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Unveiling Science Edupreneurship: Perspective Analysis on Trends and Impact on SDGs

***T Sunarti[1], E Hariyono[1], I Isnawati[2], F M Sunni[1], I R Dawana[1], L Z Wardi[1], M A Arivi[3]**
[1]Department of Physics Education, Faculty of Mathematics and Natural Science, Universitas Negeri Surabaya, Indonesia
[2]Department of Biology, Faculty of Mathematics and Natural Science, Universitas Negeri Surabaya, Indonesia
[3]Graduate Institute of Science Education, College of Science, National Taiwan Normal University, Taiwan

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ABSTRACT

In this dynamic era, introducing entrepreneurship into science education can produce entrepreneurial-minded graduates capable of creating independent businesses. This concept is essential in basic science, enabling the use of scientific concepts to develop innovative solutions. This research aims to explore the trends in science edupreneurship and its impact on SDGs through bibliometric analysis. The literature review and Meta-Analyses (PRISMA) method were used in this study, combined with bibliometric analysis using the Scopus database. The findings show that research on science edupreneurship has increased significantly over the last 10 years. The most common document type is articles, with the majority of sources coming from journals, and the most publications contributed by the United States of America. The results of this study provide a broad overview of the importance of integrating science edupreneurship and its impact on SDGs. The mapping results also offer several strategic recommendations, including the need to further develop interdisciplinary approaches to meet the challenges of education and innovation. Additionally, the use of educational technology and innovative teaching methods should be considered to enhance learning effectiveness. International collaboration among researchers and institutions is also necessary to share knowledge and develop effective strategies. Education tailored to the individual needs of students is recommended to ensure effective learning. Integration with local communities and industries can increase the relevance of education to the relevance of industries' needs.

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INTRODUCTION

In recent decades, interest in entrepreneurship within the field of education has surged significantly, leading to improvements in both educational plans and principles. The focus of education has now shifted more towards the development of critical thinking and problem-solving skills rather than merely understanding content (Jamil et al., 2024; Konstantinos, 2022). This shift towards fostering entrepreneurial skills within the educational system has paved the way for the integration of entrepreneurship in education (H. A. Suprapto et al., 2024). The integration of entrepreneurship into the educational framework has introduced reforms and innovations that affect various standards and aspects of schooling. Entrepreneurial education is divided into three levels. The first level involves the acquisition of knowledge, where students learn the fundamentals of entrepreneurship, including its nature, characteristics, and benefits.

The second level emphasizes the skills and attitudes necessary to become an entrepreneur, equipping students with essential attributes such as creativity, perseverance, and adaptability. The third level is education through entrepreneurship, where students apply the knowledge and skills they have acquired through hands-on experimentation, thereby reinforcing their understanding of entrepreneurial practices (OECD, 2015). These three levels of entrepreneurial education play a crucial role in shaping an entrepreneurial mindset, which is necessary for addressing global challenges, advancing innovation, and cultivating strong ethics.

Entrepreneurship in education is increasingly vital in the 21st century, as it prepares students to become proactive problem-solvers and innovators. This mindset enhances human resources with cutting-edge knowledge, innovative ideas, and strong ethics. The concept of edupreneurship, where educators take on entrepreneurial roles by creating innovative educational solutions and fostering entrepreneurial thinking, has become an essential component of modern education. Entrepreneurship is now integrated into educational curricula in various countries and can be applied across all subjects (Al Balushi et al., 2023; Sulistyowati, 2021). Students are expected to embody entrepreneurial characteristics, not only seeking employment after graduation but also creating job opportunities (Christy & Wu, 2022; Junaidi et al., 2023).

Preliminary studies indicate that while entrepreneurial education has gained traction globally, there is still a lack of comprehensive understanding regarding the effectiveness of entrepreneurial education programs, particularly in relation to how they impact students' long-term entrepreneurial endeavors (Aadland et al., 2023). Recent research has also highlighted the gap in the integration of entrepreneurial education with sustainability goals, especially concerning the role it plays in advancing the Sustainable Development Goals (SDGs). This gap presents an opportunity for research to explore the synergy between entrepreneurship education and sustainability, an area that remains under-explored (Leiva-Lugo et al., 2024). The research presented in this paper seeks to address this gap by exploring how entrepreneurial education can contribute to the achievement of SDGs, particularly in terms of fostering innovation and addressing global challenges. Understanding this link is crucial, as it can drive new educational frameworks and enhance the alignment between education, entrepreneurship, and global sustainability.

In science education, the introduction of entrepreneurship has not yet fully achieved the objective of producing self-reliant graduates (Ezeudu et al., 2013). However, by incorporating entrepreneurship, science education has the potential to produce graduates with an entrepreneurial spirit who are capable of establishing independent ventures. This entrepreneurial concept is particularly significant in fundamental sciences such as physics, chemistry, and biology, enabling the application of scientific concepts to develop innovative solutions (Deveci, 2023; Nicolaou et al., 2021; Nicolaou & Shane, 2014). Entrepreneurship contributes to economic and social development by creating and sustaining employment opportunities and supporting the achievement of the Sustainable Development Goals (SDGs) (Prashantham et al., 2018; Talukder et al., 2024; Závodská et al., 2019). Science edupreneurship, which merges science education with entrepreneurship, supports SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth) by training students to become innovative entrepreneurs. This research aims to analyze the trends in science edupreneurship and its impact on the SDGs, providing valuable insights for achieving the SDGs and making a positive impact on quality education and economic growth.

RESEARCH METHOD

A quantitative approach is adopted in this research, utilizing bibliometric analysis through a literature review and employing the Scopus database to assess the distribution of publications, article contributions, and scientific impact in the studied field (Dawana et al., 2022; Dawana et al., 2024; Prahani et al., 2023; N. Suprapto et al., 2021). The primary focus of this study is to explore research trends related to the development of science edupreneurship in education over

the period from 2014 to 2023. By leveraging bibliometric analysis, researchers can gain a comprehensive understanding of the dynamics and advancements in this area (Dawana, Dwikoranto, et al., 2022). Data were obtained from the Scopus database as of June 2024, chosen for its extensive coverage and inclusion of scholarly articles in the field. The keywords utilized in this research include science edupreneurship. These keywords were chosen based on their relevance to the subject matter and to ensure a thorough exploration of the research trends and scientific impact related to science edupreneurship.

