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Teacher Educators: A Bibliometric Mapping of an Emerging Research Area

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Abstract: There has been increasing research attention on teacher educators in recent years; however, the dynamics of this research area have not been examined through bibliometric analysis of the relevant studies. This study aimed to perform a systematic mapping of the trends in research studies on teacher educators through the bibliometric data obtained from the Web of Science database. The bibliometric analysis led to four substantial findings: (1) research on teacher educators is an emerging field of educational studies that have experienced a progressive increase since the 2000s; (2) scientific publications in this field are produced by a small group of researchers from the USA, Australia, Canada, several European, and few Asian countries through collaborative research networks; (3) research on teacher educators is primarily spread in general teacher education journals; (4) the main topics regarding teacher educator research area are: professional development, professional identity, works, and practices.

Keywords: Teacher educators, bibliometric analysis, Price's law, Lotka's law, collaborative networks

Introduction

Teacher educators (TEs) are often described as "teachers of teachers" (Lanier & Little, 1986, p. 528), and broadly speaking, there are two main groups of TEs (Dengerink et al., 2015). The first group refers to induction tutors and mentors working in schools with a responsibility to support on-the-job training as part of practicum work for preservice teachers. The second group is the academics positioned in higher education institutions with a responsibility for teacher qualifications, continuous professional development, research or subject studies, and didactics (Dengerink et al., 2015). Mentoring and practicum processes have long received considerable research attention (e.g., Lawson et al., 2015). However, studies on university-based TEs have remained rather limited until recently (Castro, Superfine & Li, 2014). Due to the lack of research attention, TEs have long remained an underexplored and undertheorized research area. Therefore, teacher educators are often described as 'hidden' and least understood professionals (Livingston, 2014; Murray & Male, 2005). The realization of this deficiency led the teacher education community to pay more attention to the group of TEs, which has eventually emerged as a research area (Tack et al., 2018). Studies in this research area have attended to a variety of issues. Broader categories of

research interests involve TEs' academic, educational, and research profiles (Bouckaert & Kools, 2018; Murray & Male, 2005); transition process to the profession (Allen et al., 2016; Murray & Male, 2005) professional preparation and development (Brody & Hadar, 2018); job descriptions and assignment (White et al., 2021) identity development and professional adaptation (Allen et al., 2016) knowledge bases (Goodwin et al., 2014; Ozmantar & Agac, 2021); and instructional practices (Arya et al., 2016); program development efforts in various areas (Bleiler, 2015; Goos & Bennison, 2018); professional qualifications or set of standards (Murray & Male, 2005); conceptions, practices, and responsibilities about equity and social justice (Fylkesnes et al., 2018).

As this brief consideration suggests, there has been a significant increase in the number of studies on TEs. These studies make important contributions to developing new and further insights into this research area; however, such an increase also creates certain challenges in performing systematic examinations of published research. Such examinations are crucial, and required, to understand recent developments, observe future directions, keep track of changes and thus achieve a better grasp of the ever-evolving research dynamics in the area. To date, there appear sporadic attempts to synthesize the existing literature on TEs with particular aspects such as identity (Izadinia, 2014), in particular fields such as physical education (McEvoy et al., 2015) or a particular context such as faculty development (Phuong et al., 2018). Systematic literature reviews provide important insights into the themes, methodologies, and theoretical foundations of research in a field. However, there are two main obvious difficulties involved in such review attempts. Firstly, extant examinations adopt a micro-focus on a rather particular aspect of TEs and hence remain insufficient to provide a holistic or macro understanding of the research area. Secondly, these attempts employ traditional methods such as meta(thematic)-analysis or structured literature review and hence, as Aria and Cuccurullo (2017) rightly argue, due to a highly time-consuming nature, the analysis procedure is applied to only a set of selected studies with a very limited number. This limitation creates an obstacle to achieving an understanding pertinent to evolving dynamics of the research area and does not enable to make comprehensive and multi-dimensional projections. Upon the realization of similar shortcomings, researchers in many disciplines have begun to employ more efficient and consistent approaches to track the developments in a research area by adopting quantitative techniques. To perform a systematic examination of voluminous scientific publications with a lower investment of time, as Keathley-Herring et al. (2016) point out, bibliometric analysis or review has become a prevalent approach, leading to a more balanced understanding in terms of depth and breadth.

Bibliometric reviews employ a set of quantitative methods to track, measure, and analyze the considerably higher volumes of scientific publications produced over a long period (Hernández-Torrano & Ibrayeva, 2020). The bibliometric analysis draws on the encoded bibliographic information stored on scientific databases (such as Web of Science, Scopus, and ERIC). By processing this information, the bibliometric analysis serves at least two main purposes (Cobo et al. (2011): performance analysis and scientific mapping. While performance analysis expresses the performance of scientific production of individual scholars, institutions, or countries; scientific mapping attempts to designate the dynamics and structure of a scientific field. The bibliometric analysis allows drawing inferences about the development of a particular research area from the trends in scientific publications, their citations, and distributions across the journals and disciplines. It also enables us to determine the scientific collaborations among the authors, institutions, and countries at national and international levels (Andrés, 2009). The information obtained from such analysis provides a useful perspective to review a particular line of research. Hence bibliometric analysis achieves subjective evaluation of literature with quantitative rigor.

Despite its extensive use in different scientific disciplines to portray a scientific map of the field, a bibliometric analysis of TE literature has not been carried out until now. Having realized this gap, this study aims to perform a bibliometric analysis of published literature on TEs. More specifically, based on bibliometric indicators and laws, we aim to address the following research questions:

- What is the current state of scientific production growth in the TE research area?
- How could the individual scholar's scientific productivity in TE research be described?
- What trends could be observed in the publications and citations of TE research?

Attending to these questions, we aim to portray an overall picture of the development and current state of research on TEs and establish the scholarly connections at institutional and international levels as well as the impact of researchers and scientific platforms.

Method

This study utilized metadata obtained from the Web of Science (WoS) database by Clarivate over a period of 40 years. WoS was the only platform employed for citation analysis until 2004. Afterward, however, data about the citations of the scholarly research became available on two other platforms, namely, Google Scholar and Scopus. There are serious concerns about the validity of the data presented in Google Scholar platform, which is hence found often unsuitable for evaluation purposes. Hence, Scopus and WoS remain the main sources of citation data (Archambault et al., 2006). The metadata extracted from WoS database were employed for the bibliometric mapping purposes in this study as the research indexed in this platform is considered to be "industry-standard" in the field of education (Ivanović & Ho, 2019).

Dataset

The search for published research on TEs was performed in August 2021. WoS core collection database was employed for data extraction. To document the articles, the search strategy included the selection of keywords as "teacher educator*" in the title field to avoid irrelevant hits. The search was filtered and further refined by selecting research category "Education - Educational Research" and document type "article". With this strategy, our search ended up with 882 documents, each of which was individually checked (through the abstract) to verify the relevance to TE research. Hence the dataset for this study was composed of 882 research articles. For each article, we have extracted bibliometric metadata including publication year, citation count, author(s) and institutions, country, and journal. We are aware that our search strategy has certain limitations worth noting here. The first is that we exclusively employed WoS for keyword search and this database like many others internationally recognized and credited such as Scopus mostly excludes publications produced in languages other than English. Hence, it is likely that the relevant research to TE published in other languages and/or in journals not indexed in WoS has remained outside of our dataset. Secondly, we performed keyword search in the title field, which might have also led to exclusion of some relevant research. So, we were aware of these limitations and cautious about our considerations and arguments in this paper.

