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Science Mapping the International Knowledge Base on the 21st Century Skills

21. Yüzyıl Becerileri Eksenli Araştırmaların Uluslararası Görünümü

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ABSTRACT: There have been considerable efforts to define, conceptualize and specify the components of 21st century skills in the field of education since the first years of the new millennium. This article presents the results of a broad bibliometric review of educational research on 21st century skills by identifying the volume, growth trajectory, and geographical dispersion of studies, as well as bringing out the intellectual structure and topical foci of the existing knowledge production in this area. Bibliometric analysis was conducted to examine a total of 4096 articles published on this topic in Web of Science (WoS) indexed journals between 2000–2021 years. VOSviewer, WoS analytical tools, and Tableau software were used to analyze the data. The results of this analysis yielded five major Schools of Thought: "New Literacies and Skills", "Teachers in the 21st Century", "Digitalization of Education", "Media and Communication", and an "Eclectic" cluster. Furthermore, the co-occurrence keyword map revealed four topical foci: "Media Literacy," "New Literacies and Digital Technologies in Education," "Digital Literacy and Competencies," and a "Multidimensional" cluster. This study adds nuanced evidence to the literature by providing a baseline for the patterns and characteristics of the knowledge base on 21st century skills.

Keywords: 21st century skills, new literacies and skills, bibliometrics, educational studies.

ÖZ: Yeni bin yılın ilk yıllarından itibaren eğitim alanında 21. yüzyıl becerilerinin bileşenlerini tanımlama, kavramsallaştırma ve belirleme konusunda önemli çabalar sarf edilmiştir. Bu araştırma, mevcut çalışmaların hacmini, büyüme yörüngesini ve coğrafi dağılımını belirleyerek ve aynı zamanda bu alandaki mevcut bilgi birikiminin entelektüel yapısını ve güncel odaklarını ortaya çıkararak 21. yüzyıl becerilerine ilişkin eğitim bilimleri bağlamında gerçekleştirilen araştırmalar üstünde yapılan geniş bir bibliyometrik incelemenin sonuçlarını sunmaktadır. Araştırma kapsamında 2000-2021 yılları arasında Web of Science (WoS) indeksli dergilerde bu konuda yayınlanmış toplam 4096 makaleyi incelenerek bibliyometrik analiz gerçekleştirilmiştir. Verilerin analizi sürecinde VOSviewer, WoS analitik araçları ve Tableau yazılımı kullanılmıştır. Analiz sonuçları beş büyük temayı ortaya çıkarmıştır: "Yeni Okuryazarlıklar ve Beceriler", "21. Yüzyılda Öğretmenler", "Eğitimin Dijitalleşmesi", "Medya ve İletişim" ve bir "Eklektik" küme. Ayrıca, araştırmalarda birlikte kullanılan anahtar sözcükler haritası alanda dört güncel odak noktasını ortaya çıkartmıştır: "Medya Okuryazarlığı", "Eğitimde Yeni Okuryazarlıklar ve Dijital Teknolojiler", "Dijital Okuryazarlık ve Yeterlikler" ve bir "Çok Boyutlu" küme. Bu çalışmanın, 21. yüzyıl becerilerine ilişkin uluslararası literatürün yapısı ve niteliksel özellikleri için bir temel sağlayarak alanyazına katkılar sunacağı ve yeni tartışmalar açacağı beklenmektedir.

Anahtar kelimeler: 21. yüzyıl becerileri, yeni okuryazarlıklar ve beceriler, bibliyometrik analiz, eğitim araştırmaları.

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In every period of history, it has long been broadly discussed what important competencies, knowledge, skills, abilities, and attitudes people should acquire through education. Globalization, the rapid pace of change in technological and scientific advancements, transformation in production, consumption, and lifestyle habits resulted from the increase in the accumulation of knowledge, and technological advances and the necessity of updating the required human qualities led to the emergence of the need for some new skills and competencies which are crucially essential today for the field of education.

The dizzying speed of information is a powerful resource that permeates all areas of contemporary life, including media production and consumption, as well as employment. Moreover, internationalization, demographic transformation, and a lifestyle built on consumption are other key features defining this century (Jerald, 2009). These variables specific to the digital age play a decisive role in defining 21st century human qualities. Issues such as the management of scarce resources, pressures to increase profitability, gaining competitive advantage, seeking innovation (Trilling & Fadel, 2009), the replacement of human labor with automated tools (Levy & Murnane, 2013), the transition to a technology-based global knowledge economy (Bellanca & Brandt, 2010), the transformation of the industry-based economy into a service economy driven by knowledge and innovation (Unger, 2019), competition, and cooperation (Beamish & Lupton, 2016) have all played key roles in defining the required skills of employees in this era.

