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To cite this article:

Şahin, A., Dikmen, S., & Karakaya, Y. E. (2023). Bibliometric mapping of research on thinking skills and creativity in education. *International Journal of Research in Education and Science (IJRES), 9*(2), 365-388. https://doi.org/10.46328/ijres.3133

IJRES International Journal of Research in Education and Science
2023, Vol. 9, No. 2, 365-388 https://doi.org/10.46328/ijres.3133

Bibliometric Mapping of Research on Thinking Skills and Creativity in Education

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Article Info

Article History

Received:
24 November 2022
Accepted:
17 March 2023

Keywords

Thinking skills
Creativity
Education
Web of Science
Bibliometric analysis

Abstract

The present study is undertaken to investigate research towards thinking skills and creativity in the field of education by utilizing the bibliometric mapping method. The metadata of a total of 326 studies completed between the years 1975-2021 retrieved from the Web of Science (WoS) database constitute the scope of the study. In this context, the program VOSViewer was used to reveal the most used keywords and common citations. The findings present a systematic map demonstrating the increasing interest in thinking skills and creativity in education. The findings demonstrate that the majority of the studies consist of papers and articles of Indonesian, Chinese, and American origin written in English. In addition, the results highlight that the number of studies in the relevant field increased rapidly between 2012 and 2021. King Abdulaziz University and The Hong Kong Polytechnic University have been identified as the leading educational institutions in terms of thinking skills and creativity in education. The results of the current study appeal not only to the academic community but also to educators and politicians to strengthen the spirit of thinking skills and creativity in education, design effective policy tools, and ultimately improve social well-being. In addition, it was observed that the academics who conducted research in this field explained the theme of thinking skills and creativity by associating it with various teaching processes and technology-supported elements at different levels of education. Therefore, it is predicted that our study will contribute to the field of thinking skills and creativity in education as a guide.

Introduction

Today, there is an increasing interest in promoting the thinking skills (Wegerif et al., 2015) and creativity (Hernández-Torrano & Ibrayeva, 2020) of learners. This interest has been reflected comprehensively in the education policies (Pang & Plucker, 2012; Tahirsylaj & Wahlström, 2019), curriculum design (Marshall, 2005; Kong, 2016), and teaching practices (Fanchini et al., 2019) in different countries. The underlying assumption of focusing on improving students' thinking skills and creativity is the positive contribution of these skills to academic and social outcomes (Fanchini et al., 2019; Gajda et al., 2017). On the other hand, increasing globalization requires more people to be equipped with 21st-century skills (Polakovic et al., 2017). This highlights the need for educational institutions to restructure themselves to include a greater focus on thinking skills and

creativity (Kasirer & Shnitzer-Meirovich, 2021).

In recent years, various reviews of literature related to thinking skills, creativity, and education have been made (e.g., Bereczki & Kárpáti, 2018; Chan, 2013; Frith et al., 2019; Mullet et al., 2016). Despite these studies, the current situation and developments in these subjects remain unclear. One of these studies by Soufi and See (2019) is a systematic review of international studies to determine whether critical thinking is effective in improving the skills of English language learners in higher education. Bogilović and Černe (2018) presented a dynamic perspective of studies related to creativity conducted between 1950 and 2016 by making an analysis based on systematic review and bibliographic coupling methods. Kong et al. (2014) conducted a systematic review and meta-analysis study to examine the effectiveness of problem-based learning in the development of critical thinking. Long et al. (2014) reported their research results about four journals specializing in creativity research using bibliometric techniques to examine publication and citation trends, the growth of the impact factor, and the number of articles that were never cited. The study by Chan (2013) identified the types of nursing course structures that support students' creative thinking and creativity.

There is an abundance of retrospective research into thinking skills and creativity in education. Therefore, the bibliometric mapping method can be employed to determine research trends and to produce an overview of the field (Van Eck & Waltman, 2014). Traditional literature review investigations entail the reading of relevant articles that contain the subjective partiality of the researchers who conducted the study. This subjectivity can only be mitigated by a keyword analysis (i.e., bibliometric mapping) because it is based on automated quantitative analysis with a predefined algorithm (Fergnani, 2019). In this respect, bibliometric mapping has been gaining active attention in the field of education in recent years (Begeny et al., 2018; Hallinger et al., 2020; Huang et al., 2019; Ivanović & Ho, 2019). This bibliometric study aims to reflect a global perspective about the status and development of thinking skills and creativity research in education by investigating studies and citation data published between 1975 and 2021 as retrieved from the Web of Science (WoS) database, thereby closing a gap in the literature.

Defining Thinking Skills and Creativity

The set of basic and advanced skills and sub-skills that manage a person's mental processes constitute their thinking skills. These skills consist of knowledge, tendencies, cognitive, and metacognitive processes (Cotton, 2002). In addition, thinking skills include structures such as comparison, questioning, making connections, giving examples, expanding, giving ideas, implementation, evaluation, and research (Scriven & Paul, 1987). Alternative definition lists can be created for other terminologies commonly used in thinking skills research. With an attempt to look for compromise owing to these definitional differences, Alvino’s (1990) "Glossary of Thinking-Skills Terms" contains a series of definitions that are widely accepted, if not universally, by theorists and program developers. In this context, cognition is defined as the mental processes involved in thinking and the biological/neurological processes of the brain that facilitate thinking in the dictionary.

Creative thinking, which is one of the thinking skills, is defined as a new way to see or make situations

characterized by "four-component fluency (generating many ideas)," "flexibility (easily changing perspective)," "originality (designing something new)," and "detailing (building on other ideas)." As another ability to think, critical thinking is the process of determining the reality, accuracy, or value of something. This ability to think involves the structure characterized by the ability to search for causes and alternatives, to perceive the whole situation, and to change one's opinion based on evidence. At the same time, critical thinking skill is expressed as "logical thinking" and "analytical thinking." Metacognitive thinking is another thinking skill. This skill is described as the process of planning, evaluating, and monitoring one's own opinion. In addition, in Costa and Presseisen's (1985) thinking skills dictionary (A glossary of thinking skills), it has been emphasized that these skills cannot be classified in a single category and that many thinking skills exist. In the dictionary, thinking skills are defined separately as "convergent thinking," "creative thinking," "critical thinking," "epistemic thinking," "divergent thinking," "lateral thinking," and "vertical thinking."

Creativity is defined as innovations that meet broad requirements for a purpose (Plucker et al., 2004). Traditional definitions of creativity emphasize two key components: originality (innovation or uniqueness) and mission suitability (usability) (Patston et al., 2021). Originality is novelty and incomparability. In this respect, an idea that is not unusual or unique is not creative. On the other hand, usefulness is related to being beneficial and suitable (Hernández-Torrano & Ibrayeva, 2020). These two dimensions are multiplicative. If something is very original but useless or very suitable for the task but not original, this structure cannot be said to be creative (Simonton, 2012). These two basic components are unanimously considered within the definition of creativity (Cropley, 2015) from the beginning of academic creativity studies (Guilford, 1950) to modern concepts (Kaufman, 2016). However, even though research on creativity (Sakr, 2018; Sawyer, 2012) brings the productive aspect of the individuals to the foreground, contemporary and innovative studies state that creativity is the result of collective and collaborative social relationships by emphasizing the dynamic structure of creative processes. Moreover, it is emphasized that creativity is not only about personal tendencies or competence, but also a combination of personal characteristics, cognitive ability, and social environment (Deng & Tavares, 2013). In this context, the development of creativity and thinking skills can contribute positively to individuals socially, psychologically, and academically.

