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Bibliometric analysis of the literature on critical thinking: an increasingly important competence for higher education students

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ABSTRACT

In recent years, interest in critical thinking(CT) has grown considerably. An evaluation of this research field and its challenges are provided in this paper. A bibliometric study was performed to analyse 1,295 papers on CT published in the last 50 years. The data were obtained from the WOS Core Collection database. The findings of this study improve the understanding of the CT domain by showing key studies, the main studies developing the field, key past studies and their influence in subsequent publications, emerging trends and potentially transformative ideas. Most publications and citations are from the last decade, reflecting the momentum of this concept over the period examined. The topic has also expanded geographically. Although the University of Iowa and the University of Alberta are the most prolific institutions, Asian universities have gained in prominence in recent years, as shown by the number of papers published. According to the analysis, the increase in the number of authors, publications and journals in this field and the rise in the number of publications written in collaboration with authors from different parts of the world are two trends that reflect the interest in CT as a way to understand the development of thinking skills.

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1. Introduction

Critical thinking (CT) has been described as one of the most important soft skills because of its relevance and contribution to academic and professional success (Altuve, 2010; Crenshaw et al., 2011; Facione & Facione, 2013). Over the last two decades, CT has been linked to the development of better professional and personal skills (Altuve, 2010; Crenshaw et al., 2011; Facione & Facione, 2013; Justino, 2003; Moore, 2013), higher levels of employment, stronger civic engagement and better finances (Arum et al., 2012; Bezanilla et al., 2019; Franco et al., 2017; Janssen et al., 2019;

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Toplak et al., 2017). Additionally, in a context of continuous rapid social transformation, CT is considered a fundamental cognitive resource (Halpern, 1998; Ku, 2009; Phan, 2010) and a decisive element to perform tasks and solve problems (Halpern, 1998; Phan, 2010). However, CT is a difficult concept to operationalise (Bensley et al., 2016).

Given the social importance of thinking critically, the growing interest in research on CT and the lack of consensus in the literature about the definition of CT, there is a need to understand this concept better and to learn how it has evolved over time (Moore, 2013). Despite the attention received by CT and the fact that the definitions in the literature offer common conceptualisations of its characteristics (Kahlke & Eva, 2018), there is no clear definition.

This article provides a systematic examination of the literature on CT by applying bibliometric and content analysis methods to assess the current state of CT in the literature objectively and quantifiably. The analysis focuses on the evolution of annual publications and citations, the most representative articles, authors and institutions, the keywords associated with the concept and the journals with the largest number of publications. The aim of this study is to help identify trends and suggest future lines of research in the CT domain.

The article is organised as follows. Section 2 presents the theoretical framework. Section 3 describes the method employed and data source. Section 4 presents the results of the performance analysis (number and importance of published articles and the most prominent authors by country and institution) and mapping analysis (keywords, co-authorship, co-citations, etc.). Finally, Section 5 offers the main conclusions and proposals for future lines of research on CT.

2. Theoretical framework

Two of the most cited studies in the CT literature define CT as 'the use of those cognitive skills or strategies to increase the probability of a desired outcome' (Halpern, 1998, p. 450) and as 'the ability to engage in purposeful, self-regulatory judgement' (Abrami et al., 2008, p. 1102). The absence of a common definition of CT can be explained by the variety of domains in which CT is studied and the contexts in which it can be applied (Philley, 2005), attracting interest from researchers in psychology, philosophy and education (Yanchar et al., 2008). Moreover, whilst some definitions centre on the specific reasoning process of CT, others emphasise its results, such as decision making or problem solving (Liu et al., 2014).

From a psychological viewpoint, CT is a set of thinking skills and dispositions that can be used in multiple contexts (Abrami et al., 2008; Halpern, 1998; Jansen et al., 2019; Kuhn, 1999; Ritchhart & Perkins, 2005) to increase the likelihood of a desired outcome (Halpern, 1997; Tiruneh et al., 2014). Halpern (2013, p. 8) defined CT as a 'kind of thinking involved in solving problems, formulating inferences, calculating likelihoods, and making decisions'.

From the philosophical viewpoint, context and thinking are so deeply related (Biggs & Collins, 1982; Laurillard, 1993; Pithers & Soden, 2000; Ramsden, 1992) that good thinking requires good contextual knowledge (Bereiter & Scardamalia, 1993;

Chi et al., 1988; Pithers & Soden, 2000) to evaluate specific beliefs, claims and actions (Abrami et al., 2008). The Delphi Report (Facione, 1990, p. 2) provided one of the most commonly used definitions of CT as 'a purposeful self-regulatory judgement which results in interpretation, analysis, evaluation and inference, as well as explanation of the evidential, conceptual, methodical, criteriological, or contextual considerations upon which judgement is based'. Even though it is more than 30 years old, this definition is still in use in the literature (Abrami et al., 2015; Desai et al., 2016; Stephenson & Sadler-Mcknight, 2016).

According to Sternberg (1986), the educational tradition is led by figures such as Bloom (1956), Gagne (1965), Perkins (1981) and Renzulli (1976). The educational view focuses on the skills needed by students to solve problems, make decisions and learn concepts. These theories draw on classroom observations, text analysis and in-class thought analysis processes to guide thinking towards CT. Brookfield (1987), Giancarlo and Facione (2001) and Hashemi et al. (2010) reported that CT skills should be a priority for educators. Scriven and Paul (2004) cited CT as a standard for the intellectual excellence required to ensure complete and constructive participation in the individual, social and educational environment of students. Recently, researchers' interest has been in understanding how the CT process works, how this concept fits into the field of self-regulated learning and motivation, and how it affects academic performance (Leung & Kember, 2003; Phan, 2009, 2010; Phan & Deo, 2007).

On a separate issue, the literature identifies two dimensions of CT: the individual and the social (Davies, 2015). The individual dimension can be linked to the development of the person. Accordingly, CT is necessary for both education and work. Society demands CT skills and dispositions in citizenship because of their importance in employability and social commitment. In the social (or critical pedagogy) dimension, CT is understood to be as much about changing society and the social conditions of the oppressed as it is about demonstrating individual skills in reasoning, argumentation and judgement (Burbules & Berk, 1999; Kaplan, 1991; Noddings, 1992). In this sense, CT can be defined as 'the acquisition of the competence to participate critically in the communities and social practices of which a person is a member' (Ten Dam & Volman, 2004, p. 375). Thus, moral and cultural characteristics also become part of CT. Davies (2015) refers to this dimension as the socio-cultural dimension of CT.

