

Research Article

A Bibliometric Analysis of Studies on Radiation Education

Esin Aggul^{1,*} , Paşa Yalcin² ¹Independent Researcher, Ankara, Turkey²Department of Mathematics and Science Education, Faculty of Education Erzincan Binali Yıldırım University, Erzincan, Turkey

Abstract

This study aims to provide a comprehensive bibliometric analysis of research on radiation education and to identify major research trends, influential contributors, and thematic developments in the field. Data were retrieved from the Web of Science Core Collection (WoS) and Scopus databases and analyzed using VOSviewer software. A total of 167 publications indexed in Web of Science and 471 publications indexed in Scopus were included in the analysis. The findings indicate that research on radiation education has increased considerably in recent years. The United States emerged as the most productive country in both databases, while English was the dominant publication language. Co-authorship, citation, bibliographic coupling, and keyword analyses revealed that radiation education, radiation protection, radiation oncology, radiation therapy, and medical education are among the most prominent research themes. The results also demonstrate the existence of strong international collaboration networks and increasing scholarly interest in radiation-related educational issues. Overall, this study provides a comprehensive overview of the intellectual structure of radiation education research and offers valuable insights into emerging trends and future research directions in the field. In addition, the study highlights the most influential authors, institutions and journals contributing to the development of radiation education research. The analysis also reveals emerging research topics and knowledge structures within the field, providing a broader understanding of its scientific evolution and supporting future interdisciplinary studies related to radiation awareness, safety and professional training.

Keywords

Radiation Education, Radiation Safety, Bibliometric Analysis, Science Mapping

1. Introduction

The accelerating increase in scientific knowledge production over the last half-century has made it increasingly difficult to keep track of the volume and diversity of academic literature. Traditional literature reviews have proven insufficient for understanding trends, turning points, and intellectual collaborations within this vast dataset, and there is a growing

need for more systematic analysis methods based on quantitative data. In this context, bibliometrics, first defined by [34] as "the application of mathematical and statistical methods to illuminate the processes and nature of written communication," stands out as a fundamental methodology in mapping scientific productivity. Bibliometric analyses aim to objectively reveal the past, present, and potential future areas of

*Correspondence: Esin Aggul (esinzaim@outlook.com)

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study in a given discipline by using bibliographic data (author, citation, keyword, institution, etc.) of publications within that discipline [1, 2].

From a methodological perspective, bibliometric research is conducted along two main axes: performance analysis and science mapping. Performance analysis measures the productivity and impact of research actors (authors, institutions, countries) through publication numbers and citation metrics, while science mapping visualizes the relational networks between these actors and the conceptual structure of the field [3]. The reliability of these analyses depends on the quality of data obtained from comprehensive databases such as Web of Science (WoS) and Scopus, and the correct interpretation of impact factors such as the h-index developed by [4]. Today, bibliometric processes are carried out through advanced software such as VOSviewer, developed by [5] or Bibliometrix, offered as an R-based software by [6] in this way, the theoretical foundations of citation indexes Garfield [7] are transformed into complex network structures and presented to researchers.

In educational sciences research, and especially in field education (science and mathematics education), bibliometric analyses are of strategic importance for tracking the developmental trajectory of the discipline. Paradigm shifts in field education, such as the transition from behaviorist approaches to constructivist approaches or, in recent years, to STEM (Science, Technology, Engineering, Mathematics) education, can be clearly read through keyword and citation networks in bibliometric data [8]. In pioneering studies by [9] and [10] topic and methodological trends in science education research were periodically examined; the topics of study ranged from conceptual change to. It has been reported that science education has evolved towards scientific inquiry and argumentation. Similarly, [11] outlined the discipline's main features through automated content analysis in the science education literature.

Studies are generally shaped by variables such as publication year, author collaborations, methodological preferences, and sample groups. When examining studies conducted in the Turkish context, [12] revealed methodological trends in the field of educational technologies, while [13] provided a general overview of postgraduate theses in science education. In bibliometric analyses of STEM education, which has gained popularity in recent years, [14] examined the intensity and direction of studies. [15] focused on global trends in this field. Furthermore, bibliometric mapping in specific subfields such as distance education [16], mobile learning [17], and educational management [18] guides researchers in identifying "hot topics" and research gaps in the relevant literature.

