Girişimcilik ve STEM Eğitimi Çalışmalarında Yeni Akımlar: Bir Bibliyometri Çalışması

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Öz

STEM eğitimi ve girişimcilik, teknolojinin ilerlemesi ve küreselleşme ile artan bir ilgi görmektedir. Alan yazında STEM eğitiminin ve girişimciliğin önemini ayrı ayrı göstermekte olan çeşitli araştırmalar bulunmaktadır. STEM'de yenilikçiliğin önemli bir yere sahip olması nedeniyle ise son yıllarda artan sayıda çalışma, STEM ve girişimcilik arasındaki ilişkiye dikkat çekmeye başlamıştır. Sistematik olmayan bir literatür taraması da bu bulguyu desteklemekte ve bu alanların ilişkisine dair çok sınırlı sayıda çalışma ortaya koymaktadır. Bu araştırma, ilgili alandaki akımları belirlemek ve gelecekteki araştırmaların yönelmesi gereken alanlara dair öneriler vermek için bibliyometrik ve birlikte oluşum analizlerini kullanarak STEM eğitimi ve girişimcilik arasındaki ilişkiyi incelemektedir. Web of Science veri tabanı kullanılarak konuyla ilgili 2865 yayın tespit edilmiştir. Seçim ve uygunluk sürecinin ardından kalan 61 yayın ile çalışma yürütülmüştür. Analiz için Vosviewer ve HistCite yazılımı kullanılmıştır. Yapılan analizler, araştırma kategorilerinin yayın sayısına göre dağılımı; yayınların yıllık atıfları, ülke ve yazarlara göre dağılımı; trend olan anahtar kelimeler ve dergilerin analizine odaklanmaktadır. Elde edilen sonuçlar, konunun işletme ve yönetim kategorilerinin yani sıra, eğitim ve eğitim araştırması kategorileri ve arasında daha popüler hale geldiğini göstermektedir. 2020 yılında yayınlanan çalışmalarda, STEM ve girişimcilik konularının bir arada ele alındığı yayın sayısında artış gözlenmiştir. Bu artışın 2019 ve 2020 yıllarında yayınlanan devlet belgelerinin STEM ve girişimciliğe verdiği önemden kaynaklı olduğu düşünülmektedir. Bu çalışma, girişimcilik ve STEM hakkında daha fazla araştırma yapılması gerektiğini göstermekte ve gelecekteki araştırmaların, girişimcilik ve STEM entegrasyonunda sürdürülebilirlik ve toplumsal cinsiyet konularının önemine daha fazla odaklanmasını önermektedir.

Anahtar Kelimeler: Bibliyometrik analiz, Girişimcilik, STEM eğitimi

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GENİŞ ÖZET

Giriş

STEM eğitimi ve girişimcilik, teknolojinin ilerlemesi ve küreselleşme ile artan bir ilgi görmektedir. STEM eğitiminin ve girişimciliğin önemini ayrı ayrı göstermekte olan çeşitli araştırmalar bulunmasına rağmen, STEM'de yenilikçiliğin önemli bir yere sahip olması nedeniyle, artan sayıda çalışma STEM ve girişimciliğin arasındaki ilişkiye işaret etmektedir. STEM yeterliklerini geliştirmenin bir yolu STEM ve girişimciliği bir araya getiren kurumsal eğitim yoluyla olabilir. Bununla birlikte, sistematik olmayan bir literatür taramasının sonucunda, STEM eğitimi ve girişimcilik üzerine ayrı ayrı inceleme yapan çok sayıda çalışma tespit edilmesine rağmen, bu alanlara aynı anda odaklanan çok sınırlı sayıda çalışma bulunmuştur.

Çalışmanın Amacı

Bu araştırmada, ilgili alandaki akımların belirlenerek gelecekteki araştırmaların yönelmesi gereken alanlara dair öneriler verilmesi amaçlanmaktadır. Bu nedenle, çalışmada STEM eğitimi ve girişimcilik arasındaki ilişki bibliyometrik ve birlikte oluşum analizleri kullanarak incelenmiştir. Bu kapsamda beş tane araştırma sorusuna ve üç tane alt soruya yer verilmiştir. Araştırma soruları arasında: (1) STEM ve girişimcilik alanındaki yayınlarda görülen akımlar nelerdir?, (2) STEM ve girişimcilik üzerine yayınların yaygınlaştırılmasına en çok hangi ülkeler katkıda bulunmuştur?, (3) STEM ve girişimcilik üzerine yayınların yaygınlaşmasına en çok hangi yazarlar katkıda bulunmuştur?, (4) STEM ve girişimcilik üzerine yayınların yaygınlaştırılmasına en çok hangi dergiler katkıda bulunmuştur?, ve (5) STEM ve girişimcilik ile ilgili yayınlarda en sık kullanılan anahtar kelimeler nelerdir? yer almaktadır.

Yöntem

Web of Science veri tabanı kullanılarak konuyla ilgili 2865 yayın tespit edilmiştir. Seçim ve uygunluk sürecinin tamamlanmasının ardından geriye kalan 61 yayın ile çalışma yürütülmüştür. Analiz için Vosviewer ve HistCite yazılımı kullanılmıştır. Yapılan analizler, araştırma kategorilerinin yayın sayısına göre dağılımı, yayınların yıllık atıfları, yayınların ülke ve yazarlara göre dağılımı, trend olan anahtar kelimeler ve dergilerin analizine odaklanmaktadır.

Bulgular

Elde edilen sonuçlar, konunun işletme ve yönetim kategorilerinin yanı sıra eğitim ve eğitim araştırması kategorilerinde de daha popüler hale geldiğini göstermektedir. En fazla yayın eğitim alanında yapılırken, bunu işletme ve yönetim alanlarında yapılan yayınlar takip etmektedir. Bir başka bulgu ise en fazla yayının yanı sıra en fazla atıfın da 2021 ve 2022 yıllarında yapıldığını göstermektedir. 2020 yılında yayınlanan çalışmalarda, STEM ve girişimcilik konularının bir arada ele alındığı yayın sayısında artış gözlenmiştir. Bu artışın 2019 ve 2020 yıllarında yayınlanan devlet belgelerinin STEM ve girişimciliğe verdiği önemden kaynaklı olduğu düşünülmektedir. Yayın sayılarının ülkelere göre dağılımına bakıldığında en yüksek sayıda yayınlar ABD, Türkiye, İngiltere ve Almanya'da yapılmıştır. Konuyla ilgili yapılan yayınlar toplamı en yüksek olan dergilerin başında "International Entrepreneurship and Management Journal" gelmektedir. Yazarların kullandığı anahtar sözcüklere bakıldığında STEM ve girişimcilik entegrasyonunda toplumsal cinsiyetle ilgili çalışmaların sayısının 2017 itibariyle artış gösterdiği gözlenmektedir.

