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Comprehensive science mapping of STEM studies in gifted education

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ABSTRACT
The integration of gifted learners into STEM education has raised two key issues: providing suitable learning experiences for them and utilising their potential to contribute to the ultimate goals of STEM education. Hence, research in this area is essential for both researchers and practitioners in gifted education. The purpose of this study was to examine pertinent trends in recent years as revealed by the bibliometric analysis of published studies on STEM in gifted education. A total of 170 publications on gifted and STEM education obtained from Web of Science and Scopus databases were examined. The PRISMA model was used for data collection. RStudio was employed for data analysis. The results of the study revealed that 59 different journals, 170 articles, and 332 authors had contributed to the field of STEM in gifted education. The most frequently used keywords in research in both databases were "STEM", "gifted students", "gifted education", and "talent development". The most productive journals on STEM-related studies in gifted education were Rooper Review and Gifted Child Quarterly. The most relevant authors were C. June Maker and Paula Olszewski-Kubilius. The most productive institutions were the Northwestern University and the University of North Texas. Trending topics have evolved from gender differences to enrichment and science mathematically focused subjects, and then technology and engineering focused stem and talent development.

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Introduction

In the knowledge-based global economy of the 21st century, the need for scientific and technological advances and associated professionals has been steadily increasing (Wu et al., 2019). Integrating Science, Technology, Engineering and Mathematics (STEM) in schools has been a major attempt to address this need. It has been noted that there is a scarcity of persons demonstrating exceptional aptitude in STEM fields in the ever-evolving realm of technology (U.S. Department of Commerce, 2017), while demand for STEM employment is expected to rise between 2010 and 2020 in the USA. Thus, the forthcoming cohort should be equipped and nurtured with science, technology, engineering and mathematics (STEM) education as a national priority (Steenbergen-Hu & Olszewski-Kubilius, 2017). It is important that learners' dispositions towards STEM and their STEM education should be prioritised as a policy in many countries.

As stated by Wu et al. (2019) and Maker (2020), identifying learners who exhibit exceptional talent (gifted learners) in STEM and providing enrichment programmes to improve their skills to the highest level of their capability is also critical to each nation's future. In this sense, the National Science Board (NSB) (2012) established a core goal for the domain of gifted education to identify and nurture gifted learners who would become the world's pioneering STEM professionals. To do this, the NSB proposed eight policy actions –including accelerated and well-designed enrichment programmes and accessing formal and informal education opportunities such as out-of-school programmes- to promote STEM education for gifted learners.

In this respect, since the curricula implemented at school may be restricting in terms of advanced nurturing of gifted students in STEM fields (Adams et al., 2008), it is recommended that a differentiated curriculum including enriched syllabi and challenging activities should be implemented (Ericsson, 2014). Many efforts have been made to create challenging STEM activities such as advanced placement programmes, summer enrichment programmes, extracurricular academic competitions, and dual-enrolment programmes. Numerous studies propose the use of STEM as an optimal learning environment to nurture gifted learners' abilities, to be interested in complex problems in line with their interests, to make novel discoveries (Schroth & Helfer, 2017; Steenbergen-Hu & Olszewski-Kubilius, 2017; Stoeger et al., 2017; Tofel-Grehl & Callahan, 2017; Ulger & Çepni, 2020; Yoon & Mann, 2017).

Although gifted learners tend to exhibit high motivation and high achievement (Tofel-Grehl & Callahan, 2017), there is a paucity of research on STEM studies in gifted education. And there is no unified viewpoint on the optimal STEM education programme for gifted pupils in either school or out-of-school systems. Accordingly, the current investigation endeavoured to amalgamate extant literature on STEM studies in the realm of gifted education. The results of this study furnish a comprehensive outline of the field and proffer recommendations for future research studies. It sought to explore the following research questions:

1. How does scientific production, the productivity of sources, authors, and countries vary per year?
2. What is the relationship between sources, authors, and keywords?
3. What is the distribution of the publications in terms of their authors, year of publication, type of publication, the country and institution where they are published, and journals?
4. What is the most relevant sources, authors, intuitions, and countries?
5. How the collaborations among scholars, intuitions, and countries are constructed?
6. What are the publication charts of the most published journals on the subject?
7. Which studies are the most cited in the field of gifted STEM education?
8. What is the historiography of STEM-gifted oriented studies?
9. What are the most used keywords and the co-occurrence networks of the keywords in the subject area, among the list of keywords?
10. What are the changing and up-to-date trends in the studies carried out in this field and how does the thematic evolution take place?

Theoretical Framework

Characteristics of Gifted Students

According to the Marland Report (1972), gifted individuals are the ones who show superior performance to their peers in the fields of general cognitive skills, special academic talent, visual or performance-based artistic talent, creativity, leadership or psychomotor skills. While IQ had been seen as a single measure of giftedness for a long time, it has of late been considered a multidimensional construct including creativity and socioemotional attributes (Kaufman & Sternberg, 2008). For example, the Triarchic Theory of Intelligence developed by Sternberg (2005), Gagné's (2004) Differentiated Model of Giftedness and Talent (DMGT) or Renzulli's (1986) Three-Ring Model of giftedness views including multiple factors and variables. The concept of giftedness is confused with many concepts. Renzulli et al. (1982) tried to tackle the confusion by distinguishing between schoolhouse giftedness and creative-productive giftedness. Due to their unique and distinct characteristics, gifted learners are more advanced and superior to their peers in areas such as the cognitive, social, emotional and creative (Renzulli, 1986). They are at an advantage regarding physical, perceptual, analysis, synthesis, problem-solving, abstract thinking, logical process, language skills, and creativity (Kurup et al., 2015). In regular schools, these learning characteristics and advantages generally turn into disadvantages because the general curriculum and classroom instruction are inadequate for creating cognitive, creative, and affective challenges for gifted learners. For this reason, many efforts for meeting the educational needs of gifted learners have been made through differentiation of curriculum components (content, process, learning products, and the physical and social environment) (Tomlinson, 2017).

Given the apparent learner differences, gifted learners need content delivery through a variety of instructional and learning methods. Siegle et al. (2014) reported that some enjoy authentic learning experiences such as labs or field trips, while others prefer classroom discussions and Socratic dialogue; for these, discussions motivate them to come to class prepared after reading major literary works. Vanderbrook (2006) noted that gifted learners preferred active discussion to passive activities such as watching film renditions of literary works because discussion allowed valuable time for analysis. In accordance with this trend of active learning found in other subjects, Gavin et al. (2013) noted that to develop a deeper understanding of mathematics, gifted learners needed to grapple with challenging problems, try different strategies, engage in dialogue with peers and teachers, find new ways of solving problems, and explain their reasoning to others. Challenging and meaningful content motivate gifted learners to excel.

STEM Education

The STEM approach is the integration of four different disciplines including science, technology, engineering and mathematics with respect to real-life course content (Moore et al., 2014). The use of science, technology, engineering and mathematics disciplines together provides the opportunity for learners to gain more permanent and deeper learning and to have the opportunity to apply what they have learned (Wicklein & Schell, 1995). Those educated through STEM are expected to exhibit 21st-century skills such as creative thinking, problem-solving, self-confidence, logical thinking, communication, using technology at a high level, competitiveness and critical thinking. STEM education uses a student-centred approach to provide learners with these skills (Kocaman, 2022; Stehle & Peters-Burton, 2019).