This macro perspective provided by bibliometric analyses in educational sciences is essential, especially for specific disciplines that directly affect the scientific literacy of society and where conceptual confusion is intense. At the forefront of these disciplines is "radiation education," considered one of the most challenging subjects to teach due to its interdisciplinary nature and abstract structure. Although radiation is present in life from modern medicine to energy production, it is

generally coded with images of "fear," "danger," and "invisibility" in the minds of students and society [19, 20]. A review of the literature reveals that in teaching radiation, students frequently confuse the concepts of "radiation" and "radioactivity," and tend to associate radiation only with nuclear weapons or accidents [21, 22].

Radiation education is not only a cognitive process but also has a dominant affective dimension. For example, [23] states that students' emotions and risk perceptions directly affect the learning process in teaching radiation; while [24] examined the contribution of discussing nuclear energy and radiation topics in the classroom to students' critical thinking skills. In this context, a large part of the studies have focused on identifying the misconceptions of students and prospective teachers regarding radiation. In the Turkish context, studies by [25, 26] revealed that high school and university students have serious knowledge gaps and misconceptions about the nature, sources, and effects of radiation. Similarly, in the international literature, [27], while examining the radiation literacy of Portuguese students, drew attention to the importance of teaching strategies regarding the safe use of radiation.

Particularly following nuclear power plant accidents such as Chernobyl and Fukushima, radiation education has gained more importance as a socio-scientific issue; how society perceives nuclear energy and radiation risks and how this perception is shaped through education has become a subject of research [28, 29]. Furthermore, with the widespread adoption of health physics and medical imaging technologies, awareness of radiation safety among students and personnel in the healthcare field has also become a focus of current studies [30, 31].

Although the existing literature on radiation education includes independent studies focusing on attitude scales, misconceptions, risk perception, and teaching material development [32], a comprehensive bibliometric analysis that creates a holistic map of this accumulated knowledge is lacking. Identifying the intellectual framework in radiation education, the most studied sub-themes, the leading authors shaping the field, and international collaboration networks is a vital need for future research in this area. Based on this need, this study aims to analyze research on "radiation education" in the international literature using bibliometric methods, identify trends in the field, and offer researchers a global perspective.

2. Method

The scientific publications that constitute the data used in this study. Data was obtained by searching the Web of Science Core Collection and Scopus databases. In both databases, the term "radiation education" was searched using the "all field" option. Because this search yielded a large number of research articles, making downloading and analyzing them in Vosviewer difficult, searches were then performed using the "article title, abstract, keywords" option in both databases.

This method yielded 167 studies in the Web of Science database and 471 studies in the Scopus database, which were then downloaded. All searches were conducted on February 1, 2026. The downloaded data was then transferred to Vosviewer software and matched according to the study's objective.

Bibliometric analysis is a method that analyzes trends in the literature, research dynamics, and collaboration networks between authors and countries by utilizing data such as the field, subject, author, keywords, citation status, and geographical origin of publications [1]. In this study, VOSviewer software was used for bibliometric analysis. This software allows for the visual mapping of connections between scientific publications, enabling the examination of network relationships such as authors, citation relationships, keywords, and country collaborations [5]. Before the networking phase, the connection

strengths and citation amounts of the units within the scope of the analysis are obtained in the form of a data table in the VOSviewer program. Based on this data, the observation units, clusters, total number of connections, and total connection strength are described in detail for each finding.

3. Findings

3.1. Findings Related to Scopus

3.1.1. Co-authorship Analysis of Authors

The co-authorship analysis of the authors is shown in Figure 1.

