Revista Românească pentru Educație Multidimensională
ISSN: 2066-7329 | e-ISSN: 2067-9270
Covered in: Web of Science (WOS); EBSCO; ERIH+; Google Scholar; Index Copernicus; Ideas RePeC; Econpapers; Socionet; CEEOL; Ulrich ProQuest; Cabell, Journalseek; Scipio; Philpapers; SHERPA/RoMEO repositories; KVK; WorldCat; CrossRef; CrossCheck

2023, Volume 15, Issue 3, pages: 288-311 | https://doi.org/10.18662/rrem/15.3/767
Submitted: November 1st, 2022 | *Accepted for publication:* June 15th, 2023

Examination of Studies on Critical Thinking in Teacher Education: a Bibliometric Analysis

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Abstract: *The purpose of this paper is to examine the studies conducted on critical thinking in teacher education using bibliometric analysis method. Education Educational Research category of Web of Science was preferred as the database. 2,717 publications published between 1989 and 2022 were analyzed using citation, bibliographical coupling, and co-occurrence techniques. Obtained results reveal that the earliest works on critical thinking in teacher education were published in 1989. It was determined that critical thinking in teacher education was met with increased interest after 2010, and that 2019 was the year when the published papers reached a record high. An examination of the citation years of the studies showed that 2021 saw the highest number of citations. USA was found as the country with highest number of publications on critical thinking in teacher education. Most researchers publish their works on the field in the form of articles, and English is the most preferred publication language. The author with the highest citation figures in the field is found as Hwang, Gwo-Jen, while the most frequently cited work was written by Fang in 1996. Document with the highest number of links was authored by Gomez-Jarabo and Sosa in 2018. The keywords with the highest popularity in the studies of researchers in recent years, which have the highest total number of links, were identified as teacher education, higher education, education, learning, curriculum, professional development, creativity, technology, and pedagogy. In this context, researchers who will perform studies in the field are especially advised to prefer keywords with high citation rates in literature review stage. Similarly, researchers are recommended to examine the documents with high citation and link scores in the field. Finally, in their efforts to regulate teacher education policies and programs, countries are advised to find examples in national settings with high total link scores as regards critical thinking approach.*

Keywords: *Teacher education programs, pre-service teachers, 21st century learning skills, bibliometric analysis method.*

How to cite: Hursen, C. (2023). Examination of Studies on Critical Thinking in Teacher Education: a Bibliometric Analysis. *Revista Românească pentru Educație Multidimensională, 15*(3), 288-311. https://doi.org/10.18662/rrem/15.3/767

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1. Introduction

Critical thinking is one of the high-profile thinking skills which individuals should possess in the 21st century. John Dewey introduced the concept of critical thinking in 1910 in his book titled "How we think" was defined. Progressive Education Association in the United States of America encouraged critical thinking concept as a criterion in its eight-years action in 1930s. In 1941, Glaser defined the concept of critical thinking as "an attitude of being prone to reflectively consider questions and issues that fall within one's field of experience, knowledge of logical inquiry and reasoning methods, and the knowledge and ability to apply these methods." In 1962, Robert Ennis described critical thinking as "the correct assessing of statements" (Hitchcock, 2011). In 1970s and 1980s interest towards critical thinking increased, and in 1990s Delphi report was published in the field of critical thinking, which was prepared by 46 specialists including philosophers, psychologists and education researchers. The report defined critical thinking as "purposeful, self-regulated judgment that results in interpretation, analysis, evaluation and inference, as well as an evidence-based, conceptual, methodological, criterion or contextual decision-making mechanism" (Hitchcock, 2011).

Defined as rational, reflective, systematic and productive thinking ability employed to evaluate a situation and make a decision (Susiani et al., 2018), critical thinking is also explained as an indicator that helps individuals to solve problems properly and shows the level of reflective thinking skills (Nuraini et al., 2020). Accepted as a vital target of education (Wan et al., 2022), critical thinking is explained as cognitive processes required to deal with complex challenges (Alvarez-Huerta et al., 2022). Halpern (2013, p. 2), who described critical thinking as a type of reasoning used in problem solving, formulating deductions, calculating possibilities and making decisions, offered 4-stage model for its development:

1. *"Explicitly teach the skills of critical thinking*
2. *Develop the disposition for effortful thinking and learning*
3. *Direct learning activities in ways that increase the probability of trans-contextual transfer (structure training)*
4. *Make metacognitive monitoring explicit and overt"*

Watson-Glatser, one of the leaders in the development of critical thinking skills, examined the steps of critical thinking skills in 5 stages:

1. *"Inference Making*
2. *Recognition of Assumptions*
3. *Deduction*

4. *Interpretation*
5. *Evaluation of Arguments"* (Zulmaulida et al., 2018, p. 5).

Critical thinking, defined with the questions "what, when, where, how, who, and why", is explained as an important educational life skill that can be taught and learned, which is considered extremely necessary to increase success and deepen understanding among disciplines (Zandvakili et al., 2019). Arguing that critical thinking plays an essential role in problem solving, Fitriana, Fuad and Ekawati (2018) emphasized that this approach should be integrated into the curricula so as to improve the learning, performance and questioning skills of students. Lim (2015) underlined the importance of critical thinking in education programs and stated that schools should make some arrangements so as to encourage and improve thinking patterns of students. Emphasizing that critical thinking is not a novel concept in education, Lombardi, Mednick, De Backer and Lombaerts (2021) supported Lim and explained that in order to improve critical thinking skills of individuals, it should be integrated in the curricula. Oner and Gunal-Aggul (2021) claimed that one of the fundamental objectives of education at all grade levels is to develop critical thinking skills and stated that future teachers should be trained as critical thinkers in order to develop the critical thinking skills of students. In this context, critical thinking should be an essential part of teacher education and systematically included in teacher education programs (Oner & Gunal-Aggul, 2021). Özelçi and Çalışkan (2019), on the other hand, found in their study that the opinions of pre-service teachers as regards critical thinking do not change with time, and that they refrain from making decisions, questioning and researching. Teachers are expected to be prepared for the responsibilities of the education of the new generation in terms of change, fluency, and flexibility; for this reason, teacher education programs must be designed to meet this expectation. One of the most important tasks of teacher education is to encourage students to think critically and to establish the connection between teaching and learning. Pre-service teachers must teach students how to think critically and provide opportunities for them to be raised as critical thinkers. This requires pre-service teachers to command critical thinking skills and have self confidence in their abilities (Lorencová et al., 2019). Teachers must focus on the content, learning process and assessment methods so as to support critical thinking, and use questioning techniques that reinforce analyzing, synthesizing and evaluating knowledge instead of teaching methods that encourage rote learning. Arguing that the biggest obstacle to integrating critical thinking skills into the classroom is time constraints, the researchers

also state that instructors should focus on student learning rather than content (Snyder & Snyder, 2008).