STEM is an integral part of people’s lives every day. Creative problem-solving in the areas of STEM has become increasingly critical. For example, STEM-based learning via real-world applications can help learners design environmentally friendly transportation systems that reduce the detrimental effects of climate pollution. Thus, through STEM, students find solutions to real-world problems, make designs, and ultimately develop products for the problem (Margot & Kettler, 2019). Based on various sources, it can be stated that this approach contributes greatly to their acquisition of high-level cognitive skills (Haryadi et al., 2021), the development of their affective characteristics (Blaique et al., 2023), and their career planning (Cheng et al., 2021). In this way, learners can eventually contribute to the world where technology and science develop with STEM.

Giving the necessary importance to STEM education can improve learners' interests, attitudes and future goals involving STEM fields. Their positive attitudes toward STEM fields will enable them to be willing to plan their careers in these fields (Ihrig et al., 2018). In the literature, there are many studies showing that school students' STEM attitudes (Vossen et al., 2021) and career interests (Cheng et al., 2021) are formed during the secondary school years.

STEM Education for Gifted Students

Due to their distinct cognitive, affective, and learning characteristics, gifted learners need differentiated learning experiences which generally include methods like acceleration, grouping and enrichment (Tomlinson, 2017). In order for better integration of gifted students into STEM education, the instructional practices in STEM education must be differentiated accordingly (Morris et al., 2021). Drawing upon the long-term research and practical experiences gained during the DISCOVER assessment development projects funded by the U.S. Department of Education (Maker, 2005; Maker & Schiever, 2010), the research team defined exceptional talent in STEM as consisting of two essential aspects: a highly integrated and interconnected knowledge structure, and the ability to solve a variety of types of problems, from well-structured and known to ill-structured and novel, in science, technology, engineering, and mathematics in the most effective, efficient, original or economical ways.

Gifted pupils need early experiences in science that serve to increase their interest and engagement in the discipline (VanTassel-Baska, 2003), and STEM can provide these opportunities. For example, enjoying learning, analytical thinking, problem solving, creative and critical thinking, high career goals, ability to work both independently and collaboratively, and using mathematics and sciences to solve problems are common characteristics of both engineers and gifted students (Mann et al., 2011). There are many studies showing that STEM is one of the important approaches that can be used to develop the skills of gifted learners in an effective learning environment (Schroth & Helfer, 2017; Sen et al., 2021). STEM is a suitable education model to provide gifted learners with the necessary skills, develop creative and original solutions to problems, and direct them to STEM-related professions (Stoeger et al., 2017). Yoon and Mann (2017) determined that gifted students are more likely to pursue a career in STEM.

Cultivating exceptional talent not only requires the development of a domain-specific, integrated knowledge structure but also the development of domain-general, creative problem-solving abilities. Particularly in STEM, knowledge and conceptual understanding in specific domains (content), problem-solving skills (process), and the ability to apply knowledge and understanding to novel situations (application) are essential elements (English, 2017). It was reported that when academic skills are taught within the context of real-world, open-ended problem-solving, diverse, underrepresented pupils experience greater success in school. Furthermore, STEM-based laboratory experiences have offered important benefits and impacts because such activities promote students' logical and problem-solving skills if constructed appropriately (Porter, 2017).

In brief, the relationship between gifted education and STEM education is mutual. On one hand, STEM education provides a good opportunity for gifted learners if they are supported in their skills, productivity, creativity, encouraged in interest, and demonstrate their potential. On the other hand, STEM education could be more effective and successful in reaching its eventual purposes mentioned above if gifted learners are well integrated into STEM education since they are considered as most capable learners regarding the abovementioned skills (Morris et al., 2021). In this respect, investigating the various aspects of STEM education for gifted students mentioned above poses importance for both researchers and practitioners in the field.

Methodology

Research Design

Bibliometric research methodology was employed in this study (Moreno-Guerrero et al., 2020). Bibliometric analysis is a powerful tool which enables measuring the impact and influence of research journals, articles, authors, institutions, and countries in a subject-specific area. It provides valuable insights into trends and patterns. This approach works by analysing the publications included in certain databases precisely. In this way, the researchers easily identify emerging research areas, evaluate research productivity, and track research trends. The current study focuses on analysing and interpreting educational research on STEM-related studies in gifted education.

Data Collection

In the data scanning process, a rigorous protocol offered by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) was followed. The PRISMA guideline is a systematic approach to reviewing studies in the literature (Moher et al., 2007). In this study, the Web of Science and Scopus databases were reviewed (on 1 February, 2023) Table 1 details the inclusion and exclusion criteria for this study.

Table 1

Inclusion and Exclusion Criteria

Inclusion	Exclusion
Must -include STEM studies in gifted education, -be in WoS and Scopus databases -be published before february 2023 -be written in English -be accesible	-Including reviews, editorials, early access articles -Not written in English -Not related to STEM studies in gifted education

Table 2 presents the research query used in both WoS and Scopus.

Table 2

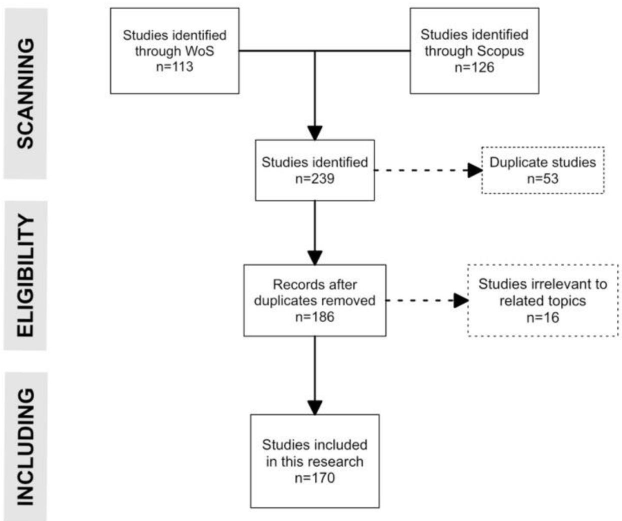
The Research Query Used in WoS and Scopus

Databases	Research query
WoS and Scopus	(“gifted” or “giftedness” or “talented” or “highly able” or “intelligent” or “genius”) AND (“STEM” or “science and technology” or “science and mathematics” or “science and engineering” and “science and design”)

Figure 1 illustrates how the PRISMA guideline was implemented in this study.

Figure 1

Flow Diagram of Studies Selected



Data Analysis

RStudio was employed as a medium for bibliometric analysis. As noted by Gandrud (2013), the integration of this tool with the R programming language makes it highly effective for displaying scientific maps. Data on sources, authors, documents, countries, institutions, conceptual structure, intellectual structure and social structure were examined through the Web application Biblioshiny, which is integrated and synchronised with the R programming language to provide a detailed thematic view: the authors and institutions that have contributed the most to this field; the countries that see this field of study as a priority; which journals are more focused on this field; the cooperation between authors, institutions, and countries; and how the subject has evolved in the historical process have been revealed. For the validity of the study, the findings were examined by two researchers who are experts in R programming language and bibliometrics. For reliability, the data were kept open to the researcher who requested.

Results

When we examine all the data scanned in WoS and Scopus (Table 3), the information being studied was likely gathered between 2000-2023. STEM-oriented studies gradually emerged in the 2000s and became widespread after 2005. During this period there were 59 different sources (journals), 170 documents (articles), and 332 authors that contributed to the field of STEM in gifted education. Although there has not been rapid development over the years, it is evident that work in this field is continuing.