Thinking Skills, Creativity and Education

Developing the thinking skills of students can be considered an important educational goal. Teaching thinking is important for learning and social structure, raising global citizens with creativity and innovative capacity (MacDonald, 2005). Therefore, numerous books and research articles that focus on improving students' thinking skills as an important goal of education are available in the literature (e.g. Adey, 1999; Adey & Shayer, 1994). On the other hand, the interest in teaching thinking skills has also been highly influenced by the development of digital and networked technologies and the emergence of 21st-century skills (Voogt et al., 2013; Wegerif, 2006). Besides transforming the structure of education and teaching practices, the changes that occurred in the 21st century require the development of a different perspective towards this process.

Moreover, 21st-century skills entail being creative, being able to think about an innovative subject from different

perspectives, and internalizing stronger arguments and evidence (Li, 2016). Learning environments and social practices are important to teach thinking and to educate global citizens with creativity and innovative capacity (MacDonald, 2005). The studies conducted (Butler et al., 2017; Ren et al., 2020) demonstrate that thinking skills are a strong predictor of academic achievements and life satisfaction in children and adults. In this regard, McGuinness (1999) defines three models by addressing the importance of developing thinking skills in educational institutions. The first one is related to developing general thinking skills, and the second is building curriculum models towards developing subject-specific learning skills. The last one involves presenting a model that creates opportunities for developing thinking skills within the curriculum. McGuinness (1999) states that the development of thinking skills is in line with an international movement to give students responsibility and improve the self-management of learning.

In recent years, it is seen that the interest in creativity has been increasing exponentially along with thinking skills in the field of education (Huang et al, 2019; Smith & Smith, 2010). The reason for this trend includes the accumulated empirical evidence pointing out the positive contribution of creativity on academic and social outcomes such as scholastic performance (Fanchini et al., 2019; Gajda et al., 2017; Hansenne & Legrand, 2012; Sternberg, 2002; Plucker, 2000). Two fundamental powers guide the increasing emphasis on creativity in the education context. These are "the fulfillment of students' individual needs" and "their future success in a complex, uncertain world" (Craft, 2003). Guilford (1950) maintains that a creative action occurs as a result of learning. In addition, he emphasizes that a comprehensive learning theory should consider both insight and the development of creativity. Studies (Craft, 2011) indicate that creativity has become one of the fundamental aims in the education systems of many countries.

In addition, the studies conducted (Craft et al., 2001; Runco, 2008) emphasize that creativity dwells in every human being and can be developed through education. Accordingly, improving the thinking skills and creativity of individuals at all levels of education is an important goal (Seng, 2000). As a result, thinking skills and creativity, which can be improved with education as highlighted in the literature above, can also be considered as an important output of education systems.

The Present Study: Mapping Studies on Thinking Skills, Creativity and Education

Although the visibility of systematic review studies in the literature of education is increasing as outlined above, it can be stated that bibliometric studies about thinking skills and creativity in education are limited in number (Bogilović & Černe, 2018; Castillo-Vergara et al., 2018; Hallinger, 2020; Long et al., 2014; Chan, 2013). Besides, the subjects of thinking skills and creativity are observed to be investigated independently in these studies. However, the overall tendency in these studies, which are conducted with a descriptive point of view, is limited to co-author analyses, whereas the most common bibliometric methods of citation, co-citation, and word analyses are not included.

Furthermore, of the bibliometric studies focusing generally on education research (Chan, 2013; Puryear et al., 2017), very few can be said to have utilized current mapping methods. With this regard, the present study aimed

at contributing to the literature by outlining the general status of thinking skills and creativity studies in education published in internationally indexed journals (WoS: SSCI, SCI-Expanded, AHCI, and ESCI) with the help of bibliometric analyses and visual maps. The study may also be important in supporting bibliometric analyses in the field of education, in revealing current research trends, and in providing researchers and practitioners in this field with an idea of the diversity of the subject area. From this point of view, a general situational analysis of the current state of thinking skills and creativity research in the field of education is carried out based on publication and citation data obtained from the WoS database, and closing a gap in the field is aimed.

More specifically, this study aims to determine the acceleration of publication and citation data on thinking skills and creativity research in the field of education, as well as to uncover important journals and the most effective studies in this field. In addition, the present study is designed with the aim of learning, teaching, and developing thinking skills and creativity by conceptually demonstrating innovative approaches and carrying further studies a step forward. The current research reveals networks of scientific collaborations between authors, institutions, and countries that contribute to studies on thinking skills, creativity, and education. In line with this information, the questions identified leading this investigation are determined as follows:

- What is the distribution of the studies by year and by the journal?
- Which authors are most cited in co-citation cases?
- What are the citation ranks of publications, authors, journals, and institutions?
- How is the network map of the most-cited authors and countries structured?
- What kind of structure emerged for the co-word network?
- How do the most-cited studies and their inter-relationship appear visually?

Method

This study provides a general overview of all studies in the literature on thinking skills and creativity in education as retrieved from the "Web of Science Core Collection (WoS)" database through bibliometric analysis and relational mapping methods. Using the scientific data provided by WoS for the years between 1975-2021, studies conducted in the subjects of "thinking skills" and "creativity" in the field of "education" were investigated. The analysis of the WoS-indexed international studies was performed employing the bibliometric mapping analysis method. The relational network maps of the most frequently used keywords, most cited publications, journals, countries, and the most-cited authors in the dataset obtained from the scan in the literature were analyzed using the bibliometric analysis.

Generation of the Dataset

The search for data was made on December 13-19, 2021 looking for studies published from 1975 to 2021. In the research, seven citation indexes in the Web of Science (WoS) database were sought: Conference Proceedings Citation Index-Social Science & Humanities (CPCI-SSH), Conference Proceedings Citation Index-Science (CPCI-S), Social Sciences Citation Index (SSCI), Emerging Sources Citation Index (ESCI), Science Citation Index Expanded (SCI-Expanded), Arts & Humanities Citation Index (A&HCI), and Book Citation Index-Social

Sciences & Humanities (BKCI-SSH). WoS was preferred since it is one of the most important scientific citation index databases in the world (Wang et al., 2016). The search query applied in WoS is presented in Figure 1:

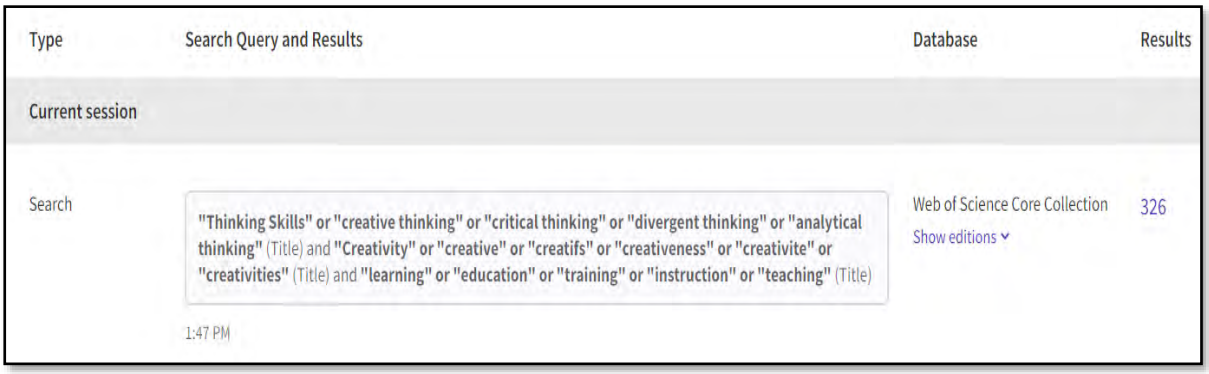

Figure 1. Search Query String

The data of studies to be used for bibliometric analysis were obtained using the WoS database. No language or year restrictions were applied during the query. Advanced search methods and keywords obtained from the literature review were used in the WoS database to access research in education within the scope of thinking skills and creativity (Figure 1). The WoS database is one of the most respected and well-known international databases that provides reliable data with detailed information about important studies and researchers. Therefore, it can be said to be the most appropriate database to conduct bibliometric studies (Wang et al., 2016; Zhai et al., 2017). Therefore, the study was carried out by including the studies in the Web of Science database to ensure that the data is accurate and reliable.

Data Analysis

The data for a total of 326 studies were accessed by scanning for title according to the predetermined concepts. The reason for applying any inclusion/exclusion criteria is to analyze the development, evolution and relationships of all research on thinking skills and creativity in education. The dataset was downloaded as “tab limited file” and “excel” files. First, the data for publications was uploaded to “VOSViewer (Visualization of Similarities),” a free bibliometric analysis software commonly used worldwide. VOSViewer was utilized to analyze and visualize the relationships between authors, countries, journals, citations, and keywords (Van Eck & Waltman, 2014; Yu et al., 2020).

Results

Descriptive Findings

The distribution of the studies by their type of publication, language, and the country is presented in Table 1. As demonstrated in the table, the studies on thinking skills, creativity, and education existing in the WoS database consisted mainly of proceedings papers (N=183, f=56.13%) and articles (N=125, f=38.14%). In addition, the studies were predominantly published in English (N=306, f=93.87%). When the countries were considered, most

of the studies were published in Indonesia (N=87, f=26.69%) and in China (N=59, f=18.10%).

A total of 326 documents published between the years 1975 and 2021 were examined within the scope of the study. When the change in the number of studies over the years was examined, it was observed that the first study in this field was made in 1980 (Figure 2). The number of studies increased in the 1990s, but it was determined that the highest increase occurred between 2012 and 2021. In those years, it can be said that researchers tended to determine how the thinking skills and creativity of the learners were shaped in the educational processes in the field of education. The main reason for this tendency is that creativity is thought to have a positive impact on academic performance (Fanchini et al., 2019; Freund and Holling, 2008; Gajda et al., 2017; Hansenne & Legrand, 2012).

Table 1. The Dispersion of Studies by Their Type of Document, Language, and Country

Research Type		n	f (%)
1	Proceedings Papers	183	56.13%
2	Articles	125	38.34%
3	Meeting Abstracts	4	1.23%
4	Review Articles	3	0.92%
5	Editorial Materials	4	1.23%
6	Book Chapters and Reviews	4	1.23%
7	Early Access Publications	3	0.92%
Research Language			
1	English	306	93.87%
2	Spanish	5	1.53%
3	Chinese	4	1.23%
4	Russian	4	1.23%
5	Turkish	3	0.92%
6	Portuguese	2	0.61%
7	Croatian	1	0.31%
8	Indonesian	1	0.31%
Countries (Top 10)			
1	Indonesia	87	26.69%
2	China	59	18.10%
3	The United States of America	40	12.27%
4	Thailand	16	4.91%
5	Turkey	15	4.60%
6	Taiwan	13	3.99%
7	The United Kingdom	9	2.76%
8	Spain	9	2.76%
9	Malaysia	8	2.45%
10	Slovakia	7	2.15%

In addition, the importance of thinking skills and creativity on life satisfaction (Sternberg, 2002) could be a reason for the increase in the number of these studies. When the change in the number of citations over the years was examined, it was seen that between 1975-2021 a multivariate chart occurred. Due to the increase and decrease of studies in this field, a graph has emerged that has also increased and decreased in the number of citations (Figure 2). The growth of the bubbles in the graph indicates an escalation in the number of publications and citations. In this respect, it can be seen that the highest number of citations occurred between 2015-2018.

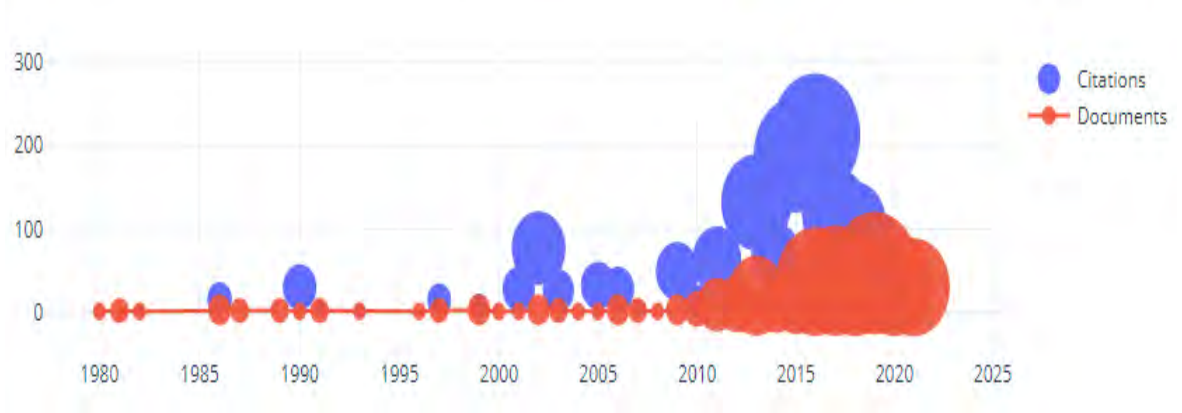

Figure 2. Changes in Numbers of Documents and Citations over the Years

Bibliometric Findings

The number of studies carried out in this field by the authors included in the research, the number of citations they received, and the "Total Link Strength" (According to the VOSViewer manual, each link has a strength that is represented with a numerical value. The greater the value is, the stronger the link becomes. The total link strength feature represents the total strength of the co-authorship connections of a specific author with other authors) are investigated (see Table 2).