Although many researchers agree that CT involves both skills and dispositions (Nieto & Saiz, 2011), measurement tools and CT models are mainly based on skills. In these models, CT is conceptualised as a higher-order thinking skill, which revolves around an adequate process of instruction and learning (Frijters et al., 2008; Hashemi et al., 2010). For example, Watson and Glaser (2002), the designers of the world's most widely used CT measurement tool (the Watson–Glaser Critical Thinking Appraisal), associate it with the following skills: discriminating between levels of truth or falsity of interferences, recognising hidden assumptions in a series of assertions, valuing whether conclusions are justified or not, determining whether conclusions result from the information that emerges from a given statement and evaluating arguments as strong and relevant or weak and irrelevant. Scrutinising CT skills leads to the risk of seeing CT as simply a set of techniques rather than a complex and useful

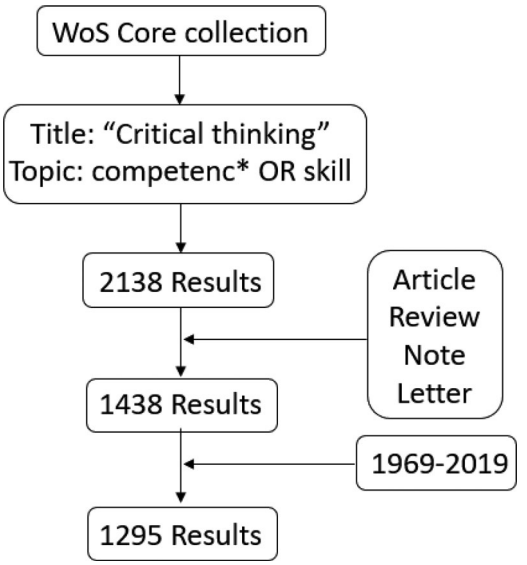

Figure 1. Stages of the data extraction process.
Source: authors.

thought process to form judgements based on reasons and evidence (Facione et al., 2000; Paul & Binker, 1990).

3. Method

3.1. Data collection

The Web of Science (WoS) (Web of science website, 2021) from Clarivate Analytics is one of the most popular databases in the world for scientific publications, particularly for conducting bibliometric analysis (Thelwall, 2008; Waltman & Van Eck, 2012). There is a consensus that the WoS Core Collection is one of the most trustworthy available databases (Merigó, Mas-Tur, et al., 2015). The WoS Core Collection includes more than 21,100 peer-reviewed journals, conference proceedings and books from over 250 disciplines and has several advantages over other databases such as Scopus in terms of keyword selection and disambiguation, amongst others (Krämer et al., 2017).

Given its advantages, the WoS Core Collection was chosen to conduct this study. To collect the data, the search keywords were carefully selected. A search was conducted for documents with 'Critical Thinking' in the title and *competenc** OR *skill* in the topic to ensure that the bibliometric analysis truly covered the publications on this competence, avoiding other fields or topics.

The search was conducted in October 2020, returning 2,138 documents (see Figure 1). The search was then limited to include all documents published in the last 50 years up to 2019 (i.e., 1969–2019) and was restricted to the following document types: Article, Review, Note and Letter. As a result of these restrictions the number of documents was reduced to 1,295. The type of document restriction was applied to

guarantee that the documents included in the study had undergone peer review to ensure their scientific quality (García et al., 2017).

As discussed in the results section, the search returned documents from very diverse fields. The authors decided to consider all of them in the study, despite their range of domains, to analyse the trends and evolution of the studied topic over the last 50 years.

3.2. Bibliometric analysis

Over the years, many authors have tried to offer an accurate definition of the term 'bibliometrics' (Broadus, 1987). However, bibliometrics is simply the discipline devoted to analysing bibliographic material from a quantitative perspective (Merigó, Gil-Lafuente, et al., 2015). In bibliometrics, the combination of performance analysis with structural analysis, also known as science mapping, greatly enriches the outcome (Noyons et al., 1999).

3.2.1. Performance analysis

Different quantitative and qualitative indicators were employed to analyse the historical evolution of CT as a competence. For example, the total number of published papers was used as a quantitative indicator of the amount of research performed on this topic. The total number of citations and cites was used as a qualitative indicator of the interest aroused by this subject.

The h-index is a commonly used indicator given its ease of interpretation. The h-index was also included in this study because it combines quantitative and qualitative measures. This index refers to the largest number of publications, h, such that each of those publications has received at least h cites. Several citation thresholds (1, 5, 10, 20, 50 and 100) were also included. These thresholds helped to assess the number of publications that received at least a certain number of citations and thus to perform a comparative study of the quality of the publications considered in the study.

3.2.2. Mapping analysis

Clustered bibliometric networks were obtained with visualisations of similarities produced in VOSviewer software version 1.6.15 (van Eck & Waltman, 2010). This software was employed to obtain graphical visualisations of co-authorship, co-citations (Small, 1973) and co-occurrence of keywords. In this graphical representation, the relevance of an item is represented by the size of the associated circle, and the links between items are displayed as lines connecting the items.

4. Results

4.1. Publication and citation structure

This section analyses the progression of the number of publications and citations in 'Critical Thinking' over the last 50 years (from 1969 to 2019). No CT publications were found prior to 1978. Hence, all results refer to the period 1978 to 2019. In the

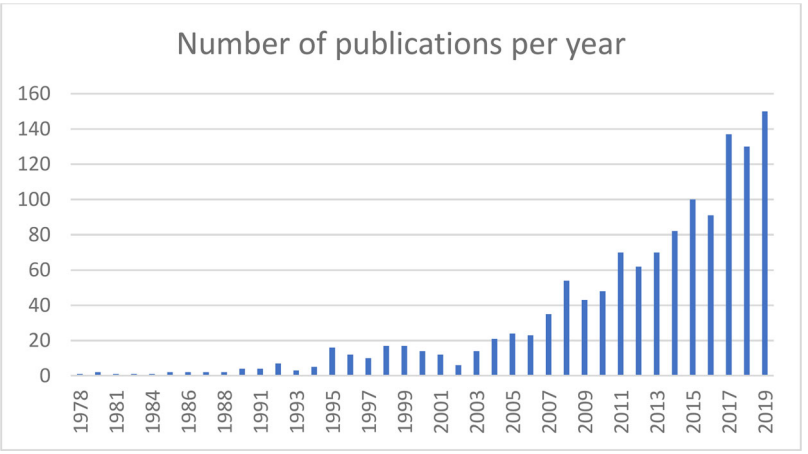

Figure 2. Annual number of papers published in CT.
Source: Compiled and calculated by the authors from the WOS CC.

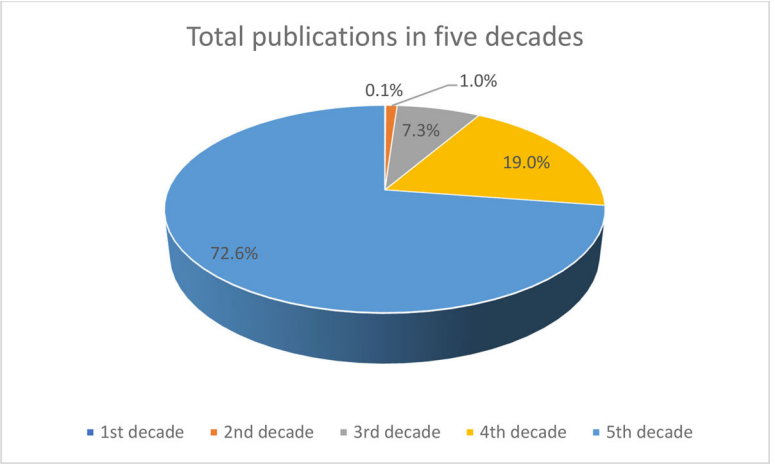

Figure 3. Percentage of total publications in each decade.
Source: Compiled and calculated by the authors from the WOS CC.

period 1978 to 2019, the number of publications grew exponentially, especially in the last decade (when 72% of all publications appeared), as shown in Figures 2 and 3.