Tartışma ve Sonuç

Bugüne kadar yapılmış araştırmalar ile ilgili bulgular, konu ile ilgili sınırlı sayıda çalışma olmasına rağmen, STEM ve girişimciliğin bir araya getirilmesi konusunda yapılan araştırmaların

artışta olduğunu göstermektedir. Hükümet ve araştırma belgeleri de bu ilişkilendirmeyi desteklediğinden, STEM ve girişimcilik arasındaki ilişki ve konuların bütünleştirilmesi kapsamında daha fazla araştırma yapılmalıdır. Gelecekteki araştırmaların, girişimcilik ve STEM'in bütünleştirilmesinde yenilikçilik, sürdürülebilirlik ve toplumsal cinsiyet konularının önemine daha fazla odaklanması önerilmektedir. Eğitim dergilerinin girişimciliği eğitimde ortaya çıkan bir konu olarak ele alarak bu alandaki yayınları desteklemelidir. Alandaki tekelleşmeyi önlemek için farklı ülkelerde aynı konuda araştırma yapan yazarlar arasında daha fazla iş birliği yapılması önerilmektedir.

The New Trends in Entrepreneurship and STEM Education Studies: A Bibliometric Study

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Abstract

STEM education and entrepreneurship have gained increasing attention with the advancement of technology and globalization. Various studies have shown the importance of STEM education and entrepreneurship separately. In the last years, a growing number of studies started to draw attention to the relationship between STEM and entrepreneurship due to the utmost importance of innovation in STEM, where very few studies are available. This study examines the relationship between STEM education and entrepreneurship through bibliometric and co-occurrence analyses to identify trends and suggest future research directions. Using the Web of Science database, 2865 publications were identified on the topic. Following the selection and eligibility process, the study was conducted with the remaining 61 publications. The Vosviewer and HistCite software were used for the analysis. The analysis focused on the distribution of the research categories according to the number of publications, distribution of publications according to the yearly citations, countries, and authors, the trending keywords, and the analysis of the journals. The results showed that the topic is becoming more popular between education and educational research categories as well as business and management categories. There was a significant increase in the studies focusing on entrepreneurship and STEM together in 2020. This may be because of the importance given to entrepreneurship and STEM by the government documents published in 2019 and 2020. This study shows the need for further research on entrepreneurship and STEM incorporation and recommends future research to focus more on the importance of sustainability and gender issues in this integration.

Keywords: Bibliometric analysis, Entrepreneurship, STEM education

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The Trends in Entrepreneurship and STEM Education Studies: A Bibliometric Study

STEM education has been commonly accepted as an interdisciplinary learning approach bringing Science, Technology, Engineering, and Mathematics together to contribute to everyday life by improving students' STEM literacy, providing an opportunity to compete in today's global economy, and helping to find solutions to everyday problems (McLoughlin et al., 2020). Although its history goes back further, the idea of STEM education has become more prominent in 1957 when the Soviet Union successfully launched the first artificial satellite which orbited the Earth. This event gave rise to the idea of making STEM disciplines prioritised areas in education, which is known as Sputnik moment, to bring up qualified workforce for the professions needed in the future (Bybee, 2013). In 1990s, National Science Foundation used the abbreviation of "SMET" for these prioritised disciplines and then changed it to "STEM". Different studies focus on different features of STEM education (Bybee, 2013; McLoughlin et al., 2020). A recent study reviewed the literature and identified 10 characteristics of STEM education (Akarsu et al., 2020):

1. To be an interdisciplinary approach
2. To have a real-life context derived from a phenomenon with a social value
3. To use an engineering design process
4. To include an evidence-based decision-making process
5. To be a recurrent design process
6. To construct the learning step by step
7. To learn from the mistakes
8. To focus on the process rather than the product
9. To bring diverse solutions to a problem rather than one absolute answer
10. To support teamwork

The reasons for the involvement of STEM in everyday life include but are not limited to the need for qualified STEM workforce in the industry, the need for workforce to support defence mechanisms, and the pedagogical reasons supporting the benefits of integrated learning (Aydeniz & Bilican, 2018). Apart from these reasons, many studies emphasize the importance of STEM education, which has a strong connection with the above-mentioned 10 characteristics. STEM education prepares students for life, develops their 21st-century skills, and increases their interest and curiosity in everyday phenomena. By doing so, STEM education contributes to create students who are qualified in the fields that will be prominent in the future, who can keep up with scientific, social, economic, and technological developments, and who are successful in their personal and professional lives (Corlu et al., 2014, Kelley & Knowles, 2016; Palotai, 2017). Furthermore, students who are exposed to STEM education will be able to use their interdisciplinary knowledge and skills, such as creativity, in order to bring an innovative solution to a daily problem (Nguyen et al., 2020). These students will also be able to comprehend and establish relationships between school, society, business, and global initiatives (Bruce-Davis et al., 2014), realise the connections between the interdisciplinary knowledge and real-life problems (Jamali et al., 2022), and critically analyse the components of STEM education as a source of innovation to bring solutions to economic, social, geopolitical, environmental, and societal problems (Hynes et al., 2023). To reach these benefits, educators should consider how STEM education competencies can be integrated into teaching to promote STEM literacy.

One way of fostering STEM competencies can be through enterprise education as STEM education is driven by innovation, which is an integral part of entrepreneurship, and therefore enterprise education. Here, it is significant to highlight the difference between entrepreneurship education and enterprise education. While entrepreneurship education is concerned with business and enterprise, enterprise education aims to support the personal development and the improvement of entrepreneurial skills (Leffler, 2014), such as the ability to start something new, realising and pursuing the opportunities, responsibility, and creativity (Kaya-Capocci, 2022). That is, enterprise education prioritises the development of entrepreneurial skills, environment, and pedagogies. Therefore, it is important to focus on enterprise education rather than entrepreneurship education in education-related areas. This study focuses on both entrepreneurship education and enterprise education and refers to their combination as entrepreneurship. Many STEM applications are inspired by the nature and promoted and spread across the world by entrepreneurship. For example, the medical syringe was designed by looking at a mosquito stringer from an innovative perspective (Bosman & Shirey, 2023), which is driven by an entrepreneurial mindset. The seamless integration of entrepreneurship into STEM education can be achieved effectively by equipping students with transferable and applicable skills of entrepreneurship (Hynes et al., 2023).