Data Analysis

To address our research questions, we attempted to determine the overall productivity, individual scholar's scientific productivity, dynamic trends in the publications and citations to discriminate leading authors, institutions, countries, and journals, and associative relationships about co-authorships and co-occurrent research themes. Concerning the first research question regarding overall productivity, to delve into the development of scientific production in TEs, we tested Price's law (Price & Tukey, 1963). This law hypothesizes that scientific growth goes through four stages. The first stage is called pre-cursors phase where a small number of scientists begin to produce publications on a new research area. It is in the second stage where occurs proper exponential growth. In the third stage, connections are established among different aspects of the accumulated body of knowledge, which is hence called the consolidation phase. The fourth refers to the collapse of a research area with considerably reduced publications. In his original research, Price proposed a duplication time of scientific productions every 10 to 15 years (Price, 1962, p. 119), though this claim later received much criticism.

Regarding the second research question for scholars' productivity, we tested Lotka's law (Lotka, 1926). The law proposes a relationship between the number of authors and publications in a particular discipline or research area in a given period. The law states that the number of scholars producing a certain number of publications is a fraction of the authors producing a single publication. The law is expressed, when i represents the number of publications, as $n_i = n_1/i^2$ (n_1 is the number of authors with a single publication). Hyperbolic distribution of Lotka's law also suggests that the exponent of the denominator is not always two, providing insights into the nature of scholars' productivity in a particular research area.

Apart from these two laws, we have also performed frequency counts to observe the dynamic trends in the publications and citations while addressing the third research question. These counts were employed to determine the leading scholars, institutions, and countries along with core journals and influential articles. To visualize and examine the relationships, we utilized VOSviewer software version 1.6.16. VOSviewer is a freely available software useful to create maps and visually present networks among scholars and their academic activities. VOSviewer networks are produced based on nodes, lines, clusters, and distances. Nodes represent the re-occurrences of certain items under scrutiny such as authors, institutions, or countries. A link between two nodes (e.g. two institutions cooperating for research) is represented with a line. The nodes and links have a strength expressed in a numerical value reflected in the size of nodes or thickness of the line; the nodes and links constitute a cluster differentiated with a color and the distance between the nodes indicates how closely connected these two (Hernández-Torrano & Ibrayeva, 2020).

With the help of VOSviewer, we also undertook a series of co-authorship analyses to observe and explore the trends in the research collaborations between and among scholars, institutions, and countries. In our analysis, every single co-authorship was evaluated with the same weight. In the produced VOSviewer maps, the size of the nodes increases depending on the number of publications produced by the particular items (scholars, institutions, or countries) in our dataset. The stronger the collaboration between the items is, the thicker the lines and the closer the nodes in the maps become. Particular collaborative networks on TEs research could be observed in the maps with clusters represented with different colors.

Results

In this section, we share the results of overall productivity, individual scholar's scientific productivity, dynamic trends in publications, and citations regarding authors, institutions, countries, and journals.

Overall Productivity

The distribution of 882 scientific publications over the period of 1967-2021 is presented in Figure 1. The number of articles included in the database ranged from 1 to 7 until the early 2000s, this number grew 95+ per year since 2018 and reached the top in 2020. There has been an increasing research interest in TEs until the present day.

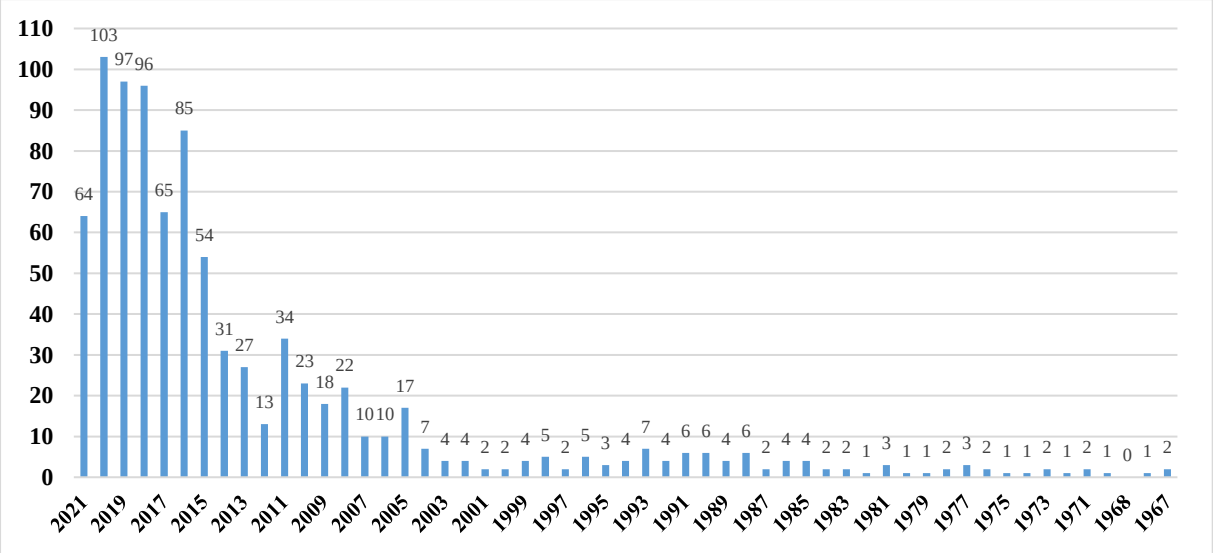

Figure 1: Evolution in publication data in teacher educators' research

To determine the overall productivity with regard to Price's law, we have tried out linear and exponential regression analyses with SPSS. Our initial regression analyses covered the period of 1967-2020 as a whole. The linear regression model produced a correlation coefficient (r) of 0.696 and an adjusted r-square value of 0.474; exponential regression produced r as 0.885 with an adjusted r-square value of 0.784. Unexplained variability was approximately 53% and 22% respectively. Afterward, we repeated the linear and exponential regression from 2000 to 2020. For this period, r was calculated as 0.895 with an adjusted r square value of 0.791. This suggested almost 20% unexplained variability. Exponential regression however for the same period yielded r as 0.957 with an adjusted r square value of 0.915 (see Figure 2). With this regression model, there remained only 9% unexplained variability. The regression analyses indicated two different phases as predicted by Price's law: the first or precursors' phase starting from the 1960s continued until the early 2000s; the second phase or exponential growth continues until the present day. During the second phase, duplication time for the publications ranged between 1 to 6 years, with an average of 3.5 years.