Table 1 shows the annual citation structure in the CT literature. The highest number of publications occurred in 2017, 2018 and 2019, with 137, 137 and 150 publications, respectively. Publications that appeared in 2008, 2014 and 2019 are the most cited, with 1,318, 1,151 and 980 citations, respectively. As shown in Figure 4, most of the total citations occurred in the last two decades, corresponding to the years of greatest scientific production. The total number of citations per paper in each decade was 1.00, 17.31, 24.17, 24.98 and 7.66. These results show that the decade from 1999 to 2009, closely followed by the decade from 1989 to 1999, had the highest rate of cites per document. However, comparing total citations and indices derived from total citations from recent and old publications might hide the actual trend because the time frames are different.

Table 1. Annual citation structure of CT.

Year	TP	TC	≥100	≥50	≥ 20	≥ 10	≥ 5	≥ 1
1978	1	1	–	–	–	–	–	1
1980	2	1	–	–	–	–	–	1
1981	1	1	–	–	–	–	–	1
1983	1	0	–	–	–	–	–	–
1984	1	6	–	–	–	–	1	–
1985	2	189	1	–	–	–	–	–
1986	2	19	–	–	–	1	–	1
1987	2	8	–	–	–	–	1	1
1988	2	1	–	–	–	–	–	1
1990	4	53	–	–	–	3	–	1
1991	4	32	–	–	–	1	3	–
1992	7	120	–	–	3	2	1	1
1993	3	211	1	–	–	–	2	–
1994	5	70	–	–	2	1	–	1
1995	16	311	–	2	2	5	5	1
1996	12	243	–	1	3	2	3	3
1997	10	373	1	1	3	3	2	–
1998	17	238	–	–	7	2	–	6
1999	17	645	1	2	8	3	1	2
2000	14	617	2	1	5	1	4	1
2001	12	389	–	3	5	1	2	1
2002	6	142	–	1	2	2	1	–
2003	14	593	–	6	5	–	2	1
2004	21	416	1	–	6	8	2	4
2005	24	784	2	2	7	2	3	5
2006	23	381	–	1	7	5	6	3
2007	35	525	1	1	7	7	6	9
2008	54	1318	2	2	16	14	10	7
2009	43	980	3	1	12	8	4	9
2010	48	834	–	5	10	9	6	11
2011	70	966	1	2	12	17	11	20
2012	62	687	–	–	13	13	10	17
2013	70	866	–	4	10	14	14	20
2014	82	1151	1	3	14	20	15	17
2015	100	843	–	1	11	18	29	72
2016	91	672	–	–	9	15	22	30
2017	137	631	–	–	4	18	27	59
2018	130	380	–	–	1	10	20	49
2019	150	169	–	–	–	1	8	63

Note: TP = total papers; TC = total citations; ≥100, ≥50, ≥10, ≥5 and ≥1 = number of papers with at least 100, 50, 10, 5 and 1 citation.
Source: Compiled and calculated by the authors from the WOS CC.

4.2. Influential papers in the field

Table 2 shows the 50 most cited documents in the CT literature. All have more than 50 citations. Moreover, 17 of these documents have more than 100 citations. The most cited publication is 'Instructional Interventions Affecting Critical Thinking Skills and Dispositions: A Stage 1 Meta-Analysis' by Abrami et al. (2008), with 240 citations and a mean of 18.46 cites per year. This article is followed by 'Critical thinking in education: a review' by Pithers and Soden (2000), with 211 citations and an average of 10.05 cites per year, and 'Systems thinking - critical thinking skills for the 1990s and beyond' by B. Richmond (1993), with 195 citations and an average of 6.96 citations per year. Despite no clear trend between number of cites and the year of publication, to avoid problems related with comparisons of old and recent publications and to offer a more informative analysis, the measure of average citations per year was used. The article 'Developing information literacy and critical thinking skills

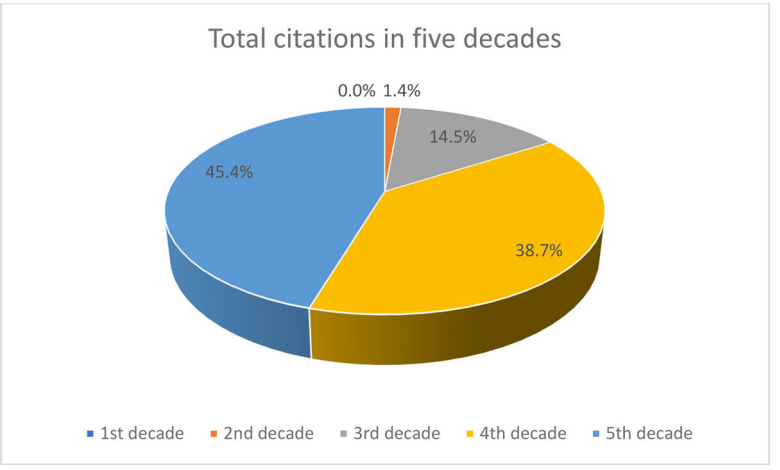

Figure 4. Percentage of total citations in each decade.
Source: Compiled and calculated by the authors from the WOS CC.

through domain knowledge learning in digital classrooms: An experience of practicing flipped classroom strategy' by S.C. Kong (2014) has the highest number of citations per year (19.43). Also, 10 of the 50 most cited CT documents have more than 10 citations per year, and 28 documents have more than six citations per year.

4.3. Leading authors, institutions and countries

The 25 authors who have made the biggest contribution to this field are listed in Table 3. Details of their affiliation, country, total citations, h-index and total citations per paper are also included. The authors with the highest number of publications are E.T. Pascarella, with nine documents, and A.G. Carter, D.K. Creedy, M. Sidebotham and Y.C. Yang, with eight articles. Pascarella and Yang are the most prominent authors, with an h-index of eight and a total of 288 and 306 citations, respectively. Seven of the most relevant authors have more than 100 cites and 15 out of 25 have more than 50. J. Profetto-McGrath, from the University of Alberta (Canada), has the highest total cites per paper (44.6), followed by Y. C. Yang (38.25) and K. Y. L. Ku (38.17).

Regarding the decade with most productive authors, the authors with the most publications (A. G. Carter, D. K. Creedy, M. Sidebotham, C. P. Dwyer and H. Hogan) published their research in the decade 2010 to 2019. These authors have between six and eight publications each. This finding is in consonance with the exponential growth of the total number of publications in recent years. However, the most cited articles and the authors with the most citations per article are from the decade 2000 to 2009. This difference may be due to the comparison of two different periods and the fact that the most cited sources are books and manuals that are not included in the WoS Core Collection. P.C. Abrami and R.M. Bernard have 260 citations but only two published articles on CT. The reliance of articles published from 2010 to 2019 on publications from 2000 to 2009 can be explained by the small number of articles and eminent authors in the field of CT (Table 4).