Although entrepreneurship has been used since the Middle Ages, it is a concept that has changed over time and adapted to different fields. This concept was previously used only in the field of business and economics by mainly focusing on establishing a new business and making profit (Hisrich & Peters, 2002). The concept has currently been integrated into the fields of sociology, psychology, and education (Anette, 2011). In such fields, entrepreneurship is commonly viewed as a process of introducing something new or the ability to start something new where entrepreneurs are expected to be equipped with the required future skills (Kaya-Capocci & Ucar, 2023). STEM education shares many similarities with entrepreneurship perspectives, including coming up with new and innovative ideas about everyday problems and instilling social values. For example, the common aspects of social entrepreneurship involve being equipped with social-based mission and vision, creating social values, realising social entrepreneurship opportunities, being innovative, providing resource creation and sustainability, and benefiting from social networks (Kilic Kirilmaz, 2014). Innovative entrepreneurship commonly targets to deliver significant and varied results at the individual, firm, industry, regional, and even country level, to contribute to social progress as well as creating individual and regional wealth (Block et al., 2017). Other than having similar goals, integration of entrepreneurship into STEM education can contribute to (1) long-term economic growth, (2) global competitiveness, (3) the improvements in the quality of life, and (4) finding solutions to STEM-related social problems (Marquez et al., 2023).

A non-systematic literature review showed that although various studies exist on either entrepreneurship education (e.g., Blankesteijn et al., 2021; Brüne & Lutz, 2020) or STEM education (Bybee, 2013; Kelley & Knowles, 2016; Martín-Páez et al., 2019; Peters-Burton et al., 2021), the number of studies bringing these areas together is very limited. To understand the relevance and integration of entrepreneurship and STEM education better, it is important to be aware of the literature on the targeted area. One of the best ways of doing so is through conducting bibliometric analysis. Therefore, this study aims to employ a bibliometric approach to explore the studies conducted on entrepreneurship and STEM education together. The study

also targets to identify the trends in the topic as well as the key terms and journals for publishing to help making the future studies more impactful.

Definition of Bibliometric and Relevant Bibliometric Studies

Bibliometric is commonly described as a technique to assess and quantify the publications in a specific research area (Fellnhofer, 2019). Bibliometric allows researchers to conduct unbiased research (Jiang et al., 2019), understand the facets of and trends in specific research areas, identify the top-cited publications and frequently used keywords (Ale Ebrahim et al., 2020), and analyse the literature at a statistical and scientific level in terms of its size, advancement, and distribution (Gutiérrez-Salcedo et al., 2017).

In the recent years, the research has been conducted on scientific bibliometric analysis of STEM education (e.g., Özkaya, 2019). A number of these studies focused on bibliometric analysis of different aspects of STEM education, such as the quality of education (Jamali et al., 2022), academic trends through the co-citation method (Yu et al., 2016), specific regions (Ha et al., 2020), scientific performance (Hinojo-Lucena et al., 2020), the use of spectrophotometer (Shidiq et al., 2021), and its structure in co-word analysis (Assefa & Rorissa, 2013). The research is also conducted on the scientific bibliometric analysis of entrepreneurship and enterprise education. For example, some researchers focused on entrepreneurial intention (Rodriguez-Ulcuango et al., 2023), entrepreneurial competencies (Fagadar et al., 2021), entrepreneurship *education* and *entrepreneurship* education (de Pablo Valenciano et al., 2019; Tiberius et al., 2023), entrepreneurial higher institutions/ education and academic entrepreneurship (Gabrielsson et al., 2020; Garcez et al., 2022; Syed et al., 2023), social entrepreneurship (Cardella et al., 2021; Vázquez-Parra et al., 2022), women, entrepreneurship and education (Slavinski et al., 2020), creative entrepreneurship (Abad-Segura & González-Zamar, 2019), and entrepreneurship education in a specific country (Xia et al., 2016; Zheng, 2018). Although there are bibliometric studies on STEM or entrepreneurship separately, the non-systematic literature review did not yield any bibliometric study on STEM and entrepreneurship together. This study will combine the two topics and conduct a bibliometric analysis.

Method

This bibliometric study aims to quantify the number of studies conducted on entrepreneurship and STEM education together and address the trends in the identified studies. This research, thus, will lay the groundwork for future research to incorporate entrepreneurship and STEM education. The research questions (RQs) and sub-questions of the study are determined as follows:

RQ1. What are the publication trends in STEM and entrepreneurship?

RQ1.1. What is the distribution of the publications on STEM and entrepreneurship according to the field of study?

RQ1.2. How does the number of publications in STEM and entrepreneurship change per year?

RQ1.3. How does the number of citations in STEM and entrepreneurship publications change per year?

RQ2. Which countries have contributed the most to disseminating publications on STEM and entrepreneurship?

RQ3. Which authors have contributed the most to disseminating publications on STEM and entrepreneurship?

RQ4. Which journals have contributed the most to disseminating publications on STEM and entrepreneurship?

RQ5: What are the most commonly used keywords in publications on STEM and entrepreneurship?

To answer the RQs, the data were analysed through three phases according to PRISMA (2020); identification, screening, and inclusion. A flow diagram is created to summarise the systematic review process and presented in Figure 1.