To succeed as 21st century workers and citizens, individuals must adapt to this new period and its transformations by effectively leveraging rapidly changing technological innovations (Griffin et al., 2012), as well as developing the skills and competencies to constantly renew themselves (Fullan & Langworthy, 2014). Based on these requirements, the meaning of education is now defined as preparing human beings to become global and conscious citizens (Kellner, 2001) who can cope with the demands of such a technology-heavy society (Berry, 2012).

Although the literature employs a variety of terms interchangeably to denote these competencies—including "survival skills," "life skills," "global skills," and "life and career skills" (e.g., Higgins, 2014; Wagner, 2008)—the most widely accepted term is "21st century skills." Though there is no clear consensus on the definition of the term (Dishon & Gidead, 2020), researchers agree that it encompasses a general framework of competency areas and skills (Joynes et al., 2019). The specific skills included within this concept may vary however, they can generally be grouped into three categories: life and career skills, digital literacies, and learning and innovation skills (e.g., Salas-Pilco, 2013; Voogt & Roblin, 2012).

Across the world, researchers and policymakers are increasingly recognizing the need to incorporate 21st century skills into national and global education systems (Care, 2018; World Economic Forum, 2015). Such skills have been taken into consideration when defining educational policies, setting learning outcomes, developing curricula, and designing teacher training and instructional modules. This increased focus has also bolstered research into 21st century skills in recent years. A limited number of studies have systematically reviewed the research on 21st century skills (e.g., Chalkiadaki, 2018; Van Laar et al., 2017, 2020); however, these studies tend to focus only on one specific skill (e.g., digital skill) or one particular context (e.g., primary education), and

none of them analyzed comprehensive databases representing the collective knowledge on this phenomenon. Moreover, none of these review studies utilized the bibliometric tools typically employed for mapping disciplines or fields of research. To fill this gap in the literature, this research seeks to provide comprehensive insight into the global knowledge base on 21st century skills through the analysis of a broad corpus of related literature.

The purpose of this study is to document, clarify, and illustrate the structural and relational characteristics of the knowledge base in order to provide a bibliometric profile of the educational studies about 21st century skills. The following research questions guided the study:

1. What is the volume, growth trajectory, and geographic distribution of research about 21st century skills?
2. What are the most influential authors, articles, and journals in the literature?
3. What is the intellectual structure of the knowledge base on 21st century skills?
4. What topical foci have attracted a great deal of attention in the literature?

Method

This section outlines the steps taken for finding and identifying sources, extracting data, and data analysis.

Conceptual Framework

Existing review studies in this field can be classified into one of three groups: a) studies showing the "big picture," which illuminate the size, geographical dispersion, etc. of the knowledge base; b) studies that seek to determine the topical foci, conceptual models, etc. of the relevant studies in the literature; and c) studies that synthesize the results of existing research in depth, which could be regarded as a kind of content analysis (Bellibaş & Gümüş, 2019).

Our conceptual framework was based on previous review studies in the field of educational research (e.g., Diem & Wolter, 2012; Hallinger, 2018). The conceptual framework was adopted according to the research questions which was asked based on the purpose of the study. Thus each dimension was added in order to find answers to the research questions. The researchers whose work we sought to emulate combined the first and the second path explained above. Our framework included four dimensions to illustrate the state of the research on 21st century skills: "size," referring to the volume of publications in the dataset; "time," tracing the developmental path or growth trajectory of the publications; "space," meaning the geographical dispersion of the publications; and "composition," referring to the topical foci and the intellectual structure (Small, 1999), which is typically defined as the research traditions, research topics, and pattern of interrelationships among the research and researchers in a specific field (Shafique, 2013).

Search Criteria and Identification of Sources

The criteria used to establish the eligibility of publications during the source identification process included the type and index of publications, time period, and topical scope. As shown in Figure 1, we utilized PRISMA flow diagram (Moher et al.,

2009), which is regarded as procedural guidelines for identifying sources for this kind of review to limit the scope of this study with articles and reviews published in the journals indexed in SSCI, SCI-Expanded, ESCI, and AHCI. The aforementioned journals were selected due to their high impact value, article acceptance rates, compliance with scientific and ethical principles, transparency of article evaluations, and double-blind peer-review processes.