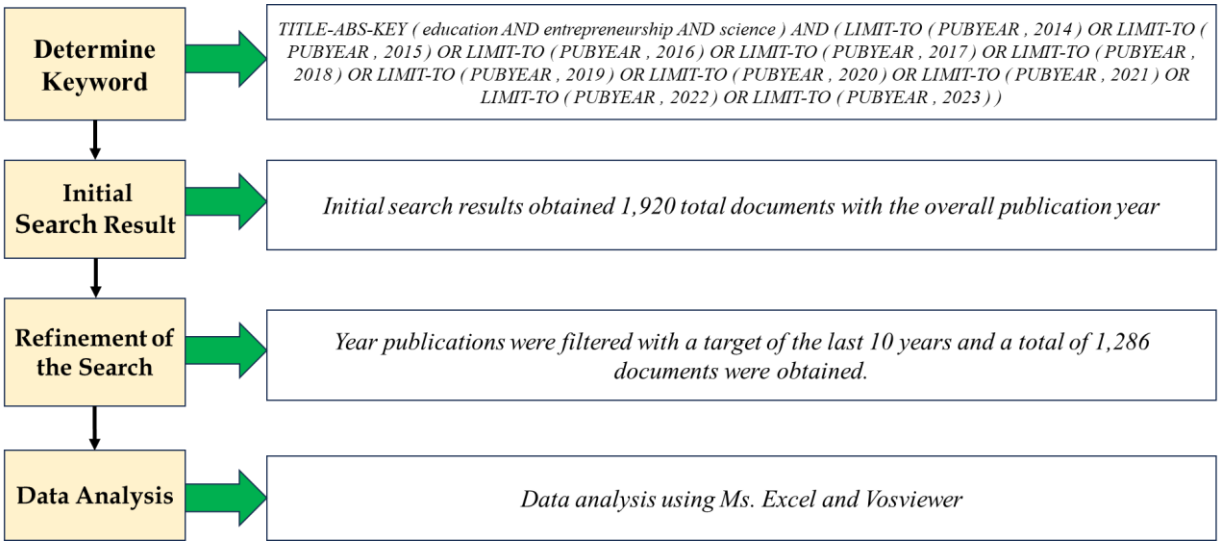


Figure 1. Five steps in performing a bibliometric analysis adapted (Dawana et al. 2022; Dawana et al. 2022)

This bibliometric analysis aims to identify collaboration patterns among researchers, journals with the highest impact, and rapidly developing research areas. The Scopus database was selected due to its extensive coverage of relevant international journals, supporting comprehensive bibliometric analysis, and offering optimal accessibility (Dawana, Dwikoranto, et al., 2022; Karakose et al., 2022; Mongeon & Paul-Hus, 2016; Yirci et al., 2023). Utilizing Scopus as the primary database allows access to high-quality articles and the retrieval of necessary metadata for bibliometric analysis (Herrera-Franco et al., 2020).

Data were downloaded in (.ris) and (.csv) formats to ensure compatibility with various analysis software. Once downloaded, the data were processed using Microsoft Excel and VOSviewer to generate graphs and tables that visualize research patterns (Hashim et al., 2018). Bibliometric analysis not only provides insights into the novelty and trends in research but also highlights the impact and contributions of scientific works to the advancement of knowledge in the field of science edupreneurship.

After the data were downloaded, they were analyzed using Microsoft Excel. VOSviewer was employed for mapping and visualizing bibliometric data. This software facilitates citation network analysis, co-citation analysis, and co-authorship analysis (Kleminski et al., 2022). By using VOSviewer, we were able to identify major research clusters, frequently discussed topics, and the relationships between various scientific works in the field of science edupreneurship.

The results of the bibliometric analysis were integrated with a systematic review to provide a deeper understanding of the research findings. Each article was evaluated based on its contribution to the impact on the Sustainable Development Goals (SDGs) through science edupreneurship. This study highlights how science edupreneurship has developed in various parts of the world and its impact on achieving the SDGs. The analysis not only includes the identification of effective teaching and learning methods but also evaluates the impact of these approaches on students' capabilities. This approach ensures that the research findings are not only academically relevant but also practical and implementable in educational contexts

(Ramadhan et al., 2024). This research offers insights into the relationship between science edupreneurship and the achievement of the SDGs by evaluating how innovations in education can support sustainable development goals. Consequently, the findings of this study are expected to serve as a reference for educators, researchers, and policymakers in developing effective strategies to promote science edupreneurship and achieve the SDGs.

RESULTS AND DISCUSSION

Result

This research evaluates the development of science edupreneurship in science education over the past decade. The primary objective is to identify emerging patterns and trends from the published studies. The keywords used in the search were "(education AND entrepreneurship AND science)." This analysis provides a comprehensive overview of how science edupreneurship has been integrated into science education and illustrates how interest in this topic has evolved over time and its impact on achieving the Sustainable Development Goals (SDGs). The publication growth graph is displayed in Figure 2.