Table 3

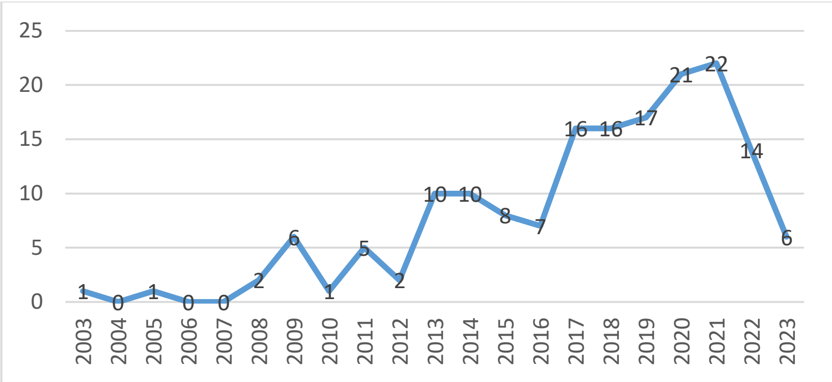
Main Information about Data

Timespan	2000-2023
Sources	59
Documents	170
Authors	332
Annual Growth Rate	4,58 %

When we look at the change in STEM-related research over the years (Figure 2), it is seen that the studies have increased since 2007, reached the highest numbers between 2017 and 2021, while the studies on this subject decreased in 2022 compared to the previous five years. In the years before 2007, it is seen that sporadic efforts were made to bring science and technology and science and engineering to the agenda, although not STEM.

Figure 2

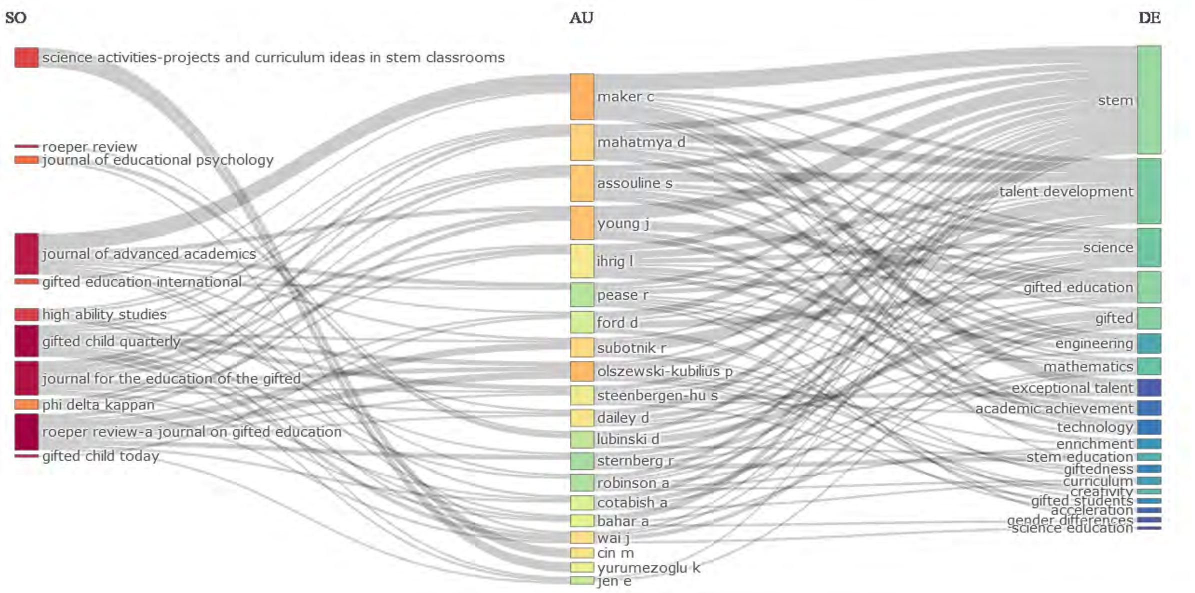
Number of Scientific Publications by Year



When the relationship between the authors, the journals preferred by the authors for publishing and the keywords found in the articles published in these journals were analysed (Figure 3), it is seen that researchers generally focused on talent development, engineering, mathematics, academic achievement technology, enrichment, curriculum, creativity, and acceleration in relation to STEM through the Journal of Advanced Academics, Gifted Child Quarterly, Roeper Review, Journal for the Education of the Gifted, and Science Activities.

Figure 3

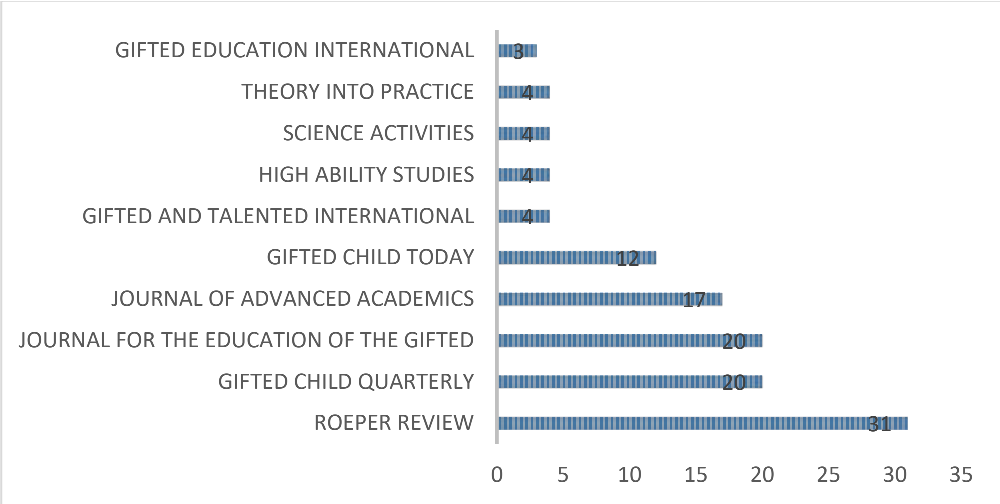
Relationship between Sources, Authors, and Keywords



In Figure 4, it is seen that the most productive journal on stem-related studies in gifted education is Rooper Review, followed by Gifted Child Quarterly, Journal for the Education of Gifted, Journal of Advanced Academics and Gifted Child Today. However, we can assert that other gifted journals (Gifted and Talented International, High Ability Studies, and Gifted Education International) are also interested in this topic, although not in large numbers.