Table 2. Author Rankings (The Most Cited 10 Authors)

Rank	Author	Document	Citations	Total Link Strength
1	Al-Zahrani, Abdulrahman M.	1	102	6
2	Chan, Zenobia C. Y.	2	67	10
3	Çelik, Pınar	1	59	3
4	Forthmann, Boris	1	59	3
5	Gerwig, Anne	1	59	3
6	Holling, Heinz	1	59	3
7	Lubart, Todd	1	59	3
8	Storme, Martin	1	59	3
9	Karpova, Elena	2	57	21
10	Chen, Wy	2	53	1

Within the scope of the study, the top 10 authors were given in Table 2 according to the number of citations among

the authors who had at least one study in the relevant indexes. Al-Zahrani, Abdulrahman M.; Chan, Zenobia C. Y.; Çelik, Pınar; Forthmann, Boris; Gerwig, Anne were the most prominent authors in the subjects of thinking skills and creativity in education. The most cited author was Al-Zahrani, Abdurrahman M. (Citations=102). From the total link strength perspective, the author Karpova, Elena (The Iowa State University-The USA) stood out. This finding can be considered as an indication that this author has collaborated with many authors from different regions.

Based on the data obtained, the ranking of the institutions where the most cited authors work is listed by their number of citations, the number of articles, and the strengths of the total links in Table 3. King Abdulaziz University was observed as the university receiving the most citations. This university is where Al-Zahrani, Abdulrahman M., who was identified as the most cited author with his studies, works. In the second rank, the studies conducted at the Hong Kong Polytechnic University attract attention in terms of the number of citations. In line with this, Chan, Zenobia C. Y. works at this university. Another highly cited institution is Paris Descartes University, where the author Pınar Çelik is employed. From the total link strength perspective, Iowa State University ranks first. This suggests that this university is more preferred in the context of collaborations. In addition, the author Karpova, Elena works at this university.

Table 3. University Rankings (The Most Cited 10 Universities)

Rank	Institution	Country	Document	Citations	Total Link Strength
1	King Abdulaziz University	Saudi Arabia	2	102	5
2	The Hong Kong Polytechnic University	China	3	68	5
3	Paris Descartes University	France	2	62	4
4	Münster University	Germany	1	59	1
5	Iowa State University	The USA	2	57	13
6	Temple University	The USA	2	53	1
7	Brasilia University	Brazil	1	47	2
8	Connecticut University	The USA	2	47	2
9	Southwest University	China	1	47	2
10	Radboud University	The Netherlands	1	46	-

When the studies included in the research are examined based on the journal, it is seen that the most effective journal in this field is "Thinking Skills and Creativity" (see Table 4). This journal ranks first with 15 studies published in the relevant field and 120 citations. In addition, it was determined that the total link strength was higher than in other journals. It can be stated that this journal focuses more on the reflections of teaching and learning creativity on teaching practices in the context of thinking skills.

In addition, it focuses on the development of thinking skills and creativity in the learning and teaching process and on methodological studies that solve the problems that arise in the relevant field. The second journal with the most citations is the “British Journal of Educational Technology.” Two articles published in this journal received

102 citations, and the total link strength was found as 1. Additionally, this journal was also observed to be in the second rank in terms of impact factor (IF=4.929). The journal focuses mainly on applications of digital technologies on educational implementations, learning psychology, learning pedagogy, as well as the design, development, and implementation of learning systems and tools with support and guidance.

Another striking piece of information in Table 4 is the impact factor size. It was determined that particularly the impact factors of the journals "Human Brain Mapping" (IF=5.038), "British Journal of Educational Technology" (IF=4.929), and "Nurse Education Today" (IF=3.442) were greater than the other journals. The journal with the lowest impact factor in the list was "Human Brain Mapping," which essentially focuses on studies in the field of mapping the human brain. In addition, the journal was found to include research investigating the in-depth organization of neural systems that support human behavior. When the articles within the scope of the studies are considered, it is stated that the development of thinking skills and creativity in education can be explained with neurological organization and can be improved with structures in which originality is supported in the education process (Sun et al., 2016).

Table 4. Journal Rankings (The Most Cited 10 Journals)

Rank	Name of the Journal	Document	Citations	Total Link Strength	Impact Factor*
1	Thinking Skills and Creativity	15	120	9	3.106
2	British Journal of Educational Technology	2	102	1	4.929
3	Creativity Research Journal	3	79	3	2.371
4	International Journal of Technology and Design Education	2	77	3	2.177
5	Journal of Creative Behaviour	6	65	1	3.153
6	Intelligence	1	59	1	2.770
7	International Journal of Instruction	9	58	13	2.332
8	Clothing and Textiles Research Journal	2	54	3	1.900
9	Nurse Education Today	2	48	1	3.442
10	Human Brain Mapping	1	46	-	5.038

* Impact Factor: The year 2020 values of the journals on their websites

The examination of the studies regarding the countries revealed that studies with the most citations were mainly conducted in the United States of America (see Table 5). Similarly, the first three universities among the most cited 10 universities as presented in Table 2 were also from the United States of America. This ratio indicates that 30% of all universities were those in the USA. The country rankings by the number of citations are in parallel with these results. The country in the second rank among the 10 countries as shown in Table 2 is China with two universities accounting for 20% of the citations. Indonesia is seen at the first rank in terms of total link strength. Considering this, it can be stated that the co-authoring networks of authors working in Indonesia are in a wider range. Another country that ranks second in terms of total link strength is Turkey. If a ranking is to be made in terms of the total number of studies, it is seen that the country in first place is Indonesia and China is second.

Table 5. Country Rankings (First 10 Countries with Most Citations)

Rank	Country	Document	Citations	Total Link Strength
1	The United States of America	34	304	14
2	China	59	176	6
3	Indonesia	87	150	22
4	Saudi Arabia	3	102	2
5	The United Kingdom	9	95	2
6	Turkey	15	72	17
7	France	2	62	2
8	Germany	2	61	1
9	Brazil	2	47	1
10	The Netherlands	4	46	8

Co-authorship: Authors

The "Co-authorship" analysis of the studies examined is presented in Figure 3. The non-relational network map was accessed from the 'co-authorship according to authors' tab at the VOSViewer program. The studies with 25 or more authors were not included in the analysis. When the authors with at least one publication were added to the analysis, information for a total of 774 authors was retrieved. However, a network was generated only for 29 authors in the resulting visual because there was not a bibliometric network among all authors. The clusters formed through the networks of the co-authorships of authors were colorized according to years. As the colors gradually moved from purple to yellow, current studies of authors emerged from 2010 to 2020. All authors were represented in the map, in which seven clusters became evident through the relational network of the co-authorship networks. The size of the shapes in the visual vary depending on the number of citations the authors received. Of the clusters that emerged, authors such as Hobri (N=22), Saadah L. Z. K. (N=3), Irvan M. (N=3), Hadi A. F. (N = 1), and Kusumawati R. (N = 1) were in the most emergent one (f=5). Another characteristic of this cluster is that it is the yellow cluster with the most recent studies. The studies that caused this cluster to take place in the co-authorship network map were "Implementation of Integrated Inquiry Collaborative Learning Based on the Lesson Study for Learning Community to Improve Students' Creative Thinking Skill" (Kusumawati & Hadi, 2019) and "The Application of Problem Based Learning (PBL) Based on Lesson Study for Learning Community (LSLC) to Improve Students' Creative Thinking Skill" (Saadah & Irvan, 2019). In addition, only the author Hobri had co-authoring networks with other clusters, so a network was formed with other clusters.