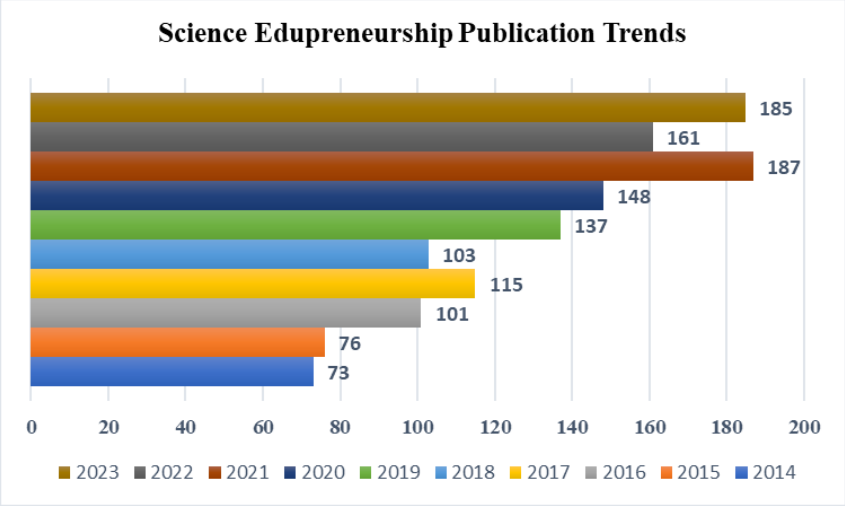


Figure 2. Number of Scopus database publications of science edupreneurship in the last 10 years

Figure 2 illustrates the publication and citation trends related to science edupreneurship over the past decade (2014-2023). Research publications cited by Science Edupreneurship in the last 10 years are displayed in Figure 3 and distribution types and source are in Figure 4.

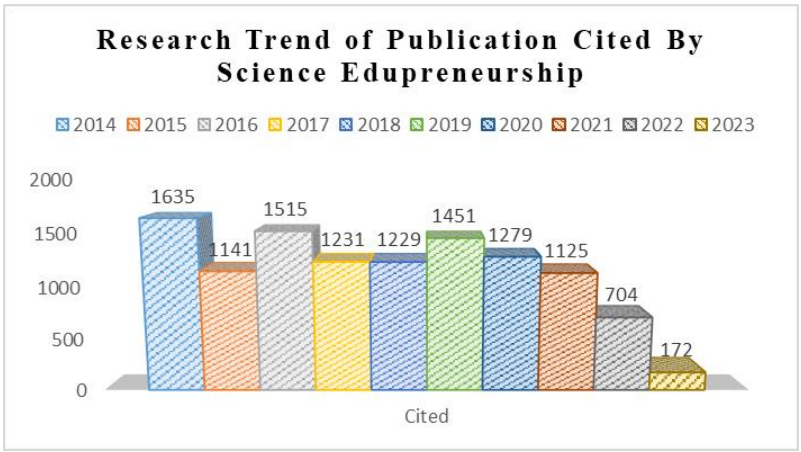
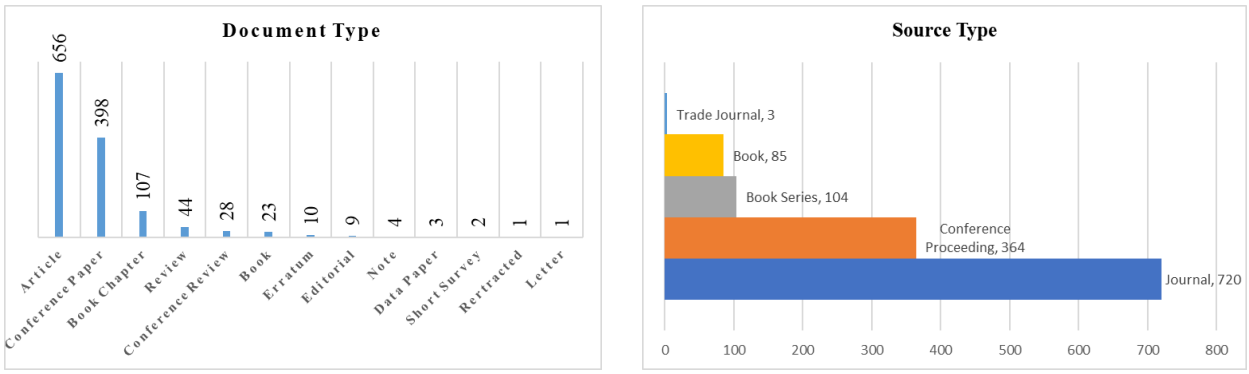


Figure 3. Distribution of research publications cited by science edupreneurship in the last 10 years



(a) (b)

Figure 4. Distribution types and source of science edupreneurship for SDGs research

Figure 5 shows the distribution of publications from the ten countries with the highest number of publications related to science edupreneurship in education, highlighting significant international involvement in this research.

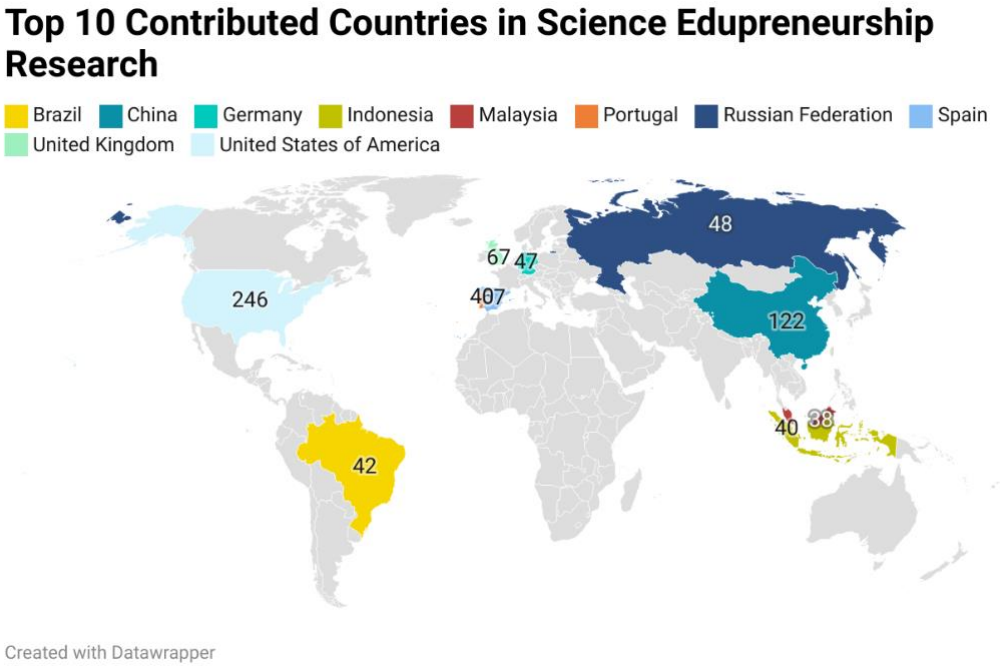


Figure 5. Top 10 countries' contribution to science edupreneurship for SDGs research and mapping by country