Defining critical thinking as the most important indicator of learning quality of learners Alsaleh (2020) underlined that critical thinking should be included in teaching approaches so as to raise critical thinkers, and emphasized that more studies on new approaches are needed to teach critical thinking abilities. Similarly, Nor and Sihes (2021) argued that one of the most essential targets of education in the 21st century is to reinforce critical thinking abilities, and that teachers should use different methods and techniques in education to improve the critical thinking skills of learners. Özelçi and Çalışkan (2019), on the other hand, point out that critical thinking skills, which develop the ability of individuals to make sense of the world and the events around them, are one of the leading research areas in the education systems of various countries. In this context, the purpose of this paper is to examine studies conducted on critical thinking in teacher education using bibliometric analysis method and to determine the tendencies in the field. In addition, it is aimed to analyze the countries, researchers, resources, and documents that give direction to critical thinking studies in teacher education, and thus to identify the development of critical thinking in teacher education and the gaps in the field. It is believed that this study will serve as a guide for researchers who will carry out research on critical thinking in teacher education to reach scientific data.

2. Method

In this study, bibliometric analysis method was used with the purpose of conducting a systematic evaluation on critical thinking in teacher education. Bibliometric analysis is a technique used to determine tendencies in the field, choose research components and cooperation models in a research topic, and explore and analyze large datasets (Castañeda et al., 2022). In this context, bibliometric analysis was preferred in this paper to identify the development and direction of critical thinking studies in teacher education from the past to the present and to offer a broad perspective to researchers in the field.

2.1. Data Collection

Web of Science (WoS) Core Collection database was preferred for the bibliometric analysis technique in this study. WoS is the world's oldest, most widely used, and most reliable research publications and citation database which offers services such as daily search and discovery by researchers around the world, provision of analytical datasets, and exclusive

access to raw data for bibliometric partners. WoS was chosen as it is a selective citation index (Birkle et al., 2020) of scientific publications covering journals, proceedings books and data collections.

In the study, advanced search function and topic option was preferred in the Web of Science Core Collection (TS= *teacher education AND critical thinking*) using keywords in Web of Science database. All languages, all document types (Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI) and all years were included in the search. The query retrieved 3,898 publications, but this study included 2,717 of them which were published in Education Educational Research category. The first year of publication was found as 1989. Data collection process ended on 29 August, 2022.

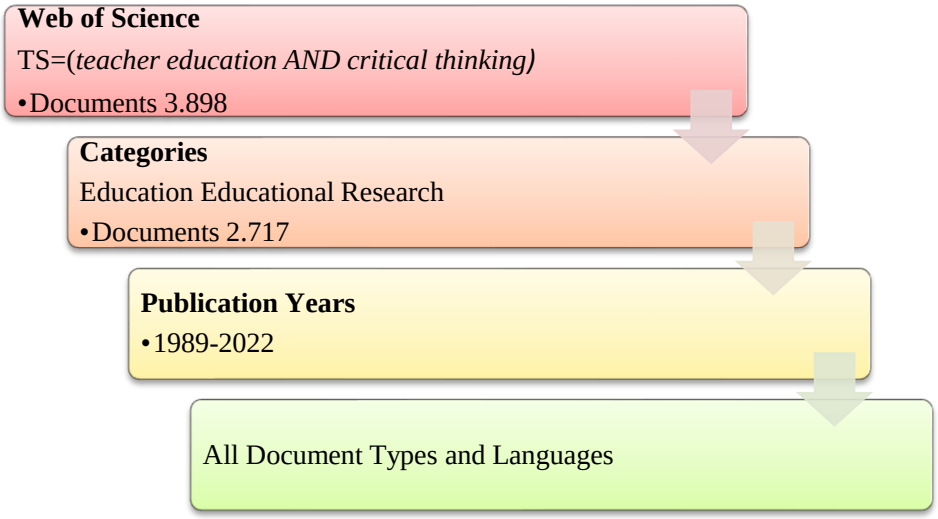


Figure 1. Data collection process and criteria

2.2. Data Analysis

In the study, 2717 publications published on critical thinking in teacher education in the Education Educational Research category of Web of Science database between the years 1989 and 2022 were analyzed using bibliometric analysis method. Network structures of the publications subject to bibliometric analysis were examined using VOS viewer software (version 1.6.18, https://www.vosviewer.com). Developed by Van Eck and Waltman (2010), VOSviewer is a free of charge software tool used for creating and visualizing bibliometric networks that allows for viewing and interpreting large bibliometric maps easily (VOSviewer, 2020).

Bibliometric networks created with VOSviewer include journal, researchers or individual publications. These provide data mining functionality that can be used to determine citations, bibliographic couplings, co-authorship relations or networks in which important terms extracted from the literature occur together (co-occurrence). Bibliometric methods which are used to define, evaluate and monitor published studies represent a quantitative approach that direct the researcher to the most effective works, provide an unbiased mapping of the research field, express the findings, citations, cooperations and opinions of the researchers, and display insights as regards the structure of the field, social networks, and current areas of interest (Župič & Čater, 2015).