Table 2. The 50 most cited documents in the field of critical thinking.

Rank	Title	Authors	Publication year	Total citations	Average cites per year
1	Instructional Interventions Affecting Critical Thinking Skills and Dispositions: A Stage 1 Meta-Analysis	Abrami, Philip C.; Bernard, Robert M.; Borokhovski, Evgueni; Wade, Anne; Surkes, Michael A.; Tamim, Rana; Zhang, Dai	2008	240	18.46
2	Critical thinking in education: a review	Pithers, RT; Soden, R	2000	211	10.05
3	SYSTEMS THINKING - CRITICAL THINKING SKILLS FOR THE 1990S AND BEYOND	RICHMOND, B	1993	195	6.96
4	A LOGICAL BASIS FOR MEASURING CRITICAL THINKING SKILLS	ENNIS, RH	1985	189	5.25
5	Information-seeking behaviour in generation Y students: Motivation, critical thinking, and learning theory	Weiler, A	2005	180	11.25
6	A critical approach to critical thinking in TESOL	Atkinson, D	1997	168	7
7	A consensus statement on critical thinking in nursing	Scheffer, BK; Rubenfeld, MG	2000	157	7.48
8	A CRISIS in Critical Thinking	Del Bueno, Dorothy	2005	149	9.31
9	Critical thinking as a citizenship competence: teaching strategies	ten Dam, G; Volman, M	2004	148	8.71
10	Heuristics and Biases as Measures of Critical Thinking: Associations with Cognitive Ability and Thinking Dispositions	West, Richard F.; Toplak, Maggie E.; Stanovich, Keith E.	2008	145	11.15
11	The domain specificity and generality of belief bias: Searching for a generalisable critical thinking skill	Sa, WC; West, RF; Stanovich, KE	1999	137	6.23
12	Developing information literacy and critical thinking skills through domain knowledge learning in digital classrooms: An experience of practicing flipped classroom strategy	Kong, Siu Cheung	2014	136	19.43
13	Effects of an online problem based learning course on content knowledge acquisition and critical thinking skills	Sendag, Serkan; Odabasi, H. Ferhan	2009	130	10.83
14	Critical Thinking, Transformative Learning, Sustainable Education, and Problem-Based Learning in Universities	Thomas, Ian	2009	125	10.42
15	Purposely teaching for the promotion of higher-order	Miri, Barak; David, Ben-Chaim; Uri, Zoller	2007	123	8.79

(*continued*)

Table 2. Continued.

Rank	Title	Authors	Publication year	Total citations	Average cites per year
	thinking skills: A case of critical thinking				
16	Promotion of critical thinking by using case studies as teaching method	Popil, Inna	2011	110	11
17	Assessing students' critical thinking performance: Urging for measurements using multi-response format	Ku, Kelly Y. L.	2009	103	8.58
18	Pedagogy for developing critical thinking in adolescents: Explicit instruction produces greatest gains	Marin, Lisa M.; Halpern, Diane F.	2011	95	9.5
19	An integrated critical thinking framework for the 21st century	Dwyer, Christopher P.; Hogan, Michael J.; Stewart, Ian	2014	94	13.43
20	INFLUENCES AFFECTING THE DEVELOPMENT OF STUDENTS CRITICAL THINKING SKILLS	TERENZINI, PT; SPRINGER, L; PASCARELLA, ET; NORA, A	1995	94	3.62
21	New Graduate Nurses' Perceptions of the Effects of Clinical Simulation on Their Critical Thinking, Learning, and Confidence	Kaddoura, Mahmoud A.	2010	90	8.18
22	The relationship of critical thinking skills and critical thinking dispositions of baccalaureate nursing students	Profetto-McGrath, J	2003	89	4.94
23	Concept maps: A strategy to teach and evaluate critical thinking	Daley, BJ; Shaw, CR; Balistrieri, T; Glasenapp, K; Piacentine, L	1999	89	4.05
24	The effectiveness of problem-based learning on development of nursing students' critical thinking: A systematic review and meta-analysis	Kong, Ling-Na; Qin, Bo; Zhou, Ying-qing; Mou, Shao-Yu; Gao, Hui-Ming	2014	88	12.57
25	Do diversity experiences influence the development of critical thinking?	Pascarella, ET; Palmer, B; Moye, M; Pierson, CT	2001	84	4.2

Source: Compiled and calculated by the authors from the WOS CC.

Table 5 presents the most productive and influential institutions in CT research. The universities with the most publications are Iowa (U.S.A.), Alberta (Canada) and Griffith (Australia), with 14, 12 and 10, respectively. The university with the highest number of citations is the University of Toronto (Canada), with 436, also ranking amongst the top 25 universities in the world – 23rd in the Academic Ranking of World Universities (ARWU) and 25th in the Quacquarelli Symonds (QS) ranking. Interestingly, six of the most important institutions in CT research are amongst the top 100 universities in the world according to both the ARWU and QS rankings.

Table 3. Top 25 authors on CT.

R	Authors	University	Country	TP	TC	H	TC/TP
1	**Pascarella, Ernest T.**	**University of Iowa**	**USA**	**9**	**288**	**8**	**32**
2	Carter, Amanda G.	Griffith University	Australia	8	94	5	11.75
3	Creedy, Debra K	Griffith University	Australia	8	94	5	11.75
4	Sidebotham, Mary	Griffith University	Australia	8	84	5	11.75
5	**Yang, Ya-Ting C.**	**National Cheng-Kung University**	**Taiwan**	**8**	**306**	**8**	**38.25**
6	Dwyer, Christopher P.	National University of Ireland,	Ireland	6	173	5	28.83
7	Hogan, Michael J.	National University of Ireland,	Ireland	6	166	4	27.67
8	**Ku, Kelly Y. L.**	**The Chinese University of Hong Kong**	**China**	**6**	**229**	**4**	**38.17**
9	van Gog, Tamara	Utrecht University	Netherlands	6	94	5	15.67
10	Bensley, D. Alan	Frostburg State University	USA	5	96	5	19.2
11	Castle, Alan	University of Portsmouth,	UK	5	19	2	3.8
12	Elen, Jan	KU Leuven	Belgium	5	44	3	8.8
13	Kaya, Hulya	Istanbul University	Turkey	5	26	2	5.2
14	**Profetto-McGrath, J**	**University of Alberta**	**Canada**	**5**	**223**	**3**	**44.6**
15	Saiz, Carlos	University of Salamanca	Spain	5	59	5	11.8
16	Almeida, Leandro S.	University of Minho	Portugal	4	33	3	8.25
17	Carbogim, Fabio da Costa	Universidade de São Paulo	Brasil	4	20	2	5
18	De Cock, Mieke	KU Leuven	Belgium	4	39	2	9.75
19	Franco, Amanda R.	University of Minho	Portugal	4	12	2	3
20	Huang, Grace C.	Harvard	USA	4	61	3	15.25
21	Johnsen, David C.	University of Iowa	USA	4	40	3	10
22	Kaddoura, Mahmoud A.	Massachusetts College of Pharmacy and Health Sciences	USA	4	117	3	29.25
23	Vilanice Alves de Araújo Püschel	Universidade Federal de Juiz de Fora	Brasil	4	20	2	5
24	Schwartzstein RM	Harvard	USA	4	75	4	18.75
25	Dawit Tibebu Tiruneh	KU Leuven	Belgium	4	39	2	9.75

Note: R = rank; TP = total publications; TC = total citations; H = h-index; TC/TP = cites per publication. Authors with the highest total citations are indicated in bold.
Source: Compiled and calculated by the authors from the WOS CC.