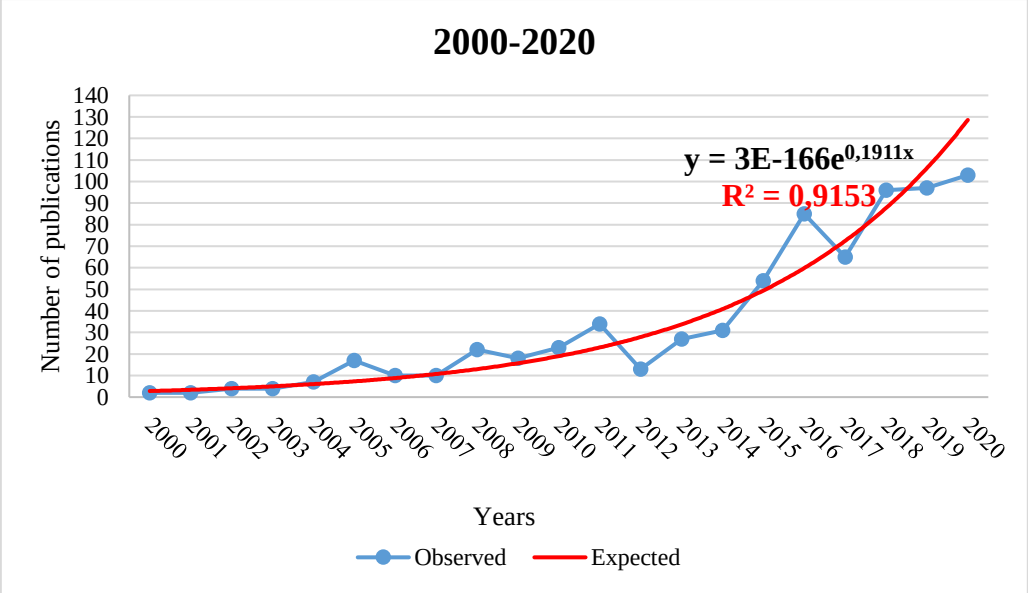

Figure 2: Number of publications during 2000-2020 on TEs according to Price's law

Scholar's Productivity: Lotka's Law

In this study, we identified 1519 authors contributing to 882 publications between 1967 and 2021. We observed that 85.1% (1292 out of 1519) of all authors made a single publication. There were 227 (14.9%) authors publishing between 2 and 14 papers on TEs. It was also observed that 101 (6.65%) authors signed three or more publications.

x	y	X=Log(x)	Y=Log(y)	XY	X^2	xy	Observed =yx/Σxy	S_n (X)	Expected (LotkaL.)	F_o (X)	|Fo (X) $- S_n$(X)|
1	1292	0,0000	3,1113	0,0000	0,0000	1292	0,6476	0,6476	0,6079	0,6079	**0,0397***
2	126	0,3010	2,1004	0,6323	0,0906	252	0,1263	0,7739	0,152	0,7599	0,0140
3	55	0,4771	1,7404	0,8304	0,2276	165	0,0827	0,8566	0,0675	0,8274	0,0292
4	13	0,6021	1,1139	0,6707	0,3625	52	0,0261	0,8827	0,038	0,8654	0,0173
5	9	0,6990	0,9542	0,6670	0,4886	45	0,0226	0,9053	0,0243	0,8897	0,0156
6	10	0,7782	1,0000	0,7782	0,6055	60	0,0301	0,9353	0,0169	0,9066	0,0287
7	4	0,8451	0,6021	0,5088	0,7142	28	0,0140	0,9494	0,0124	0,919	0,0304
8	4	0,9031	0,6021	0,5437	0,8156	32	0,0160	0,9654	0,0095	0,9285	0,0369
9	1	0,9542	0,0000	0,0000	0,9106	9	0,0045	0,9699	0,0075	0,936	0,0339
10	1	1,0000	0,0000	0,0000	1,0000	10	0,0050	0,9749	0,0061	0,9421	0,0328
11	1	1,0414	0,0000	0,0000	1,0845	11	0,0055	0,9805	0,0050	0,9471	0,0334
12	1	1,0792	0,0000	0,0000	1,1646	12	0,0060	0,9865	0,0042	0,9513	0,0352
13	1	1,1139	0,0000	0,0000	1,2409	13	0,0065	0,9930	0,0036	0,9549	0,0381
14	1	1,1461	0,0000	0,0000	1,3136	14	0,0070	1,0000	0,0031	0,9580	0,0420
Total (Σ)	1519	10,9404	11,2243	4,6310	10,0188	1995	1		0,9421		

n=-2,81791194; x: number of publications; y: number of authors
*Significant difference

Table 1: Analysis of Lotka's exponent value on number of publications per author

To determine scholars' scientific productivity in TEs research, we tested Lotka's law. The distribution of the number of publications over authors indicates a hyperbolic representation according to Lotka's law. Although the exponent of the denominator in the original Lotka's law tended to be 2, in our study the exponent was calculated approximately 2.82. Publication numbers per author according to Lotka's law as observed and expected

values were presented in Table 1. The most notable difference between the expected (60%) and observed (65%) values occurred in the number of single-publication authors who were higher in our study than anticipated by Lotka. However, when productivity increased, the difference between the expected and observed values tended to decrease (see Figure 3), leading to a gradual congruence between the two graphs.