Table 1. Top 5 authors, affiliations, and source titles of research in science edupreneurship

Top Author		Top Affiliation		Top Source Title	
Author	**Total**	**Affiliation**	**Total**	**Source Tittle**	**Total**
Huang-Saad, A.	10	ASEE Annual Conference and Exposition Conference Proceedings	59	Purdue University	17
Duval-Couetil, N.	9	Sustainability Switzerland	27	Tecnológico de Monterrey	15
González-Serrano, M.H.	7	Journal of Technology Transfer	24	University of Michigan, Ann Arbor	13
Atmojo, I.R.W.	5	Advances in Intelligent Systems and Computing	23	Universitat de València	11

Top Author		Top Affiliation		Top Source Title	
Author	**Total**	**Affiliation**	**Total**	**Source Tittle**	**Total**
Peter, F.	5	Education and Training	22	Worcester Polytechnic Institute	9

From Table 1, we can see that the top author is Huang-Saad, A., with 10 documents; the top affiliation is the ASEE Annual Conference and Exposition Conference Proceedings, with 59 documents; and the top source title is Purdue University, with 17 documents.

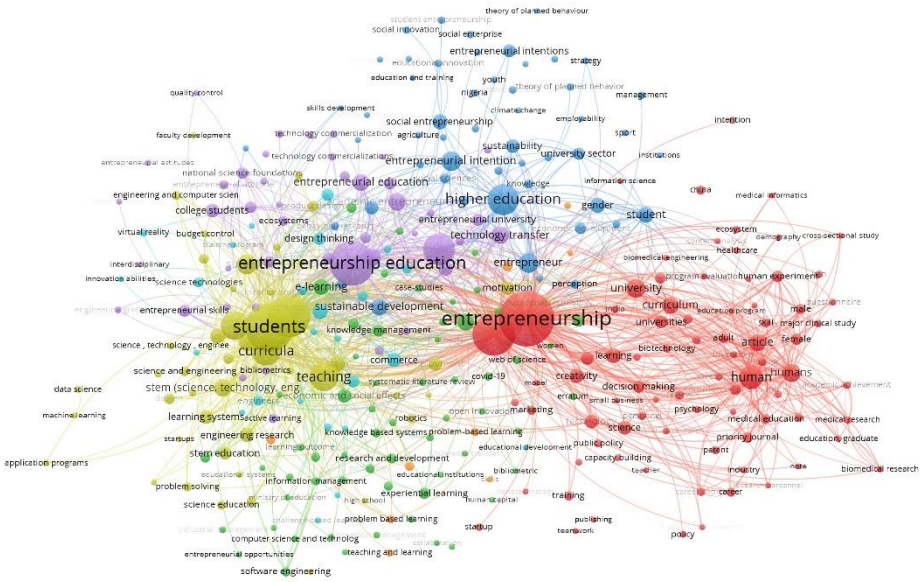
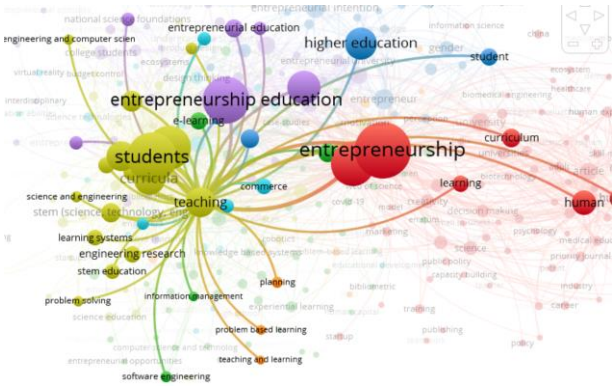
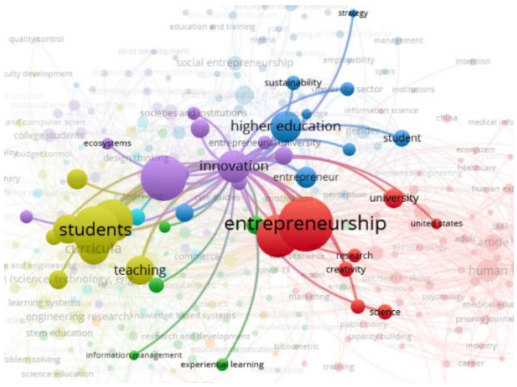


Figure 6. Keyword visualization mapping of events across science edupreneurship during the last 10 years

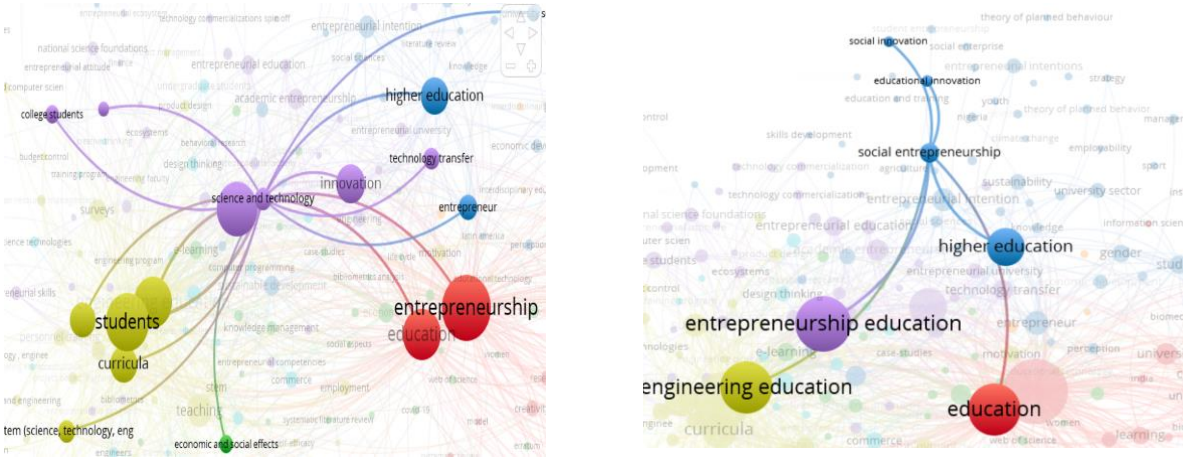
Based on Figure 6, the mapping of research trends in science edupreneurship over the past decade reveals eight main clusters that reflect various focuses and innovations in this field. The eight main clusters are red, green, blue, yellow, purple, light blue, orange, and brown. Based on the mapping results, new aspects that can be observed are obtained in Figure 7.