Figure 4

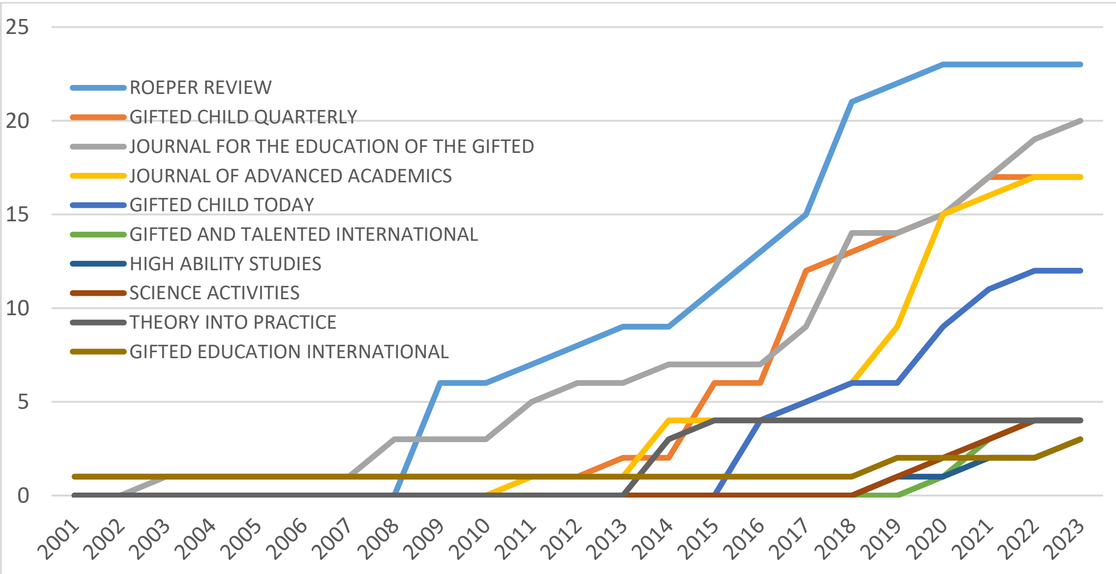
Number of Articles per Sources



When the productivity of the sources over the years was examined (Figure 5), it is seen that the Roeper Review has contributed to this field with increasing interest since 2008. The Journal for the Education of Gifted has been contributing increasingly since 2007, the Journal of Advanced Academics has been contributing increasingly since 2010, the Gifted Child Quarterly has been contributing to this field since 2011 and finally the Gifted Child Today has been contributing to this field since 2015 and continues to be productive.

Figure 5

The Productivity of Sources per Year



According to Figure 6, the most relevant authors are C. June Maker from The University of Arizona with eight publications, Paula Olszewski-Kubilius from Northwestern University with seven publications, and Jamaal Young from University of North Texas with six publications. These authors are followed by Susan G. Assouline and Duhita Mahatmya from The University of Iowa, Rena F. Subotnik from American Psychological Association and Jonathan Wai from University of Arkansas with five publications each. These authors are followed by Merve Ö. Cin from Republic of Turkey

Ministry of National Education, Debbie Dailey from University of Central Arkansas, and Lori M Ihrig from The University of Iowa with four publications each.

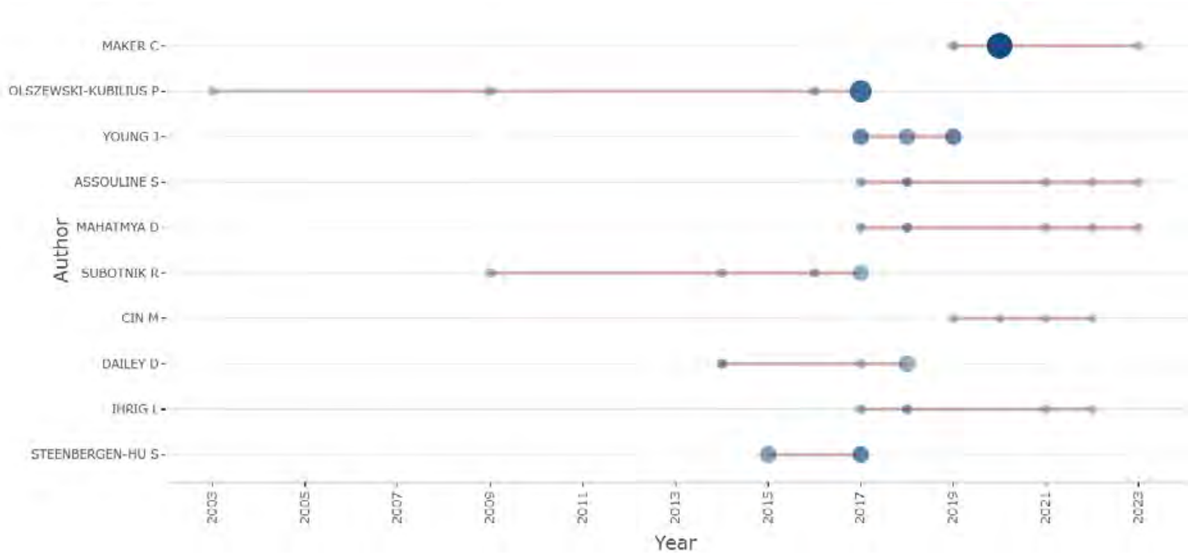
Figure 6

Most Relevant Authors

When we examine the productivity of the authors according to the years (Figure 7), it is seen that four authors continue to work on this issue. Lori M Ihrig, Susan G. Assouline, and Duhita Mahatmya have kept this topic on their agenda since 2017 and C. June Maker since 2019. Paula Olszewski-Kubilius and Rena F. Subotnik are the scientists who have been on this topic the longest. Other authors also emphasized this area at certain intervals.

Figure 7

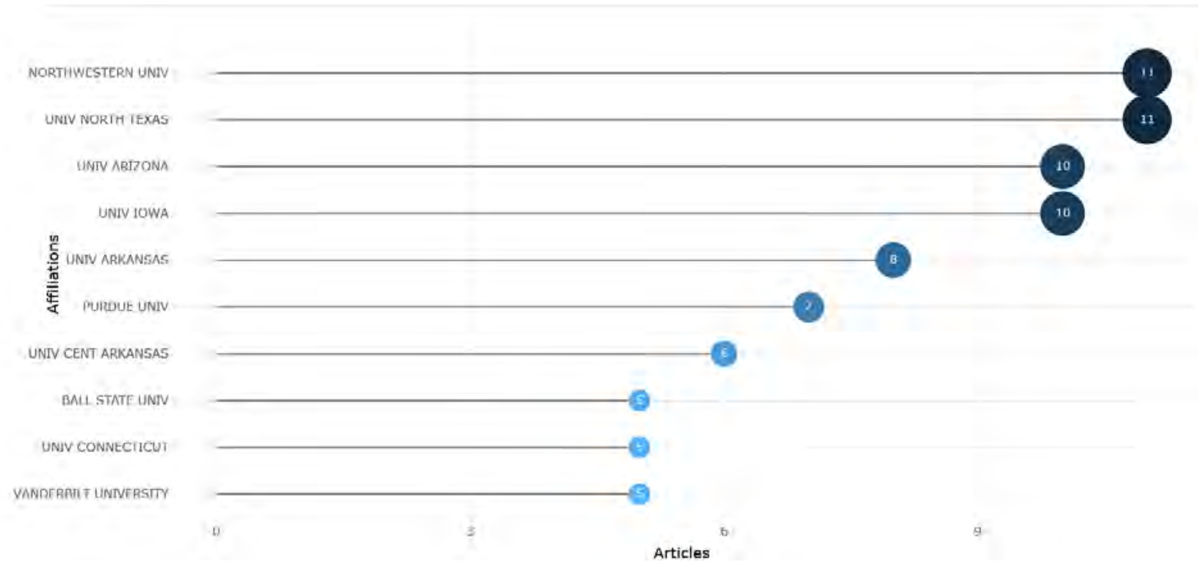
Author's Production over Time



With regard to the most productive institutions that contribute the most to this field (Figure 8), it is seen that Northwestern University and the University of North Texas lead the way, followed by the University of Arizona and the University of Iowa. These institutions are followed by University of Arkansas, Purdue University, and University Central Arkansas.