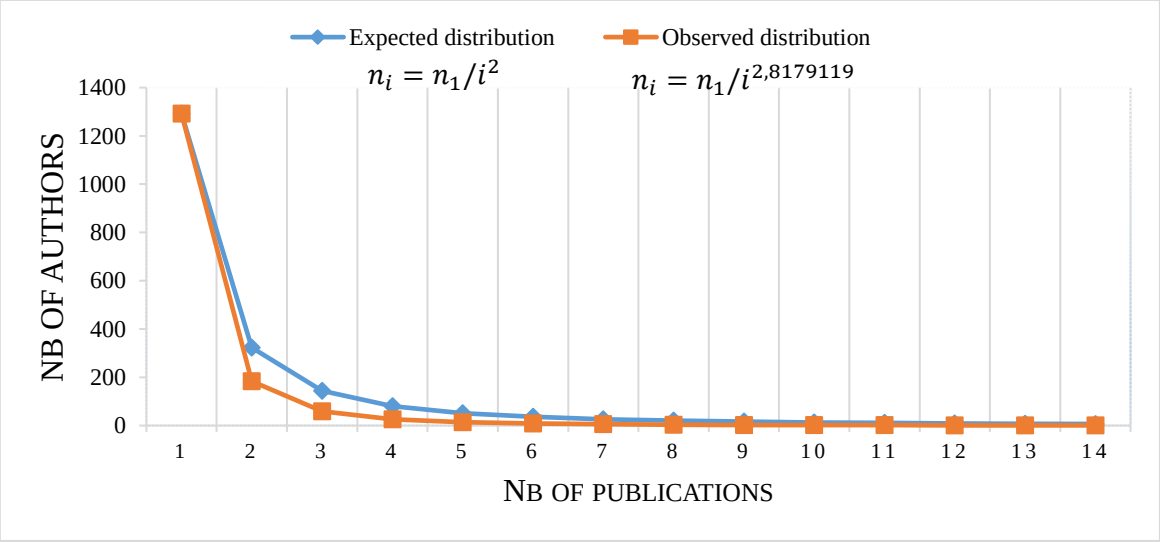

Figure 3: Number of articles per author during the period of 1967-2021

Most Influential Publications

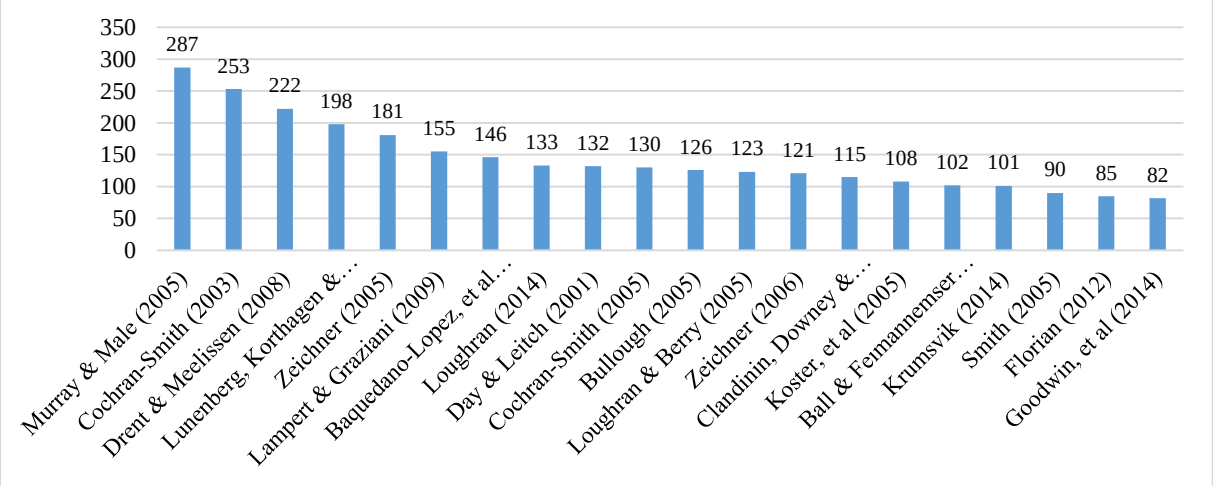

Figure 4: Most influential publications regarding citation frequency

The most influential publications about TEs were determined based on the number of citations (see Figure 4). Most cited, Murray and Male (2005) received 287 citations. In this study, the researchers focus their attention on the difficulties experienced during the transitional stage of becoming a TE and examine the formation of professional identity. The study by Cochran-Smith (2003) ranked second with 253 citations. This study attends to TEs' knowledge and competencies relevant to the preparation of qualified teachers. The third most influential article received 222 citations and was produced by Drent and Meelissen (2008), who consider TEs' use of information and communication technologies in their practices. Lunenberg et al. (2007) received 198 citations for their research examining teacher educators'

practices in teacher training process. Zeichner (2005) received 181 references with a self-study reporting personal perspectives on becoming a TE. As this brief consideration indicates, TEs' identity development and competencies required for the profession are the two issues that attracted the attention of most influential publications. Works and roles of teacher educators (e.g., mentoring, research, and teaching) are also among the research foci of the most cited papers (Bullough, 2005; Cochran-Smith, 2005). Clandinin et al. (2009) approach to TEs and their practices from critical perspectives, which have recently become the topic of heated debates, especially in the USA. Other heavily cited studies pay their attention to factors affecting the professional development of TEs (Day & Leitch, 2001; Florian, 2012; Zeichner, 2006) and reflections on TEs' practices in the teacher training process (Ball & Feiman-Nemser, 1988; Lampert & Graziani, 2009; Loughran & Berry, 2005; Lougran, 2014).

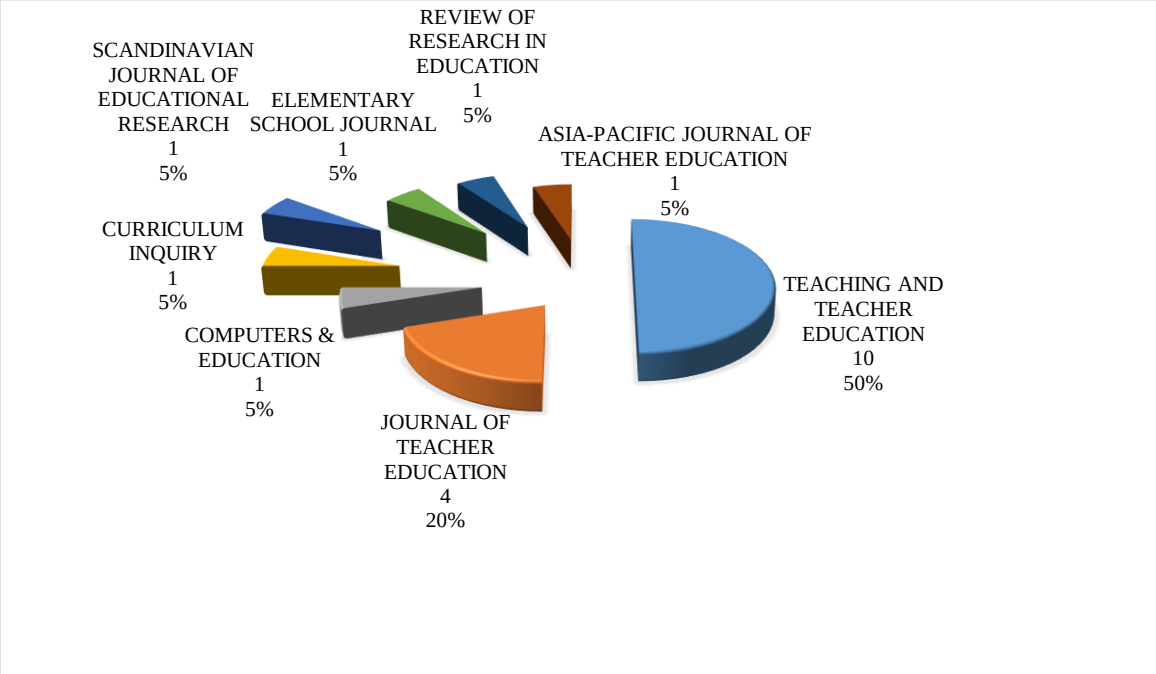

Figure 5: Journals with the most influential publications

Figure 5 shows the distribution of the 20 most influential articles to the journals in which they were published. The distribution shows that 15 (75%) of the most influential articles were published in journals specialized in teacher education. Half of the 20 most cited articles were published in "Teaching and Teacher Education", 4 (20%) in the "Journal of Teacher Education", and one in the Asia-Pacific Journal of Teacher Education. Five of the most cited articles were published in five different venues, which do not particularly specialize in teacher education. This suggests that general teacher education journals significantly impacted TE research area.

Leading (Top) Countries

Table 3 shows the leading countries in TE research ranked by the number of publications. There were 25 countries (with 5 or more publications) around the world contributing to the research on TE. It appears that English-speaking countries are dominating the research area and particularly the USA with 343 publications is far beyond the other contributing countries. The USA is followed by Australia with 94 studies, England with 84,

and Canada with 64. Interesting to observe that while there are many European countries on the list, the number of Asian countries remains considerably limited.