Table 4. Most productive authors over time.

R	Authors	TP	TC	TC/TP
1970–1979				
1	Browne, MN	1	1	1
2	Haas, PF	1	1	1
3	Keeley, S	1	1	1
1980–1989				
1	Allen, EG	1	0	0
2	Allen, RF	1	1	1
3	Banville, BA	1	1	1
4	Baron, JB	1	0	0
5	Cortes, CE	1	0	0
1990–1999				
1	Nora, A	3	130	43.33
2	Pascarella, ET	3	130	43.33
3	Terenzini, PT	3	130	40.33
4	Colucciello, ML	2	104	52
5	Jacobs, SS	2	16	8
2000–2009				
1	Yang, YTC	4	185	46.25
2	Profetto-McGrath, J	3	217	72.33
3	Seldomridge, LA	3	48	16
4	Abrami, PC	2	260	130
5	Bernard, RM	2	260	130
2010–2019				
1	Carter, AG	8	94	11.75
2	Creedy, DK	8	94	11.75
3	Sidebotham, M	8	94	11.75
4	Dwyer, CP	6	173	28.83
5	Hogan, MJ	6	166	27.67

Note: R = rank; TP = total publications; TC = total citations; TC/TP = citations per publication.
Source: Compiled and calculated by the authors from the WOS CC.

Table 5. The most productive and influential institutions in CT research.

R	Institution	Country	TP	TC	H	TC/TP	ARWU	QS
1	**University of Iowa**	**USA**	**14**	**249**	**9**	**17.79**	**201–300**	**420**
2	**University of Alberta**	**Canada**	**12**	**339**	**8**	**28.25**	**101–150**	**119**
3	**Griffith university**	**Australia**	**10**	**104**	**6**	**10.4**	**301–400**	**303**
4	Universitas negeri Yogyakarta	Indonesia	9	18	3	2	–	–
5	University of Hong Kong	China	9	169	6	18.78	151–200	22
6	Monash University	Australia	8	62	4	7.75	85	55
7	Nanyang technological university	Singapore	8	96	5	12	91	13
8	National Cheng Ku University	Taiwan	8	261	7	31.38	301–400	234
9	National Taiwan normal university	Taiwan	8	37	3	4.63	901–1000	331
10	**University of Toronto**	**Canada**	**8**	**439**	**6**	**54.88**	**23**	**25**
11	Harvard University	USA	7	77	4	11	1	3
12	KU Leuven	Belgium	7	66	4	9.43	97	84
13	National university of Ireland Galway	Ireland	7	176	5	25.14	601–700	238
14	Universidad pedagógica y tecnológica de Colombia UPTC	Colombia	7	10	2	1.43	–	–
15	Universitas Negeri Malang	Indonesia	7	60	4	8.57	–	–
16	University of Barcelona	Spain	7	32	3	4.57	151–200	183
17	University of New Mexico	USA	7	117	6	16.71	301–400	601–650
18	University of New Castle	Australia	7	106	5	15.14	301–300	207
19	Erasmus University Rotterdam	Netherlands	6	94	5	15.67	68	197
20	Gazi University	Turkey	6	42	3	7	901–1000	801–1000

Note: R = rank; TP = total publications; TC = total citations; H = h-index; TC/TP = cites per publication; ARWU = Academic Ranking of World Universities; QS = Quacquarelli Symonds University Ranking. Authors with the highest total citations are indicated in bold.
Source: Compiled and calculated by the authors from the WOS CC.

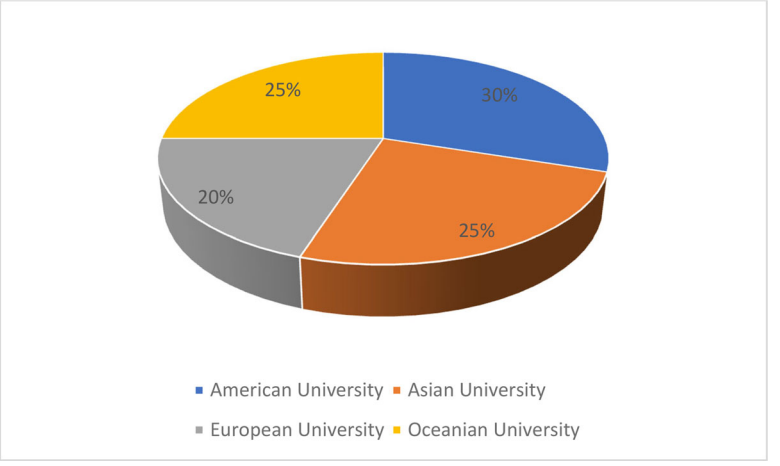

Figure 5. Distribution of the 20 universities with the most publications on CT.
Source: Compiled and calculated by the authors from the WOS CC.

Even though U.S. universities are the most numerous, representing 30% of the top institutions in CT research (Figure 5), the other relevant institutions are almost equally distributed amongst America, Asia, Oceania and Europe.

Table 6 shows that, once again, most of the CT publications were produced in the last decade from 2010 to 2019, mainly in the University of Iowa (U.S.A.) and Griffith University (Australia). Most citations correspond to publications from the previous decade (2000–2009). The main institutions are the University of Alberta and the University of Toronto, both in Canada, with a total of 556 citations. There was an

Table 6. Institutions with the greatest contribution to CT research by decade.

R	Institution	TP	TC	TC/TP
1970–1979				
1	Bowling Green State University	1	1	1
1980–1989				
1	Bowling Green State University	1	2	2
2	Connecticut State Department of Education	1	0	0
3	Loyola University	1	1	1
4	Ohio State University	1	7	7
5	St Joseph College	1	1	1
1990–1999				
1	Bowling Green State University	3	38	12.67
2	University of Alberta	3	56	18.67
3	West Chester University of Pennsylvania	3	26	8.67
4	Wright State university	3	72	24
5	Hebrew University of Jerusalem	2	34	17
2000–2009				
1	University of Alberta	5	259	51.8
2	University of Toronto	5	297	59.4
3	University Anadolu	3	138	46
4	EWHA Womans University	3	48	16
5	Harvard University	3	9	3
2010–2019				
1	University of Iowa	11	128	11.64
2	Griffith University	10	104	10.4
3	Universitas Negeri Yogyakarta	9	18	2
4	National Taiwan University	8	37	4.63
5	University of Hong Kong	8	155	19.38

Note: R = rank; TP = total publications; TC = total citations; TC/TP = cites per publication.
Source: Compiled and calculated by the authors from the WOS CC.

increase in the number of publications from Asian universities in the last decade (2010–2019), reflecting the growing interest in this topic worldwide.