We chose to use the Web of Science (WoS) as the source of data for this review because it provides reliable access to a wide variety of journals that provide an inclusive data set for the academic field under study. This review analyzed articles published between January 2000 and February 2021, and the topical scope was limited to keywords related to 21st century skills. The first step involved an initial inquiry using the WoS search engine, according to the following criteria:

Field Tags: Title (TI), Author Keyword (AK), KeywordPlus (KP);

Inclusion: (Dates) 2000 to 05 February 2021;

Inclusion: (WoS Category): Education educational research;

Inclusion: (WoS Index): SSCI, SCI-Expanded, ESCI, and AHCI;

Exclusion: (Document Type) proceedings paper, book chapter, editorial material, book review, book, and retracted publication

After that, we queried various search strings in the WoS database until we reached the most comprehensive data set for the purpose and scope of this study. This search produced a total of 4360 documents. We then utilized WoS filters to eliminate irrelevant document types, including 18 proceedings papers, 155 editorial materials, 76 book reviews, nine corrections, five letters, and one retracted publication (see Figure 1). In the end, the number of eligible articles and reviews included in the data set was reduced to 4096.

Data Extraction and Analysis

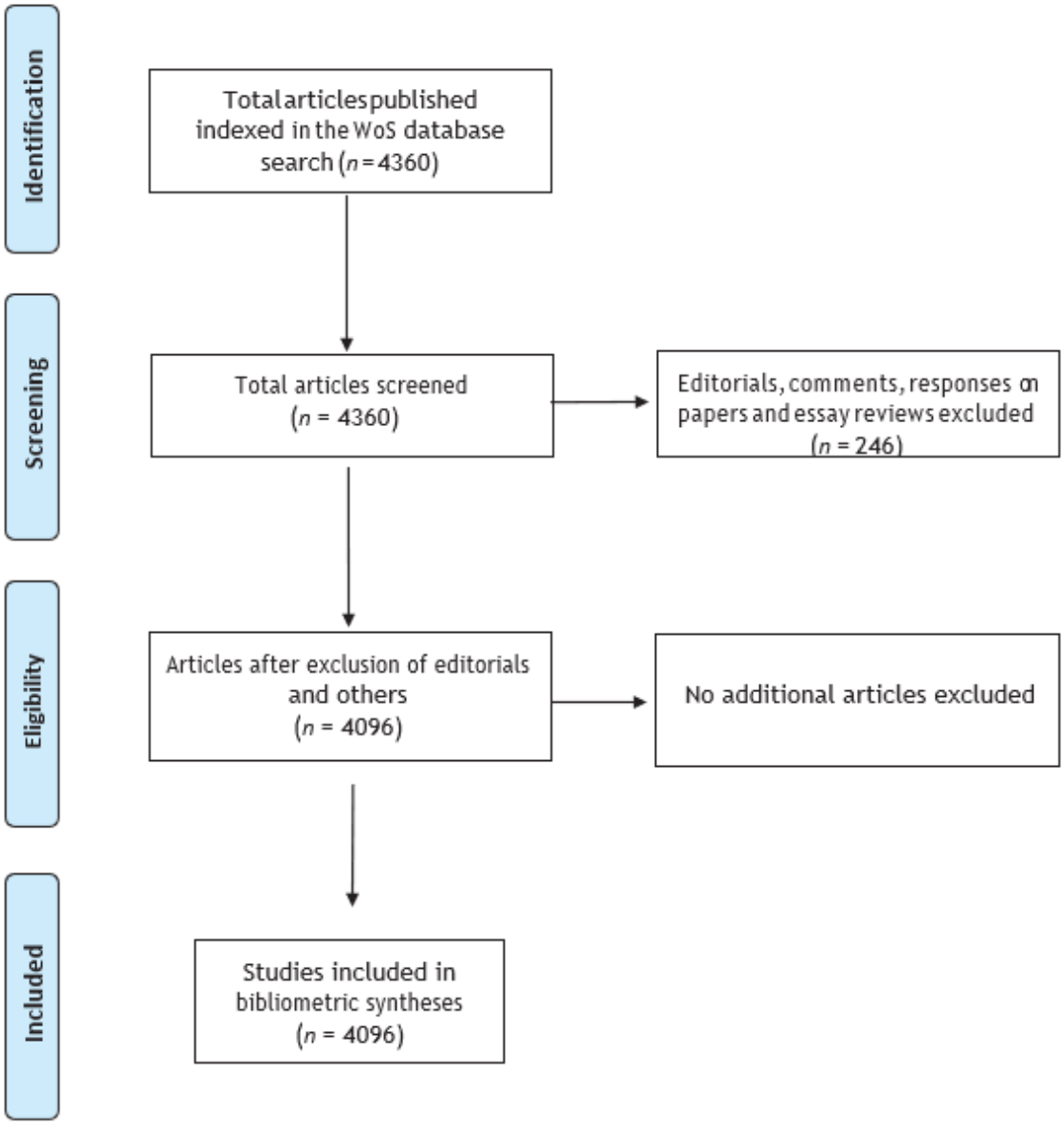
In this study, the researchers conducted both descriptive and bibliometric analysis through VOSviewer (which has been widely utilized in systematic reviews), WoS Analysis tool, and Tableau.