Particularly the study by Hobri, Tohir M., Abidin Z., and Dafik entitled "Students Creative Thinking Skills in Solving Two Dimensional Arithmetic Series Through Research-Based Learning" created a common network with two other salient clusters (Tohir & Abidin, 2018). Likewise, Hobri's research with Nazareth E., Romlah S., Safitri J., Yuliati N., Sarimanah E., Monalisa L.A. and Harisantoso J. entitled "The Students' Creative Thinking Ability in Accomplishing Collaborative Learning-Based Open-Ended Questions" made him appear in a network of co-authorship with two distinct clusters (Hobri et al., 2019).

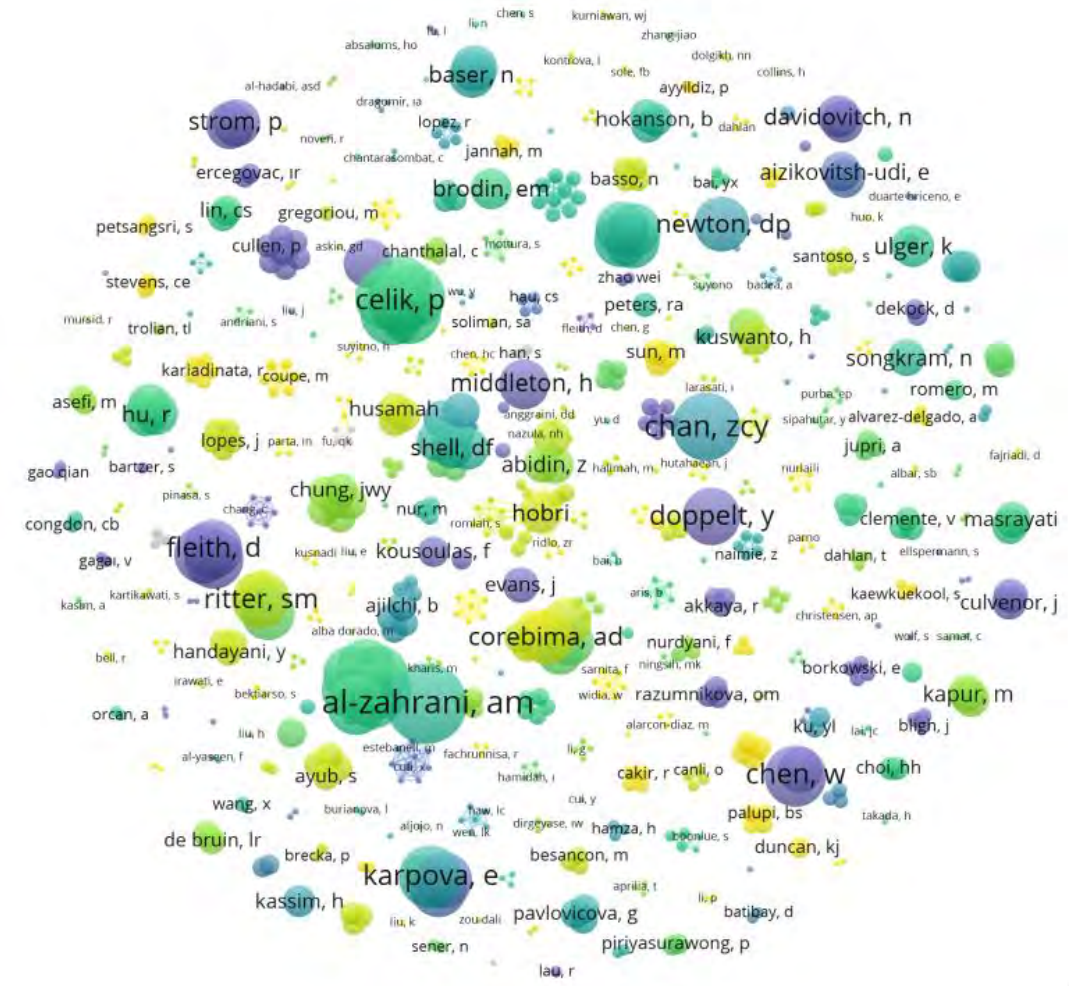

Figure 3. Co-authorship Network Map (by Years)

Co-occurrence: Keywords

The relational network map for the keywords used by authors in the studies examined is presented in Figure 4. The keywords (co-occurrence: keywords) map in the figure was generated according to the frequency of at least one-time use. It was observed that even though a total of 630 keywords were used, a relational network appeared for 526 of them. In the resulting visual, 76 clusters were formed. Of these clusters, pink, red, green, purple, blue, yellow, and orange ones were visible. The keywords used in the pink cluster (Item=16) were more definite compared to other clusters due to their total link strength and frequency of use. The phrase "Creative Thinking" stands out in terms of the frequency of common use (Total Link Strength=352). It is seen that this cluster is evident by the theme of our study. On the other hand, the phrases "Critical and Creative Thinking," "Curriculum," "Learning Models," and "Teaching Strategies" were prominent in the red cluster (f=26). The words in this cluster were mainly associated with studies about students' tendencies to problem-solving and creative thinking in curricula and teaching processes. The word most frequently used in the purple cluster (f=18) was "Creativity" (Total Link Strength=173). Apart from this word, others such as "Drama," "Education," "Interior Architecture," "Improvisation," and "Museum Historical Artefacts" were notable in this cluster. It is seen that the words in this cluster are those related to the creativity and thinking skills of students in the education and training of different

art fields. In the green cluster (f=19), another cluster that stood out, the most distinguished phrase was "Creative Thinking Skills" (Total Link Strength =29). A relationship between creative thinking skills and phrases such as "Computer-mediated Training Program," "Educational Robotic," "Science Fiction," and "E-mind Map" came to the fore in this cluster. This cluster appears to be related to the network of science and technology-centric words. In the blue cluster (f=19), another prominent network, words such as "E-learning," "Blended Learning," "Educational Technology," "Knowledge" and "Virtual Classroom" were seen. It appears that the words in this cluster are mostly related to supporting the traditional training methods with online environments and virtual classrooms and offering hybrid learning opportunities. Meanwhile, the keywords such as "Gamification," "Innovation," "Stem Education," "Digital Learning," "Electronic Book," and "Virtual Learning Ecosystem" emerged in the turquoise cluster (f=17). It is seen that the common aspect of these words is to use digital media as an access point to game technology, science, and mathematics to improve the questioning ability of the student. Since other clusters did not have a substantial difference, the relational network map analysis of keywords was expressed in this way.