Bibliometric data and indicators which emphasize the structure of scientific disciplines and their interrelations also define the questions that arise in the scientific world. Župič and Čater (2015) explained bibliometric methods in 5 main titles: citation analysis, co-citation analysis, and bibliographical coupling methods use citation data to create impact and similarity criteria, whereas co-author analysis employs co-authorship data to measure cooperation, and co-word analysis explores the connections between titles, keywords or abstracts that occur together in documents. Okubo (1997) stated that the citation method was accepted as a criterion of the impact, currency and practicality of cited articles. Co-authors citation is, on the other hand, used to determine the cooperation through publications which are written by at least two different researchers. Co-citations measure the number of simultaneous citations of two articles to the same article, showing thematic networks and the influence and strength of the authors. Clusters of co-citations can show the development of fields and sub-fields. Co-occurrence, on the other hand, examines the frequency with which words given in a particular field are used together in articles or patents. For each word, its frequency and association with another word are analyzed (Okubo, 1997). Bibliographical coupling method, on the other hand, combines documents, authors and journals according to the number of shared citations, and helps to identify documents that refer to a common source (Kessler, 1963; Župič & Čater, 2015). In this study, the publications in the data set (n=2.717) were analyzed using citation, bibliographic coupling and co-occurrence methods. The citation analysis method was preferred in order to determine the impact of authors, documents and countries, and to guide researchers about important specialists and works in the field. A bibliographic coupling analysis was performed to combine documents and countries according to the number of shared citations, and co-occurrence

analysis method was used to determine the frequency of use of keywords related to the field together in publications.

2.3. Limitations of the study

The study was limited with Web of Science database, an online electronic source, and with Education Educational Research category, one of the categories listed in this database. Bibliometric analysis was preferred as the method in this study, and citation analysis, bibliographical coupling and co-occurrence were used as analysis techniques. The search index was limited with the terms "teacher education" and "critical thinking".

3. Findings

In the findings section of the study, the distribution of studies (n=2.717) published in the Education Educational Research category of Web of Science between 1989 and 2022 will be tabulated according to publication years, languages, countries, and document types. In addition, publications in the dataset will be analyzed, tabulated, and interpreted in this section using citation, bibliographical coupling and co-occurrence analysis techniques.

3.1. Findings regarding publication year, language, country and document types of publications

3.1.1. Distributions by year of publication and time of citation

The findings regarding the years and citation figures of the publications published on "critical thinking in teacher education" in the category of Web of Science Education Educational Research are given in Figure 2. Findings obtained from the study displayed that the earliest study on critical thinking in teacher education was published in 1989. It has been found out that not many studies were published on critical thinking in teacher education in 1990s, and that the number of studies began to increase after 2010 and reached a record high in 2019 (n=309, 11.373%). When the findings regarding the citation times of the studies were examined, it was determined that the year with the highest number of citations was 2021 (Publications=256, Citations= 3325). The findings reveal that the interest in critical thinking studies has increased in recent years.

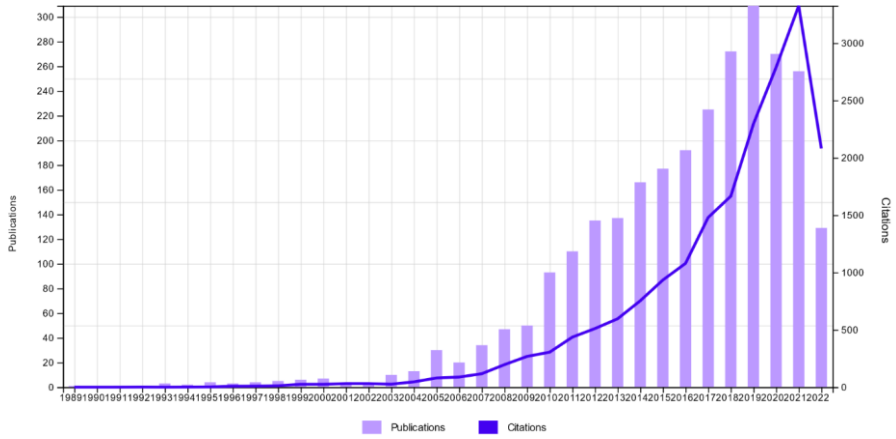


Figure 2. Times Cited and Publications over Time
https://www.webofscience.com/

3.1.2. Distributions by language of publications

The distribution of studies on critical thinking in teacher education according to the languages in which they are published is given in Table 1.

Table 1. Distribution of studies by languages

Languages	Frequency	Records % of 2.717
English	2352	86.566
Spanish	191	7.030
Portuguese	102	3.754
Russian	27	0.994
Turkish	16	0.589
French	4	0.147
Ukrainian	4	0.147
Chinese	3	0.110
Croatian	3	0.110
Icelandic	3	0.110
Italian	2	0.074
Latvian	2	0.074
Serbian	2	0.074
Czech	1	0.037
German	1	0.037
Polish	1	0.037
Slovak	1	0.037
Slovenian	1	0.037
Unspecified	1	0.037

Source: Author's own conception

As can be seen in Table 1, majority of published works were written in English language (n=2352, 86.566%) followed by Spanish (n=191, 7.030%) and Portuguese (n=102, 3.754%).

3.1.3. Distribution by countries

One of the objectives was to determine the distribution by country of the 2717 publications analyzed in the study. Obtained findings display that 112 countries have publications on critical thinking in teacher education. It was found out that the USA is the country with the highest number of publications (n=584, 21.494%) followed by Spain (n=277, 10.195%), Australia (n=179, 6.588%), Turkey (n=150, 5.521%), England (n=147, 5.410%), Brazil (n=120, 4.417%), Peoples Republic of China (n=111, 4.085%), Canada (n=89, 3.276%), South Africa (n=70, 2.576%), and Russia (n=63, 2.319%).