Descriptive analysis was employed to reflect the topographical features and the dynamics of the related literature (e.g., growth trajectory, as well as the number and percentage of the documents from authors, countries, etc.). Bibliometric analysis, which visually demonstrates the composition of the literature like a "neural network" (Hallinger, 2018), typically sheds light on the intellectual structure of the knowledge base and topical foci through citation analysis, co-citation analysis, and co-occurrence analysis.

Citation analysis is considered a measure of influence based on the hypothesis that if an article, author, or journal is cited frequently, it is relatively powerful in the related literature (Hood & Wilson, 2001; Zupic & Čater, 2015), The citation analysis in this study was limited only to authors, documents, and journals included in the WoS database, so it can be referred to as "WoS citation analysis."

Figure 1

PRISMA Flow Diagram



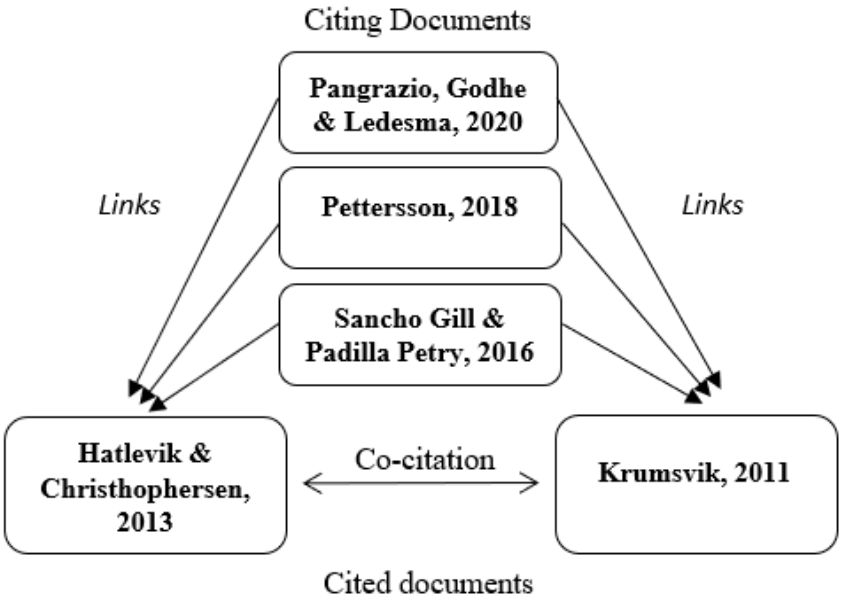
Note. (Adapted from Moher et al., 2009).

Thanks to recent advances in bibliometric software, co-citation analysis can be used on multiple levels to illuminate the relationships among authors, as well as among topics or research fronts consisting of a group of co-cited core publications (Van Eck & Waltman, 2019). As shown in Figure 2, the underlying logic of co-citation analysis is that the more frequently two authors, publications, or journals are cited together, the more likely their research field and focus are associated (McCain, 1990). In this review, author co-citation analysis was employed to identify the schools of thought within the disciplinary knowledge base of the studies.

Furthermore, co-occurrence analysis was conducted to determine the trends in the topical foci studied by scholars in the research field. Before the analysis, a thesaurus file (Van Eck & Waltman, 2017) was prepared to minimize unnecessary repetition between duplicated keywords, such as "twenty-first century skills" and "21st century skills."

