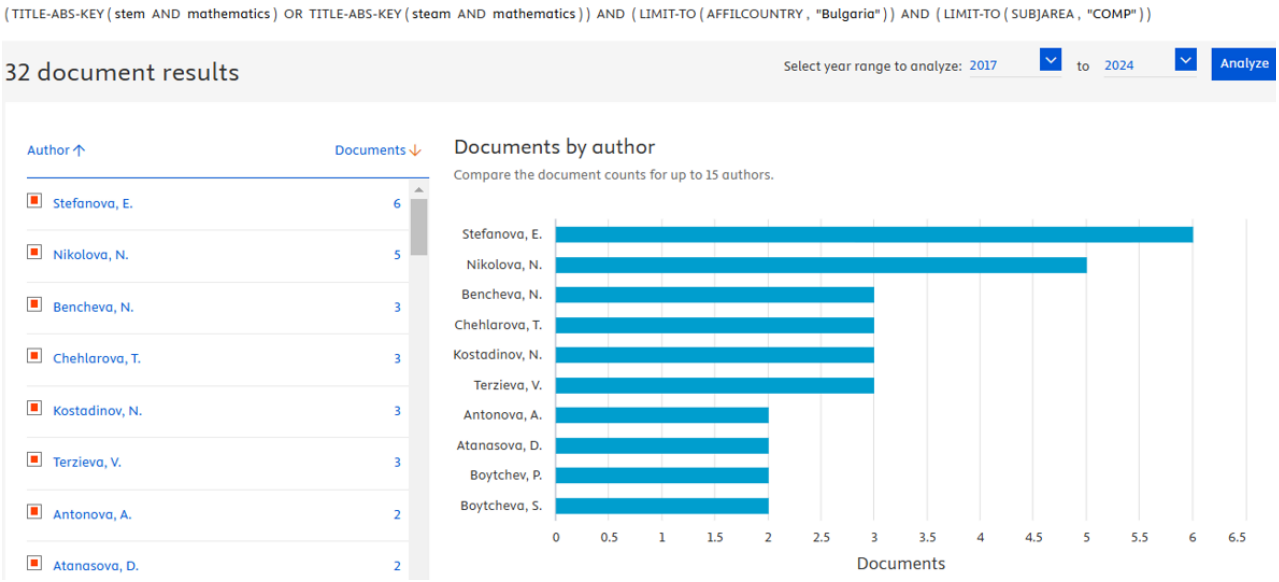
Source: Scopus data processed with the VOSviewer program.

We searched for publications on the topic with an affiliation from Bulgaria, focusing on those with the highest number of citations, as well as authors by the number of publications and their field of expertise.

Figure 9 presents the authors for the specified search in the field of "computer science", and in Table 3, the first publications are listed by the number of citations in this field.

Figure 9

Authors affiliated with Bulgaria with the highest number of papers in the field of "computer science"



Source: Scopus.

Table 3

Authors affiliated with Bulgaria with the highest number of citations in the field of "computer science"

№	Author, year	Cited		№	Author, year	Cited
1	Petrov and Atanasova, 2020	65		6	Tuparova, Veleva and Tuparov, 2019	8
2	Yordanova, Filipe and Coelho, 2020	16		7	Chehlarova and Chehlarova, 2020	6
3	Boytchev and Boytcheva, 2020	15		8	Yakimov and Iovev, 2019	5
4	Terzieva et al., 2020	9		9	Tramonti and Dochshanov, 2018	5
5	Yakimov et al., 2020	8		10	Ivanov et al., 2019	4

Source: Scopus.