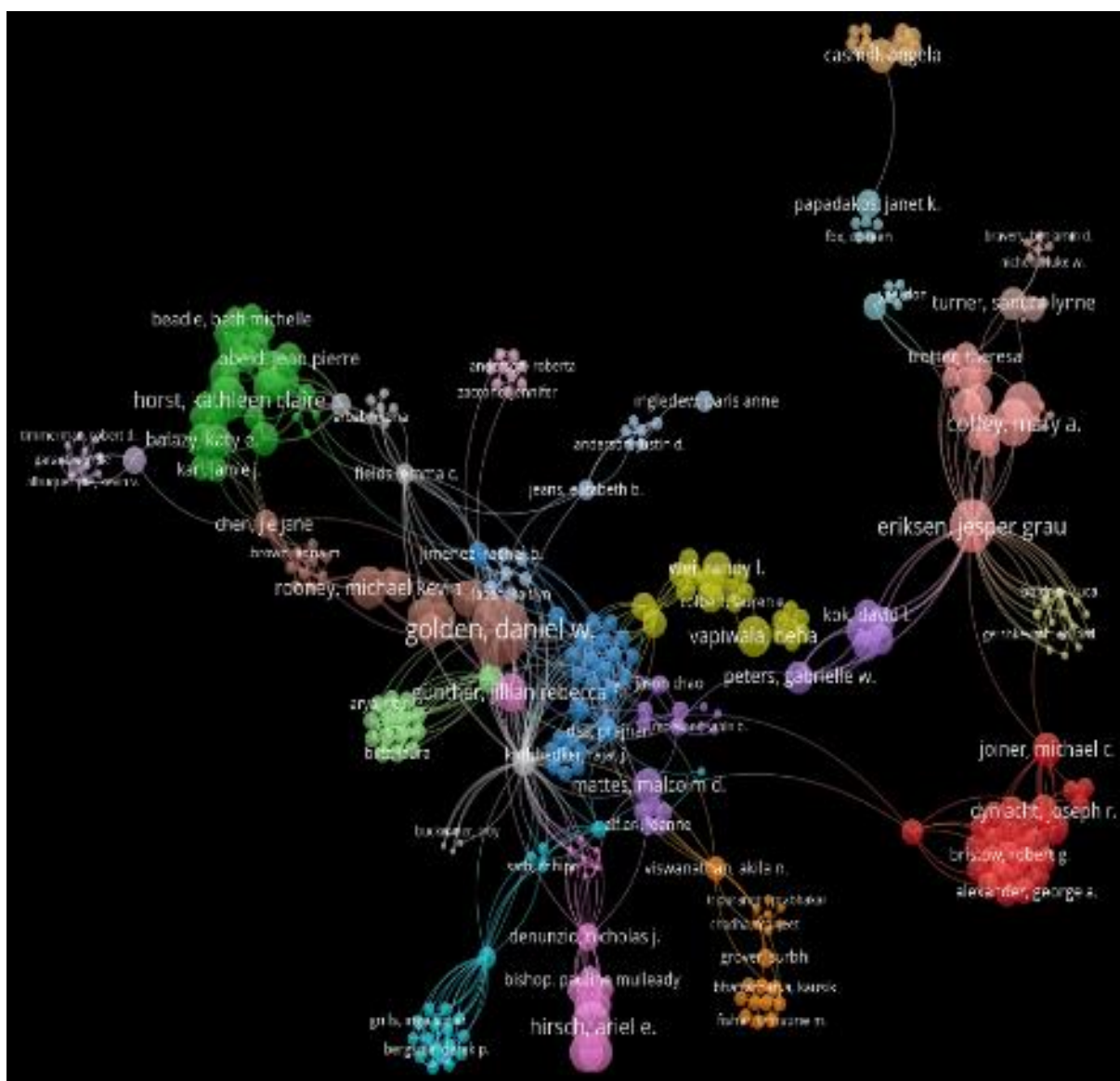


Figure 1. Co-authorship analysis of authors in the Scopus database.