The United States is the most productive and influential country in CT research (Table 7), with 499 publications, 8,908 citations and an h-index of 43. One of the reasons for this dominant position is the U.S. tradition of developing CT in educational settings, often linked to the practice of debating. Turkey and Australia follow the United States in the number of publications produced (73 and 72, respectively), and Canada and Australia follow the USA in terms of number of citations (1,532 and 1,214, respectively) and h-index (20 and 19, respectively). With only 12 publications, Scotland has the highest number of citations per publication (TC/TP = 34.25) and citations per capita (TC/POP = 75.23).

The U.S. dominance of this field is also reflected by the evolution of CT publications by country over time (Table 8). The United States leads the ranking in the past five decades. Since the first article published in the United States between 1970 and 1979, there has been an exponential increase in the number of publications in the United States and elsewhere, initially in Canada, England and Australia but later in other countries. The five countries with the most publications are the United States (499), Turkey (73), Australia (72), Canada (59) and Indonesia (55). There was growing interest in this subject in Asian countries in the last decade (2010–2019) because five of the 10 countries with the highest number of publications are Asian. Figure 6 graphically shows that these countries also follow a common trend, with most of their publications appearing in the last decade. This trend is not an isolated phenomenon for CT publications but a general trend in all fields of research (Zhang et al., 2015).

Table 7. The most productive and influential countries in CT research.

R	Country	TP	TC	H	TC/TP	Population	TP/POP	TC/POP
1	USA	499	8908	43	17.8	330,410,471	1.51	26.96
2	Turkey	73	506	11	6.9	84,590,080	0.86	5.98
3	Australia	72	1214	19	16.86	25,581,816	2.81	47.46
4	Canada	59	1532	20	15.89	37,833,422	1.56	40.49
5	Indonesia	55	178	7	3.24	274,323,398	0.20	0.65
6	China	51	1013	19	19.8	1,440,846,102	0.04	0.70
7	England	48	410	10	8.54	67,981,342	0.71	6.03
8	Iran	46	251	9	5.46	84,291,172	0.55	2.98
9	Taiwan	44	710	18	16.14	23,828,548	1.85	29.80
10	Spain	37	142	7	3.84	46,759,714	0.79	3.04
11	Colombia	35	54	4	1.54	51,032,890	0.69	1.06
12	Malaysia	25	127	6	5.08	32,481,043	0.77	3.91
13	South Korea	20	327	11	16.35	51,281,220	0.39	6.38
14	South Africa	18	74	5	4.11	59,516,078	0.30	1.24
15	Israel	13	229	6	17.62	8,693,239	1.50	26.34
16	Netherlands	12	316	8	26.33	17,145,232	0.70	18.43
17	Scotland	12	411	7	**34.25**	5,463,300	2.20	**75.23**
18	Ireland	11	195	6	17.63	4,953,051	2.22	39.37
19	Japan	10	70	4	6.36	126,371,446	0.08	0.55
20	Singapore	10	136	7	13.6	5,863,016	1.71	23.20
21	Italy	9	25	4	2.78	60,437,658	0.15	0.41
22	Portugal	9	47	4	5.22	10,188,643	0.88	4.61
23	Saudi Arabia	9	55	3	6.11	34,964,875	0.26	1.57
24	Belgium	8	66	4	8.25	11,603,448	0.69	5.69
25	Brazil	8	73	5	9.13	212,975,207	0.04	0.34

Note: R = rank; TP = total publications; TC = total citations; H = h-index; TC/TP = cites per publication; TP/POP = total publications per capita; TC/POP = total cites per capita. Country with the highest total citation/ total publication (TC/TP) ratio is indicated in bold.
Source: Compiled and calculated by the authors from the WOS CC.

Table 8. CT publications by countries over time.

R	Country	1970–1979	1980–1989	1990–1999	2000–2009	2010–2019	'10	'11	'12	'13	'14	'15	'16	'17	'18	'19	TP
1	USA	1	8	75	132	283	23	29	24	24	37	34	28	37	18	29	499
2	Turkey	–	–	–	8	65	3	10	6	5	2	12	6	9	9	3	73
3	Australia	–	–	3	14	55	2	6	2	7	6	7	4	11	6	4	72
4	Canada	–	1	7	23	28	1	2	1	4	3	2	4	6	5	–	59
5	Indonesia	–	–	–	1	54	–	–	1	–	1	2	6	7	17	20	55
6	China	–	–	–	9	42	3	3	1	4	4	2	3	11	4	7	51
7	England	–	–	3	11	34	2	4	4	–	3	3	2	6	4	6	48
8	Iran	–	–	–	1	45	–	1	4	1	6	3	8	9	8	5	46
9	Taiwan	–	–	–	9	35	3	2	3	6	2	6	2	7	–	4	44
10	Spain	–	–	–	4	33	–	3	3	1	3	4	1	3	7	8	37
11	Colombia	–	–	–	4	31	2	2	3	5	2	4	2	2	3	6	35
12	Malaysia	–	–	–	3	22	1	–	2	1	1	1	3	1	7	5	25
13	South Korea	–	–	1	4	15	1	–	–	–	5	4	2	–	2	1	
14	South Africa	–	–	–	7	9	–	–	–	1	2	–	2	1	1	2	16
15	Israel	–	–	2	5	6	–	–	–	1	1	2	–	–	2	–	13
16	Netherlands	–	–	–	2	10	1	1	–	1	2	2	–	–	1	2	12
17	Scotland	–	–	–	5	7	–	1	1	1	1	–	1	–	–	2	12
18	Ireland	–	–	–	1	10	–	–	1	–	2	3	–	1	2	1	11
19	Japan	–	–	–	1	9	–	–	–	2	–	–	1	2	1	3	10
20	Singapore	–	–	–	3	7	1	1	–	–	–	1	–	3	–	1	10
21	Italy	–	–	–	–	9	–	–	1	–	1	–	1	2	–	4	9
22	Portugal	–	–	–	–	9	–	1	–	–	1	1	–	2	2	2	9
23	Saudi Arabia	–	–	–	1	8	–	–	–	1	1	–	–	–	3	3	9
24	Belgium	–	–	–	–	8	1	–	–	1	–	–	1	1	2	2	8
25	Brazil	–	–	–	–	8	–	–	–	1	–	–	2	1	2	2	8

Note: R = rank; TP = total publications; '10, '11, '12, '13, '14, '15, '16, '17, '18, '19 = publications in 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018 and 2019.
Source: Compiled and calculated by the authors from the WOS CC.

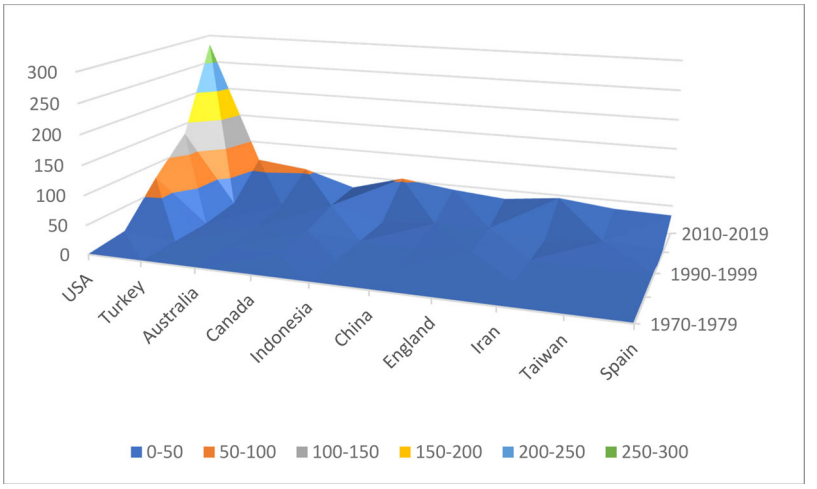

Figure 6. Number of publications of top 10 countries from 1970 to 2019.
Source: Compiled and calculated by the authors from the WOS CC.