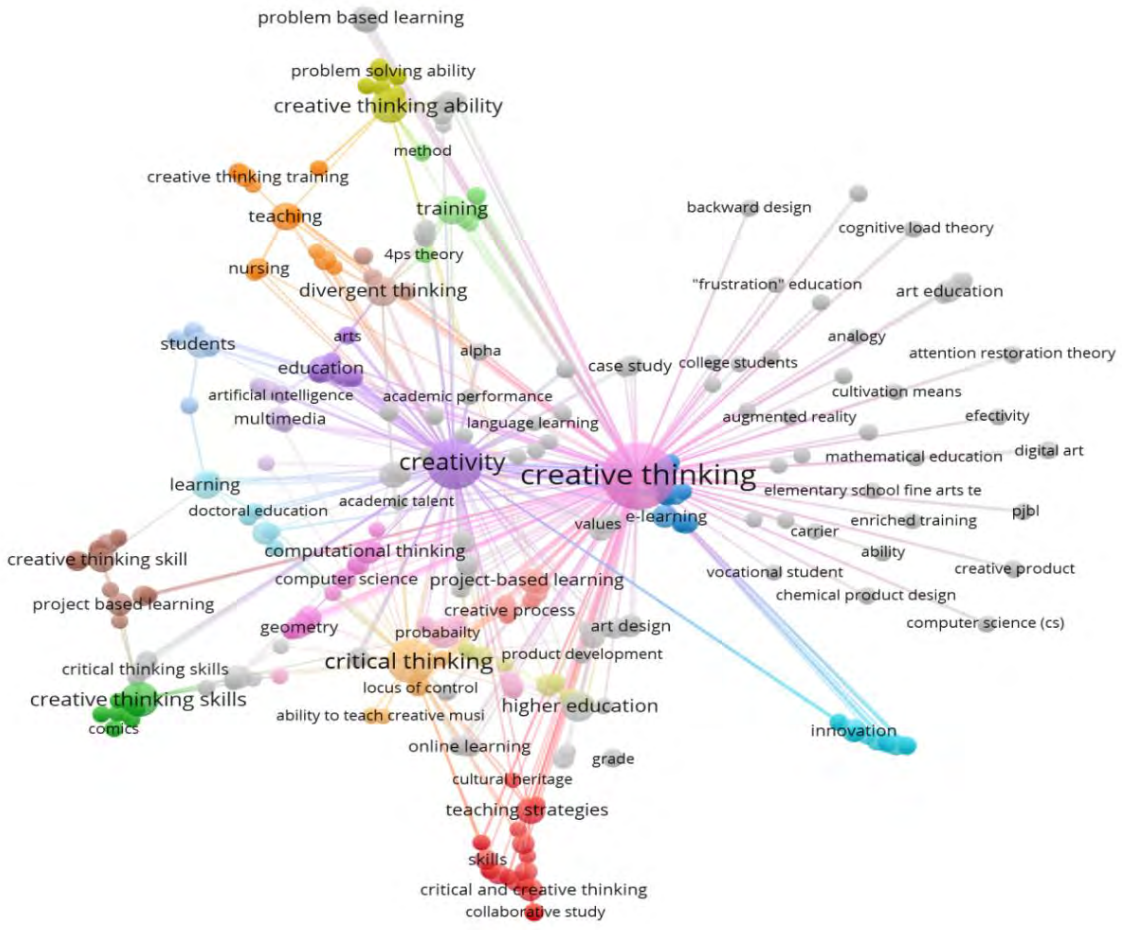

Figure 4. The Network Map of Most Frequently Used Keywords

Citation: Documents

The density visualization map of the most cited studies investigated in this research is presented in Figure 5. All

studies are included in our research regardless of the number of citations. The phrase “minimum number of citations of a document=0” was entered into the program, which yielded data for a total of 326 studies. However, a network occurred only among 52 of the studies. In the visual that emerged, 12 clusters were formed. The gradual change in the color value of the blue, green, yellow, and red shapes is indicative of the number of citations in the visual. The study in the most visible area was the research conducted by Al-Zahrani (2015), and it investigated the effect of flipped classes on students’ creative thinking. In another area that stood out, the study by Karpova et al. (2011) was located. This study, in general, outlined how the creative thinking skills of university students could be improved. Doppelt’s (2009) research investigating the relationship between project-based learning and creative thinking was located in another definite area. In the research, after the students of the mechatronics department at a high school were informed about creative designs, they were asked to design their projects, and the projects were evaluated on the scale of creative thinking. Another study that attracted attention on the map was by Chan (2013). A systematic review of creative thinking studies in nursing education was carried out in the research. Another study that came to the front was conducted by Newton (2013). It can be said that a different point is dealt with in this study compared to others. The study noted that when designing curriculums, students' cognitive levels are generally considered, but their emotional states are ignored. Therefore, if a teaching is to be planned, it is emphasized that students’ creative thinking skills will improve when they are given active roles during the planning phase taking into account their moods. In addition, Forthmann et al. (2016) stated that divergent thinking develops creativity. Lastly, Sun et al. (2016) stated that brain functions should be made more operational to increase creativity.