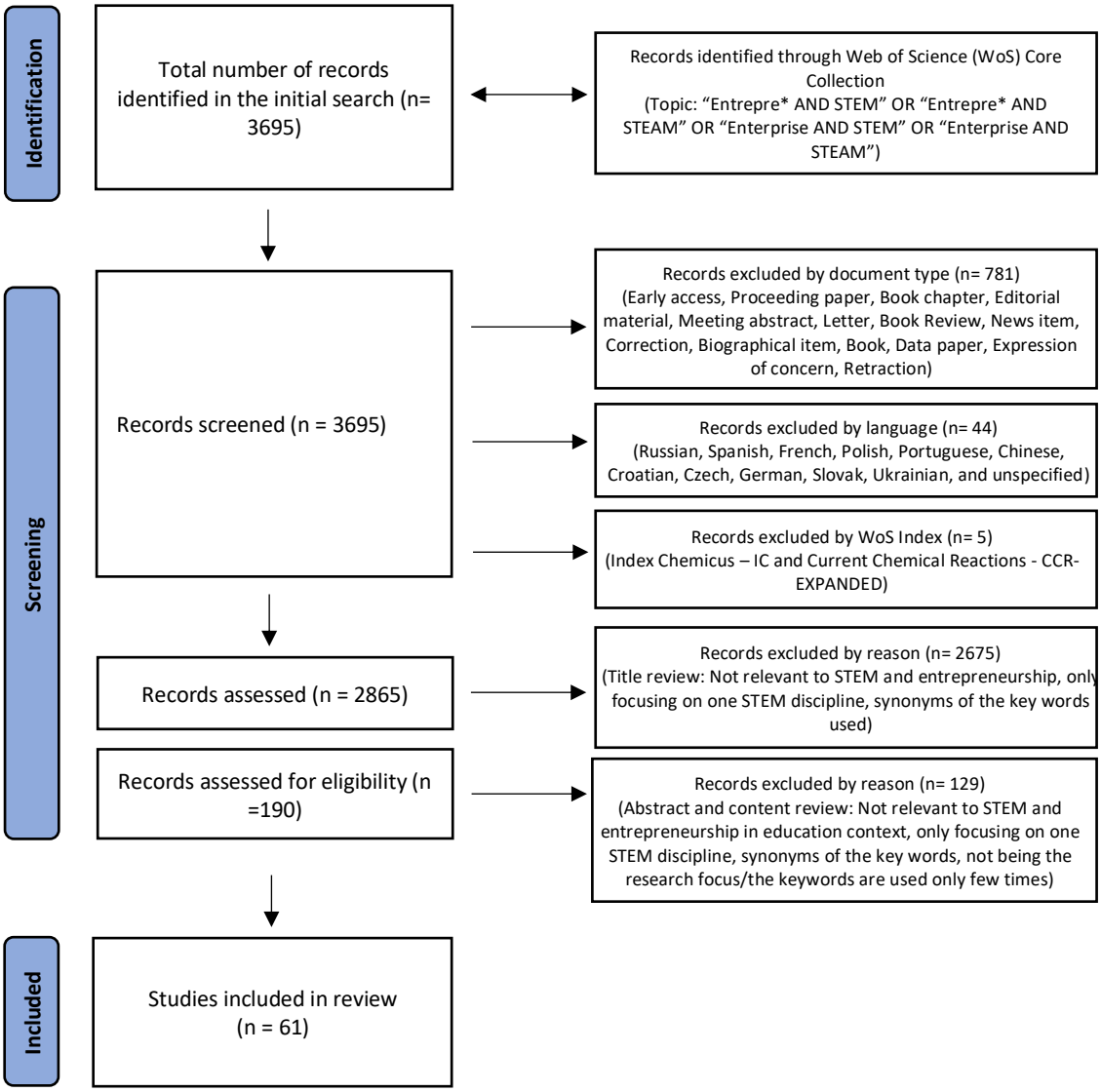

Figure 1

The flowchart of the data selection [adapted from PRISMA (2020)]

Figure 1 maps out the total number of records identified, what is included and excluded, the reasons for exclusions, and the final number of publications to be reviewed. Each phase is introduced in the following.

Identification: This phase included the selection of the database and keywords, the search of the keywords, and the control of the duplicate publications. Before selecting the keywords, the database of the study was determined as the Web of Science (WoS) by Thomson Reuters in its main collection. This database was selected due to being a social sciences repository with a large number of high-impact and top-indexed publications. Then, the keywords were identified to conduct the WoS search based on the previous literature. Due to the main topic of the study, key words were selected within two categories. STEM category included the keywords "STEM" and "STEAM". STEM includes its variations such as "E-STEM" or "STEM+". The entrepreneurship category included the keywords "Entrepre*" and "Enterprise". "Entrepre*" includes its variations such as entrepreneur, entrepreneurial, and entrepreneurship. Then, the cross-correlation of these words were created and presented in Table 1.

Table 1

Cross-correlation of the key words

	STEM	STEAM
Entrepre*	Entrepre* AND STEM	Entrepre* AND STEAM
Enterprise	Enterprise AND STEM	Enterprise AND STEAM

In Table 1, education related words were not selected to ensure no data were missed out because the word education can involve various words, such as K12, K9, teaching, learning, activities, and so on. Missing one of the words would mean missing data. Therefore, after identifying the whole data, the publications were selected according to their relevance to education (in different departments). The data mining was conducted on the 20th of April 2023 through using the keywords mentioned. The cross-correlation of these words (see Figure 1: "Entrepre* AND STEM" OR "Entrepre* AND STEAM" OR "Enterprise AND STEM" OR "Enterprise AND STEAM") were searched on WoS with all disciplines and the document field "all fields". As seen, the conjunction "*AND*" was used between two topics of the study, and the conjunction "*OR*" was also used to include all the derivatives of the keywords. The reason for that was to enhance the probability of accessing all studies. No restrictions were used about the year of the publication. Also, no duplicate results were identified.

***Screening*:** This phase included inclusion and exclusion criteria and the eligibility process. The PRISMA protocol was followed for the review to provide the details of the document selection process (Page et al., 2021). As part of this process, the inclusion and exclusion criteria were identified as in the following.

Exclusion criteria:

- Early access publications are excluded.
- In document type, proceeding papers, book chapters, editorial materials, meeting abstracts, letters, book reviews, news items, corrections, biographical items, books,

data papers, publications with expression of concerns, and retracted publications are excluded.

- Languages other than English are excluded.
- Within WoS indexes, book citation indexes (BKCI-SSH and BKCI-S) and conference proceedings citation index are excluded.

Inclusion criteria:

- Review, open access, and enriched cited references publications are included.
- In document type, articles and review articles are included.
- The publications written in English are included due to targeting the international publications.
- Within WoS indexes, social sciences citation index (SSCI), emerging sources citation index (ESCI), science citation index expanded (SCI-EXPANDED), and arts & humanities citation index (A&HCI) are included.
- Multidisciplinary sciences, business, education educational research, economics, education scientific disciplines, social sciences interdisciplinary, business finance, and education special categories are included.

As presented in Figure 1, using the key words mentioned, the WoS database yielded the total of 3695 publications. Between these 3695 publications, when early access publications were removed, the number of publications dropped to 3630. Within the screening process, only leaving publications as article and review article (excluding others mentioned previously) left 2914 publications. Removing the other languages and leaving only English left 2870 publications. When the other indexes were removed 2865 publications were left indexed in the SCI-EXPANDED, SSCI, ESCI, and A&HCI. Here, the eligibility process started. These publications went through two more screening to ensure that they are eligible for the study. In the first screening, the publications were excluded with the titles that were irrelevant to the topic or synonyms of the keywords, such as stem cells, stemming from, and steam power, rather than STEM and STEAM interdisciplinary approaches. 190 publications remained as a result of the first screening. In the second screening, the publications that were mentioning entrepreneurship related words or STEM related words few times without focusing on them as the main topic were eliminated.

Included: As a result, 61 publications remained focusing on entrepreneurship and STEM related topics. Between these publications, 1 was a review article and 60 were articles.

Findings

The WoS database yielded the total of 3695 publications using the key words mentioned in the methods section. After the screening process (including eligibility), 61 publications remained to conduct the analysis. To be able to identify the trends and tendencies in the field, the analysis continued with bibliometric analysis. The analysis included the distribution of the publications according to the fields, distribution of the publication with the citation per year, distributions of publications by country, the author details with the highest number of publications, the most common keywords that the authors used, and the journals that publish in the field. The results showed that while 60 publications (n=98.4%) were original publications, only 1 publication (n=%1.6) was a review article. This result also points to the need for review

articles in the field. The findings section is structured in relation with the RQs. The findings of each question are presented in the following.

The publication trends in STEM and entrepreneurship

This subsection presents the findings about the distribution of publications by field of study, changes in the number of publications per year, and changes in citations per year. The data is analysed through WoS in this section. Between 61 publications, a variation of the fields was observed for publication. The distribution of publications (n, %) according to the field of study (i.e., WoS categories) is presented in Figure 2.