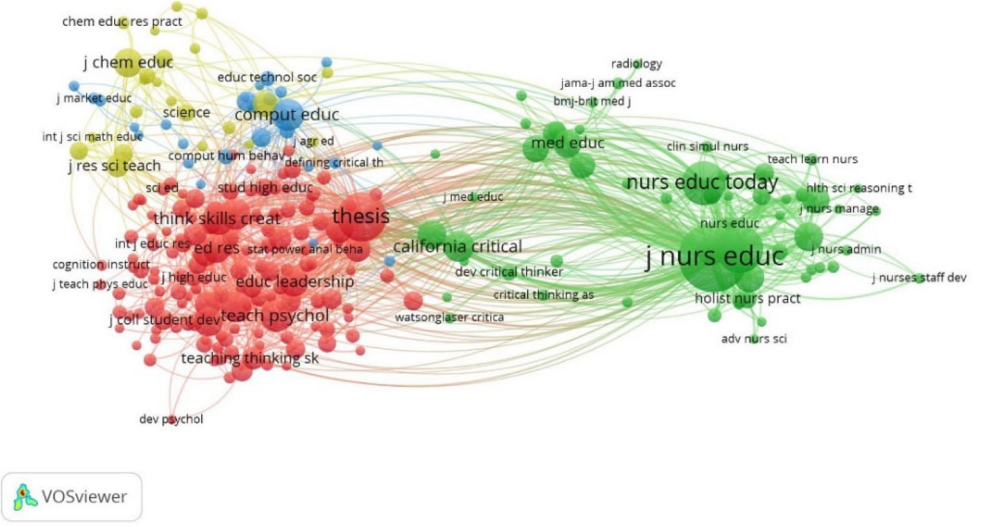

Figure 7. Co-citations in CT research. Minimum number of citations per document = 25; 252 of the 16,113 documents meet this threshold.
Source: Compiled and calculated by the authors from the WOS CC.

4.4. Mapping the CT literature with VOSviewer

To complete the analysis of the CT literature, science mapping is used to visualise the underlying networks in this field. Co-citations were defined by Small in 1973 as the frequency with which two documents are cited together (by a third journal or author). Co-citations are useful to assess the similarity amongst documents and the progression of a topic over time. As shown in Figure 7, there are two large clusters of co-citations, represented in green and red. Green represents the co-citations related to medical journals, mainly from nursing schools, such as the *Journal of Nursing*

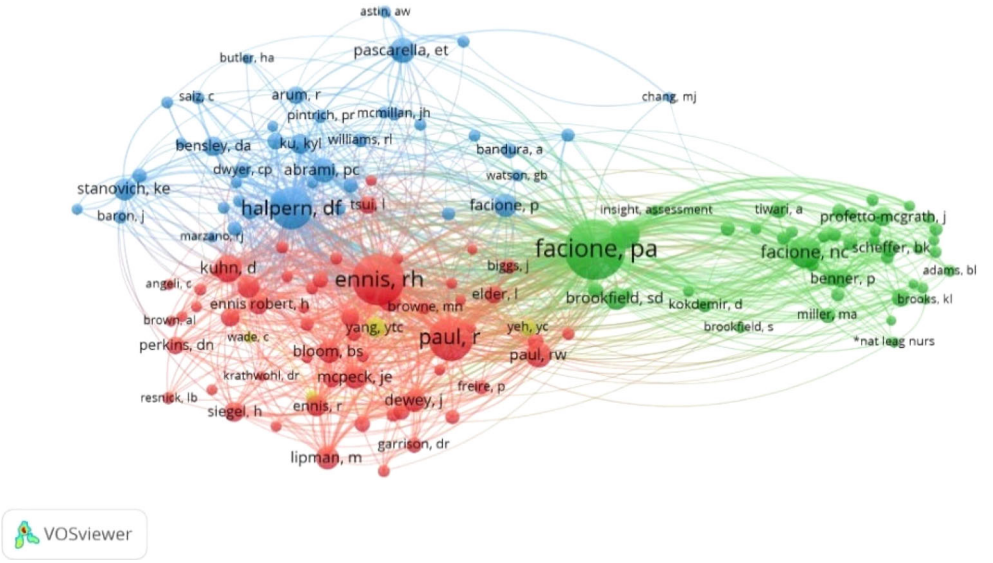

Figure 8. Co-citations of authors in the CT literature. Minimum number of citations per document = 5; 148 of the 22,967 authors meet this threshold.
Source: Compiled and calculated by the authors from the WOS CC.

Education and Practice. These journals' focus on CT is due to the importance of developing CT skills to improve professional performance (Arum et al., 2012; Bezanilla et al., 2019; Franco et al., 2017; Jansen et al., 2019; Toplak et al., 2017). Red represents co-citations related to education journals. These co-citations are from doctoral theses and education and psychology journals such as the *Journal of Teaching of Psychology* and the *Journal of College Student Development*. In these cases, the development of CT at different educational levels is addressed.

Figure 8 shows the co-citations of authors. There are three main clusters. Cluster 1, in green, is led by P. A. Fancione and includes authors such as Benner, Brookfield and N. C. Fancione, amongst others. This cluster consists of studies of the need for CT in professional practice and examines the evaluation of CT as an educational outcome that predicts competent professional judgement. The research in this cluster focuses on nursing because the professional performance of nurses requires clinical reasoning that demands solid, impartial judgement and an ability to interpret and analyse cases. Cluster 2, in red, is led by R. H. Ennis and includes authors such as R. Paul, D. Kuhn, J. Dewey and B. S. Bloom, amongst others. Authors in this group present different models of development of CT based on the processes of cognitive development and suggest different forms of teaching and evaluating CT. Cluster 3, in blue, is led by Halpern and includes authors such as Pascarella, Abrami, Stonovich and P. Facione, amongst others. Authors in this group highlight the importance of developing CT skills today, discuss how these skills can be learned and offer pedagogical models for CT.

The leading authors of these clusters are not those who have received the most citations. The last ones published books on the milestones of CT research that are not indexed in the WoS. This is not an isolated phenomenon, having already been reported in other fields (e.g., Lopez-Rubio et al., 2022).