According to the co-authorship analysis, a network map was created and analyzed using the criteria of at least one publication and at least one citation to identify authors with the most connections and the strongest collaboration among them. Furthermore, since the "full counting" method was used in the analysis, it was observed that multi-authored studies had a more significant impact on the network structure. According to the analysis results, 327 names and a total of 2122 connections were identified, divided into 4 clusters. The most cited authors were determined (109 citations Daniel W. Golden, 64 citations Steve E. Braunstein, 55 citations Rachel B. Jimenez, 48 citations Jesper Grau Eriksen, 43 citations Michel C. Joiner). However, authors with a high number of citations despite having weaker connections (218 citations Shawn Farley,

Donald P. Brush, Marta Hernanz-Schulman, Jennifer Boylan) are also noteworthy. Through these networks, it is possible to see the authors who have conducted the most research in radiation education, have the most citations, and have the strongest connections among themselves. The large nodes in the image represent authors who have contributed to numerous co-authored publications. This size indicates the frequency of participation in the collaboration, not the individual contribution of the author. The thicker links in the image show recurring and strong collaborations among the authors.

3.1.2. Occurrence of Author Keywords Analysis

Keyword analysis is given in Figure 2.

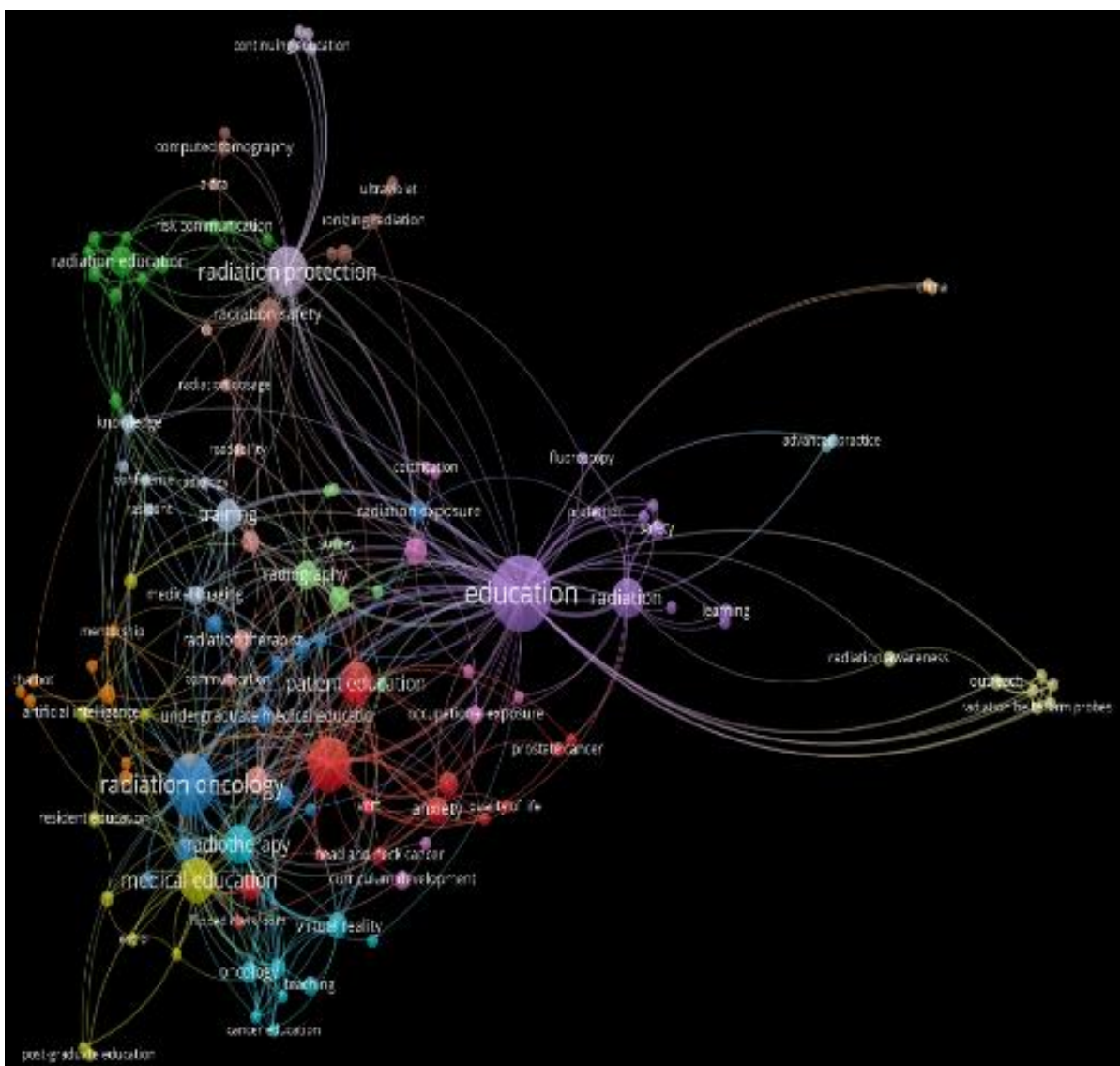


Figure 2. Co-occurrence network of author keywords in the Scopus database.

In this analysis, the author examined the frequency of keyword concurrent use to reveal the thematic structure and research trends of the field. A minimum of two keywords were

selected from each article, and keywords appearing in at least two different publications were included. By including key-

words that appeared at least twice, 135 keywords were evaluated. In the network map shown, large nodes represent the most frequently discussed concepts, while the thickness of the connections between nodes reveals the strength of the relationships between concepts. Different color clusters indicate the main research themes in the literature. Based on the defined criteria, the most frequently used keywords in radiation education are: education (135 repetitions), radiation oncology

(84 repetitions), radiation therapy (71 repetitions), medical education (51 repetitions), patient education, radiation protection, and radiotherapy (44 repetitions). Analyses conducted with 327 observation units that appeared at least twice and showed a relationship between them resulted in a total of 20 clusters and 2257 connection strengths. In summary, the strongest node is "Education," indicating an education-centered relationship. Radiation oncology and radiation protection are seen as growing subfields.