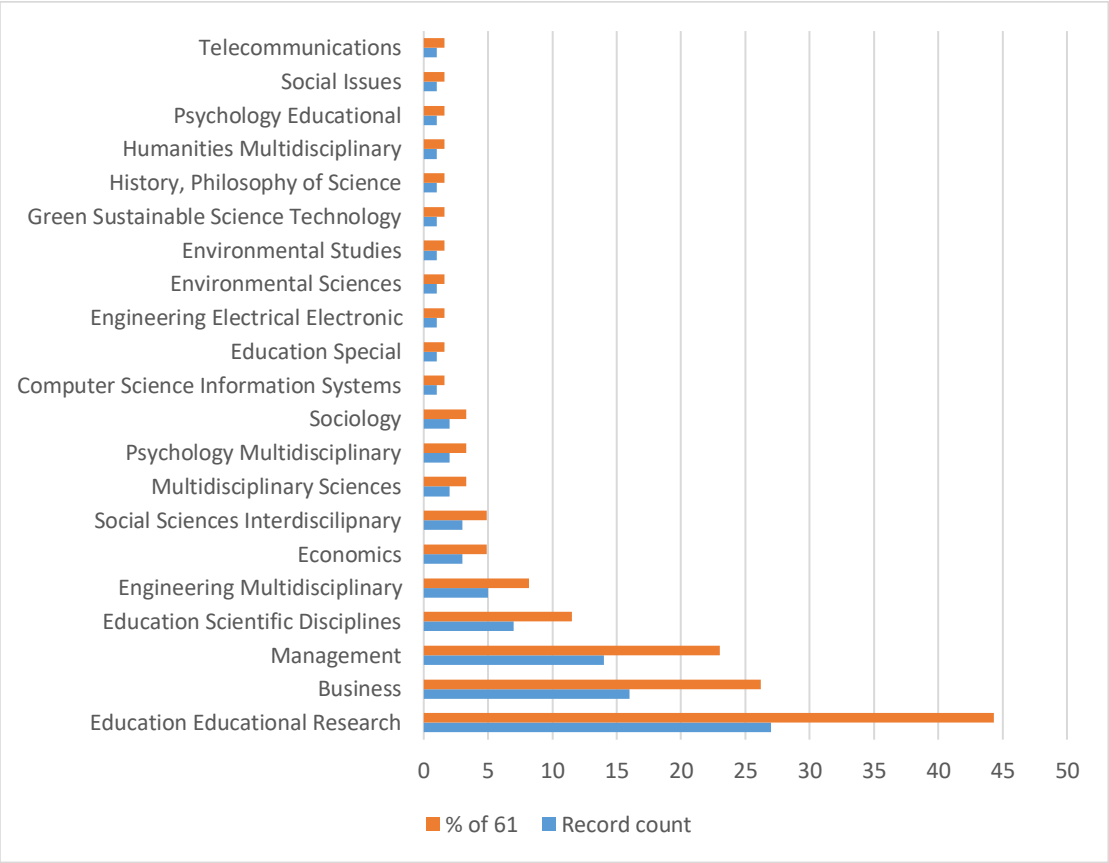

Figure 2

Distribution of publications according to the field of study

Figure 2 shows that close to the half of the publications on entrepreneurship and STEM were published in Education Educational Research area (n=27, %=44.3), followed by Business (n=16, %=26.2) and Management (n=14, %=23). While there are 7 publications in Education and Scientific Disciplines (%=11.5), 5 publications were in Engineering Multidisciplinary (%=8.2). The number of the remaining publications were equal or lower than three. This may be because while integrated STEM education is currently studied in education, it is usually viewed as segregated disciplines in business schools.

The number of publications and their citations have increased over the years (see Figure 3).

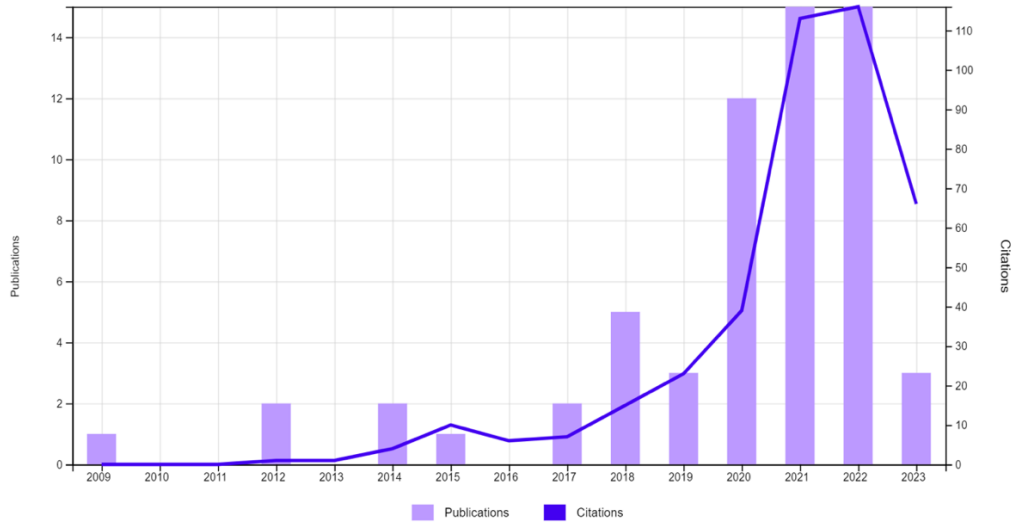

Figure 3

Distribution of publications and citations by year

Figure 3 indicates that publications increased significantly in 2020. Compared to previous years, the highest publications numbers were in 2021 and 2022 with similar numbers. As the year 2023 is not finished yet, the drop in this year can be accepted normal. Looking at the citations, the highest numbers of citations were found in 2021 and 2022. The result may be because of a critical event happened in 2019 which affected the publications in 2020.

The contributions of the countries to disseminate publications on STEM and entrepreneurship

The findings about the distribution of the publications according to countries, the number of citations for each country, and the co-authorship between the countries are presented in this subsection. The data is analysed through HistCite and VosViewer in this section. The data were analysed to identify the countries that have the highest number of publications. The results are presented in Figure 4.