(a)



(b)



(c) (d)

Figure 7. The results of specific keyword mapping are as follows:a) Science and Technology, b) Innovation, c) Social Entrepreneurship, and d) Teaching.

Table 2. Top 3 Most Relevant Articles

Author	Cited; SJR	Research findings and recommendations
Daniela Maresch, Rainer Harms, Nobert Kailer, & Birgit Wimmer-Wurm	90; 3.12 (Q1)	This research indicates that entrepreneurship education (EE) can influence students' entrepreneurial intentions (EI) differently depending on their field of study, namely between business students and science and engineering students. Findings suggest that EE generally effectively enhances EI, but its effectiveness can vary depending on the context and approach used. The study recommends that EE should be specifically designed to meet the needs and challenges of specific target groups.
Ibrahim A. Elshaer & Abu Elnasr E. Sobaih	15; 0.61 (Q1)	This study demonstrates that the three dimensions of entrepreneurial orientation—risk-taking propensity, innovativeness, and proactiveness—have a direct and positive influence on graduates' entrepreneurial intentions. Innovativeness and proactiveness were also found to mediate the relationship between risk-taking propensity and entrepreneurial intentions. The recommendations provided in this document suggest that higher education policymakers in Saudi Arabia should design entrepreneurship curricula emphasizing these three dimensions of entrepreneurial orientation to ensure the development of entrepreneurial intentions among graduates. Curricula and training programs should encourage students to engage in new and innovative activities, solve problems with original approaches, and think forward in initiating new projects. Additionally, entrepreneurship education should be prioritized to support Saudi Vision 2030 and its developmental programs, such as the National Transformation Program and Human Capability Development Program, aimed at improving food accessibility and security in Saudi Arabia.

Author	Cited; SJR	Research findings and recommendations
Guangfu Qu, Wenbo Hu, Wenxiu Jiao, & Jiangbo Jin	4; 0.8 (Q2)	The document presented focuses on the application of a learning method that integrates Deep Learning (DL) with Trial-Error and STREAM (Science, Technology, Reading/Writing, Engineering, Arts, Mathematics) approaches in entrepreneurship education at the college level. This research demonstrates that using these learning methods can enhance educational quality and effectiveness. Recommendations from this study emphasize the importance of developing and implementing innovative and interdisciplinary learning methods in entrepreneurship education. Integrating STREAM approaches in education can help students understand and apply knowledge more comprehensively, thereby fostering innovation and sustainable economic growth. Furthermore, further research is crucial to explore how these approaches can be applied and adapted in broader educational contexts, ensuring that education meets the challenges and needs of a rapidly changing world.

Discussion

This study discusses publications related to science edupreneurship from the database dimension and analyzed and visualized through descriptive and evaluative bibliometric analysis methods. The publication trend data from 2014 to 2023 reveal several key findings. The number of documents published each year has generally increased, with some minor fluctuations. The peak number of publications was recorded in 2021 with 187 documents, followed by a slight decline in 2022, but nearly reaching the peak again with 185 documents in 2023. This increase in the number of publications indicates a growing interest from the academic and research community in the topic of science edupreneurship.

The increase in the number of publications indicates that science edupreneurship is becoming an increasingly relevant and popular topic. This could be attributed to the growing need for innovation in education and the development of entrepreneurial skills among scientists and educators. The data show that science edupreneurship is an emerging trend in educational research. The rising number of publications year after year suggests that more researchers are becoming interested in this topic and view it as an important field for further exploration (Mejia et al., 2021).

The analysis of citation trends for publications related to science edupreneurship during the period from 2014 to 2023 reveals several important patterns. Early publications in this field show significant impact, with a high number of citations despite the relatively low number of documents. This indicates that early research played a crucial role as foundational references for subsequent studies. During the mid-period, although there was an increase in the number of publications, the number of citations fluctuated, reflecting variations in the influence of the published research. In the most recent period, despite the high number of publications, there has been a significant decline in the number of citations. This may indicate that the latest publications have not yet gained significant recognition or require more time to be acknowledged within the scientific community. This decline also underscores the need for more innovative and high-quality research to maintain relevance and influence in this field. Overall, the results of this analysis highlight the importance of the quality and impact of research in science edupreneurship to support the development of knowledge and the achievement of sustainable development goals.

Although the number of publications has increased, the number of citations per year has not shown the same upward trend. The year 2014 recorded the highest number of citations, totaling 1,635, despite having a relatively lower number of documents compared to subsequent years. This indicates that early publications in this field had a significant impact and became important references for later research. After 2014, the number of citations decreased and

fluctuated year by year. In 2022 and 2023, the number of citations dropped significantly, even though the number of documents was high. The number of citations reflects the level of recognition of research related to literacy and numeracy in physics. Citations are an indicator of how frequently a study is referenced by other researchers, which reflects its relevance, quality, and impact on the field. The higher the number of citations, the greater the influence and contribution of the research to the advancement of knowledge in its area (Khanra et al., 2022; Lim et al., 2022).