3.2. Data Related to the Web of Science

3.2.1. Co-authorship Analysis

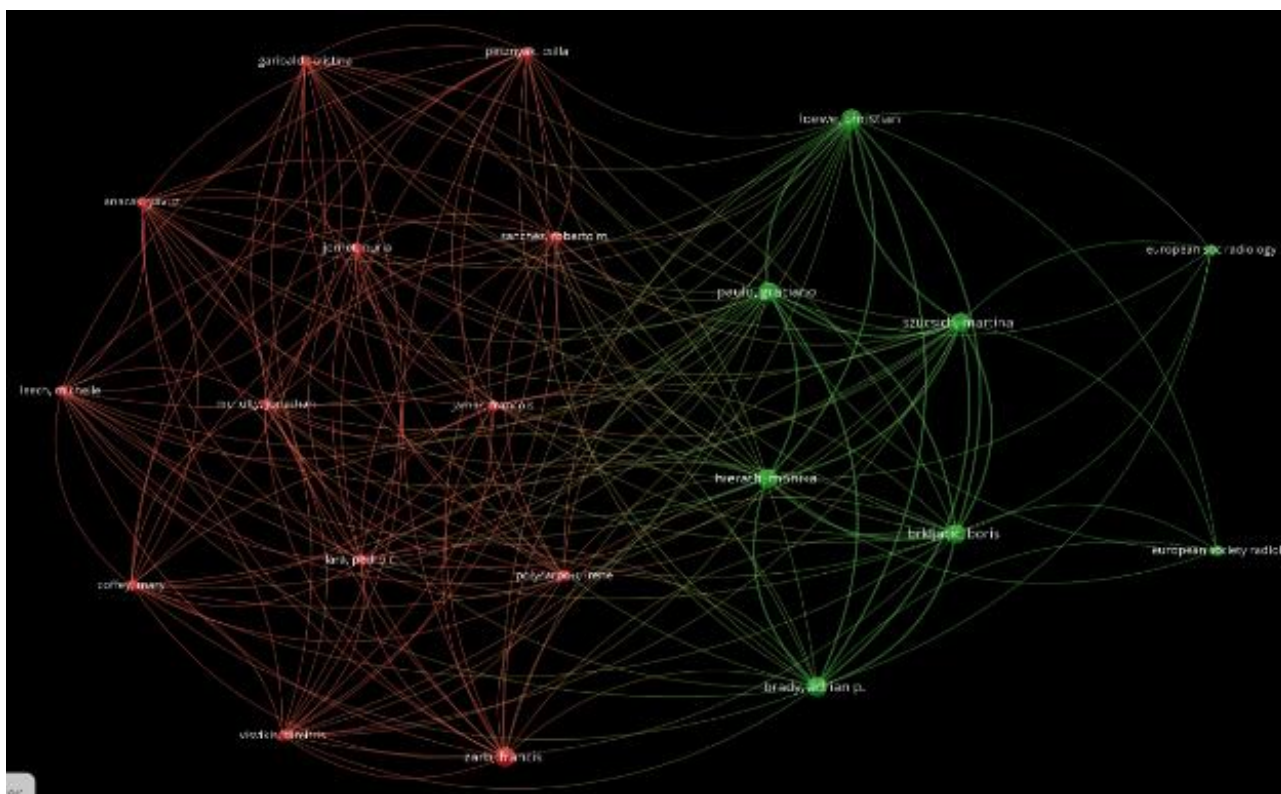


Figure 3. Co-author links.

According to the collaborative author analysis, a network map was created and analyzed using the criteria of at least one publication and at least one citation to identify the authors with the most connections and collaboration. The analysis revealed 27 names clustered into 5 groups, with a total of 73 connections and a total connection strength of 103. The most cited authors (61 citations for Paul Slovic, 30 for Claire Leppold, 25 each for Monika Hierath, Adrian P. Brady, Christina Loewe, Graciana Paulo, 24 each for Eiichi Honda, Midori

Yoshida, and 18 for Minori Sakama) were also the most connected authors (except for Paul Slovic) according to the collaborative author analysis. The most cited authors were found in two different color clusters. Despite being in different color clusters, networks were observed both among the authors themselves and between other authors.

3.2.2. Citation Analysis of Authors

The authors' citation analysis is shown in [Figure 4](#).

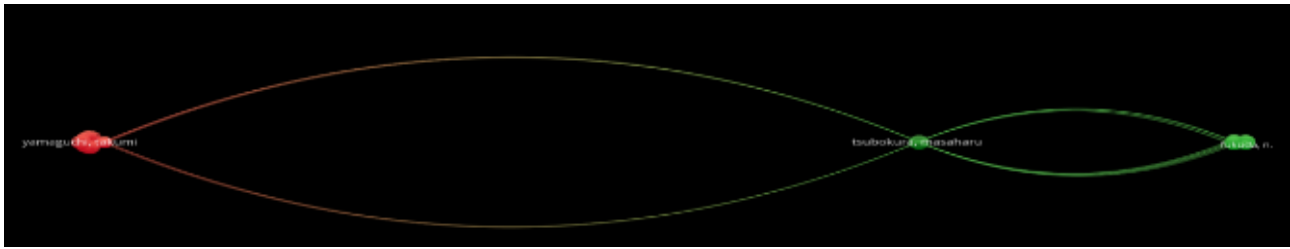


Figure 4. Authors' citation links.

Analyses were conducted to identify the citation networks of authors by defining a minimum of 1 publication and a minimum of 1 citation. The analysis, conducted across 21 observation units, revealed a total of 2 clusters, 183 connections, and a total connection strength of 213. Eiichi Honda and Midori Yoshida contributed 3 works each, Minoru Sakama and Masaharu Tsubokura contributed 2 works each, and other authors mentioned in the analysis contributed 1 work each.

These authors also rank in the top five in terms of total connection strength. Author-level connections indicate a dominance of multi-authored publications. Furthermore, the high connection strength shown by many authors despite having only one publication suggests collaborative work.