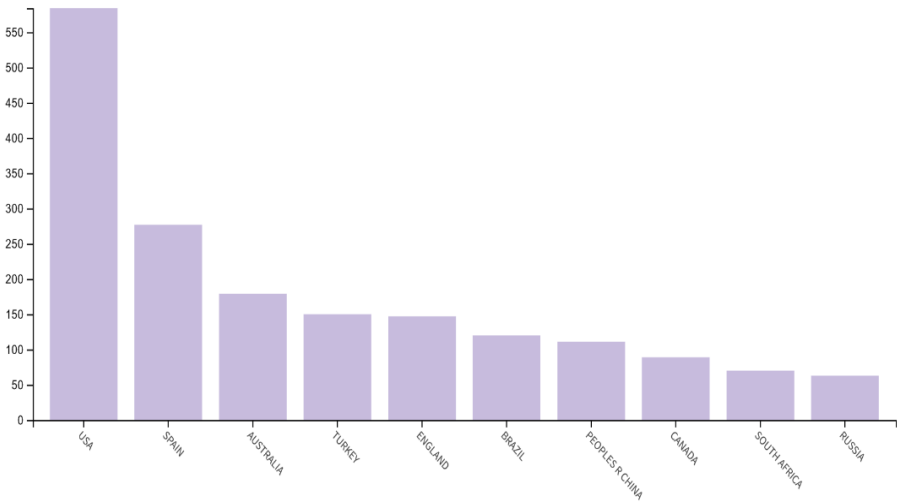


Figure 3. Distribution of studies by country
44 records (1.619%) do not contain data in the field being analyzed
https://www.webofscience.com/

3.1.4. Distribution of publications by document types

When the document types of the publications were examined, it was determined that 1,981 of the 2,717 publications were articles (72,911%). The distribution of studies according to document types is detailed in Table 2.

Table 2. Distribution by document types

Document Types	f	Record Count % of 2.717
Article	1981	72.911
Proceeding Paper	668	24.586
Book Chapters	83	3.055
Early Access	73	2.687
Review Article	63	2.319
Editorial Material	10	0.368
Book Review	3	0.110
Book	2	0.074

Source: Author's own conception

It is seen that "article" and "proceeding paper" are the most preferred types of publication on critical thinking in teacher education (n=668, 24.586%) whereas "book" is the least popular type of document on the subject (n=2, 0.074%).

3.2. Citation, bibliographical coupling and co-occurrence analyzes of publications

Citations of the authors

The authors who conducted studies on critical thinking in teacher education with the highest citation strength are given in Figure 4 using density visualization. Maximum number of authors per document was limited with 25. In this analysis, the total strength of citation links with other authors was calculated for each author and the authors with highest link strength were chosen. The minimum number of publications of a researcher was 5, and 3 of the 5875 authors reached the threshold.

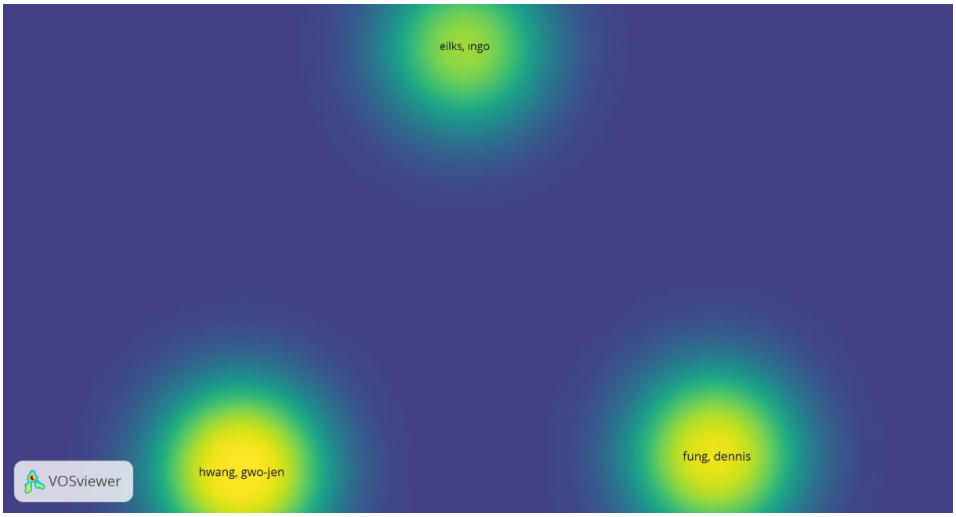


Figure 4. Density maps of the most cited authors
Source: Author's own conception

The author with the highest citation strength was identified as "hwang, gwo-jen" with 12 documents and 189 citations. Other authors were "eilks, ingo" with 5 documents and 144 citations, and "fung, dennis" with 9 documents and 100 citations, respectively.

Citation of the countries

Maximum number of countries per document was decided as 25 in the analysis conducted to determine the countries with the highest citation strength. As a result of this analysis, minimum number of publications of any country was found as 5, and 65 of the 113 countries reached this threshold. For each of the 65 countries, total strength of citation links with other countries was calculated, and countries with the highest link strength were chosen. In the analysis, items were estimated as 56, clusters as 12, links as 254 and total link strength as 632.

In the study, USA was determined as the country with the highest citation power (Documents, 575; Citations, 6908; Total link strength, 166). The inter-country relations of studies on critical thinking in teacher education are given in Figure 5 with network visualization.