Ranked by number of publications			Ranked by number of citations			Ranked by number of average citations per item		
Rank	**Country**	**Documents**	**Rank**	**Country**	**Citations**	**Rank**	**Country**	**Average citations per item**
1	USA	343	**1**	USA	3167	**1**	N. Ireland	32,8
2	Australia	94	**2**	Netherlands	1308	**2**	Netherlands	25,65
3	England	84	**3**	England	1250	**3**	Scotland	18,36
4	Canada	64	**4**	Australia	901	**4**	Belgium	15,74
5	Netherlands	51	**5**	Israel	592	**5**	England	14,88
6	Israel	45	**6**	Canada	588	**6**	Israel	13,16
7	China	38	**7**	Norway	351	**7**	Norway	11,32
8	Ireland	34	**8**	Belgium	299	**8**	Spain	10,33
9	Norway	31	**9**	Ireland	274	**9**	Australia	9,59
10	Finland	26	**10**	Scotland	257	**10**	USA	9,23
11	N. Zealand	21	**11**	Finland	218	**11**	Canada	9,19
12	S. Africa	20	**12**	China	188	**12**	Turkey	8,63
13	Belgium	19	**13**	Turkey	164	**13**	Portugal	8,6
14	Turkey	19	**14**	N. Ireland	164	**14**	Finland	8,38
15	Sweden	15	**15**	Sweden	99	**15**	Taiwan	8,17
16	Scotland	14	**16**	N. Zealand	71	**16**	Ireland	8,06
17	Germany	7	**17**	Spain	62	**17**	Estonia	7,83
18	Pakistan	7	**18**	Taiwan	49	**18**	Sweden	6,6
19	Estonia	6	**19**	Estonia	47	**19**	China	4,95
20	India	6	**20**	Portugal	43	**20**	Germany	3,86
21	Spain	6	**21**	S. Africa	36	**21**	N. Zealand	3,38
22	Taiwan	6	**22**	Germany	27	**22**	Pakistan	2,71
23	Ethiopia	5	**23**	Pakistan	19	**23**	S. Africa	1,8
24	N. Ireland	5	**24**	Ethiopia	7	**24**	Ethiopia	1,4
25	Portugal	5	**25**	India	3	**25**	India	0,5

Table 3: Top countries ranked by number of publications, citations and average citations per item

As seen from Table 3, the top ten countries contributing to the field are quite the same when ranked by the number of publications and citations, though with slight differences in the ranking of certain countries between the two categories. However, the USA is far beyond the top ten countries when ranked by the number of publications (with 343 documents) and citations (with 3167 times). Netherlands (with 1308 citations) and England (with 1250 citations) ranked second and third in terms of citations, after the USA. Australia follows these countries with 901 citations. When the ranking is considered based on average citations per item (document), a different situation emerges. Ranked 24th in the number of publications and 14th in the number of citations, Northern Ireland ranked first based on average citations per item. The Netherlands comes second in this category (with an average of 25.65 citations per item). Scotland, Belgium, and England find a place within the top five countries in this category.

Top (Core) Journals

Journals with the most articles published and cited among 882 documents about TEs are shared in Table 4.

Ranked by number of publications			Ranked by number of citations		
Rank	**Journal**	**Number**	**Rank**	**Journal**	**Number**
1	Teaching and Teacher Education	70	**1**	Teaching and Teacher Education	2639
2	Journal of Teacher Education	52	**2**	Journal of Teacher Education	1008
3	European Journal of Teacher Education	49	**3**	European Journal of Teacher Education	641
4	Journal of Education for Teaching	47	**4**	Journal of Education for Teaching	550
5	Studying Teacher Education	25	**5**	Computers & Education	309
6	Professional Development in Education	20	**6**	Asia-Pacific Journal of Teacher Education	262
7	Asia-Pacific Journal of Teacher Education	19	**7**	Journal of Teaching in Physical Education	207
8	Australian Journal of Teacher Education	15	**8**	Elementary School Journal	173
9	Teachers and Teaching	13	**9**	Professional Development in Education	165
10	Journal of Mathematics Teacher Education	11	**10**	Teachers and Teaching	
11	Journal of Teaching In Physical Education	11	**11**	Curriculum Inquiry	
12	International Journal of Science and Mathematics Education	10	**12**	Quest	117

Table 4: Top journals ranked by number of publications and citations

Table 4 shows that 12 journals have published 10 or more out of 882 studies. The order of the top four journals with the highest number of publications on TE research does not change when ranked by the number of citations. The majority of the publications appeared in general teacher education journals. Other journals in the list were concerned with either general education or field-specific education journals (e.g., science, mathematics, sports).

Top Authors

It has been determined that there were a total of 1519 authors publishing on TEs in journals indexed in WoS. To determine the most influential authors, we ranked researchers based on publication and citation numbers. In Table 5, we only share the authors, with 5 and more publications or 110 and more citations.

Ranked by number of publications			Ranked by number of Citations		
Rank	Author	Documents	Rank	Author	Citations
1	Macphail, A	14	1	Murray, J.	512
2	Yuan, ER	13	2	Cochran-Smith, M	396
3	Murray, J	12	3	Korthagen, FAJ	392
4	Kosnik, C	11	4	Lunenberg, M	355
5	Dharamshi, P	10	5	Loughran, J	325
6	Loughran, J	9	6	Swennen, A	322
7	Brody, DL	8	7	Zeichner, K	317
8	Hadar, LL	8	8	Male, T	287
9	Menna, L	8	9	Wubbels, T	262
10	Vanderlinde, R	8	10	Drent, M	222
11	Smith, K	7	11	Meelissen, M	222
12	Guberman, A	7	12	Brody, DL	179
13	Lunenberg, M	7	13	Hadar, LL	179
14	Vanassche, E	7	14	Smith, K	177
15	Berry, A	6	15	Macphail, A	168
16	Gutman, M	6	16	Koster, B	166
17	Kelchtermans, G	6	17	Berry, A	161
18	Loo, S	6	18	Bullough, RV	158
19	Pellegrino, K	6	19	Graziani, F	155
20	Pinnegar, S	6	20	Lampert, M	155
21	Tack, H	6	21	Alexander, RA	146
22	White, S	6	22	Baquedano-Lopez, P	146
23	Willemse, TM	6	23	Hernandez, SJ	146
24	Williams, J	6	24	Day, C	132
25	Beck, C	5	25	Leitch, R	132
26	Boei, F	5	26	Huber, J	122
27	Hamilton, ML	5	27	Kelchtermans, G	122
28	Kitchen, J	5	28	Vanderlinde, R	122
29	Kools, Q	5	29	Ball, DL	120
30	Korthagen, FAJ	5	30	Willemse, TM	120
31	Miyata, C	5	31	Clandinin, DJ	116
32	Swennen, A	5	32	Downey, CA	115
33	Wan, ZH	5	33	Vanassche, E	110

Table 5: Top authors ranked by number of publications and citations

It has been determined that 33 of the researchers working on TEs have published 5 or more publications in this field. Based on publications, Macphail, Yuan, Murray, Kosnik, and Dharamshi employed the top five places. When ranked by the number of total citations, Murray, Cochran-Smith, Korthagen, Lunenberg, and Loughran came in the top five respectively. In addition, among the researchers with 5 or more publications, Korthagen (5 publications in total and 392 citations; 78.4 average), Swennen (5 publications in total and 322 citations; 64.4 average), Lunenberg (7 publications in total and 355 citations; 50 .7 avg.), Murray (12 publications and 512 citations; 42.7 avg.), and Loughran (9 publications and 325 citations; 36.1 avg.) were the authors with the highest average of citations per article.