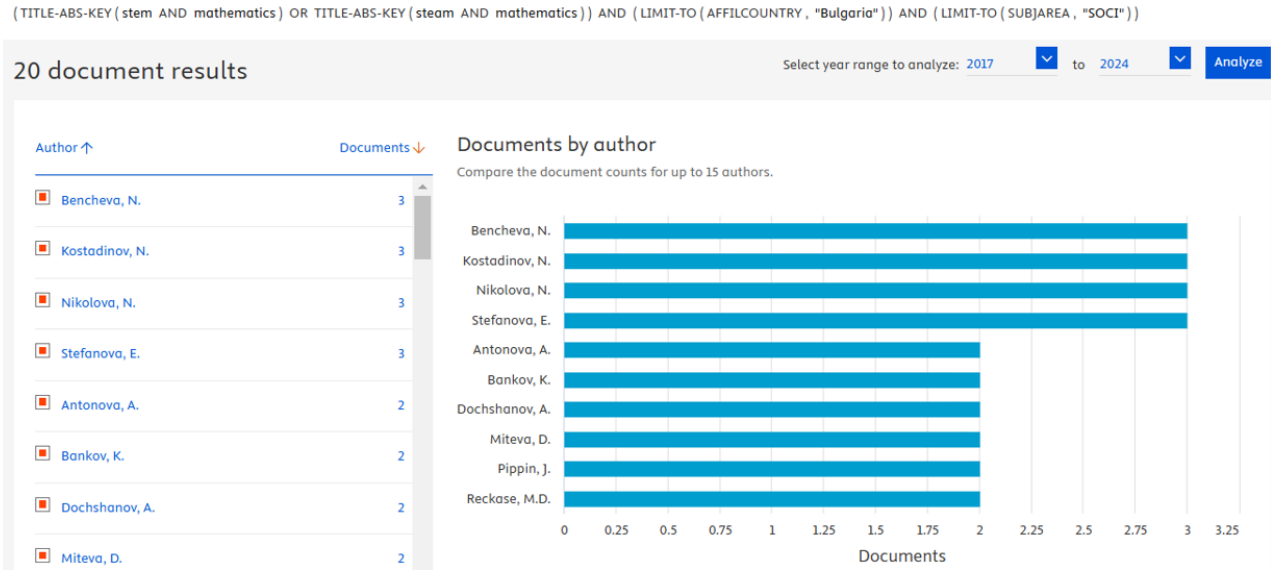
These publications are predominantly related to the application of a specific technology or the use of a specific technological product, including games. Some consider the pedagogical aspects of their application or a specific pedagogical technology, for example, related to teamwork.

In the field of computer science, conference articles predominate – 81.3%, and half of the articles in Table 3 are also of this type. It is striking that a large part of the articles in this field are also from another field, and that a significant portion of them are funded by the Ministry of Education and Science of the Republic of Bulgaria.

Similarly, Fig. 10 and Table 4 present the data for the field of "social sciences", Fig. 11 and Table 5 present the data for the field of "engineering", Fig. 12 and Table 6 present the data for the field of "mathematics", Fig. 13 and Table 7 present the data for the field of "arts and humanities".

Figure 10

Authors with affiliation from Bulgaria, with the most significant number of documents in Scopus, for the field of "social sciences"



Source: Scopus.

Table 4

Authors according to the described search, with affiliation from Bulgaria, with the most significant number of citations in the field of "social sciences"

№	Author, year	cited		№	Author, year	cited
1	O'Connor et al., 2020	35		6	Tramonti and Dochshanov, 2018	5
2	Yordanova et al., 2020	16		7	Bencheva et al., 2018	4
3	Tatto et al., 2020	10		8	Bencheva & Kostadinov, 2021	3
4	Pergelova et al., 2023	8		9	Bencheva & Kostadinov, 2019	3
5	Yakimov et al., 2020	8		10	Nikolova et al., 2018	3

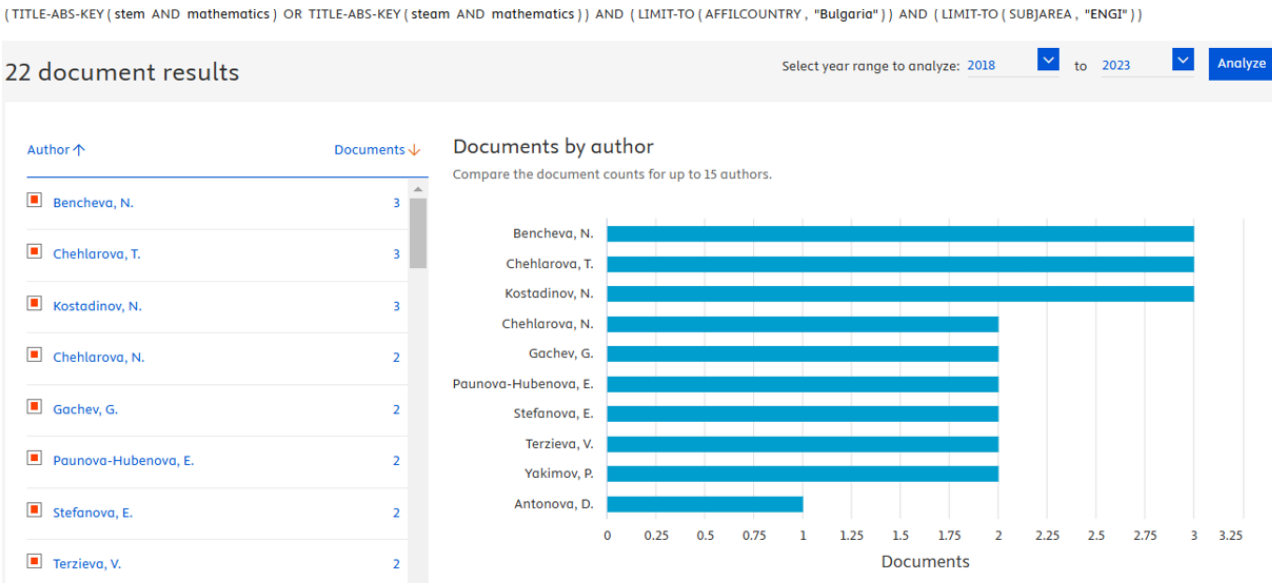
Source: Scopus.