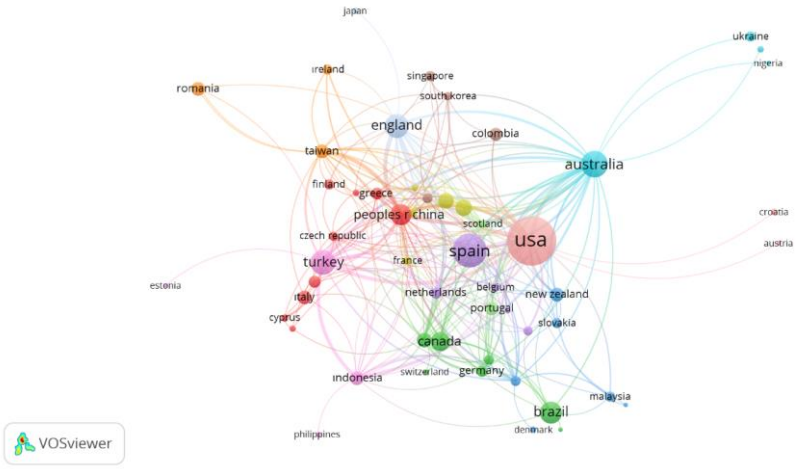
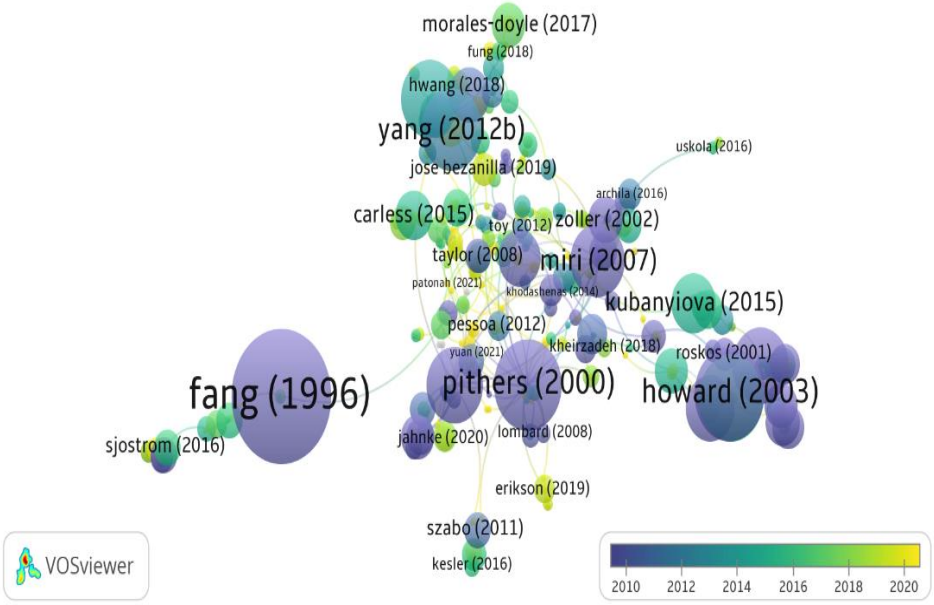


Figure 5. Network maps of the countries with the highest citation strength
Source: VOSviewer (2020)

Countries with the highest citation strength consist of 12 different color clusters, which indicate the interconnections of respective countries. It can be inferred from the foregoing that studies conducted in the countries in the same cluster tend to cite each other more frequently. In the largest cluster, USA was determined as the country with the highest citation power with 575 documents (citations=6908, total link strength=166). Croatia and Austria are in the same cluster with the USA. Australia is in the cluster with the second highest citation strength with 175 documents (citations=2033, total link strength=132). Ukraine, Saudi Arabia, and Nigeria are in the same cluster with Australia. England is in the third cluster with 142 documents (citations=1818, total link strength=83) accompanied by Japan. In the fourth cluster Taiwan, Ireland and Romania can be seen. Peoples Republic of China, Finland, Greece, Czech Republic, Mexico, Italy, Pakistan, Argentina, and Cyprus are in the fifth cluster. The sixth cluster includes Spain, the Netherlands, Belgium, Chile, and United Arab Emirates, while Turkey, Estonia, Indonesia, and Philippines are in the seventh cluster. New Zealand, Slovakia, Israel, Malaysia, and Denmark constitute the eighth cluster, and Sweden, Canada, Switzerland, Norway, Germany, Brazil, and Lebanon can be found in the ninth. The tenth cluster includes South Africa, Russia, Kazakhstan, and France, whereas Singapore, South Korea, Colombia, and Iran are in the eleventh cluster. Finally, it can be seen that Scotland, Portugal and Hungary are the countries with the highest citation power in the twelfth cluster.

Citation of the documents

2,717 documents on critical thinking in teacher education cross the threshold. By calculating the number of citation links for each of the 2,717 documents, the 1000 documents with the most links were selected. The overlay and density visualization analyzes of the most cited documents are given in Figure 6. As a result of the citation analysis, 356 items, 41 clusters and 468 links were determined.



Source: VOSviewer (2020)

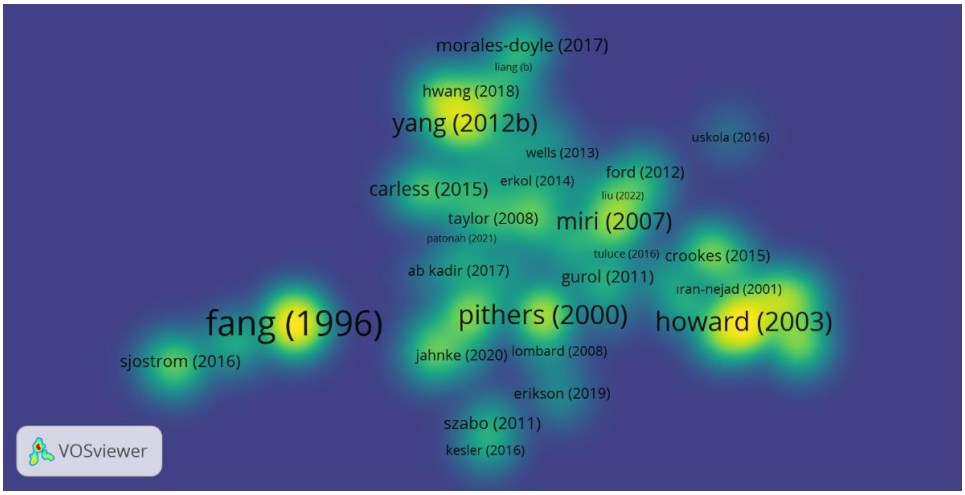


Figure 6. Time and density map of documents with high citation strength
Source: VOSviewer (2020)

One of the objectives of this study is to identify the most important works int eh field through citation rates. In this context, when Figure 6 is examined, it can be seen that the most important works of the field were produced between 2010 and 2020. According to the size of the clusters, the document with the highest citation strength was produced by Fang (1996) (Fang, Z.H. (1996). Educational research, 38, 47-65) (Citations=582, Links=4). When the citation rates are examined, it is seen that the other documents with high citation power in the field belong to Howard (2003), Yang and Wu (2012b), Pithers and Soden (2000) and Miri, David and Uri (2007).