Figure 8

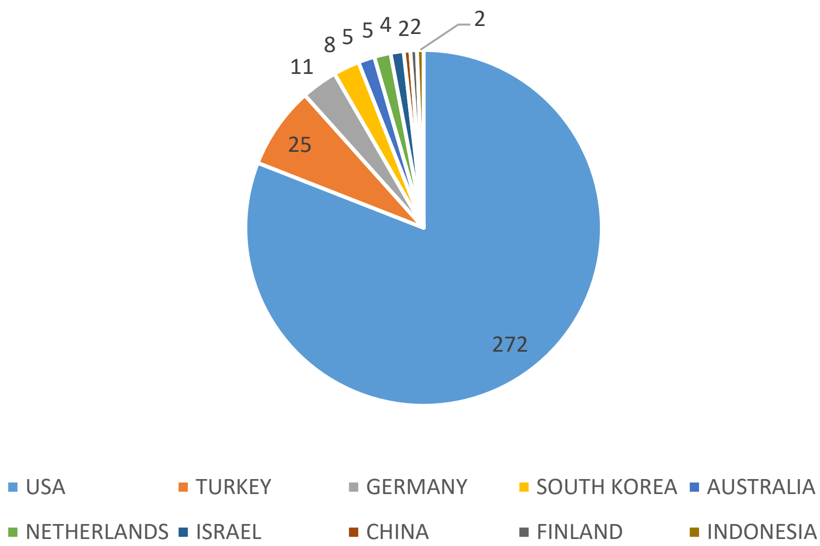
Academic Contribution of Institutions



When the productivity of countries in this field is examined (Figure 9), it is shown that the United States is the dominant country in this field, followed by Turkey, Germany and South Korea. However, Australia, the Netherlands, Israel, China, Finland, and Indonesia are also interested in this field, although not in large numbers.

Figure 9

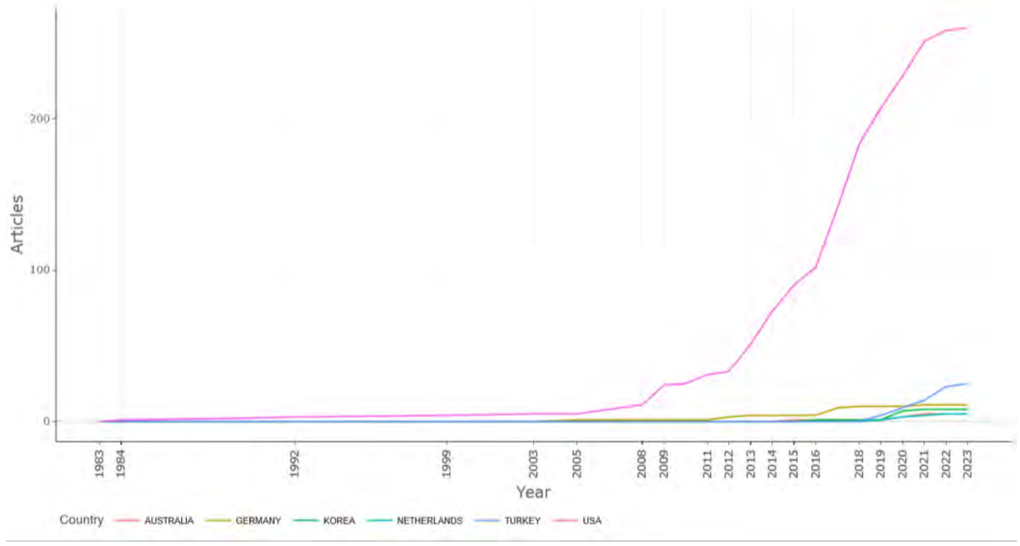
The Scientific Productivity of Countries



The US has focused on this area with a continuous and increasing dynamic since the 2000s, Germany has focused on this issue since 2008, but has not continued to do so, while Turkey has focused on this issue since 2018 and has continued to do so. The Netherlands, Korea and Austria have been focusing on this area since 2019.

Figure 10

The Productivity of Countries by Years



The most cited publications have been published in the last fifteen years. Here, it is seen that the most cited article is a longitudinal study published by Wai et al. (2010). This study is followed by Miller and Halpern's (2013) article on spatial training.

Table 3

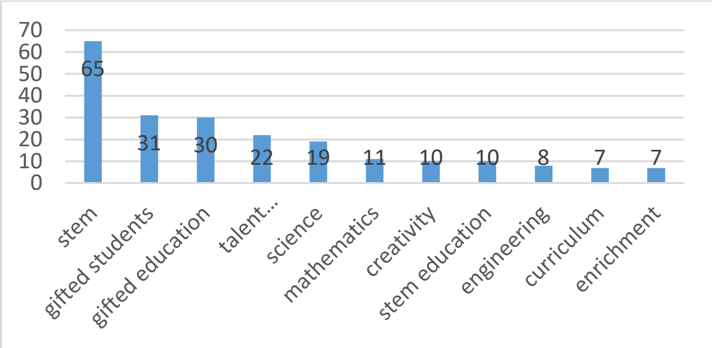
Main Information about Data

Author	Title	Citations
Wai et al. (2010)	Accomplishment in science, technology, engineering, and mathematics (STEM) and its relation to STEM educational dose: A 25-year longitudinal study.	264
Miller & Halpern (2013)	Can spatial training improve long-term outcomes for gifted STEM undergraduates?	84
Heilbronner (2013)	The STEM Pathway for Women: What Has Changed?	53
Park et al. (2013)	When less is more: Effects of grade skipping on adult STEM productivity among mathematically precocious adolescents.	52
Abdurrahman et al. (2019)	Design and Validation of Inquiry-based STEM Learning Strategy as a Powerful Alternative Solution to Facilitate Gift Students Facing 21st Century Challenging	40
Andersen (2014)	Visual–Spatial Ability: Important in STEM, Ignored in Gifted Education	39
Robinson et al. (2014)	The Effects of a Science-Focused STEM Intervention on Gifted Elementary Students' Science Knowledge and Skills	38
Peters-Burton et al. (2014)	Inclusive STEM High School Design: 10 Critical Components	38
Heilbronner (2011)	Stepping Onto the STEM Pathway: Factors Affecting Talented Students' Declaration of STEM Majors in College	36
Root-Bernstein (2015)	Arts and crafts as adjuncts to STEM education to foster creativity in gifted and talented students	35

When we tabulate the most frequently used keywords (Figure 11), STEM, gifted student, science, mathematics, engineering, and gifted education naturally appear to be the most frequently used keywords. We see that talent development, creativity, curriculum, and enrichment are the most frequently used keywords.