Half of the publications in the field of social sciences with affiliation from Bulgaria are in conference volumes, most of which are related to the field of computer science. The expectation that matches of the most cited articles will be found when searching in different fields is confirmed. This is also the case for the field of engineering. According to the data in Scopus, most authors who have published on the topic have indicated the Bulgarian Academy of Sciences, specifically the Institute of Mathematics and Informatics, and the Technical University of Sofia, as the relevant organizations.

The focus of the most cited publications in the field of "engineering" is on education, using information and communication technologies for work in a specific e-environment and remotely; overcoming some problems in STEM education by introducing new teaching methods, games, and increasing the percentage of women in science.

Figure 11

Authors with an affiliation from Bulgaria, with the most significant number of documents in the field of "engineering"



Source: Scopus.

Table 5

Authors according to the described search, with affiliation from Bulgaria, with the most significant number of citations in the field of "engineering"

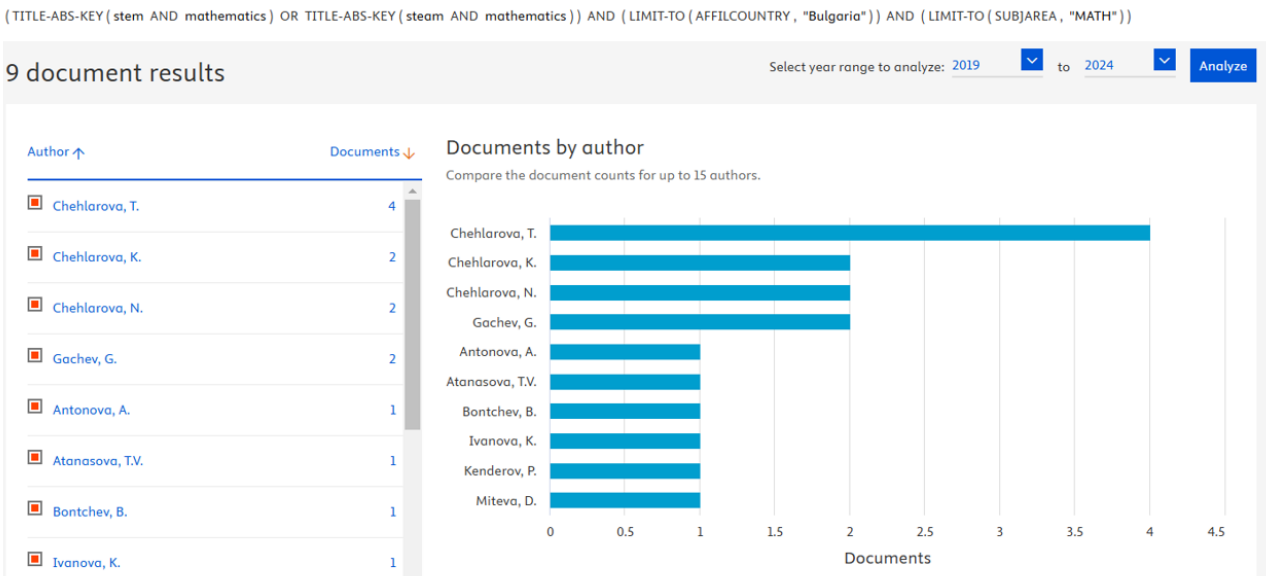
№	Author, year	cited		№	Author, year	cited
1	Terzieva et al., 2020	9		6	Ivanov et al., 2019	4
2	Yakimov et al., 2020	8		7	Bencheva et al., 2018	4
3	Tuparova, Veleva and Tuparov, 2019	8		8	Marinova et al. 2022	3
4	Yakiinov and Iovev, 2019	5		9	Bencheva and Kostadinov, 2021	3
5	Yakimov and Iovev, 2019	5		10	Yoshinov et al., 2021	3

Source: Scopus.