Bibliographic coupling of the countries

Bibliometric analysis method was used to determine the similarity between countries as regards studies on critical thinking in teacher education. Network visualization analysis for bibliometric coupling of countries is given in Figure 7. Each node represents a country, and each color represents a cluster. In the analysis, the maximum number of countries per document is 25, the minimum number of publications is 5, and 65 out of 113 countries reached the threshold. The countries with high link strength were determined by calculating the number of publications, citations, and total link strength of 113 countries.

The country with the highest bibliographic coupling link strength with other countries in critical thinking studies in teacher education was identified as USA with 575 documents, 6908 citations and 60,261 total link

strength. Other countries with high total link strength were found as Spain (277 documents, 657 citations and 31119 total link strength), Australia (175 documents, 2033 citations and 23201 total link strength), Turkey (150 documents, 629 citations and 22101 total link strength), England (142 documents, 1818 citations and 19830 total link strength), Peoples Republic of China (111 documents, 972 citations and 13387 total link strength), Germany (31 documents, 257 citations and 10754 total link strength), Canada (88 documents, 473 citations and 10556 total link strength), South Africa (70 documents, 221 citations and 9308 total link strength), Portugal (49 documents, 78 citations and 8702 total link strength), Taiwan (49 documents, 1033 citations and 7285 total link strength), Sweden (52 documents, 553 citations and 7191 total link strength), New Zealand (45 documents, 554 citations and 7098 total link strength), Singapore (27 documents, 357 citations and 6830 total link strength), Brazil (119 documents, 175 citations and 5725 total link strength), Iran (28 documents, 142 citations and 5283 total link strength), Colombia (42 documents, 62 citations and 5152 total link strength), Italy (46 documents, 41 citations and 5152 total link strength), Slovakia (24 documents, 34 citations and 5140 total link strength), Netherlands (32 documents, 553 citations and 4888 total link strength), Israel (28 documents, 463 citations and 4817 total link strength), Ireland (27 documents, 240 citations and 4541 total link strength), Norway (25 documents, 283 citations and 3898 total link strength), Indonesia (48 documents, 184 citations and 3864 total link strength), Finland (27 documents, 177 citations and 3855 total link strength), Belgium (18 documents, 65 citations and 3658 total link strength), France (16 documents, 141 citations and 3600 total link strength), Greece (33 documents, 97 citations and 3587 total link strength), Czech Republic (22 documents, 34 citations and 3433 total link strength), South Korea (16 documents, 159 citations and 3426 total link strength), Malaysia (25 documents, 113 citations and 3269 total link strength), Chile (20 documents, 44 citations and 2799 total link strength), India (8 documents, 15 citations and 2791 total link strength), Scotland (17 documents, 454 citations and 2382 total link strength), Romania (44 documents, 59 citations and 1919 total link strength), Pakistan (12 documents, 32 citations and 1835 total link strength), Mexico (35 documents, 26 citations and 1808 total link strength), Hungary (7 documents, 14 citations and 1714 total link strength), Russia (63 documents, 78 citations and 1630 total link strength), Austria (7 documents, 8 citations and 1438 total link strength), Argentina (11 documents, 26 citations and 1421 total link strength), Switzerland (8 documents, 15 citations and 1409 total link strength), Estonia (7 documents, 7 citations and 1274 total link

strength), Oman (6 documents, 15 citations and 1210 total link strength), North Ireland (6 documents, 58 citations and 1175 total link strength), Denmark (11 documents, 84 citations and 1059 total link strength), Lebanon (6 documents, 71 citations and 957 total link strength), Thailand (16 documents, 43 citations and 890 total link strength), Japan (10 documents, 35 citations and 853 total link strength), Latvia (17 documents, 6 citations and 839 total link strength), Cyprus (13 documents, 186 citations and 830 total link strength), Saudi Arabia (11 documents, 79 citations and 775 total link strength), Croatia (12 documents, 7 citations and 743 total link strength), Kazakhstan (11 documents, 46 citations and 739 total link strength), Venezuela (12 documents, 9 citations and 586 total link strength), United Arab Emirates (8 documents, 56 citations and 577 total link strength), Lithuania (5 documents, 9 citations and 516 total link strength), Nigeria (5 documents, 3 citations and 503 total link strength), Philippines (8 documents, 14 citations and 370 total link strength), Slovenia (12 documents, 7 citations and 295 total link strength), Ecuador (11 documents, 12 citations and 212 total link strength), Ukraine (28 documents, 64 citations and 197 total link strength), Poland (13 documents, 13 citations and 146 total link strength), Costa Rica (9 documents, 3 citations and 122 total link strength) and Peru (5 documents, 18 citations and 51 total link strength).

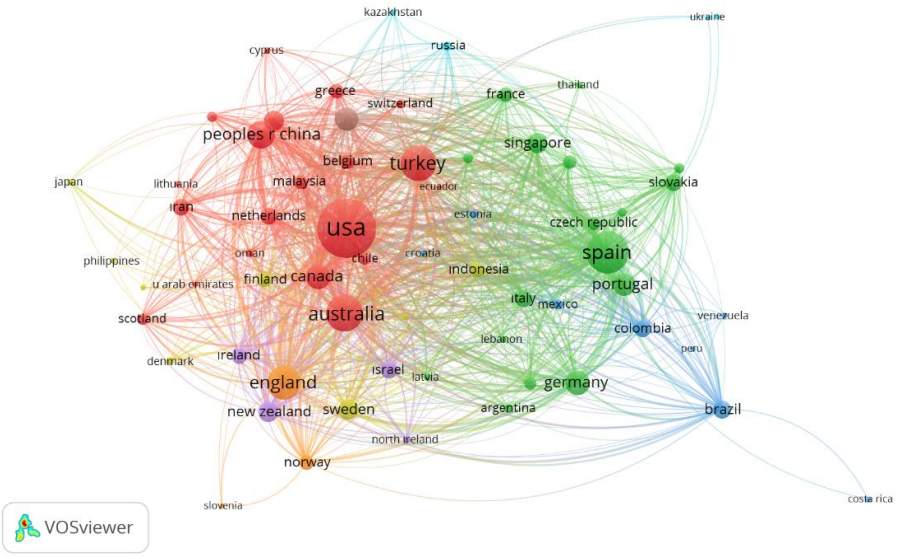


Figure 7. Network maps of countries with high bibliometric coupling strength
Source: VOSviewer (2020)