These findings indicate that despite an increase in interest and the number of publications in the field of science edupreneurship, not all publications receive the same level of attention in terms of citations. Factors that might influence this include the quality of research, the relevance of the topic, and how the research is received by the scientific community. Early publications in this field may have established a strong foundation, while subsequent publications might take longer to gain similar recognition. The significance of this data regarding the number of publications and citations is that the increasing number of publications reflects growing interest in science edupreneurship. However, challenges remain in ensuring that the published research has significant quality and impact. To enhance the influence of future research, researchers need to focus on the quality and relevance of their findings and strive to publish results that make substantial contributions to understanding and practice in this field (Aksnes et al., 2019). An improvement in the quality of research is expected to be reflected in a higher number of citations in the future.

Based on the data distribution presented in Figure 3, it is evident that the distribution of documents and sources related to science edupreneurship in education exhibits a variety of publication types and sources used by researchers. In terms of document types, articles dominate with a total of 656 documents, followed by conference papers with 398 documents and book chapters with 107 documents. Review papers account for 44 documents, and other publication types such as conference reviews (28), books (23), errata (10), editorials (9), notes (4), data papers (3), short surveys (2), retracted papers (1), and letters (1) have smaller counts. The sources of publication show that journals are the primary platform with 720 documents, followed by conference proceedings with 364 documents, book series with 104 documents, books with 85 documents, and trade journals with only 3 documents.

The findings from this data indicate that research related to science edupreneurship in education is most frequently published in the form of journal articles and conference papers. This suggests that journals and conferences are the primary platforms for disseminating research results in this field. The dominance of journal articles reflects the importance of spreading research findings through widely recognized and respected channels within the academic community. The fact that the main source of publications comes from journals indicates that this research has a strong and broadly acknowledged scientific foundation (Kraus et al., 2020). However, the significant number of conference proceedings suggests that conferences are also an important forum for discussing and presenting the latest research. The presence of book series and books shows that there are efforts to compile this research in a more comprehensive and structured form.

Based on these results, it is evident that science edupreneurship in education is an actively researched field with a wide range of publications spread across various platforms. This reflects the importance of this topic within the academic and educational communities. The widespread and diverse nature of the publications indicates that science edupreneurship has many facets being explored, ranging from in-depth scientific articles to discussions at conferences and comprehensive book chapters. This suggests that science edupreneurship is considered crucial for study and dissemination to support future innovation and the development of better education.

Based on data from Figure 5, the United States ranks first with 246 documents, demonstrating a dominant and substantial contribution to this field. China holds the second position with 122 documents, followed by the United Kingdom and Spain with 67 documents

each. The Russian Federation, Germany, Brazil, Portugal, Indonesia, and Malaysia each contribute between 38 and 48 documents. These findings indicate that research related to science edupreneurship in education is predominantly carried out by developed countries such as the United States, China, and various European nations.

The United States, as the leader in this field, demonstrates that significant attention and resources are allocated to this research, possibly reflecting a strong desire to foster innovation in science education and entrepreneurship. China's substantial number of publications indicates considerable efforts to catch up and potentially lead in certain aspects of educational research and innovation. The participation of European countries such as the United Kingdom, Spain, and Germany shows that this topic is also a major concern in Europe, with these nations making substantial contributions. Interestingly, developing countries like Brazil, Indonesia, and Malaysia also show active involvement in this research. Although their number of publications is lower compared to developed countries, their contributions highlight that science edupreneurship in education is also an important focus in these nations. This may reflect efforts to enhance the quality of education and promote local innovation through research and development.

The significance of this data is that science edupreneurship in education is a research field with global appeal, involving many countries with diverse economic and social backgrounds. The dominance of developed countries reflects their better availability of resources and research infrastructure, whereas the involvement of developing countries indicates significant potential and interest in adopting and developing these (Edsand, 2019; Gölgeci et al., 2022). Overall, this distribution of publications illustrates the importance of international collaboration and knowledge exchange in driving innovation in science education and entrepreneurship worldwide.

The bibliometric visualization mapping trends in science edupreneurship research highlights top authors, affiliations, and publication sources in this field. Huang-Saad, A., tops the list as the author with 10 publications, followed by Duval-Couetil, N. with 9 publications, and González-Serrano, M.H., with 7 publications. Atmojo, I.R.W., and Peter, F., each have 5 publications, indicating their significant contributions to this research. In terms of affiliations, the ASEE Annual Conference and Exposition Conference Proceedings stands out with 59 publications, underscoring the conference's importance as a primary platform for disseminating research findings related to science edupreneurship and SDGs (Sustainable Development Goals). Sustainability Switzerland and the Journal of Technology Transfer are also significant sources, with 27 and 24 publications, respectively.

Top affiliations include Purdue University with 17 publications, Tecnológico de Monterrey with 15 publications, and the University of Michigan, Ann Arbor, with 13 publications. Universitat de València and Worcester Polytechnic Institute also contribute significantly with 11 and 9 publications, respectively. This analysis demonstrates that researchers from leading higher education institutions such as Purdue University, Tecnológico de Monterrey, and the University of Michigan, Ann Arbor, play a key role in developing and advancing science edupreneurship in the field of education. Annual conferences like ASEE and journals such as Sustainability Switzerland and Journal of Technology Transfer serve as primary channels for publishing this research.

The conclusion drawn from this data is that research on science edupreneurship in science education receives significant attention from the academic community, particularly at renowned higher education institutions. Leading conferences and journals serve as primary platforms for disseminating research findings, reflecting the importance of collaboration and communication in driving innovation that contributes to achieving sustainable development goals. This also highlights that the research is multidisciplinary, encompassing various aspects of technology, education, and sustainability. The involvement of top authors and affiliations indicates collective and coordinated efforts to advance this field and achieve broader impacts (Beres et al., 2020) through science-based education and entrepreneurship.

The mapping of research trends in science edupreneurship over the past decade reveals eight main clusters that reflect various focuses and innovations in this field. The first cluster, marked in red (N=80), includes topics such as creativity, education, entrepreneurship, science, teamwork, skills, and investment. This cluster emphasizes the importance of integrating science education with the development of creative entrepreneurial skills. The second cluster, in green (N=61), is related to business education, collaboration, e-learning, entrepreneurship training, pedagogy, and technological innovation. This indicates a focus on innovative teaching methods and the use of technology to support entrepreneurial learning. The third cluster, in blue (N=52), covers topics like business development, climate change, economic development, entrepreneurial motivation, Industry 4.0, and sustainable development. This cluster shows the relationship between entrepreneurship, the development of industrial technology, and global challenges such as climate change.