Figure 11

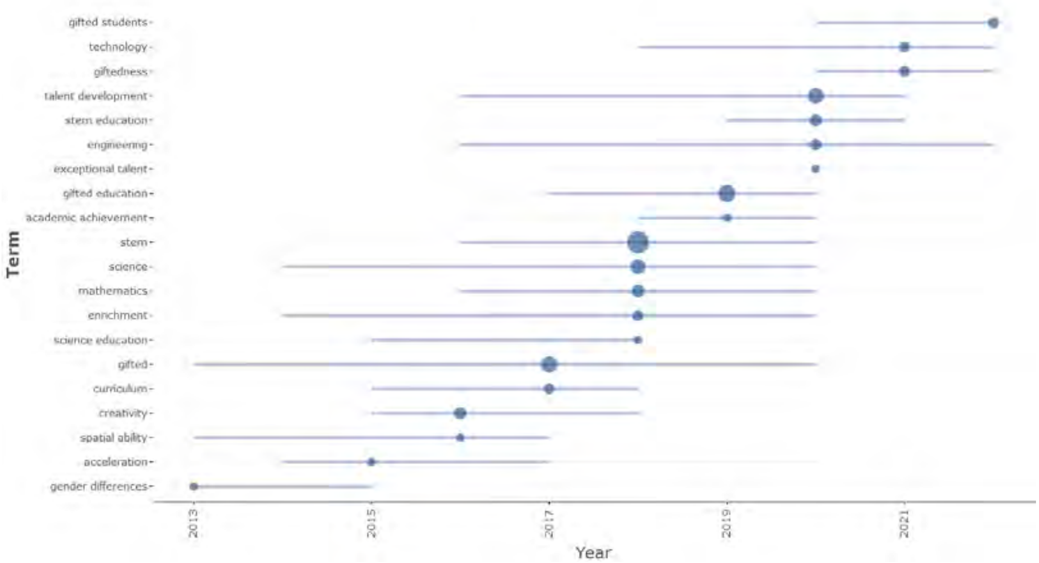
The Most Frequently Used Keywords



When the trending topics in the last ten years are analysed in two-year intervals (Figure 12), it is revealed that gender differences were the trending topic between 2013 and 2015, curriculum, creativity, and spatial ability were the trending topics between 2015-2017, enrichment and science mathematically focused stem were the trending topics between 2017-2019, and technology and engineering focused stem and talent development were the trending topics since 2019.

Figure 12

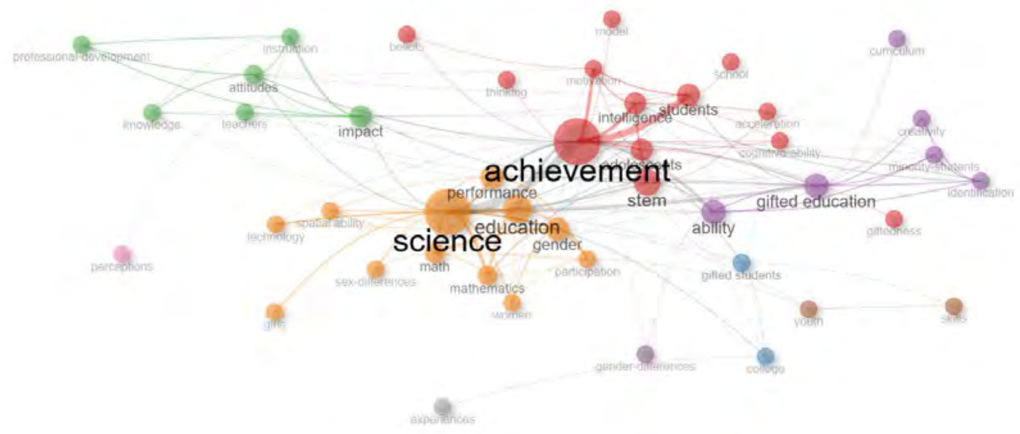
The Trending Topics in the Last Ten Years



Upon analysing the co-occurrence networks of the keywords (Figure 13), it becomes apparent that they radiate outwards, forming three distinct clusters: one centred on science, another on achievement, and a third on gifted education. In proximity to the cluster centred on achievement, the words intelligence, motivation, thinking, beliefs, acceleration, and cognitive ability were observed to branch out. In close association with the cluster centred on science, the words mat, sex differences, performance, spatial ability, participation, and technology were identified as branching. Finally, in relation to the cluster centred on gifted education, the words curriculum, minority students, identification, ability, and curriculum were found to branch out.

Figure 13

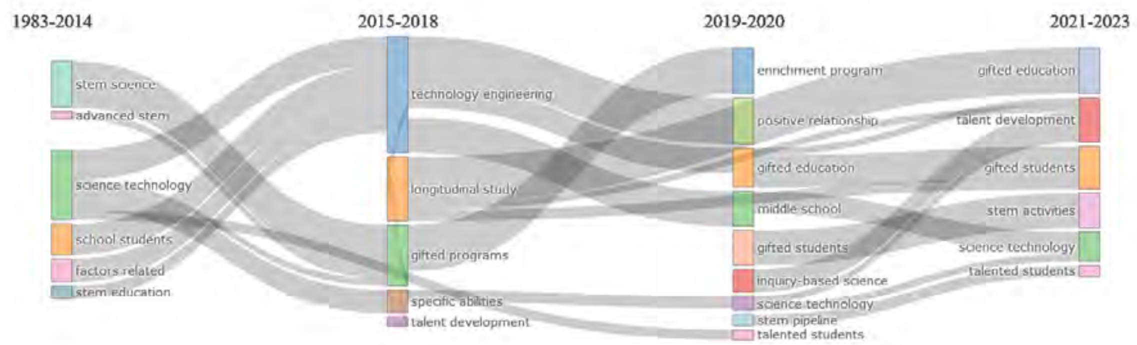
The Co-Occurrence Networks of the Keywords



Considering the thematic evolution divided into four different time periods (Figure 14), an observable transformation is evident within the domain of STEM education, where the trajectory of STEM science and advanced studies is undergoing a progression from foundational curricula towards specialized gifted programs, subsequently transitioning into enrichment initiatives. Concurrently, the landscape of science-technology-related research is undergoing a notable metamorphosis, pivoting towards the realms of technology-engineering studies. The themes focusing on specific abilities through science and technology are then seen to evolve into talent development in parallel with the previous theme through inquiry-based science and science-technology applications.

Figure 14

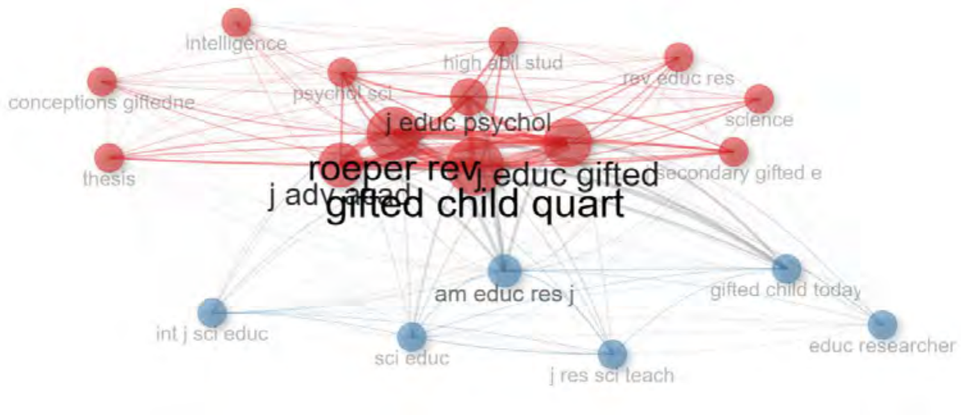
The Thematic Evolution



When the co-citation network between the sources is examined (Figure 15), it is seen that two clusters are formed, and in the first cluster, the network is shaped around the following four sources respectively: Gifted Child Quarterly, Roeper Review, Journal for the Education of Gifted, and Journal of Advanced Academics. Within the second cluster, there appears an interconnectivity among science-oriented journals, although this relationship is not very strong. These journals are the International Journal of Science Education, Science Education, and Journal of Research in Science Teaching.