Bibliographic coupling of the documents

In the study, effort was paid to calculate the bibliometric coupling strength of documents depending on the number of common citations in their reference lists. The number of shared citations in the reference lists of the studies was considered to determine the relationship between the documents. Network visualization analysis for bibliometric coupling of documents is given in Figure 8. Analysis that followed revealed that 2,717 documents reached the threshold. For each of the 2,717 documents, the total strength of their bibliographic links with other documents was calculated, and the documents with the highest total link strength were selected (n=1000).

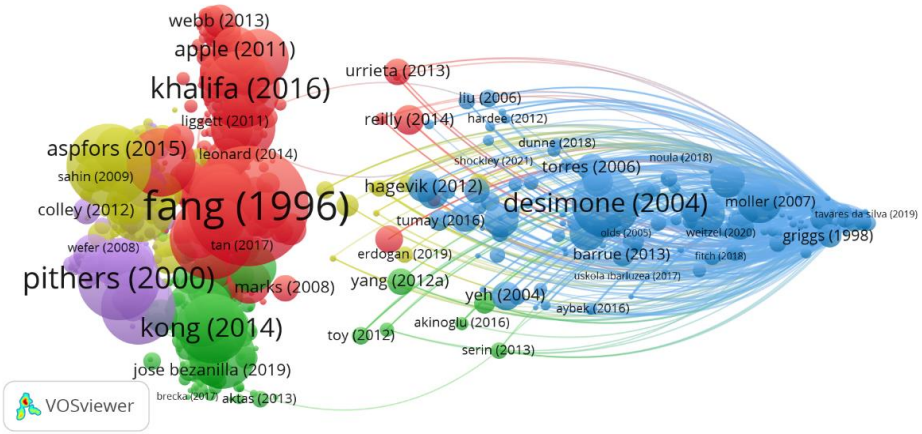


Figure 8. Network maps of documents with high bibliometric coupling
Source: VOSviewer (2020)

As a result of the analysis, gomez-jarabo and Sosa (2018) were found as the document with the highest total link strength (total link strength= 6244). Other documents with comparative high total link strength were found as alcolea-diaz (2020, total link strength= 5658), vilaca (2019, total link strength= 5385), spahiu (2014, total link strength= 4457), canelo calle (2015, total link strength= 4245), low (2017, total link strength= 3288), meneses copete (2013, total link strength= 3220), lorenzo-rial (2016, total link strength= 2284), ısidori (2015, total link strength= 2279), dostal (2015, total link strength= 1996), gopalram (2017, total link strength= 1956), urzelai (2018, total link strength= 1635), seban (2009, total link strength=

1136), kim (2007, total link strength= 1116), rovegno (1995, total link strength= 1058), and raya (2015, total link strength= 1037), respectively.

Co-occurrence analysis of the author keywords

Co-occurrence analysis method was used to determine the keywords frequently used by researchers and the relations between these words in the documents published on teacher education and critical thinking. Minimum occurrence figure of each keyword is 5, and 319 of 6,235 words reached this threshold. In this paper, total link strength indicating the number of documents where two keywords co-occurred was calculated and the documents with the highest total link strength were selected. The analysis conducted by the researchers on the keywords used in the documents is visualized in Figure 9.

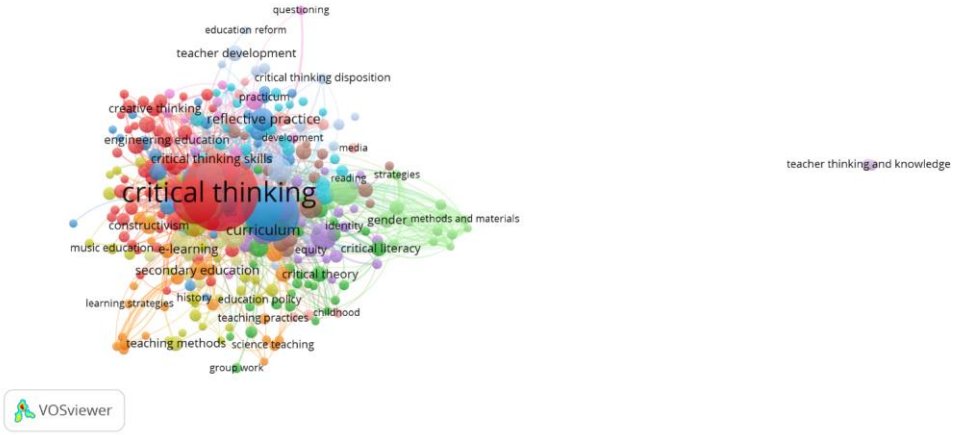


Figure 9. Co-occurrence of the authors keywords
Source: VOSviewer (2020)

"*Critical thinking*" (385 occurrences and 585 total link strength) was identified as the most frequently used keyword. Other keywords with a total impact power of over 100, which are most frequently used by the authors in interrelated documents, are as follows: teacher education (occurrences=193, total link strength=340), higher education (occurrences=129, total link strength=216), education (occurrences=114, total link strength=209), learning (occurrences=49, total link strength=123), curriculum (occurrences=50, total link strength=111), Professional development (occurrences=53, total link strength=111), creativity (occurrences=50, total

link strength=108), technology (occurrences=40, total link strength=102) and pedagogy (occurrences=56, total link strength=101).

Figure 10 provides the distribution of the keywords in the abstracts of documents published on teacher education and critical thinking by years.