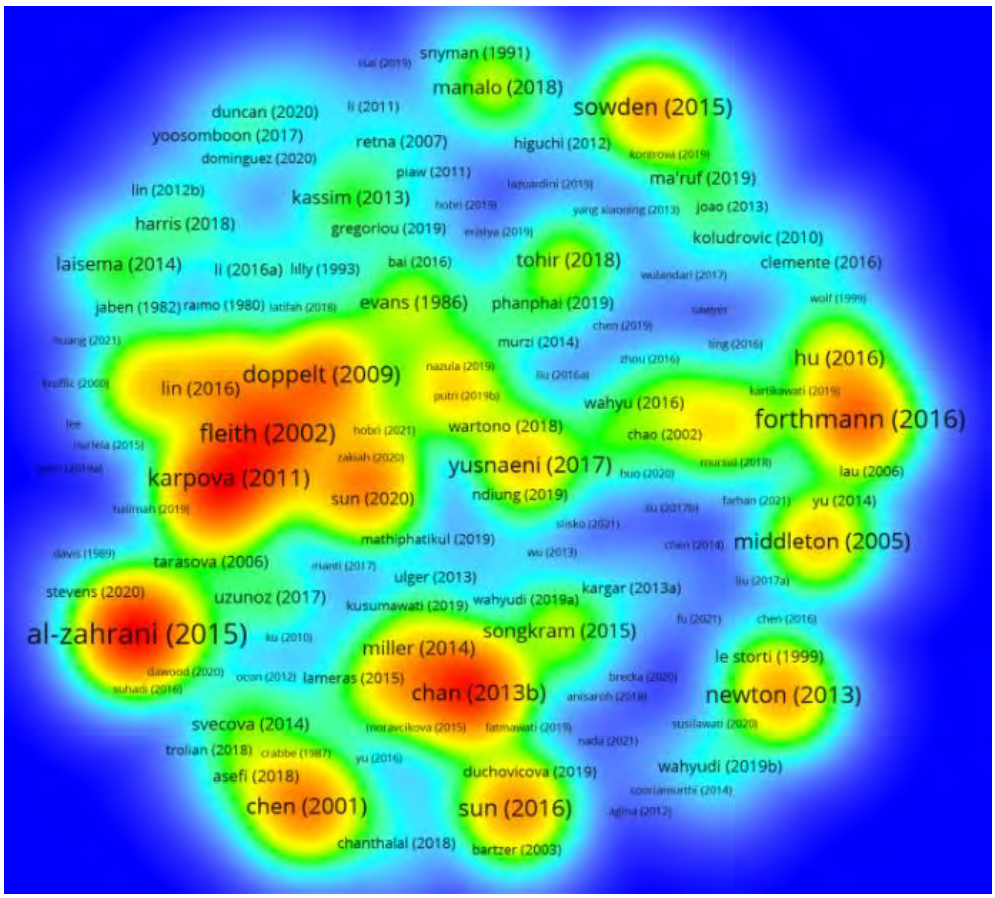

Figure 5. Density Visualization of the Most Cited Studies

Citation: Authors

The authors who received the most citations among the studies examined in this research and the relational network map they created are shown in Figure 6. Studies with 25 authors and above were not included in the analysis. As a result, data for a total of 774 authors were retrieved, but a relational map for only 157 of them occurred. In the visual that was generated, 14 clusters emanated. The size of the circles that symbolize the authors in Figure 6 indicates the multiplicity of citations. From these clusters, yellow, green, turquoise, red, purple, pink, gray, and orange clusters were visible. When the authors were listed according to the number of the citations they received in the turquoise cluster (f=12), which was the most visible one, Karpova, E. (N=57) came first followed by authors such as Westberg, K.L. (N=47), Ranzulli, J.S. (N=47) and Fleith, D.D. (N=47). Al-Zahrani, Abdulrahman M. (N=102), previously given first place in Table 1 according to the number of citations, is not listed in the visual due to not having any connections to the other authors in the image (Total Link Strength=6). In the grey cluster (f=7), Chan, Z.C.Y. (N=67) stands out. On the other hand, Ersoy, E. (N=26) and Başer, N. (N=26) are the prominent authors in the red cluster (f=23). The paper that was co-authored by these researchers with the title "The Effects of Problem-Based Learning Method in Higher Education on Creative Thinking" ranks the first in terms of total link strength among the studies within the scope of our study (Ersoy & Baser, 2014). In the yellow cluster (f=13), Corebima, A.D. (N=39), Zubaidah S. (N=30), Yusnaeni (N=29), and Susilo, H. (N=29) were the authors who came into prominence according to their citations. Since the authors who were located in the terminal ends in the visual had citation relations only with some authors in the neighbouring clusters, they can be said to be located in extreme areas that are weak in terms of connection strength.

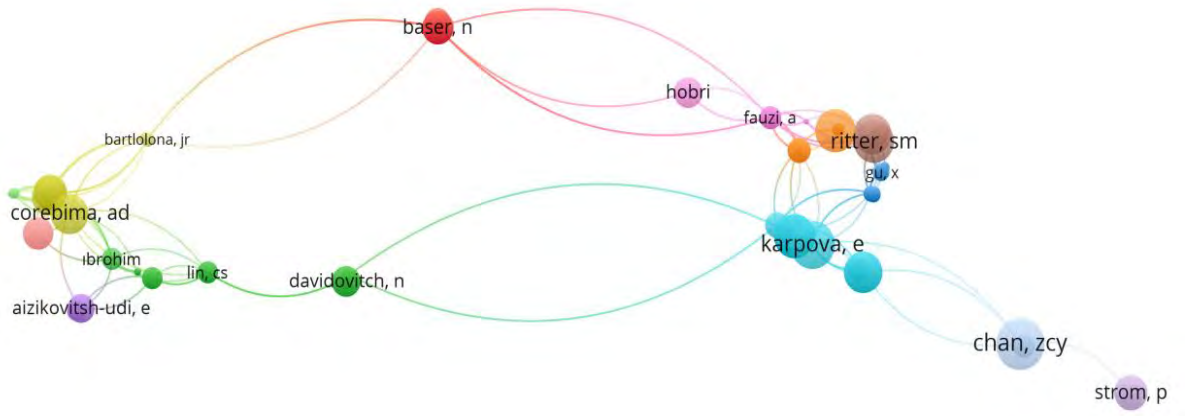

Figure 6. The Network Map of the Most Cited Authors

Citation: Countries

The countries that received the most citations in the studies examined and the relational network map they created are presented in Figure 7. While the countries with at least one study were included in the analysis, studies with 25 or more authors were excluded. In this manner, data for a total of 50 countries were obtained. However, a relational map was generated for only 21 countries among the data. Seven clusters were formed in the image of the map. The size of the circles symbolizing the countries in the visual varies according to the number of citations.

In this respect, large circles were interpreted as more citations. The red, yellow, green, purple, turquoise, orange, and blue clusters were clearly visible among others. In the purple cluster (f=3), the countries Indonesia (N=150), Turkey (N=72), and Israel (N=41) were situated. Indonesia and Turkey came in first place in terms of total link strength. Therefore, it can be said that they created connection points with other clusters. The United States of America (N=304), Germany (N=61), and Brazil (N=47) were the countries that stood out in the green cluster (f=4). In the turquoise cluster (f=2), China (N=176) and Thailand (N=52) were definite. Saudi Arabia (N=102) attracted attention regarding the number of citations in the yellow cluster (f=3). On the other hand, the salient country was Japan (N=23) in the red cluster (f=4). In this cluster, Japan, Italy, and Belgium made connections only with Iran, while Iran had a connection only with Israel in the purple cluster. Lastly, the countries the United Kingdom (N=95), France (N=62), and the Netherlands (N=52) were located in the blue cluster (f=3). It is seen that the UK in this group has links only to France and the Netherlands.

Figure 7. The Network Map of the Most Cited Countries

Co-citation: Cited Authors

The relational network of the most cited co-cited authors is presented in Figure 8. The "minimum number of citations of an author: 5" was entered as the query string during the analysis. The reason for this choice is that the clusters generated can be presented more clearly. In this manner, data for a total of 143 authors were accessed. However, a relational network map occurred among 142 of them. Seven clusters were generated in the visual. The size of the circles representing the authors in the image indicates the magnitude of the total link strength. The green, red, yellow, purple, blue, and turquoise clusters were salient among other clusters. When evaluating the authors, the magnitude of the total link strength values revealed the frequency with which the author is quoted jointly by other authors. In this respect, Ellis Paul Torrance was determined as one of the most co-cited authors with one of the highest total link strengths (Total link strength =1187) in the blue cluster (f=18). This author's studies about creativity have a worldwide reputation. The author has a creative thinking test named "Torrance Tests of Creative Thinking" developed in 1966, and it is still used in various forms (Torrance, 1966). It is known that this test has been translated into more than 35 languages (Millar, 2002). It has also been stated that this test is the most widely used creativity test (Davis, 1997) and the most applied test among all creativity tests (Lissitz & Willhoft, 1985). It is seen that this research has contributed a substantial amount to researchers conducting studies on creativity. In the green cluster (f=33), which was another distinctly visible cluster, Marc A. Runco was

the most co-cited author with the highest total link strength (Total link strength=1209). Considering that a total of 33715 citations were made to all studies of this researcher, it is evident that this author has contributed to the field of creativity and thinking skills at the highest level. His book "The Standard Definition of Creativity" has been cited 2476 times within the last 10 years (Runco & Jaeger, 2012). In the same cluster, Robert J. Sternberg attracts attention as the second most co-cited author with the second-highest total link strength (Total link strength=982). This author is known to be one of the leading figures in the field of psychology. Particularly, his studies on triple intelligence theory and subjects such as creativity and thinking are considered significant. His book "Beyond IQ: A Triarchic Theory of Human Intelligence," which is cited 8154 times, is an indication of the contributions Sternberg has made to researchers in this field (Sternberg, 1985).