Figure 15

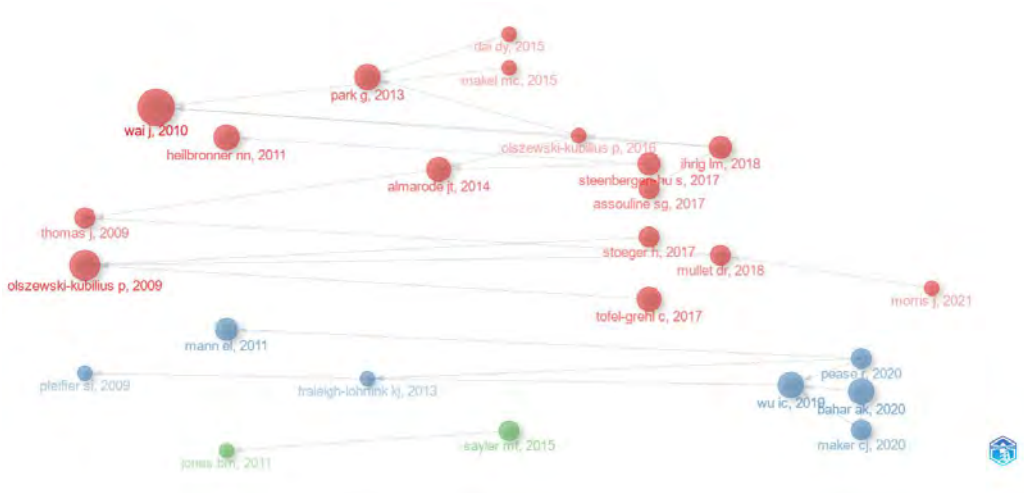
The Co-Citation Network between the Sources



When the historiography of stem and gifted-oriented studies is examined (Figure 16), it is seen that three different clusters are formed, with the strongest and most chronologically connected being the red cluster. Considering that each focal point is related to the introduction of a new topic or problem, there are four main topics in the red cluster and studies on these areas have been continued, sometimes with long periods of time between them. In the blue cluster, it was revealed that there were two main issues and that these issues intersected later. It is seen that there is no sustainable work with the green cluster.

Figure 16

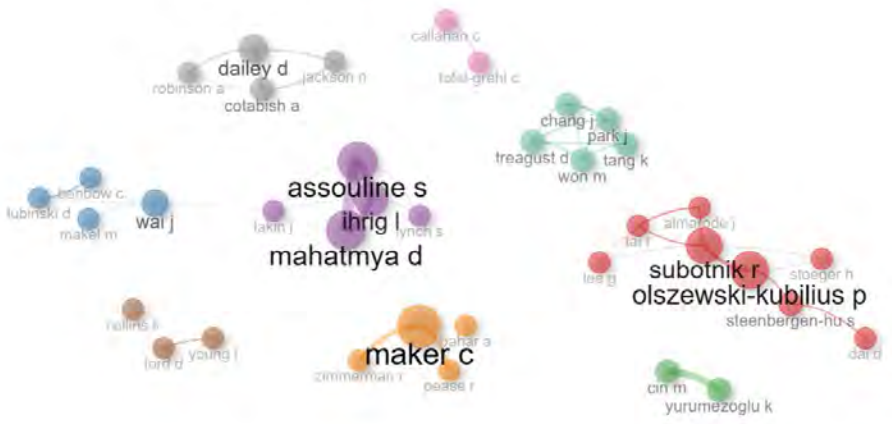
The Historiography of STEM-Gifted Oriented Studies



When we investigate the collaboration between authors (Figure 17), we see that there are many independent groups and that there is not even a slight connection between these groups (except for the blue and purple groups). The group with the strongest and most interaction and collaboration is the red group (Subotnik and Olszewski-Kubilies), followed by the purple group (Assouline, Ihrig and Mahatmya).

Figure 17

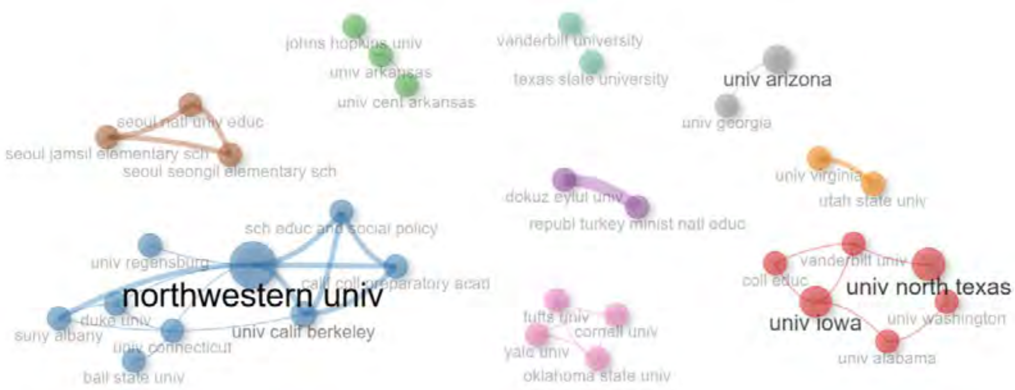
The Collaboration between Authors



In tandem with author collaboration, multiple autonomous groups have been identified in institutional collaborations (Figure 18) Notably, a significant number of institutions engage in cooperative efforts within the blue cluster, with Northwestern University serving as the central nexus. The red cluster also exhibits a relatively high degree of collaboration, while the remaining clusters demonstrate collaboration among two or three institutions.

Figure 18

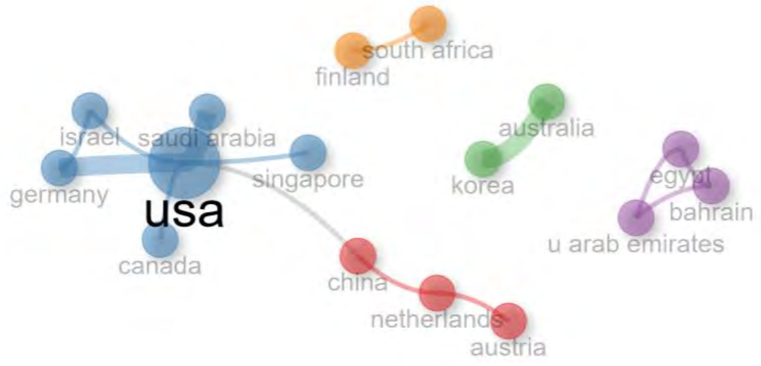
The Collaboration between Intuitions



When we examined the cooperation between countries (Figure 19), it has come to light that those countries demonstrating strong partnerships within the cluster, centred around the United States, consist of Germany, Canada, Singapore, Israel and Saudi Arabia. There is more distant cooperation with China, the Netherlands, and Austria.