Publications on the considered search in the field of mathematics are most often related to specific educational resources within the context of STEAM, particularly in areas such as mathematics, information technology, computer modeling, engineering, and art. These resources utilize various technologies, such as computer models that provide research on mathematical objects or support the creation of works of art, as well as augmented reality, virtual reality, holograms, and robotic systems. When using them, on the one hand, conditions are provided for the development of the ability to carry out research activities, and on the other, for creative activity. Thus, in addition to developing competence for specific mathematical objects, other vital goals are achieved, and teachers are assisted in motivating students to engage in mathematical activities. The Union of Bulgarian Mathematicians also plays a role in these publications through its edition, Mathematics and Education in Mathematics, as well as the international journal "Symmetry: Culture and Science," which is related to the community of symmetry researchers from various scientific fields.

Figure 12

Authors with an affiliation from Bulgaria, with the most significant number of documents in the field of "mathematics"



Source: Scopus.

Table 6

Authors according to the described search, with affiliation from Bulgaria, with the most significant number of citations in the field of "mathematics"

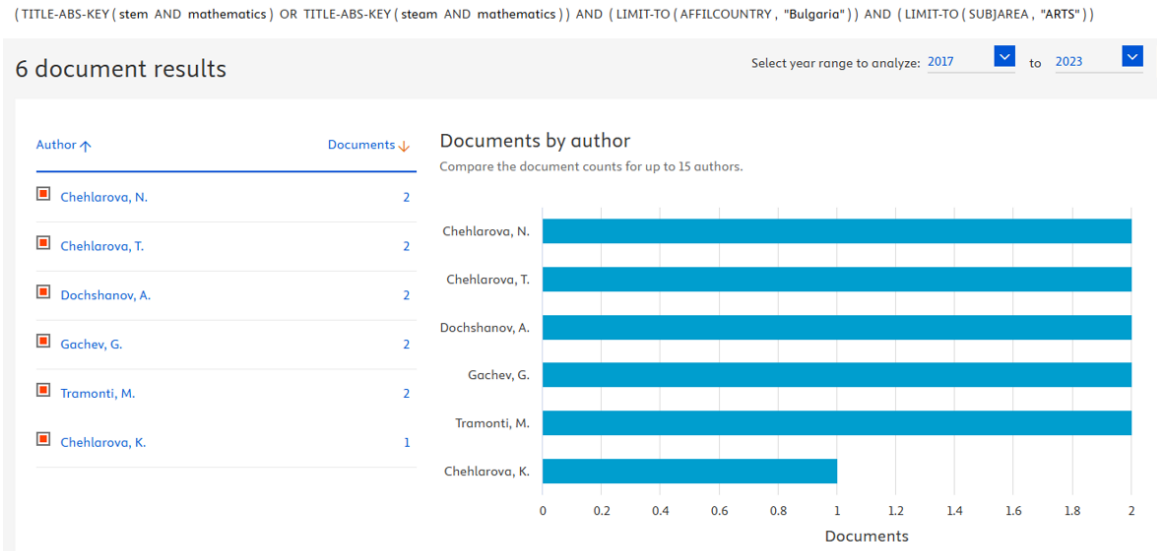
№	Author, year	cited		№	Author, year	cited
1	Chehlarova and Chehlarova, 2020	6		5	Antonova et al., 2019	1
2	Chehlarova et al., 2021	2		6	Bontchev et al., 2024	-
3	Chehlarova and Chehlarova, 2021	2		7	Chehlarova and Gachev, 2023b	-
4	Chehlarova, 2021a	1		8	Chehlarova and Gachev, 2023a	-

Source: Scopus.

Most of the top Bulgarian authors in the field of Mathematics are also those with the most documents and citations in the field of Arts and Humanities.

Figure 13

Authors with affiliation from Bulgaria, with the largest number of documents in the field "Arts and Humanities"



Source: Scopus.

Table 7

Authors according to the described search, with affiliation from Bulgaria, with the largest number of citations in the field "Arts and Humanities"

№	Author, year	Cited
1	Tramonti and Dochshanov, 2018	5
2	Chehlarova and Chehlarova, 2021	2
3	Chehlarova, 2021a	1
4	Chehlarova and Gachev, 2023a	-
5	Chehlarova and Gachev, 2023b	-

Source: Scopus.