Figure 2

Example for the Concept of Co-citation



Note. (Adapted from Hallinger, 2018).

Limitations

First, though this bibliometric study enables analysis of the multidimensional structure of the related literature based on bibliographic metadata in order to see the "big picture" of the field, unlike other review methods (such as meta-analysis or content analysis), it does not provide an assessment of the quality of the articles or considerations on their findings. With this salient limitation of the methodology in mind, we believe that the findings of this study still present a valuable contribution to the field and future research, by building on the work of similar studies that have reviewed the literature of other fields and contexts (e.g., Chalkiadaki, 2018; Van Laar et al., 2017, 2020).

Second, although we attempted to include all the possible documents (n=4096) from the WoS about 21st century skills from 2000 to 2021 in our research, the scope of the database did not cover many forms of media beyond journal articles including books, theses, conference proceedings, etc. Therefore, we cannot assure the extent to which the findings of this bibliometric study are representative of the whole knowledge base.

Finally, although our database covers a broad range of studies related to 21st century skills, the WoS is still a limited repository, which could lead to critiques regarding whether this study is representative of all published knowledge on 21st century skills. This limitation was mitigated to some extent by performing a co-citation analysis, which allowed us to capture and include the relevant knowledge base that was not indexed in WoS. This enabled the identification of numerous documents in the literature beyond our dataset comprised of WoS-indexed publications.

Ethical Procedures

Ethics approval was not required for this bibliometric review.

Findings

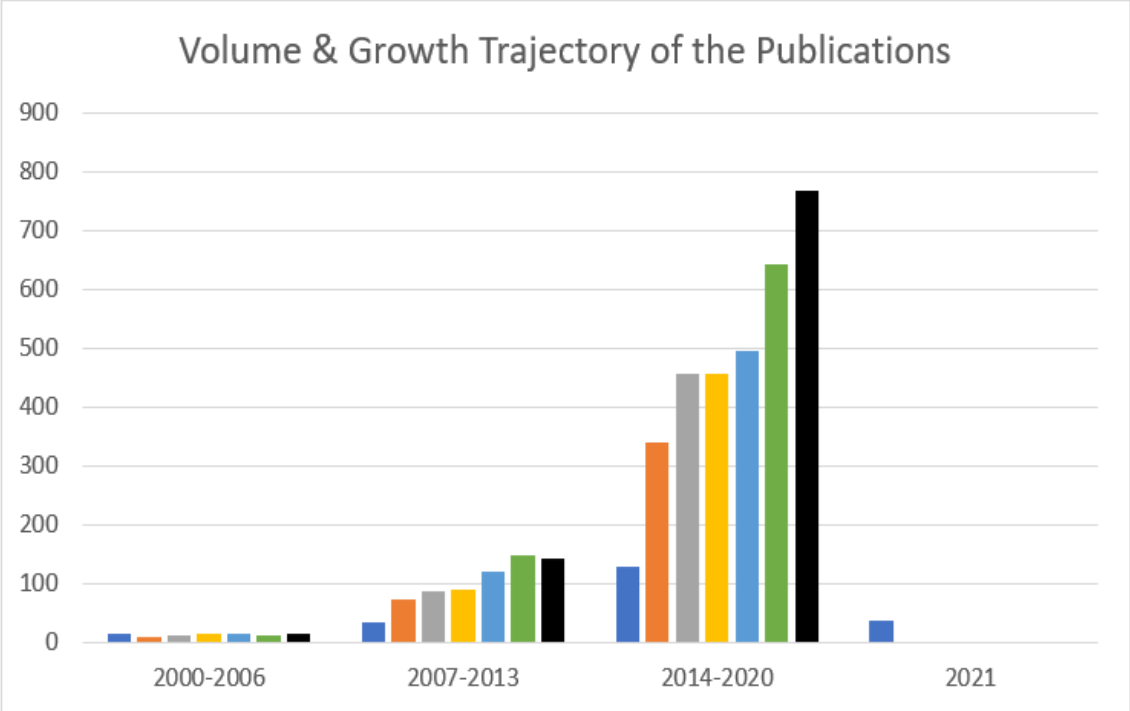
This section presents the results regarding the patterns of knowledge production in the study sample. The findings are organized around the study's four research questions.