Collaborative Networks Between Authors, Institutions, and Countries

Co-authorship analyzes were conducted to examine scientific collaborations between authors, institutions, and countries. The collaborations between the authors are presented in Figure 6.

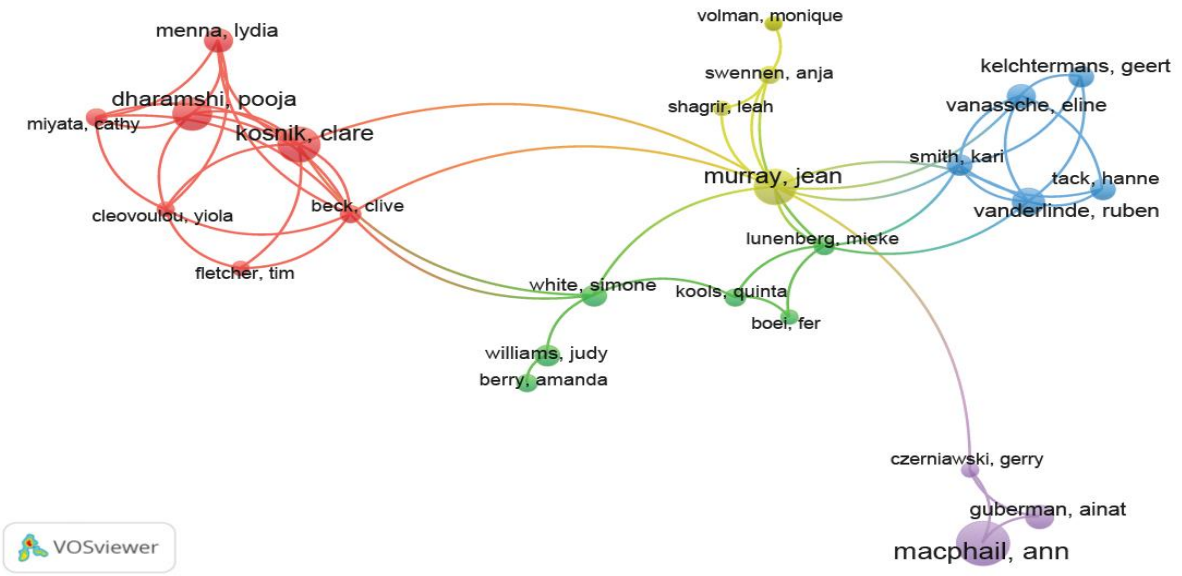

Figure 6: Collaborative research networks between authors

Figure 6 shows the common networks among 25 authors with 4 or more publications in the dataset. The authors who were not involved in collaborative studies were excluded from the analyses. It is seen that there are various scientific collaborative networks consisting of researchers ranging from 3 (e.g., purple cluster) to 7 (e.g., red cluster). In the groupings formed around different colors, the largest node includes a leading researcher who acts as a liaison between others. The yellow cluster is centrally located in the figure and is well connected to all other clusters on the map. So, the yellow cluster forms the core of research collaborations in TE research. The most active member of this cluster is Murray from the University of East London, England. She appears to act as a liaison researcher among all the clusters. The red cluster stands out as the largest one with 7 researchers. Interesting to observe that all the researchers in red cluster are from 6 different Universities, all located in Canada. So, researchers from different Canadian universities seem to have developed a strong collaborative network among themselves and two leading researchers in this network are Dharamshi and Kosnik. The green cluster is composed of researchers from Australia and Netherlands. While three researchers (White, Williams, and Berry) in this cluster come from one institution (Monash University), other three are from different universities in the Netherlands. So, the Australian network with the liaison of White centered in Monash University has collaborative connections with researchers from different universities in the Netherlands. The blue cluster involves four researchers from Belgium and one (Smith) from Norway. So, researchers from these two European countries have formed a collaborative network with the liaison of Smith and Vanderline.

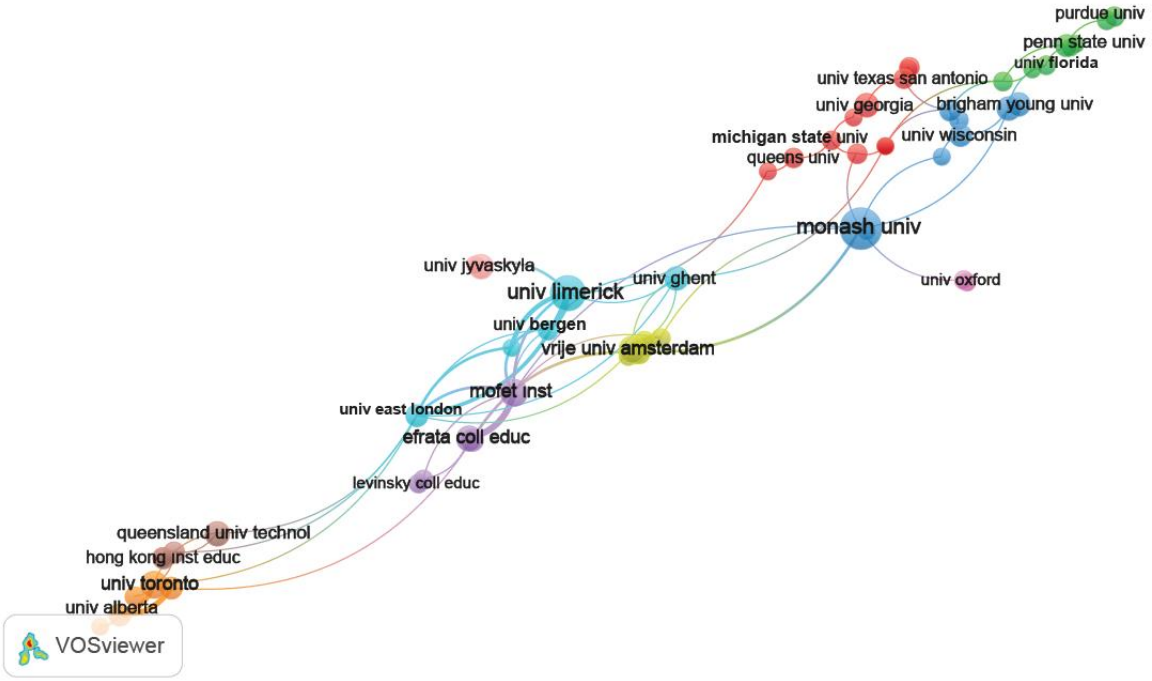

Figure 7. Collaborative research networks between institutions

Figure 7 shows the scientific cooperation networks between institutions with 5 or more publications. As can be seen, the map consists of 10 clusters as indicated by different colors. Among them, Monash University (Australia) draws attention as the largest node. This suggests that this institution is quite active in making research collaborations with different universities. The leading institutions in terms of research collaboration are as flows: the University of East London from England, The Mofet Institute from Israel, Vrije Universiteit Amsterdam and Leiden University from the Netherlands, Monash University from Australia, the University of Limerick from Ireland, Ghent University from Belgium, the University of Toronto from Canada. When clusters are considered, it could be observed that the institutions in the USA carry out joint studies both within their borders and from other parts of the world such as Ireland, Australia, Canada, and China. It appears that institutions in European countries generally cooperate with their counterparts in Europe. One exception is the Mofet Institute in Israel which has built research collaborations with different countries. The most intense connections and the highest number of countries in terms of cooperation are in the light blue cluster. There are institutions from 5 different countries in this cluster, namely England, Norway, Israel, Belgium, and Ireland, and the collaborative research undertakings between these institutions are remarkably high.