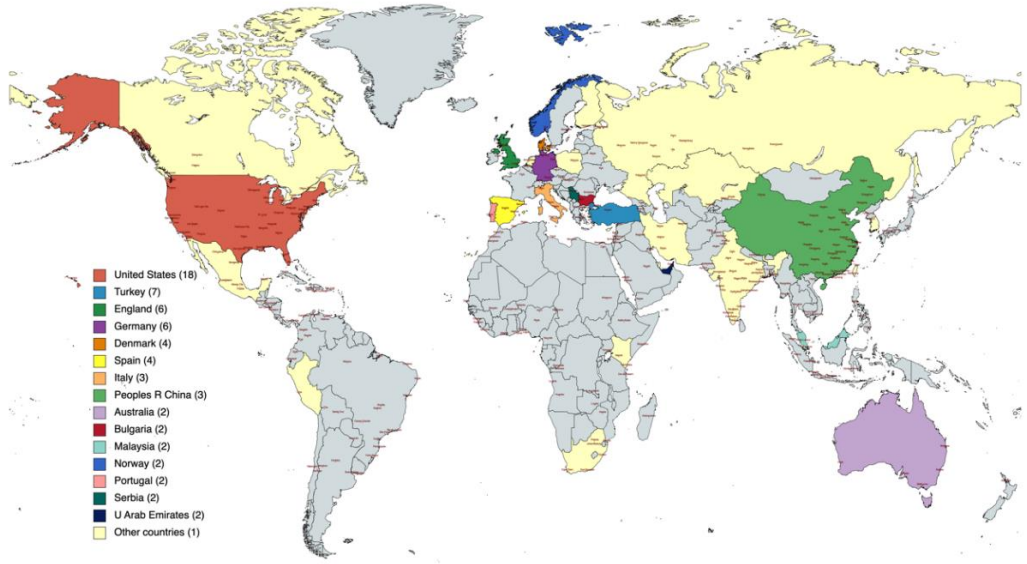

Figure 4

The highest number of publications by countries

According to Figure 4, the countries who had the highest number of publications included USA (n=18, %= 29.5), Turkey (n=7, %=11.5), England (n=6, %=9.8), Germany (n=6, %=9.8), Denmark (n=4, %=6.6), and Spain (n=4, %=6.6). The rest of the countries had three and less publications, which is 5 percent or less of the total publications. The results showed that while the number of American and European countries with the STEM and entrepreneurship topic was higher than the other countries, Asian, African, South American, and Eastern countries had less publications.

To compare the impact of these publications mentioned in Figure 4, the number of citations and the publications for each country are presented in Table 2.

Table 2

Countries with the highest number of publications and total citations

Countries	n	citations
USA	18	110
Germany	6	64
Norway	2	61
Italy	3	60
Spain	4	54
Peoples R China	3	39
Netherlands	1	39
Canada	1	33
England	6	29
Peru	1	26
Denmark	4	20
Australia	2	17
UAE	2	10
Portugal	2	9
Turkey	7	8
Bulgaria	2	6
Cyprus	1	3

As seen in Table 2, although some countries, such as Turkey had one of the highest number of publications, the number of citations was low. On the contrary, some countries, such as Norway, had the low number of publications but their number of citations were one of the highest among the other countries. This might be because Nordic countries are known for their enterprise education across all education levels. Based on the data presented in Table 2, the strength of co-authorship between the countries are calculated. The countries were excluded with “0” link strength. The analysis result in Figure 5 illustrates the relationship between the co-authorship across the countries.

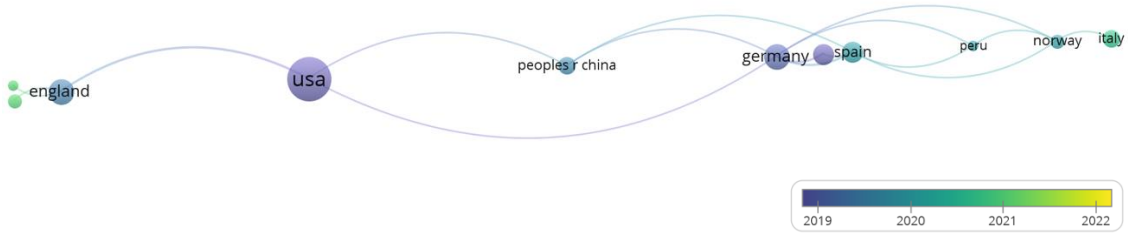

Figure 5

The co-authorship across the countries

Figure 5 shows that there are clusters between some of the countries when working with each other. While the oldest connections were between the USA, England, China, and Germany, the newest connections were observed between the UAE, Kazakhstan, and England. The oldest connections between the four countries may indicate that they have been working on this topic longer. This may not be surprising considering that the USA is one of the countries who conducts research on STEM or entrepreneurship separately for decades.

The contributions of the authors to disseminate publications on STEM and entrepreneurship

This section presents the distribution of the highest number of the publications according to the authors, their institutions and citation scores. The data is analysed through HistCite and VosViewer, and the results are combined and presented in Table 3.

Table 3

Authors with the highest number of publications

Author	n	Country	LCS	GCS	GCS/n
Ahmad J	2	Malaysia	1	1	0.5
Eltanahy M	2	UAE	0	10	5
Mansour N	2	UK	0	10	5
Mars MM	2	USA	1	23	11.5
Piva E	2	Italy	2	26	13
Siew NM	2	Malaysia	1	1	0.5
Yordanova D	2	Bulgaria	0	6	3

Note: n-number of publications; LCS-Local Citation Score; GCS-Global Citation Score

According to Table 3, only seven authors out of 175 authors published 2 papers on the topic, the rest of the authors (168 authors) published only once. Between the seven authors, Piva E in Italy and Mars MM in the USA had the highest average global citation score, followed by Eltanahy M in the UAE and Mansour N in the UK.

The contributions of journals to disseminate publications on STEM and entrepreneurship

Knowing about the most commonly publishing journals on the topic may help us find the correct journals for the publication, which, in turn, contributes to increase the impact of the publication. Furthermore, knowing these journals would make reaching the relevant

publications easier, which saves some time for further publications. Therefore, this study also investigated the journals published on STEM and entrepreneurship related topics. The data is analysed through HistCite and VosViewer, and the results are combined and presented in Table 4.

Table 4

Journals by the number of publications and citations received

Journal	n	%	LCS	GCS	GCS/n
International Entrepreneurship and Management Journal	6	9.8	21	145	24.2
International Journal of Technology and Design Education	3	4.9	1	2	0.7
Education Sciences	2	3.3	0	0	0
Frontiers in Education	2	3.3	0	0	0
Frontiers in Psychology	2	3.3	0	0	0
Journal of Baltic Science Education	2	3.3	1	1	0.5
Journal of Entrepreneurship	2	3.3	0	0	0.5
Science Activities-Projects and Curriculum Ideas in STEM Classrooms	2	3.3	0	0	0.5

Note: n-number of publications; LCS-Local Citation Score; GCS-Global Citation Score

Table 4 indicates that eight journals published at least 3% and over of the total publications on the topic. 39 more journals also published on the topic. However, they are not included in Table 4 due to having one publication (%=1.6 each). The journal with the highest publication is *"International Entrepreneurship and Management Journal".* This might not be surprising as this journal has the highest LCS and GCS with the average GCS (i.e., GCS/n). Education Sciences, Frontiers in Education, and Frontiers in Psychology had the lowest average GCS.