3.2.3. Citation Analysis of Countries

The citation analysis of the countries is shown in [Figure 5](#).

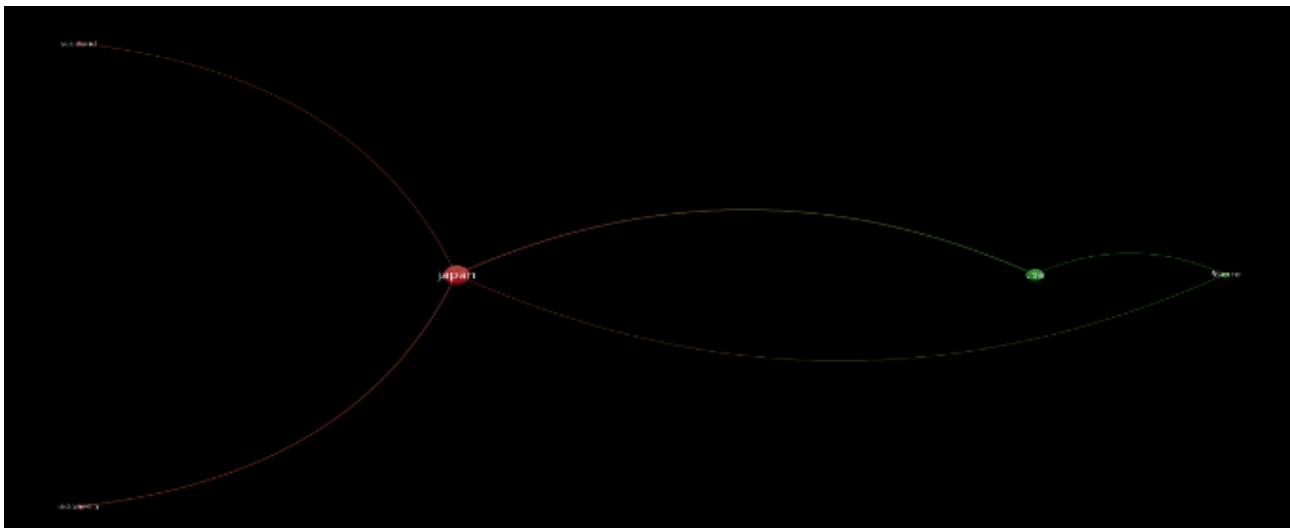


Figure 5. Citation Linkages of Countries.

To create a network map of countries' work on radiation education, analyses were conducted on 46 observation units based on the criterion of each country publishing at least one work and receiving at least one citation. The analyses revealed 2 clusters and 247 connections. The countries with the most citations were the USA (123 citations), Japan (98 citations), Switzerland (30 citations), and Australia (29 citations). In terms of total connection strength, Japan, France, and the USA ranked in the top three. In terms of the number of publications, the ranking was Japan (22 publications), USA (9 publications), Australia, and Portugal (5 publications). Japan's higher number of studies on radiation education compared to other countries may be due to a desire to take precautions following the

catastrophic events of the atomic bomb dropped on Japan by the USA in 1945. The high number of nuclear power plants in Japan and its location in a major earthquake zone could also be a reason for raising public awareness about a potential nuclear leak. We see that Japan, the USA, France, and Australia have almost identical connections.

3.2.4. Author Keyword Analysis (Co-occurrence of Author Keywords)

Keyword analysis is given in [Figure 6](#).

publications. In short, bibliographic matching shows authors who do not work together but use the same literature. Accordingly, based on an analysis of 461 units selected with the criterion of having published at least one work and received at least one citation, and which showed connections between them, 6 clusters, 998 connections, and a total connection strength of 5955 were obtained. The authors with the most bibliographic matches were Adrian P. Brady, Monika Hierath, Christian Loewe, Graciona Paulo with 25 citations (593 connection strength), Masaharu Tsubokura with 37 citations (347 connection strength), and Eiichi Honda with 24 citations (474 connection strength).