Volume, Growth Trajectory, and Geographic Distribution

Figure 3 presents the publication years of the 4096 articles on 21st century skills identified within WoS. It is apparent from this analysis that the number of studies has steadily increased over the past two decades. While only 90 (2.20%) articles were published between 2000 and 2006 years, this number increased to 690 (16.85%) between 2007–2013, before jumping to 3281 (about 80% of the total number of relevant publications) between 2014–2020 years. This illustrates the noteworthy growth trajectory of the studies about 21st century skills, demonstrating the sharply increasing research interest in this area over the last 20 years.

Figure 3

Distribution of the Publications according to the Years, 2000 to 2021.

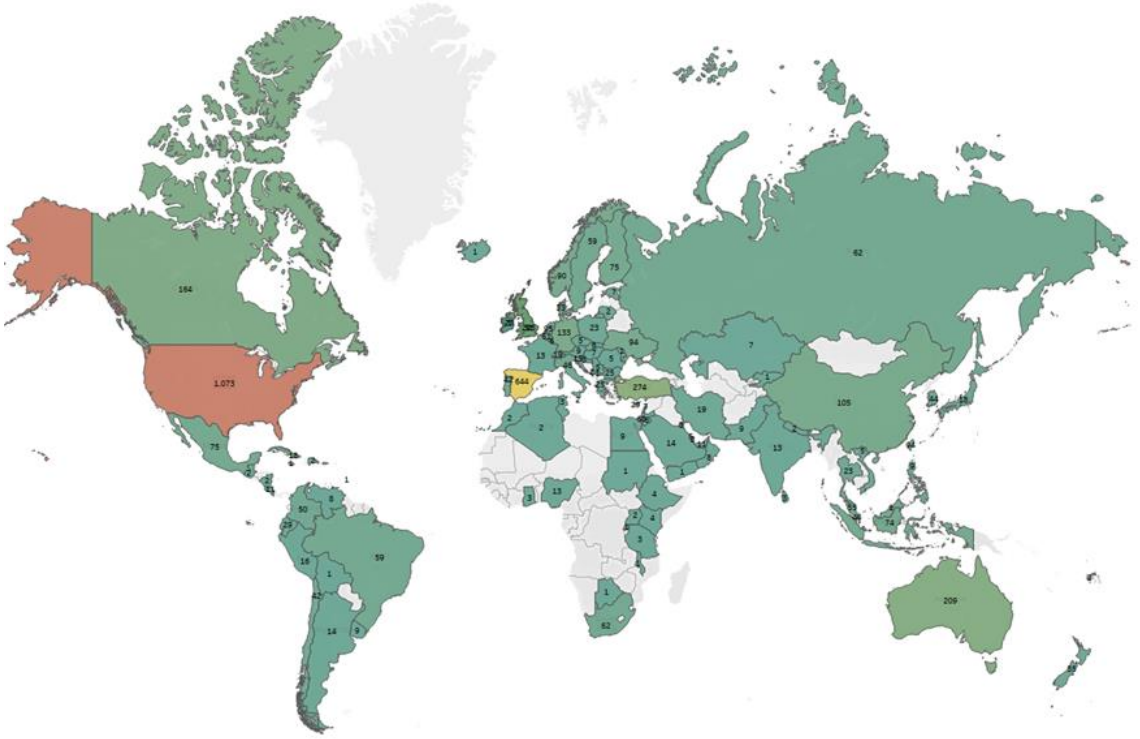


The heat map in Figure 4 shows the geographical distribution of the documents published on this topic since 2000. According to the descriptive statistics, 9262 authors from 105 countries have contributed to this knowledge base. The map shows the dominance of five countries: The United States (22.52%), Spain (13.52%), Turkey (5.75%), Australia (4.39%), and the United Kingdom (4.30%), respectively. Scholars in these countries accounted for 50.48% of the documents in the database. Other notable contributions came from Canada, Germany, China, the Netherlands, Taiwan, Ukraine, and Norway. Conversely, the heat map also displays various countries that are "lost" completely from the knowledge base. The blank spots on the heat map concretize the current limitations and deficits in scientific research in this area.

The heat map clearly demonstrates that European scholars have published the lion's share of the full corpus (45.80%). Researchers from North America accounted for 27.96% of the articles, followed by Asia (13.77%), South America (5.16%), Oceania (5.14%), and Africa (2.16%). Regional leaders in this field include Spain, Turkey, the United Kingdom, and Germany, which constitute 57.42% of the total publications in Europe; the USA, Canada, and Mexico (98.57%) in North America; China, Taiwan, and Indonesia (41.31%) in Asia; Brazil, Colombia, Chile, and Ecuador (73.06%) in South America; Australia (84.96%) in Oceania; and South Africa and Nigeria (72.82%) in Africa.