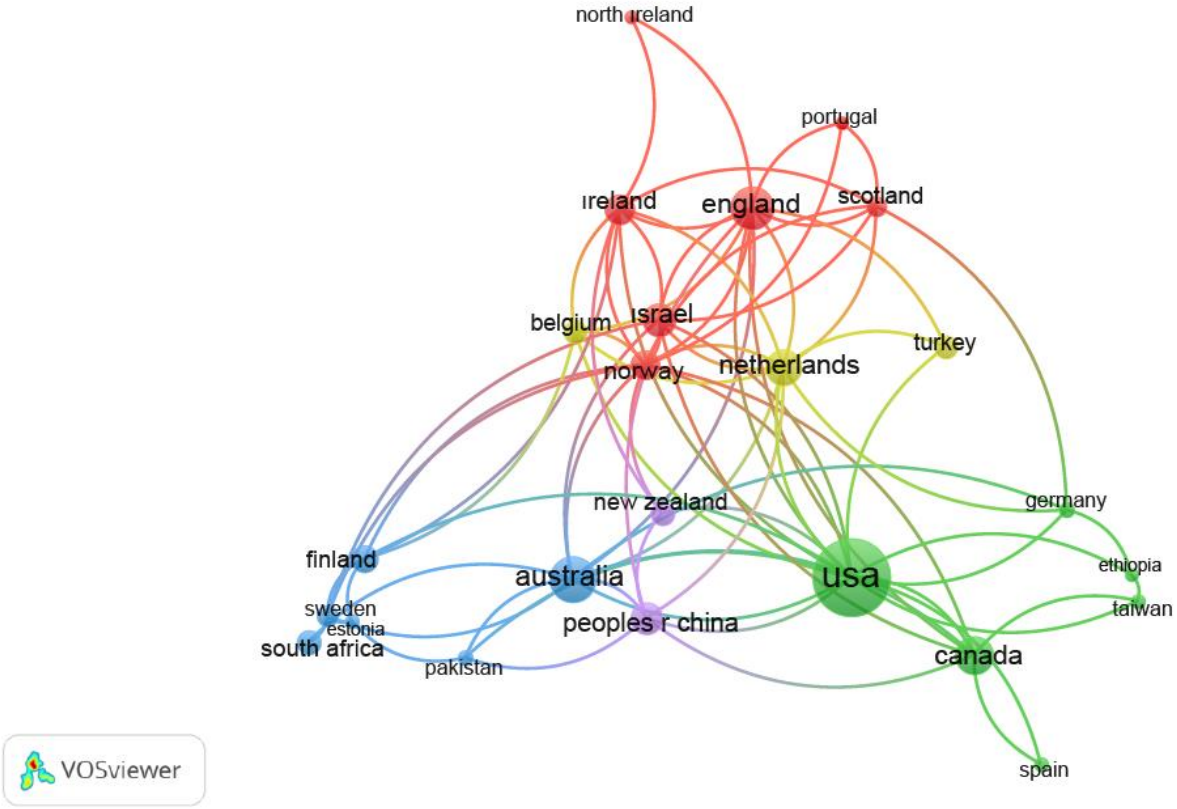

Figure 8: Collaborative research networks between countries

Research collaborations between countries with 5 or more publications are presented in Figure 8. The results indicate that the largest nodes occur in the USA, Canada, Australia, and England. It appears that English-speaking countries constitute important centers dominating the research networks between countries. Apart from these countries, Norway, Netherlands, Ireland, and Israel play a considerable part in making connections with other countries. Northern Ireland, Spain, Portugal, Ethiopia, Pakistan, Taiwan, and Turkey seem to be involved in research collaborations, though in lesser degrees with other countries as indicated by their distance from all other clusters and thin links.

Topical Foci in the Field of Teacher Educators

A mapping of the relational analysis on keywords (with 5 or more occurrences) is given in Figure 9. As could be seen, teacher education, teacher educator(s), professional learning, and professional development constituted the largest nodes. There were some other frequently cited terms attracting attention including self-study, higher education, (professional) identity, diversity, equity, teacher knowledge, teaching, teacher preparation, technology integration, standards, and academic work. On the other hand, when the average publication years of these keywords are taken into account, it is possible to make some inferences about the trends. Until 2014, most cited keywords were somehow related to the works, responsibilities, and identifications of TEs such as identity, academic work, teacher knowledge, and teaching. In around 2015, one could see an increase in the number of keywords related to learning and growth of TEs such as self-study, professional development, and professional learning. From 2017 onwards, the frequency of keywords concerned with

TEs and their practices from a critical perspective such as social justice and equity. Further to these, technology-related keywords began to come to the fore such as technology integration. In addition, the concepts of initial teacher education, curriculum, and partnerships have started to be among the working themes in recent years.