4. Discussion

This study provides a comprehensive bibliometric overview of radiation education research indexed in the Web of Science and Scopus databases. The findings indicate that the number of publications on radiation education has increased substantially in recent years. This increase may be associated with growing societal awareness of radiation-related risks and the expanding use of radiation technologies in medicine, industry, and energy production. Following major nuclear incidents such as Chernobyl and Fukushima, radiation-related issues have increasingly been addressed as socio-scientific topics in educational research. [28, 29]. The findings revealed that the United States is the leading contributor to radiation education research in both databases. A similar result was reported by [33] who found that the United States produced the highest number of publications in the field of radiation safety. The dominant position of the United States may be explained by its strong research infrastructure, extensive academic networks, and advanced applications of nuclear and medical technologies. Japan also occupies an important position in terms of citation impact and collaboration strength. This finding may be related to Japan's historical experiences with radiation and its long-standing emphasis on public awareness and education regarding radiation risks. Keyword analyses showed that the most frequently studied concepts include radiation education, radiation protection, radiation oncology, radiation therapy, and education. These findings support previous studies emphasizing the importance of radiation literacy, risk perception, and radiation safety awareness among students and the general public [22, 27]. Furthermore, the prominence of radiation protection-related keywords suggests that the literature increasingly focuses on preventive and safety-oriented educational approaches.

The co-authorship and bibliographic coupling analyses revealed the existence of strong collaboration networks among researchers. In the Scopus database, Daniel W. Golden, Steve E. Braunstein, Rachel B. Jimenez, Jesper Grau Eriksen, and Michel C. Joiner were identified as highly connected authors. In the Web of Science database, Paul Slovic, Claire Leppold, Monika Hierath, Adrian P. Brady, Christina Loewe, Graciona Paulo, Eiichi Honda, Midori Yoshida, and Minori

Sakama emerged as influential contributors. These findings indicate that radiation education research is supported by active international collaboration and shared intellectual foundations.

Overall, the results suggest that radiation education has evolved into a multidisciplinary field that encompasses science education, medical education, public health, risk communication, and radiation protection. Consistent with previous studies examining misconceptions and knowledge gaps related to radiation [21, 25, 26], the growing volume of publications demonstrates the increasing importance of radiation education in both educational and societal contexts.

5. Conclusion

This study examined the intellectual structure and development of radiation education research through a bibliometric analysis of publications indexed in the Web of Science and Scopus databases. The findings demonstrated that research activity in this field has increased considerably over time, particularly during the last decade. The United States emerged as the most productive and influential country, while English was identified as the dominant publication language in both databases. The analyses further revealed that radiation education, radiation protection, radiation oncology, radiation therapy, and medical education constitute the major thematic areas of the field. These findings suggest that radiation education extends beyond traditional science education and plays a significant role in healthcare training, public awareness, and risk communication. Similar to the observations reported by [33], safety-related themes continue to occupy a central position within the literature. The study also identified influential authors, strong international collaboration networks, and thematic clusters that shape the intellectual structure of the field. Through co-authorship, citation, keyword, and bibliographic coupling analyses, the study provides a comprehensive map of the existing literature and highlights emerging research directions. As one of the first comprehensive bibliometric investigations focusing specifically on radiation education, this study contributes to the literature by systematically revealing publication trends, research themes, and collaboration patterns. Nevertheless, the findings are limited to publications indexed in the Web of Science and Scopus databases. Future studies may incorporate additional databases and conduct comparative analyses to obtain a broader understanding of global developments in radiation education research.

6. Recommendation

Future bibliometric studies may include other databases such as Dimensions and Google Scholar.

Comparative analyses can be conducted across different educational disciplines.

More studies are needed on radiation literacy and public

awareness.

Abbreviations

WoS	Web of Science
VOSviewer	Visualization of Similarities Viewer

Author Contributions

Esin Aggul: Conceptualization, Data curation, Formal Analysis, Investigation, Methodology, Visualization, Writing – original draft

Paşa Yalcin: Methodology, Supervision, Validation, Writing – review & editing

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this manuscript.

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