Figure 4

Geographical distribution of the Publications



Identification of Influential Authors, Documents, and Journals

During data collection, 4096 articles written by 9240 authors were identified for the review. While 1010 of these researchers published more than one article in the study sample, 71 of them had published five or more articles represented in the corpus.

We followed a two-step analysis to reveal the most influential authors. First, we analyzed the most productive authors in order of their number of publications (not tabled). According to the results, these researchers' publications coalesced around a few central topics: teachers' professional development in the 21st century (e.g., Hatlevik, O. E., Volman, M.; Vanderlinde, R.; Diaz-Garcia, I.), information and communication technology (ICT) competencies (e.g., Aesaert, K.; Scherer, R.; Almerich, G.), new literacies (e.g., Burnett, C.; Kiili, C.), digital competencies (e.g., Siddiq, F.; Guillen-Gamez, F. D.), and media (e.g., Eickelmann, B.; Fedorov, A.; Gutierrez, A.). In addition, we found that only three of the top ten (and 8 of the top 20) most highly cited researchers were female. Regarding the geographical distribution of the publications, we

discovered that the most productive authors were from ten different countries located in Europe (17) and Asia (3).

Second, we examined the first ten most-cited authors in the corpus (Table 1). Though the authors were listed based on their total citations on WoS, other statistics such as their total number of documents or average citations per year and nation were also added in Table 1 to provide more insights into scholarly capacity, impact, and contributions. This analysis also enabled us to evaluate the patterns of growth and the geographical distribution of these articles. The most cited scholars in the table are noted for their research in the fields of teachers' professional development in the 21st century (e.g., Darling-Hammond, L.; Voogt, J. M.; Hatlevik, O. E.), educational psychology (e.g., Buettner), and digital technologies in education (e.g., Hwang, G. J). It is worth noting that only four of the scholars listed in Table 1 were also among the most productive authors. The most influential authors were from six countries in Europe, North America, and Asia. This list did not include any researchers from regional leader countries such as Turkey, the United Kingdom, Canada, China, Brazil, Australia, or South Africa.

Table 1

The Most Influential Authors Based on WoS

Author	Institution	Nation	*N*	WoS citation
Darling-Hammond, L.	Stanford University	USA	1	685
Voogt, J. M.	University of Amsterdam	Netherlands	5	432
Hatlevik, O. E.*	Oslo Metropolitan University	Norway	11	426
Volman, M.*	University of Amsterdam	Netherlands	7	345
Veenman, M. V. J.	Leiden University	Netherlands	5	298
Dignath, C.	Goethe University	Germany	1	296
Buettner, G.	Goethe University	Germany	1	296
Roblin, N. P.	University of Amsterdam	Netherlands	1	295
Kong, S. C.*	The Education University of Hong Kong	Hong Kong	9	292
Hwang, G. J.*	National Taiwan University of Science and Technology	Taiwan	6	248

Note. (*Also among the most productive scholars in the field.)

Next, we conducted a citation analysis to reveal the most highly cited documents in the database. Among the top ten most cited articles (see Table 2), the most recent was published in 2016—suggesting that the total citation metric could privilege older documents, to the disadvantage of newer research (Zupic & Čater, 2015). With this in mind, the finding that four of these top ten articles were published in the last ten years shows the powerful impact of these studies. Secondly, the most cited documents focused on similar topics to those mentioned previously (e.g., teachers' professional development in the 21st century, digital technologies in education, etc.).

Table 2

The Most Influential Documents

Authors	Year	Journal	Wos. Cit.
Darling-Hammond, L.	2006	Journal of Teacher Education	685
Voogt, J.; Roblin, N. P.	2012	Journal of Curriculum Studies	296
Dignath, C.; Buttner, G.	2008	Metacognition and Learning	295
Frymier, A. B; Houser, M. L.	2000	Communication Education	248
Baylor, A. L.; Ritchie, D.	2002	Computers & Education	204
Ferres, J.; Piscitelli, A.	2012	Comunicar	194
Greenhow, C.; Robelia, B.	2009	Learning, Media and Technology	187
Ng, W.	2012	Computers & Education	183
Saljo, R.	2010	Journal of Computer Assisted Learning	176
Manganello, J. A.	2008	Health Education Research	163

Note. (As of February 2021)

Even though the studies in this review were published by 555 different journals, Table 2 displays that the top ten most influential journals accounted for 15% of all the publications in the dataset. It should be noted that six of these top ten journals were founded before 2000, and 7 were published in European countries (the UK, Spain, and Germany), followed by the USA (3 journals). Finally, seven of the top journals are in Q1, while two are in Q2, and one is in Q3 quartile rank.