The most commonly used keywords in publications on STEM and entrepreneurship

Knowing about the most commonly used keywords may help us find the publications that we are looking for. Additionally, using similar key words may help increase the impact of our own research. Therefore, a bibliometric technique was used through VosViewer to identify the co-occurrence of the keywords. For this purpose, a keyword co-occurrence map was created by accepting at least one cooccurring keyword. This left us with 236 keywords and excluding the disconnected keywords, 189 keywords remained. The analysis results are presented in Figure 6.

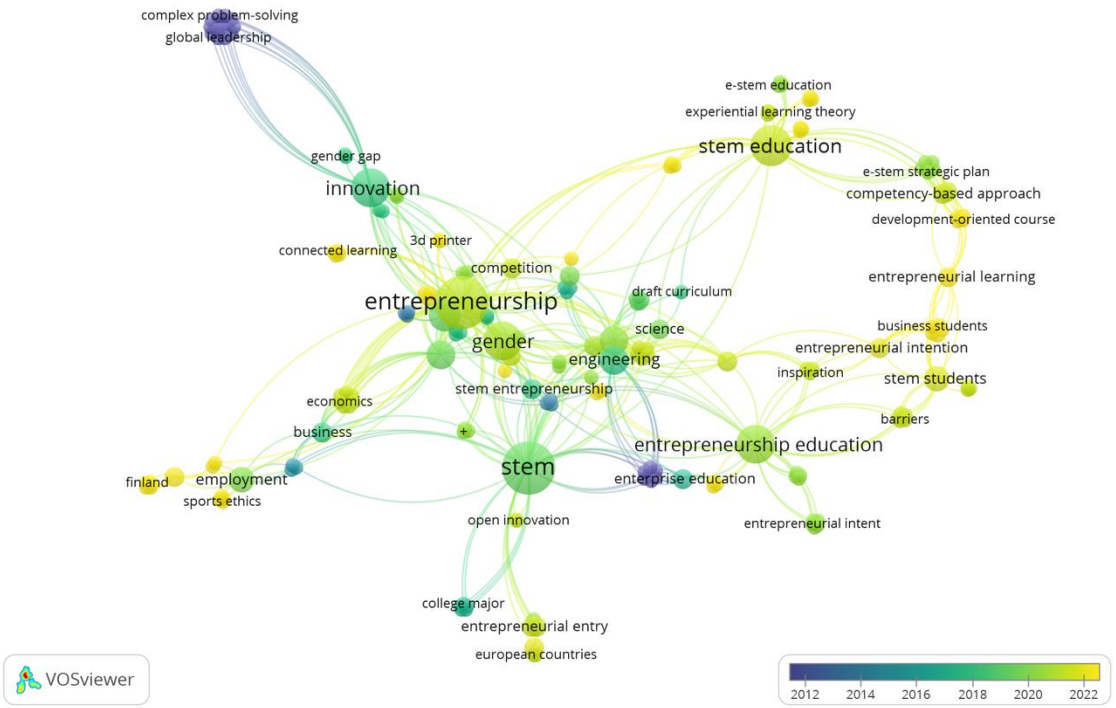

Figure 6

The co-occurrence of the keywords

The most frequently used keywords included “entrepreneurship” (n=13), “STEM” (n=13), “STEM education” (n=8), “innovation” (n=7), “entrepreneurship education” (n=7), “gender” (n=7), and academic entrepreneurship (n=5). In Figure 6, different clusters were observed. For example, the map illustrates that the words relating to problem-solving, leadership, inquiry, design-based thinking, and system-based thinking were clustered together, and this cluster included the keywords that have been used for the longest period (since approx. 2009). Another keyword cluster has been studied the longest included the words relating to bioscience, curricula, universities, enterprise education, and STEM. These results may show us that STEM and entrepreneurship have been studied in the last 15 years in education, pedagogy, and skills context. This was followed by the connection of academic entrepreneurship with STEM. Then, after 2017, a new cluster is observed connecting gender with entrepreneurship and STEM. Furthermore, another interesting result might be viewed as while “STEM” was used more commonly in the past, “STEM education” is currently used more often. The map also shows that currently new clusters emerge focusing more on the entrepreneurial learning and intention, self-efficacy, green entrepreneurship, STEM entrepreneurship and E-STEM. In addition to increasing the research impact, these results can also point to the new trends on the incorporation of STEM and entrepreneurship.

Discussion

The study presented the research conducted on STEM and entrepreneurship. In this section, the results are discussed aligned with the RQs.

The publication trends in STEM and entrepreneurship

The results showed that education related research had the highest number of publications, followed by business and management. The reason for observing the highest number in the field of education might be because recently, integrated STEM has been commonly studied in education as an integrated educational approach, whereas it is viewed as a segregated discipline in business schools. This paper focused on the publications which were not solely focusing on one STEM discipline. In education, Bybee (2013) argues that STEM education has been viewed in a segregated way, but it should be viewed in an integrated way as an interdisciplinary approach in education. English (2016) claims that closely related concepts and skills of two or more STEM disciplines should be integrated to deepen the knowledge and skills. Pabuccu Akis & Demirer (2022) argued that the interest in integrated STEM education has been increasing since the solution of many real-world problems requires more than one STEM discipline, which may also be needed by future professionals in their careers. However, in business and management field, studies commonly focus on one discipline such as technology (e.g., Kovaleva et al., 2023) or engineering (e.g., Huang-Saad et al., 2020).

According to another finding, as well as the highest number of publications, the highest number of citations were in the years 2021 and 2022. As the year 2023 had not yet been finished when the data analysis was conducted, the drop of the numbers in 2023 can be considered normal. Additionally, a significant rise in the number of studies on the topic is observed in 2020. The result may be because of a critical event that happened in 2019 or at the beginning of 2020 which affected the publications in 2020. Furthermore, considering a new topic becoming more common in 2020, the increase in the number of citations in 2021 may not be seem surprising. Different documents might have affected this situation. For example, Office of Science and Technology Policy (2019) published a progress report on the federal implementation of the STEM education strategy plan. In the report, a five-year strategic plan for STEM education, developed by the National Science and Technology Council's Committee and released in December 2018, was presented. The plan's vision involved three aspirational goals and four pathways with different objectives. One of the objectives within "Engage Students where Disciplines Converge" pathway targets to advance innovation and entrepreneurship education for STEM education. Furthermore, European Parliament (2019) published a five-year plan (2019-2024) to promote gender equality in STEM education and careers. Within this plan, it was mentioned that teachers and parents should focus on motivating girls about and drawing their interest in STEM education and careers as well as digital entrepreneurship. The plan refers to the need to promote entrepreneurship among women and create a supportive environment for them freely prosper and enterprise. Within this context, a call is made to the member states to devise policy measures incorporating the gender dimension fully to promote entrepreneurship, STEM and digital education for girls from early ages and enact on them. Additionally, the U.S. Patent and Trademark Office (2019) report that they sponsor an annual recruitment and outreach event for inventors; entrepreneurs; science, technology, engineering, and mathematics (STEM) students and academics; and others in the IP sectors, and recruit talents there. They also provide a professional development program to introduce entrepreneurship and STEM-related concepts to K-12 educators. The United States Code also announced an act about the coordination of federal STEM education encouraging to teach innovation and

entrepreneurship as part of STEM education. Therefore, the sudden increase in the number of documents can be explained with the government documents and actions worldwide.