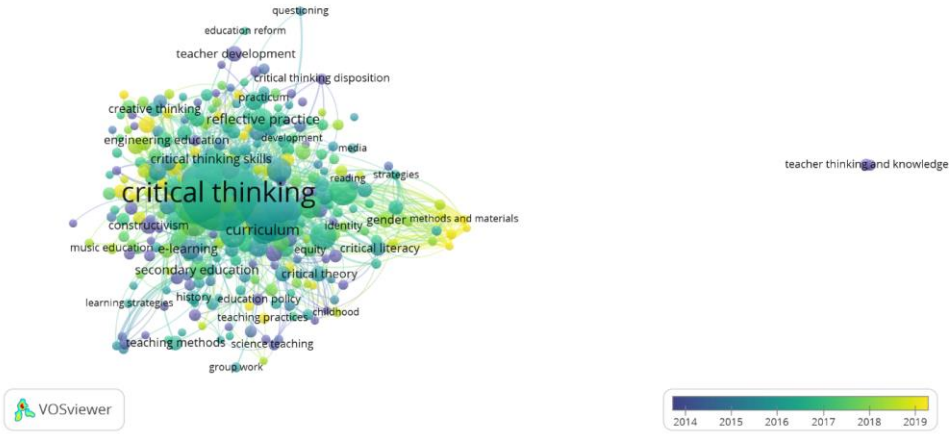


Figure 10. Time map of keywords
Source: VOSviewer (2020)

Colors indicate the development of teacher education and critical thinking terms in years. Blue-colored terms are found in publications dated 2014, whereas yellow-colored terms are found in more current works. It is observed that teacher education and critical thinking terms are mostly included in publications between 2014 and 2019. The keywords in the blue cluster were used more frequently in 2014 and 2015, while keywords in the green cluster were more mostly preferred in 2016 and 2017. Keywords in the yellow cluster were used more frequently in publications dated 2019. Among the keywords given in Figure 10, "*prospective teachers, critical thinking disposition, culture, critical analysis, preschool, educational innovation, technology integration, philosophy of education, teaching strategies, teaching and learning, distance education, education policy, collaboration, diversity, science teaching, teacher development, teacher beliefs, critical thinking disposition, teaching/learning strategies,* and *thinking and knowledge of teachers*" were more popular in papers published in 2014 and 2015. It has been found out that the most popular keywords in the years 2016 and 2017 were "*critical thinking, reflective practice, secondary education, history, early childhood, mathematics, creative thinking, argumentation, education reform, teacher education, teaching methods, inquiry, teaching practice, professional development, critical*

pedagogy, critical theory, practicum, blended learning, primary school, attitudes, social studies, secondary school, educational technology, early childhood education, project-based learning, engineering education, creativity, applications in subject areas, learning strategies, and *gender*". While all the keywords refer to documents on critical thinking in teacher education, it was determined that the most frequently used keywords in recent years are "*21st century skills, higher order thinking skills, pre-service teacher, climate change, teaching practices, lesson study, computational thinking, peer review, flipped classroom, class, methods and materials, 4-adolescence, instructional strategies, design thinking, 3-early adolescence, perceptions* and *literature*".

4. Discussion and Conclusion

Critical thinking, an essential and vital topic in contemporary education, means accurate thinking in the search for relevant and reliable knowledge about the world. Critical thinking, defined as reasonable, reflective, responsible, and skilled thinking focused on individual decisions on what to believe or do, should be taught by all educators to their students to develop their thinking skills (Schafersman, 1991). The purpose of educators is to realize critical thinking skills in their classrooms and to improve their students not only as receivers of knowledge but also its users. In addition, learning settings which actively engage students in researching and implementing knowledge, are extremely important for developing critical thinking skills in students (Snyder & Snyder, 2008). Pre-service teachers should have knowledge and skills in critical thinking so that their students can develop critical thinking skills, which reveals the importance of teacher education. In this context, this study aimed to examine the studies conducted on critical thinking in teacher education with bibliometric analysis method, to contribute to supporting teacher education programs with critical thinking approach, and to provide guidance for researchers in their future studies.

All documents published between 1989 and 2022 in the Education Educational Research category of the Web of Science database were analyzed using citation, bibliographical coupling, and co-occurrence techniques. The earliest paper on critical thinking in teacher education was published in 1989, whereas it was found out that the publications tended to increase after 2010 to reach a record high in 2019. The literature supports the findings of this study, and it is argued that 2019 is the year which saw the highest number of publications on critical thinking (Sarıkoç & Kıncal, 2022; Batur & Özcan, 2020). This result reveals that the tendency towards critical thinking approach has increased in various fields, and that this approach has an increasingly important place. When the citation times of the studies were examined, it was determined that the highest number of citations were made in 2021.

Majority of studies conducted on critical thinking in teacher education have been written in English language and in article type of publication. When it comes to countries, it was found out that USA has the highest number of publications, followed by Spain, Australia, Turkey, England, Brazil, Peoples Republic of China, Canada, South Africa, and Russia. Similarly, USA was found as the country with the highest citation strength. In addition, USA also emerged as the country with the highest bibliometric coupling power with other countries. In this context, it is recommended that the education policies of the USA should be examined by countries which intend to pay effort to encourage critical thinking on teacher education.

Another objective of this study is to determine the authors with highest citation strength who conducted research on critical thinking in teacher education. The obtained results have shown that "hwang, gwo-jen" is the author with the highest citation strength. Other researchers with high citation strength were found as "eilks, ıngo" and "fung, dennis". In this context, researchers who intend to work on critical thinking in teacher education are recommended to benefit from the works of these authors. In the study, it is also aimed to identify important works in the field through citation rates. The document with the highest citation power was written by Fang (1996). The results revealed that other documents with high citation power were authored by Howard (2003), Yang and Wu (2012b), Pithers and Soden (2000) and Miri, David and Uri (2007). On the other hand, the document with the highest total link strength was identified as Gomez-Jarabo and Sosa (2018).

In the documents published in the Education Educational Research category of Web of Science, the interrelated keywords that researchers frequently prefer to use, which have a high total impact, are identified as teacher education, higher education, education, learning, curriculum, professional development, creativity, technology, and pedagogy. Researchers are recommended to consider keywords with higher total impact and reach these studies in the works they intend to conduct in this field.

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