Figure 19

The Cooperation between Countries



Discussion and Conclusion

The STEM approach is well suited to guiding and nurturing gifted learners toward STEM-related career pathways, while also equipping them with the scientific process skills, while raising interests towards STEM careers, and competencies for achieving success in those domains (Barış & Ecevit, 2019; Ercan, 2014; Robinson et al., 2014; Yamak et al., 2014). Additionally, as posited by Wu et al. (2019), integrating STEM into gifted curriculum facilitates improvement of creative problem solving skills when dealing with real-world problems (Wu et al., 2019). Furthermore, this teaching approach enables gifted learners to devise authentic and innovative solutions to complicated and multifaceted challenges, as well as encouraging novel discoveries and breakthroughs in the STEM disciplines (Dailey et al., 2018), and increasing their task motivation towards more challenging tasks (Sahin et al., 2014). STEM, in this regard, has begun to play a crucial role in supporting educational programmes for gifted and talented learners. This research has endeavoured to synthesise existing literature pertaining to STEM studies within the realm of gifted education.

170 studies were analysed in terms of bibliometric data. The first study appeared in 2003. After this year, it became apparent that, while there were only two studies published prior to 2007, the number of studies in this particular field has experienced a marked increase, particularly during the period between 2017 and 2021, when the maximum number of studies were published. These studies are generally related to academic achievement. (Tofel-Grehl & Callahan, 2017), positive attitude towards STEM (Ihrig et al., 2018), scientific process skills (Cotabish et al., 2013; Robinson et al., 2014), content and concept knowledge (Robinson et al., 2014), self-efficacy (Almarode et al., 2014), computational thinking skills (Sen et al., 2021), self-confidence and career knowledge (Dieker et al., 2012), creativity (Root-Bernstein, 2015), visual-spatial ability (Andersen, 2014) and etc. There is a paucity of research studies focusing on gifted female learners, gifted learners who reside in rural areas, and learners with twice-exceptionalities. There has been a dearth of studies conducted at the pre-school and primary school levels. It is noteworthy that there are also relatively few studies dedicated to the development of higher-order thinking skills among gifted students, which is one of the primary objectives of differentiation, a strategy often employed in STEM education.

When we examined to which journals the authors sent their studies related to this field, it was determined that these were predominantly gifted-themed journals. It can be stated that journals with the main themes of science, engineering, technology, and mathematics do not focus much on this field. In contrast to the conclusions drawn from the present study, an alternative observation suggests a prevalence of science-themed journals within the domain of STEM studies during the preschool period (Su & Yang, 2023). Again, when STEM teaching is examined in general, it is seen that science-themed journals tend to prevail (Jamali et al., 2023). Upon examining. The primary focus is on journals centred on gifted themes, with a few journals related to science also present, although they do not hold a significant position. Most of the studies related to this field are published in Rooeper Review, Gifted Child Quarterly and Journal for the Education of Gifted, and at the same time, the articles published by these journals in this field have been increasing for years by year. These journals are prestigious in their field and have a high impact factor and are among the first journals that researchers usually consult. In this respect, their interest in this field is promising for future studies.

C. June Maker, who has contributed the most to this field, works on gifted education and talent development, Paula Olszewski-Kubilius works on gifted and talented development, Jamaal Young works directly on STEM and young learners, Susan G. Assouline and Duhita Mahatmya work on school psychology as does Jonathan Wai. Diverging from this particular finding, alternative studies indicate a prominence of experts operating within the realm of science (Özkaya, 2019; Talan, 2021). In parallel to the researchers publishing in this field, the institutions that contribute the most are the ones to which these authors are affiliated (Northwestern University, University of North Texas, the University of Arizona, and the University of Iowa). These institutions are predominantly located in the United States, with only one institution in Germany and two in Turkey. The study conducted by Taş and Bolat (2022) also reached similar findings. From this point of view, it can be said that the United States continues to work in this field in accordance with the programme but although it is included in the programmes of countries such as Turkey (Dokuz Eylul University and Uludag University), it can be asserted that researchers in these countries and other European countries do not focus much on STEM studies that enable gifted students to work interdisciplinary and develop their abilities in this field.

Upon a thorough examination of the most frequently cited articles in the field, it becomes evident that the majority of these works employ a longitudinal approach (Miller & Halpern, 2013; Wai et al., 2010) and place emphasis on the significance of STEM education for gifted learners (Peters-Burton et al., 2014), the perceptions of students, teachers, and administrators regarding STEM education in the context of gifted education, and the development of customized STEM courses catering to the needs of gifted learners (Heilbronner, 2011). In this regard, it would be prudent to engage in educational design research, causal-comparative, and experimental studies that delve into the specific effects of STEM education on gifted students' scientific process skills, higher-order thinking skills, socio-emotional and affective skills, as well as their overall inclination towards STEM-related careers and interests. The most frequent keywords used in the studies, as well as the distribution of the trending topics in these studies according to certain year intervals, support this conclusion. (see Figure 11 and 12). However, when we look at the co-occurrence map of the keywords (see Figure 13), it becomes apparent that while science, mathematics and technology exhibit strong associations with one another, engineering does not appear to share the same level of emphasis. Similarly, while gifted education is found to co-occur with terms such as curriculum, creativity, and identification, there appears to be a dearth of associations between other essential science process skills such as critical thinking, problem-solving, and design thinking.

When the historiography of stem and gifted-oriented studies is examined, although the studies started in 2003, it was determined that the studies conducted in 2009 and 2010 influenced later researchers. One of these studies is a study by Thomas and Williams (2010) examining the history and impact of STEM-specialised schools, another is a longitudinal evaluation of project excite for minority groups conducted by Olszewski-Kubilius (2010), another is a study by Pfeiffer et al. (2010) about STEM education in state-supported residential academies nationwide, and most recently, a longitudinal study by (Wai et al., 2010). All these indicate that longitudinal and survey studies are taken as reliable reference by researchers.

When the social networks between authors, institutions and countries were examined, there are not very strong ties between all these elements, although authors and institutions within the same country usually cooperate with each other (Domenech et al., 2020). This can be seen as a natural result because each country has different educational policies and educational needs arising from different cultural and social demographic structures. Nevertheless, it can be said that increased cooperation among all these elements that set the same goals will increase the international validity and reliability of the studies conducted in this field.

Academic research into gifted learners took off in 2003, and accelerated around 2007. Studies are predominantly published in gifted-themed journals, and researchers who specialise in this area are the foremost contributors to this domain. Germany, Turkey and South Korea have also turned to this field, with the United States being the pioneer.

All in all, gifted students demand learning environments that are open-ended, challenging, and geared towards higher-order thinking skills. STEM education has been identified as an effective means of addressing these needs. Studies also indicates that integrating STEM subjects into gifted programmes can significantly enhance the academic, cognitive, social and emotional skills of gifted students, while also fostering positive attitudes and self-confidence towards STEM disciplines (Baum et al., 2014; Kalik & Kırındı, 2022). In the light of these findings, it can be inferred that STEM education not only meet the unique needs of gifted learners, but also holds a promising social benefit, as gifted individuals trained in these fields are well-suited to tackling the complex problems faced by contemporary societies. Hence, the study offers guidance to researchers with an interest in this domain by elucidating the key themes, prevailing trends, institutional affiliations, authorship, and journals that are significant contributors to the field. Additionally, this study highlights gaps in the field for future studies.

As for the limitations of the study, it can be asserted that the data search was conducted only on WoS and Scopus databases, it was conducted in English, and it does not include theses and conference proceedings. Future studies that take these limitations into account may contribute to a more comprehensive picture.

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