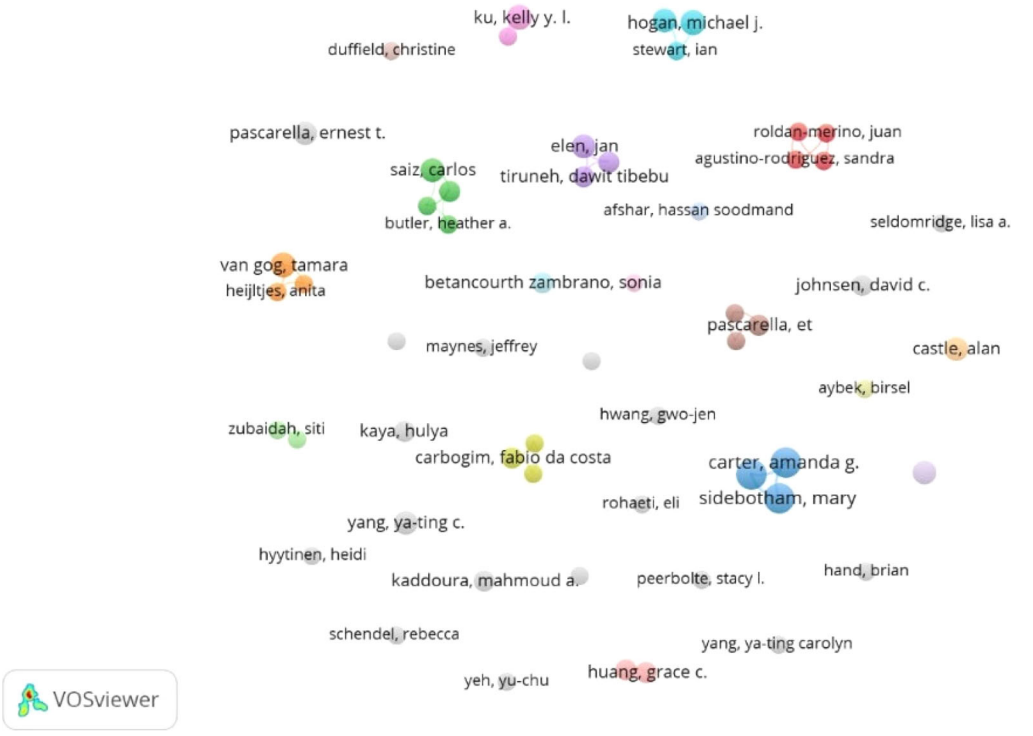

Figure 9. Co-authorship of CT publications. Minimum number of documents per author = 3; 57 authors out of 2,911 meet this threshold.
Source: Compiled and calculated by the authors from the WOS CC.

Another interesting feature of the CT research represented in Figure 9 is that, even though authors collaborate in isolated clusters, they do not form an interconnected network. This situation may suggest that there are no clear leaders in this field. Therefore, establishing collaborations amongst research groups could be an interesting line of work in this field.

In addition to 'critical thinking', the keywords with the highest co-occurrence are 'nursing education', 'nursing students', 'thinking skills', 'higher education', 'curriculum' and 'debate' (see Figure 10). The journals with the most CT co-citations are *Journal of Nursing Education*, *Nursing Education Today* and *Medical Education* (see Figure 8). Regarding the evolution of keywords over time, given that almost three quarters of CT publications appeared in the last decade (see Figure 3), the most relevant keywords also help to identify trends and to study the recent evolution of the topic. The term 'nursing' and nursing-related keywords have appeared regularly in the last few years, which fits with the results presented earlier. Interest in CT in the field of nursing can be explained by the close relationship between CT and nurses' professional performance because nursing requires reasoning, solid judgement and the ability to interpret and analyse information. Interestingly, in recent years, higher education has become a relevant keyword as well as teaching, learning and assessment. This tendency shows a growing interest in the subject in other areas, specifically in higher education. Interest in CT in higher education is due to the importance of developing and implementing teaching methods and tools that promote the

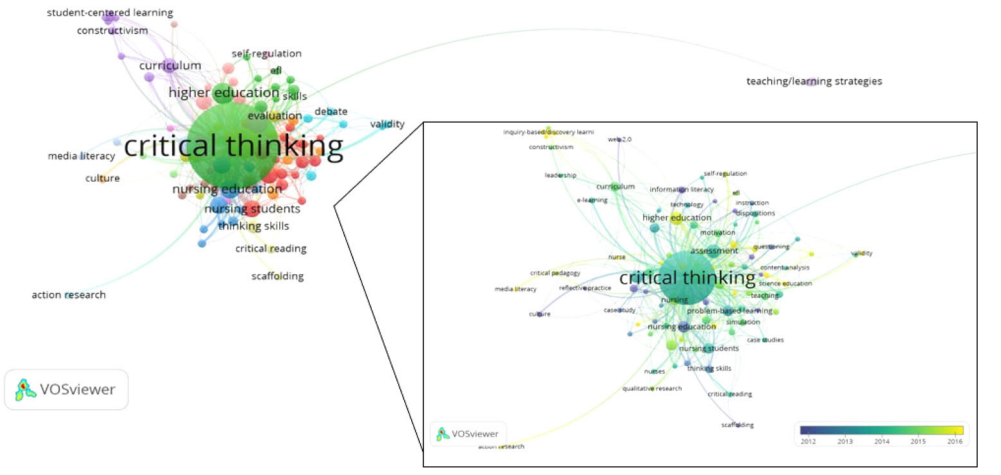

Figure 10. Co-occurrence of keywords. Minimum number of occurrences of a keyword = 5; 98 of the 2,302 words meet this threshold.
Source: Compiled and calculated by the authors from the WOS CC.

development of CT skills and dispositions in students, given the relationship between the development of students' CT skills and dispositions and their social, educational and professional success (Casner-Lotto & Barrington, 2006).

5. Conclusions

This paper presents bibliometric analysis of articles, reviews, notes and letters published in the field of CT in the last 50 years. CT has received growing attention from educators, politicians and businesspeople in the last decade, being considered one of the key learning outcomes for students in general and university students in particular. The positive relationship between the development of CT skills and dispositions by students and their academic, social and professional success, can explain the consistent growth of research interest in the field of CT.

This scientific interest in CT is reflected by the exponential growth in the number of academic publications on CT, especially in the last decade. U.S. universities have the highest number of publications, and the United States is the most influential country in this field (68% of citations in CT), followed by Canada and Australia. A major progressive increase in the number of publications on CT has been observed in Asian universities in Turkey, China and Indonesia. This sharp increase in the number of publications in the last decade (from 2010 to 2019) can explain the current tendency to cite non-academic books, manuals and articles not included in the WoS that were published in previous decades. The increase in the number of publications and areas of research in the field is expected to lead to a change from citing articles and books from previous decades to citing articles and publications in the WoS.

The bibliometric analysis helped to identify two large areas for development in CT: one related to nursing and one related to education. The analysis also revealed two research opportunities: one related to expanding the range of action of CT to other fields besides medicine and nursing and one related to training teachers in CT

so that they can teach CT or use it in the classroom effectively to improve students' CT skills.

The principal limitation of the study is that the analysis was mainly conducted using data from the WoS Core Collection database, which has a limited number of publications and omits relevant books on the topic. However, the publications used in the bibliometric analysis reflect the current state of knowledge. Hence, the results reported in this paper are applicable to this field.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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