Cluster four, colored yellow (N=48), is associated with educational technology, learning systems, motivation, problem-solving, project-based learning, and STEM. This highlights the importance of utilizing educational technology and project-based learning approaches in teaching STEM and entrepreneurship. Cluster five, colored purple (N=44), involves assessment processes, entrepreneurial attitudes, entrepreneurial behaviors, entrepreneurial self-efficacy, entrepreneurial skills, innovation, and material science. This underscores a focus on assessment, skill development, and innovative entrepreneurial attitudes. Cluster six, in light blue (N=25), focuses on business planning, challenge-based learning, creative thinking, entrepreneurial learning, and science technology. It emphasizes the significance of business planning and creative thinking in entrepreneurial education. Cluster seven, colored orange (N=9), focuses on planning, problem-based learning, skills, and teaching and learning. It indicates that planning and problem-based learning are crucial components in developing entrepreneurial skills. Lastly, cluster eight, colored brown (N=1), focuses on entrepreneurial intention. Although it consists of only one topic, it underscores the importance of studying intention as a key factor in entrepreneurship.

This analysis indicates that science edupreneurship encompasses a wide range of diverse topics, from education and training to technological innovation and global challenges. Each cluster reflects different aspects of how entrepreneurial science is taught, learned, and applied. It demonstrates that research in this field not only focuses on developing technical skills and entrepreneurship but also includes innovative pedagogical approaches and contextual relevance to global challenges. The significance of this discussion is that science edupreneurship is a complex multidisciplinary field with various research approaches and focuses. This mapping provides a clear picture of current research trends and underscores the importance of interdisciplinary collaboration to develop effective entrepreneurial education that is relevant to contemporary needs and challenges (Guertler et al., 2019; Van den Beemt et al., 2020). This diverse research also highlights significant potential for innovation in entrepreneurial education, ultimately contributing to achieving Sustainable Development Goals (SDGs).

This research highlights that the primary interest in this field of science edupreneurship is reflected in keywords with the highest frequency of occurrence and strongest associations (Mishra et al., 2023; Sachmpazidi et al., 2021; Utama et al., 2019). Meanwhile, keywords appearing in lower-ranked clusters indicate specific research into science edupreneur topics and their impacts on SDGs (Sachmpazidi et al., 2021; Sen & Ongsakul, 2018; Thananusak, 2019). Visualizations using VosViewer over the past 10 years reveal new findings that hold potential as future research prospects (Anam et al., 2020; Purnomo et al., 2020). Mapping these keywords provides a deep visualization and insight into the dominant research directions and focuses, illustrating the development and interaction of specific topics within the context of science edupreneurship that can impact SDGs. This impact is evident as the topic is interdisciplinary and continues to grow with increasing collaboration among researchers from various fields. Thus, it is conceivable that science edupreneurship may become a primary topic in education in addressing various challenges related to environmental issues and global entrepreneurship in

the future. In exploring novelty within the analyzed topic, an in-depth analysis was also conducted on less frequently appearing keywords to identify emerging topics that have been under-researched.

Figure 7 illustrates the results of mapping specific keywords related to science and technology, innovation, social entrepreneurship, and teaching. The selection of these keywords aligns with several sustainable development goals, namely Quality Education (SDG 4), Decent Work and Economic Growth (SDG 8), and Industry, Innovation, and Infrastructure (SDG 9). Therefore, the subsequent discussion will focus on these keywords, which are highly relevant to the concept of edupreneurship in achieving the SDGs (Department of Economic and Social Affairs, 2024). The visualization depicted in figures a-b demonstrates a broad scope due to the interconnected nature and significant potential for further exploration of these topics.

Science edupreneurship closely integrates learning by combining entrepreneurial approaches with science education to create innovative, relevant, and effective learning experiences (Aliyyah & Rahmah, 2017). Edupreneurship applies learning that is connected to real-world issues, enabling students to develop an entrepreneurial mindset that views problems as opportunities and fosters the development of innovative solutions (Pramesti & Prihastiwi, 2020). Science edupreneurship also promotes the development of curricula that align with the latest developments in science and technology, ensuring students acquire knowledge and skills relevant to contemporary needs (Wildan & Subiyantoro, 2022). Furthermore, science edupreneurship often develops and utilizes technology-based educational tools such as virtual simulations, interactive learning applications, and online laboratories, enhancing the attractiveness and accessibility of science learning (Arief et al., 2021). These teaching techniques and models play a crucial role in achieving sustainable development goals, particularly SDG 4, which focuses on quality education (Rohmatillah & Achadiyah, 2016; Sholeha et al., 2021). Additionally, science edupreneurship supports personalized learning tailored to the needs, interests, and abilities of individual students, ensuring that each student can learn at their own pace and learning style (Sari et al., 2020).

Science edupreneurship also emphasizes community-based learning that involves local communities in the learning process, enabling students to form partnerships with industries and experience learning relevant to their environment (Haedar et al., 2019). Thus, science edupreneurship focuses on developing 21st-century skills such as teamwork, communication, leadership, and project management, helping students cultivate entrepreneurial and innovative skills crucial for future success, aligned with SDG 17 on partnership for the goals (Rahim et al., 2022). By integrating entrepreneurship and science education, science edupreneurship not only enhances the quality of learning but also prepares students to better face future challenges. This approach contributes to creating a generation proficient not only in scientific knowledge but also capable of innovating and leading in a rapidly evolving world.