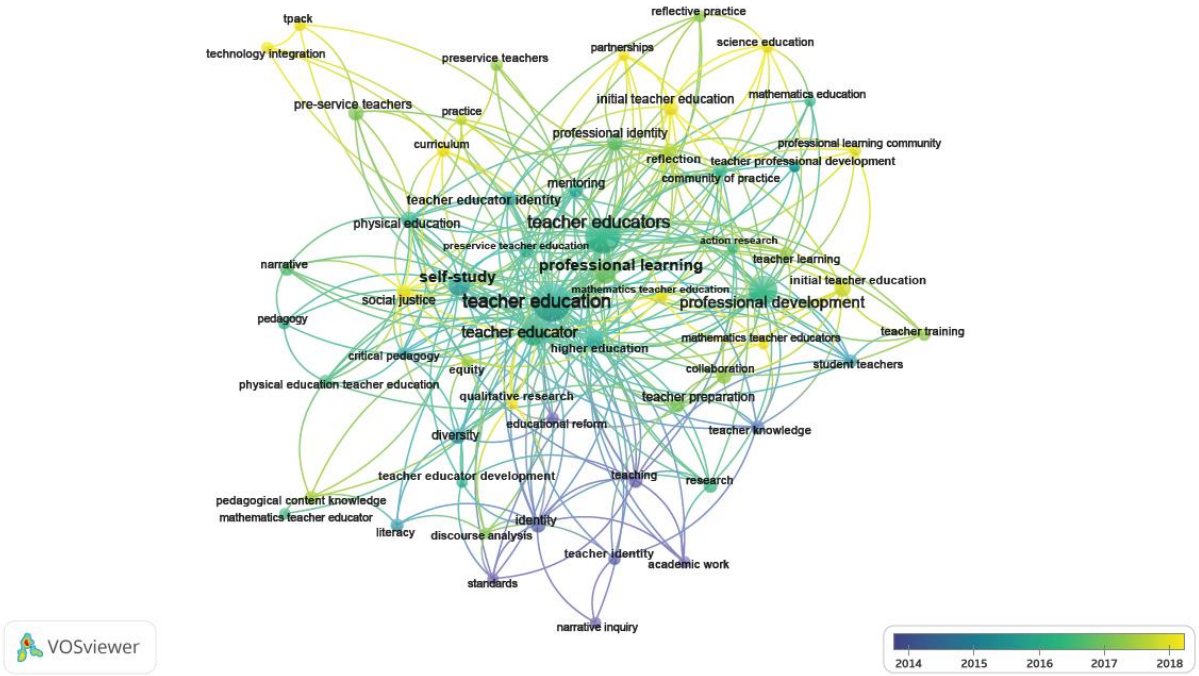

Figure 9: Evolution of research themes in TE research

Discussion and Conclusions

This paper examined the current state and evolution of research in TE research based on the data present in the WoS database during the period between 1967-2021. The distribution of research production during this period represents two phases. The first phase continued until the early 2000s during which a slow progression was apparent. This period corresponds to Price's first phase or precursors phase. Afterward, however, research on TEs has become an emergent field of study whose interest has grown exponentially since the early 2000s and continued to attract increasing research attention until the present day. The current state of research on TEs could be associated with Price's second phase where the research area represents a *terra incognita* of the scientific field. One could observe that the number of scholars interested in TEs is constant increase and the production of knowledge opens up new research topics and paves the way for new research interests. Further to this, an exponential increase in the scientific production of TE research indicates a duplication time ranging from 1 to 6 (with an average of 3.5 years) and this suggests almost thrice faster than assumed by Price's law. We feel that the rapid increase particularly apparent in the number of publications might be related to the special issues on TEs with several journals on teacher education as well as field education. Among these, Journal of Mathematics Teacher Education published a special issue on TEs in 2010; Journal of Teacher Education in 2014; Journal of Mathematics Teacher Education in 2018; Journal of Technology and Teacher Education in 2019, and International Journal of Science and Mathematics Education in 2021. These special issues seem to have fueled the increasing interest in TE research.

Considering the number of publications per scholar, we observed a hyperbolic distribution of Lotka's law. The formula of Lotka's law is a debated issue. Some (see Dabi et al., 2016) argue that the exponent of the denominator in Lotka's law does not necessarily tend to be 2, which depends on the research field. One implication of this argument is that Lotka's law overemphasizes prolific authors as the exponent on the law might be higher than 2. In our study, we calculated the exponent approximately 2.82 which is higher than estimated by Lotka. Although the gap between the expected and observed values diminished with the increase in productivity, our analysis indicated a significantly higher number of single-publication authors than expected by Lotka. Hence, we argue that the majority of researchers tended to make occasional contributions to the field of TE while few prolific researchers could be considered specialists in this area. Based on this argument, we conclude that the expertise in the field of TE is concentrated around very few scientists and the group of experts in this field needs to be expanded.

Although it is often stated that research insights on TEs remain limited (see Knight et al., 2014; Livingston, 2014), as the findings of this study revealed, there has been progress in this area in recent years. This progress has been mostly owing to the push of a small group of researchers from the United States, Australia, Canada, and several European (eg. England, Netherlands, Finland, Belgium, Norway), and few Asian (Israel, China, Turkey) countries that maintain collaborative connections nationally and with other countries. Nevertheless, the participation of scholars in different countries, and the co-created scientific literature is significantly limited. One underlying reason for this observation could be that majority of the journals listed by WoS are in English, creating an advantage in favor of English-speaking countries. Surely, language cannot be the only determinant in the number of publications and collaborations in English-speaking countries. These countries provide researchers with better opportunities when compared to many others, for research resources and funding along with relevant infrastructure (see also Hernández-Torrano & Ibrayeva, 2020). These features contribute positively to the quality and number of scientific productions. However, there is a drawback; that is, centralization of high scientific productions in particular countries may lead to the development of TE research area through a more limited cultural perspective, particular education systems, and certain philosophical traditions. This limitation becomes even more evident when we realize that the studies in TEs focus on issues sensitive to the cultural texture and education system such as professional development, professional identity, professional responsibilities, and practices as well as teacher preparation. Though remain limited, research studies from Asian countries may contribute to the development of TE field with non-western perspectives and hence enrich research insights. In addition, third-world countries whose contributions are extremely limited must be involved in scientific productions or at least take part in collaborative studies so that the field can be enriched in scope, content, and depth through cultural diversity.

When the most cited studies in the field of TEs examined, it could be realized that much of the research attention has been paid to professional identities, professional development, and works and practices. The researchers attempt to uncover TEs who are, in Livingston's (2014) words, described as "hidden professionals" through their identity developments, professional preparation processes, roles, and responsibilities along with their practices. Scholars with more than one most-cited publication such as Cochran-Smith, Zeichner, Loughran, Korthagen, and the authors receiving the highest number of citations per publication such as Swennen, Lunenberg, and Murray focused on the research topics listed here. Hence it could be argued that these researchers had a crucial impact in shaping TE research foci.

Research on TEs is primarily spread in general teacher education journals. Three are identified as leading journals according to number of research papers: *Teaching and teacher*

education, Journal of teacher education, and *European journal of teacher education*. However, from 2015 onward, other journals have begun to be discernable and showed rapid growth in the number of articles published, including *Asia-pacific journal of education; Professional development in education; Studying teacher education*. The fact that the most cited articles were published in these journals shows that these venues have an important role in shaping TE research. When the distribution of publications among journals is examined, it is reasonable to predict that general education journals will continue to dominate the development of TE research and dissemination of related scientific productions in the upcoming years. General teacher education journals are important venues as they attract educators specializing in different subject matter areas as well as provide them opportunities to develop holistic perspectives on particular research areas. However, there is also a drawback here: general teacher education journals spark off discussions and create conceptualizations on TE in a general/generic manner which might lead to ignorance of specialties peculiar to certain TEs working in different subject matter areas. Therefore, we believe that TE research would benefit from the diversification of publication venues with the involvement of subject-specific teacher education journals which contribute to the creation and accumulation of specialized knowledge and hence enables the formation of scholarly communities in particular subject matter areas.

Our findings were informative about collaborative networks as well. Thanks to research collaborations, researchers have the opportunity to share information, transfer experiences, use resources for a common purpose, and create opportunities for the development of common approaches. These are considered to be among the important features that increase the quality of research undertakings (Freshwater et al., 2006). Research collaborations also have important functions in attracting new researchers to the field and increasing scientific productivity (Barrett et al., 2011). Our findings also indicated that collaborations in TE research existed at the levels of researchers, institutions, and countries. However, a closer look at the findings indicates that international research collaborations in the field are often shaped based on cultural similarity (European networks), that language is a determining factor and that geographical proximity is also influential. Recent bibliographic studies in different fields (e.g. Hernández-Torrano & Ibrayeva, 2020; Huang et al., 2020) have also reported similar trends. Therefore, research collaborations in TE research reflect the pattern identified in studies conducted in social sciences and education. The fact that international research collaborations are mainly established via lingual, geographical, and/or cultural proximity raises some concerns about the diversification and enrichment of TE research. This is particularly because the development of TE as an emerging field of study, as it is, seems to have not been sufficiently benefiting from the contributions of researchers coming from different cultural backgrounds, involved in various teacher education systems, and adopting diverse philosophical approaches. For this reason, we assume that achieving geographical, cultural, and institutional diversity in research collaborations will make significant contributions to achieving a better understanding, and hence, extend the depth and breadth of TE research.

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