When examined globally, Lev S. Vygotsky, John Dewey, Howard Earl Gardner, and John W. Creswell are notable authors in the other clusters. These authors are not among the studies investigated in the scope of this research. However, they are among the co-cited authors in the studies examined in our study. Especially, the theories they developed about the education system and in the fields of children's learning psychology still make important contributions to the development of curricula. The need for the student to be at the center of the curriculum is emphasized. On the other hand, John W. Creswell is considered a world-renowned author in mixed-method research. It is thought that the reason he stands out in the visual is that he has contributed to the method sections of the studies carried out. In this respect, it can be stated that the results obtained from our study are consistent with each other and can potentially guide future research.

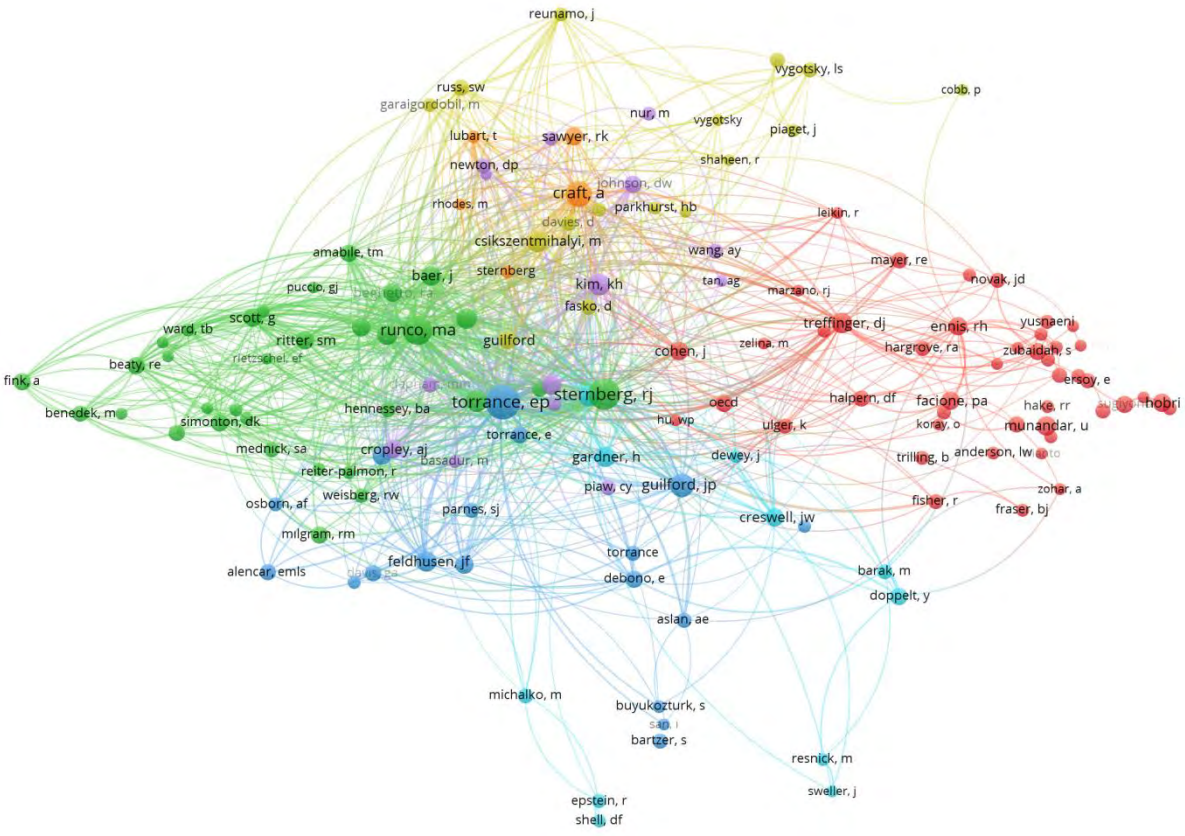

Figure 8. The Network Map of the Most Co-cited Authors

Conclusion

In this study, bibliometric mapping has been used as a means of documenting and analyzing research on thinking skills and creativity in the field of education in the last forty years. Using bibliometric analysis, the study analyzed 326 articles published in the WoS database on thinking skills and creativity in education between 1975 and 2021. Scientists in the United States were found to be at the heart of the studies. However, it can be said that a small group of scientists from Europe and Asian countries have also a limited number of studies in this field. Within the scope of studies on thinking skills and creativity in education, it was determined that the countries most cited were the United States, China, and Indonesia. Although this indicates that the United States is at the center of research on thinking skills and creativity in education, it is noteworthy that the United States is not in the top three in the ranking of the most cited universities. In addition, the studies investigated are published mainly in journals that focus on the scope of teaching thinking skills and creativity. The results also demonstrate that the researchers in this field study a variety of subjects that can be grouped under the three broad fields of "Drama," "Interior Architecture," and "Improvisation." The results suggest that research on thinking skills and creativity in education is examined with a focus on current developments. On the other hand, the interdisciplinary nature of research on thinking skills and creativity in the field of education reflects the progress made by academicians from different disciplines and perspectives. In addition, it can be said that academicians in this field discuss thinking skills and creativity at different levels of education and in association with a wide range of subjects (such as blended learning, gamification, and science fiction). Besides, it is seen that technology-supported elements are included in the studies.

Limitations

While scientific mapping provides a productive complement for research synthesis and meta-analysis, it does not combine the results of multiple independent studies and does not include the statistical results of the research findings obtained. Although the studies included in the current research were produced over forty years, the analyses only selectively examined the temporal dimensions of the studies in this field. Since the bibliometric data in our study were obtained in mid-2022, we could not include the entire year 2022. For this reason, it is possible to express as a limitation that our study covers research until 2021. The analysis of the current study tends to reveal temporal variations in this scientific structure in general. Therefore, the findings of the current study may leave important questions about the evolution of the field unanswered. Research examining the findings based on the last decade (see Berg, Vestena, and Costa-Lobo, 2020) may provide a more detailed picture of the evolution of the field. Another limitation is that the present review is limited to WoS-indexed thinking skills and creativity journals. This resulted in the absence of books, book chapters, papers, articles, and theses published in other databases on thinking skills, creativity, and education. Therefore, the current study has not examined the whole literature on thinking skills and creativity in the field of education. However, it can be said that two factors in the current research alleviate this limitation. Firstly, the database examined in this study is the largest ever compiled in any research review on thinking skills, creativity, and education. The second strength is the ability of the common citation analysis in the VOSViewer program to capture studies outside the database used in the research. The extent to which the findings of the current study can be generalized when all databases are taken into account

is difficult to predict. Another potential associated with the method of the current study also applies to the bias of non-dominance and the gender of the authors.

In the 1980s and 1990s, the publications on thinking skills and creativity in education were mostly written by male scientists. While author citation analyses have shown increased representation among female academics over the past decade, the research data set is not encoded for the gender of the authors. Therefore, the current study provides a limited perspective on the proportional changes of authors in terms of gender variability over time in creativity and thinking skills studies in the field of education. Nevertheless, future research may use similar methodological tools to analyze gender trends in the research over time in the literature related to thinking skills and creativity in education. The results of the current study are not only aimed at the academic community but also appeal to educators and politicians to strengthen the spirit of thinking skills and creativity in education, design effective policy tools, and ultimately improve social well-being.

Statement of Responsibility

Authors contributed equally to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

Conflicts of Interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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