Keywords closely related to science edupreneurship also align with innovation, as per SDG 9 focusing on industry, innovation, and infrastructure. This is because science edupreneurship supports the development of inclusive and sustainable industries, promotes innovation, and strengthens educational and technological infrastructure (Wijaya, 2021). Such innovation fosters a better and sustainable ecosystem through the development of new products and technologies applicable across various industrial sectors, including renewable energy, green technology, and healthcare devices, aligned with SDGs 3 (Good Health), 7 (Affordable and Clean Energy), and 13 (Climate Action) (Fayomi et al., 2019). According to research (Afzal et al., 2023), this innovation crucially depends on robust educational infrastructure and technology training. One example is the establishment of STEM-based curricula, as further depicted in Figure 7c. Modern learning facilities and early initiation of digital learning platforms, such as state-of-the-art science and technology laboratories, support practical learning, and research, and reinforce global educational infrastructure (Afzal et al., 2023).

This approach creates an excellent innovation ecosystem, conducive to the growth of science- and technology-based startups, providing financial support, mentoring, and networking through incubators and accelerators. These initiatives aid environmental startups in thriving and expanding (Kehinde Feranmi Awonuga et al., 2024). Furthermore, it stimulates sustainable and inclusive local industry development, generating employment opportunities and boosting local economies. By supporting innovation, education, and infrastructure development, science edupreneurship plays a crucial role in achieving SDG 9 goals (Küfeoğlu, 2022). It contributes to creating more innovative, inclusive, and sustainable industries, ultimately advancing broad economic and social progress.

Furthermore, science edupreneurship is found to have a very close connection with the concept of social entrepreneurship, depicting the ecosystem created by science edupreneurship (Figure 7d). Science edupreneurship and social entrepreneurship complement each other in efforts to create positive social impact (Wijaya, 2021). By combining expertise in science and technology with a community-focused entrepreneurial approach, they can more effectively address global and local challenges, bringing about sustainable and inclusive change (Leitch et al., 2012; Lindh & Thorgren, 2016). Science edupreneurship and social entrepreneurship are closely intertwined both in Indonesia and globally. Both focus on innovation to solve social and environmental issues, enhance inclusivity, and empower communities (D. N. Aini et al., 2024; E. K. Aini et al., 2023; Elshaer & Sobaih, 2022; Fitri & Putri Rima Jauhari, 2021). Through collaboration, they can create greater and sustainable impact, support the achievement of SDGs, and create a more just and prosperous society (Wijaya, 2021).

Based on the table above, it can be concluded that publications serve as a crucial foundation for further research on science edupreneurship and its relevance to achieving SDGs. These publications exhibit characteristics of high-quality research, such as significant citation counts, journals ranked in categories Q1-Q2, and generally high SJR values, albeit with some variation. This indicates that citations from these publications originate from various sources and journals considered influential in integrating science edupreneurship towards achieving SDGs (Mason & Singh, 2022).

The high Q1 rankings and SJR values of journals receiving citations strengthen the fact that these publications not only contribute to the literature but also have a significant impact on research into numeracy literacy in physics education. Journals with high rankings and reputations tend to exert considerable influence on the direction of research in this field. Therefore, these publications are not only crucial for advancing research in this area but also reflect positive influence within the academic community. As a result, future research can build upon the findings and methodologies from these publications as a solid foundation for further development.

CONCLUSION

This research delves into the trends and impact of science edupreneurship on the Sustainable Development Goals (SDGs), specifically SDG 4 (Quality Education) and SDG 8 (Decent Work and Economic Growth). Bibliometric analysis reveals a growing academic interest in integrating science education and entrepreneurship, reflected in an increasing number of publications. However, inconsistent citation trends suggest that not all research receives significant recognition. The study also identifies the influential roles of countries like the United States and China in publishing findings in the field of science edupreneurship. Esteemed higher education institutions and prestigious conferences serve as primary platforms for disseminating research, highlighting the interdisciplinary nature and the importance of collaboration in advancing this field.

Based on the findings, this research provides several strategic recommendations. Firstly, it is crucial to enhance the quality and relevance of published research to ensure significant contributions to understanding and practicing science edupreneurship. Secondly, interdisciplinary approaches need further development to meet the challenges in education and

innovation. Thirdly, the use of educational technology and innovative teaching methods should be emphasized to enhance learning effectiveness. Additionally, international collaboration among researchers and institutions is necessary to share knowledge and develop effective strategies. Tailoring education to individual student needs is also recommended to ensure effective learning. Integrating with local communities and industries can enhance the relevance of education to meet market demands.

Emphasis on 21st-century skills such as teamwork, communication, leadership, and project management is essential to prepare students for future challenges. Lastly, investment in strong educational and technological infrastructure is necessary to support innovation and sustainable economic growth. Overall, this research provides valuable insights into the development of science edupreneurship and how innovative and collaborative educational approaches can support the achievement of SDGs. By implementing the recommendations provided, it is expected that science edupreneurship can continue to evolve and make a greater contribution to quality education and global economic growth. For future research, it is recommended to examine the long-term impact of science edupreneurship on students' careers, the role of cultural factors in its implementation, and the effectiveness of virtual learning environments. Expanding studies to include more countries, particularly those in developing regions, would also be valuable.

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Author (s):

* Titin Sunarti (Corresponding Author)
Department of Physics Education, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya 60231, Indonesia
Email: titinsunarti@unesa.ac.id

Eko Hariyono
Department of Physics Education, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya 60231, Indonesia
Email: ekohariyono@unesa.ac.id

Isnawati
Department of Biology, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya 60231, Indonesia
Email: isnawati@unesa.ac.id

Fajriatul Mufarriha Sunni
Department of Physics Education, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya 60231, Indonesia
Email: fajriatul.19009@mhs.unesa.ac.id

Irgy Redityo Dawana
Department of Physics Education, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya 60231, Indonesia
Email: irgy.23013@mhs.unesa.ac.id

Ladika Zuhrotul Wardi
Department of Physics Education, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya 60231, Indonesia
Email: ladika.23016@mhs.unesa.ac.id

Maharani Agustina Arivi
Graduate Institute of Science Education, College of Science,
National Taiwan Normal University,
No. 162, Section 1, Heping E. Rd., Taipei City 106, Taiwan
Email: maharanigstn@gmail.com