The international journal "Symmetry: Culture and Science" also contains a significant portion of publications with affiliations from Bulgaria in the field of "arts and humanities" related to the topic under consideration. The materials published in it are closed access and paid. Although there are few published studies in the specific field, their scope is diverse in terms of modern technologies and methods of education, as well as techniques and materials used in Art.

Discussion

A strong increase in the number of publications on the subject in Scopus is observed internationally after 2011. In contrast, in Bulgaria, the number of publications remains small, with the first results appearing after 2015. The number of publications on the topic in the USA is the largest and significantly outpaces those from the following countries, which is not surprising given the numerous government sectors, educational programs, and long-standing work on implementing STEM methodology in their educational systems. The increase in the number of publications is expected, given the development of technologies and their role in implementing STEM education, as well as the actions taken at various levels in many countries to support STEM education. Bulgarian researchers should aim to publish in editions indexed in Scopus, thereby increasing the visibility of their results. It is noteworthy

that the joint publications from Bulgaria are predominantly authored by authors from a single organization.

According to the affiliations for Bulgaria, scientists from the Bulgarian Academy of Sciences, Sofia University “St. Kliment Ohridski” and the Technical University - Sofia stand out. The Union of Bulgarian Mathematicians, through its publication Mathematics and Education in Mathematics, as well as the international magazine "Symmetry: Culture and science" of the community related to symmetry research from various scientific fields, plays a role in some publications with a Bulgarian affiliation. Joint publications by authors from various organizations in Bulgaria, as well as with authors from other countries, will accelerate the implementation of good practices. For Bulgaria, the largest share of publications is in the field of "Computer Science", unlike the overall result, which shows the highest share in the field of "Social Sciences". In Bulgaria, cooperation between researchers from different fields in STEM and STEAM research, in the context of mathematics, is still not sufficiently realized. At the national level, the country began promoting policies to create conditions for a STEM approach across different education levels a few years ago. We expect an increase in the number of scientific publications by authors from Bulgaria, in the context of STEM, given the national policies for the establishment of STEM centers in schools, the ongoing project activity by scientific organizations and universities in the field, and the penetration of new technologies at various educational and economic levels.

Research on STEM in the context of mathematics is closely tied to technologies such as augmented reality and virtual reality, 3D printing, holograms, and robotic systems. There is also research related to artificial intelligence. There is also a focus on learning methods, including problem-solving, problem-based learning, project-based learning, inquiry-based learning, and personalized learning. The cluster analysis also highlights these results.

Conclusions

Focus in the 10 most cited articles in the world, from the searched terms in Scopus, are key factors influencing the spread of the STEM concept such as - spatial thinking and "computational thinking"; learning methods such as active learning; gender distribution of researchers relevant to the development of STEM careers; methodologies for application in education. Research on STEM in the context of mathematics is closely tied to technologies such as augmented reality and virtual reality, 3D printing, holograms, and robotic systems. There is also research related to artificial intelligence. There is also a focus on learning methods, including problem-solving, problem-based learning, project-based learning, inquiry-based learning, and personalized learning. The cluster analysis also highlights these results.

Bibliometric analysis shows the development of interest in the topic under consideration, fixes the main educational elements with which it is related, orients in the current state and assists researchers and managers in orienting themselves in concepts, communities, applications, connections, problems, perspectives and other elements related to STEM and STEAM education in the context of mathematics education, as well as in making management decisions.

At the national level in Bulgaria, it is appropriate to encourage collaborations across disciplines, including engineering, natural sciences, computer science, and mathematics, to create integrated STEM programs. Another opportunity is to leverage partnerships with international universities and use collaborative tools (like co-authorship networks) to share expertise.

Suggestions for Future Research

Additional conclusions can be drawn after continuing the research in databases such as Web of Ssience and Google scholar. Future research is warranted on educational projects related to STEM and STEAM education, with a particular focus on mathematics. Special focus should be placed on research into the results of forming mathematical competence when applying different strategies and models of STEM and STEAM education. The allocation of time for mathematical activities across different educational levels is also of interest. Research is also needed on the outcomes of teaching special groups of students, such as those with special educational needs or gifted students. Teacher training and motivation are important for successful implementation, and therefore research on PD courses for teachers and on university-level strategies and solutions for preparing the relevant students, who are preparing to become teachers is also important.

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Conflict of Interest

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