The contributions of the countries and authors to disseminate publications on STEM and entrepreneurship

In terms of the distribution of the number of publications across the countries, the USA, Turkey, England, and Germany had the highest numbers. Although the result relating to the USA was consistent with the other studies, the countries following the USA were changing (e.g., Jamali et al., 2022; Le Thi Thu et al., 2021). For example, Le Thi Thu et al.'s (2021) findings showed that Australia and Canada were the upcoming countries after the USA and Turkey. This might be because the study's main focus was STEM education and entrepreneurship was a secondary finding. The current study, however, includes entrepreneurship as a second variable, and the countries mentioned in Le Thi Thu et al.'s (2021) study might not focus as much on STEM and entrepreneurship incorporation as England and Germany. Additionally, some countries, such as Turkey, had one of the highest number of publications, but their citation numbers were low. Le Thi Thu et al. (2021) found a similar finding regarding the number of citations of the USA and Turkey. There might be different reasons for this, such as the quality of the paper, language, and the impact of the journals published. On the contrary, some countries, such as Norway, had the low number of publications, their number of citations were one of the highest. This might be because Nordic countries are known for their enterprise education across all education levels.

A limited number of studies were found on the topic because it is a new trending topic. It is not surprising, then, that each author published maximum of two papers on the same topic, which was only seven out of 175 authors. Between the seven authors, Piva E in Italy and Mars MM in the USA had the highest average global citation score, followed by Eltanahy M in the UAE and Mansour N in the UK. Interestingly, looking at the authors' countries and comparing it with Figure 4, there seems to be a lack of cooperation between the authors who work on the same topic. This could indicate a future risk of monopolisation in the field.

The contributions of journals to disseminate publications on STEM and entrepreneurship

Eight journals published at least 3% and over of the total publications on the topic. The journal with the highest publication is determined as *"International Entrepreneurship and Management Journal".* Furthermore, this journal has the highest LCS and GCS with the average GCS (i.e., GCS/n). The potential impact of the journal might be the reason for authors to publish the topic in this journal rather than the other educational ones. This result may also be surprising as the majority of publications presented in Figure 1 is in *Education and Educational Research* area. Furthermore, five out of eight journals with the highest number of publications on the topic are on the field of education. However, the topic is commonly published in business and management journals. Looking at the literature (e.g., Watts & Wray, 2012) this may be because entrepreneurship is a fairly new concept in education departments, although it has been researched for many decades in business schools. This results in education journals not including entrepreneurship in the focus of their journals.

The most commonly used keywords in publications on STEM and entrepreneurship

The co-occurrence of terms and frontier topics identified by the authors' keywords indicated that the number of gender related studies in STEM and entrepreneurship incorporation is trending since 2017. Some government documents also evaluate the situation on gender and provide support for the inclusion of women in STEM and entrepreneurship. For example, European Parliament (2019) claims that there is a greater marginalisation of women in entrepreneurship in the STEM and ICT sectors and provides data on the fewer number of women studying ICT and STEM disciplines and working in these fields as well as becoming founders/owners of private companies. This document promotes gender equality in STEM education and careers due to the need for promoting and supporting entrepreneurship among the greater number of women as well as developing a supportive environment for women entrepreneurs. Another interesting result might be viewed as that while "STEM" was used more commonly in the past, "STEM education" is currently used more often. Figure 6 also shows that, as time progresses from the past to the current date, new clusters emerge focusing more on the entrepreneurial learning and intention, self-efficacy, green entrepreneurship, STEM entrepreneurship, and E-STEM. Therefore, it can be interpreted that entrepreneurship and STEM studies are moving from basic enterprise education focusing on the pedagogies and skills towards more sustainability and gender related integrated entrepreneurship and STEM studies (e.g., Kuschel et al., 2020; Yordanova et al., 2020).

Conclusion and Recommendations

The study presented the research conducted on STEM and entrepreneurship. No other publication yielded in this study was to review the publications on STEM and entrepreneurship together, particularly using bibliometric analysis. The data (i.e., publications) were collected, and its screening process was completed using the WoS database. The data included publication information, such as topic, cited references, keywords, and the bibliometric information. HistCite and VosViewer were used to analyse the data. Potential research areas and potential networks were identified through the co-occurrence graphs. Five RQs were answered and discussed based on the findings. Overall, the study illustrated that the incorporation of STEM and entrepreneurship is gaining more importance every year. The conducted research and the government documents might have been affecting this result. To contribute to the field and enhance the impact of the publications, the following recommendations are provided to the audience.

All the findings and research point to that the incorporation of STEM and entrepreneurship is currently trending although there are still limited number of studies on the topic. It is recommended to conduct more research on the incorporation of STEM and entrepreneurship and the connection between them since government and research documents also support this connection and incorporation. Innovation, gender, and sustainability can be recommended to prioritise during the incorporation due to the current study results and needs of the society. One of the findings showed that the highest number of publications on the topic are on the field of education. This might be because of the disciplinary segregation of STEM in business and management. Therefore, it is recommended to publish integrated STEM focused research in business related fields due to its importance in solving complex-real life problems. Although the highest number of publications on the topic are on the field of education the topic

is commonly published in business and management journals. Thus, it is recommended for education journals to consider entrepreneurship as an emerging topic in education and support publications in the field. Finally, the results point to the future risk of monopolisation in the field. To prevent the monopolisation, further collaboration between the authors conducting research on the same topic in different countries is recommended. By conducting more and effective research on the cross-section of STEM and entrepreneurship, the future generation may be brought up as equipped with the required skills, and aware of the importance of their contribution to the science, society, economy, and environment.

Limitations

The study is limited to the use of WoS database as only one database is used for identification and screening. Other data sources besides the WOS database may be used in future studies. The study is also limited to the publications that match the inclusion-exclusion criteria. Future studies may include other document types, such as books. The keywords were limited to those derived from expert opinions and a literature review. Finally, the study is limited to bibliometric analysis rather than conducting a review. This is preferred due to time efficiency and the extent of the bibliometric analysis as co-occurrences cannot be identified by hand.

Conflict of Interest Statement

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Ethics Committee Decision

No ethics committee approval was obtained because the research is a review article.

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