Table 3

The Most Influential Journals

Journals	WoS Cit.	Number of Articles	Impact Factor	Q	Country
Computers & Education*	3759	118	5.296	Q1	UK
Comunicar*	2182	129	3.375	Q1	Spain
Journal of Adolescent & Adult Literacy*	1000	153	1.128	Q3	USA
BMC Medical Education*	845	94	1.831	Q2	UK
Learning Media and Technology*	774	42	2.547	Q1	UK
Journal of Teacher Education	714	3	3.600	Q1	USA
Learning and Instruction	629	7	3.323	Q1	UK
Metacognition and Learning	601	9	2.690	Q1	Germany
Journal of Comp. Asst. Learning	575	26	2.126	Q2	UK
Reading Research Quarterly*	569	35	3.543	Q1	USA

Note. (*Listed also among “the most active journals”)

We also analyzed the journals by volume of articles (not tabled). The results show that six of these most prolific journals were not listed among the most influential

ones, but four others (Journal of Adolescent & Adult Literacy, Comunicar, Computers & Education, BMC medical education) were also among those which devoted the most publication space to studies about 21st century skills. Taken together, the journal analyses demonstrate that while the Journal of Adolescent & Adult Literacy has been the most hospitable journal to studies related to 21st century skills, Computers & Education has demonstrated the strongest scholarly impact according to the number of citations of its articles.

Intellectual Structure of the Knowledge Base

To analyze major themes, we set a threshold of 20 citations with a display of 125 authors among the total of 78,012 researchers in the Author Co-citation Analysis (ACA) network constructed with cited scholars in the reference lists of all the publications in the corpus (*n*=4096). The cluster-enhanced co-cited author map in Figure 6 illustrates nodes, each referring to a different researcher whose size represents the frequency with which the researcher was cited in the publications in the dataset. The nodes are grouped into different colored clusters symbolizing the schools of thought that underlie the related knowledge base (Van Eck & Waltman, 2017). Additionally, the proximity of the nodes signifies co-cited researchers sharing a common perspective on the related field's traditions and disciplinary composition. These serve as crucial variables for interpreting the data represented in the co-citation map, which provides a broader picture of the state of the research in this area (White & McCain, 1998).

The ACA map in Figure 6 illustrates five consistent and distinctive "schools of thought" and visualizes the interconnectedness of the knowledge base through the density of the lines linking the different colored clusters. Gee, Cabero, Jenkins, Buckingham, Prensky, Bandura, and Livingstone feature as the biggest nodes on the co-citation map. In addition, Prensky is located in the central position on the map, which indicates a key boundary-spanning position and signifies that he integrates and interprets different ideas across the different schools of thought (White & McCain, 1998).

The purple cluster labeled "New Literacies and Skills." is composed mainly of scholars investigating new literacies and skills related to information and communication technologies (ICT). Problem solving skills (S. Brand-Gruwel), skills and literacies for multiple media (J. F. Rouet, J. A. Greene, I. Braten), new literacies emerging from ICTs (J. Coiro, D. J. Leu), and critical media literacy (L. E. Mason) are the most prominent topics within this cluster.

In the upper-right part of the map, the yellow cluster consists of researchers whose publications distinctly focus on "Teachers in the 21st Century." Scholars in this area primarily examine teachers' technological pedagogical content knowledge of teachers (M. Koehler, J. Voogt, P. Mishra, J. Tondeur, C. S. Chai), pedagogical beliefs and attitudes about technology in education (P. A. Ertmer, T. Teo), and professional development (C. Dede; L. Darling- Hammond; O. Erstad).

The blue cluster, which has a relatively central position on the map, represents a school of thought related to the "Digitalization of Education." This cluster includes scholars focusing on different subtopics, such as new digital technologies in education (J. Cabero), digital natives (M. Prensky, W. Ng, N. Selwyn), digital competence (A.

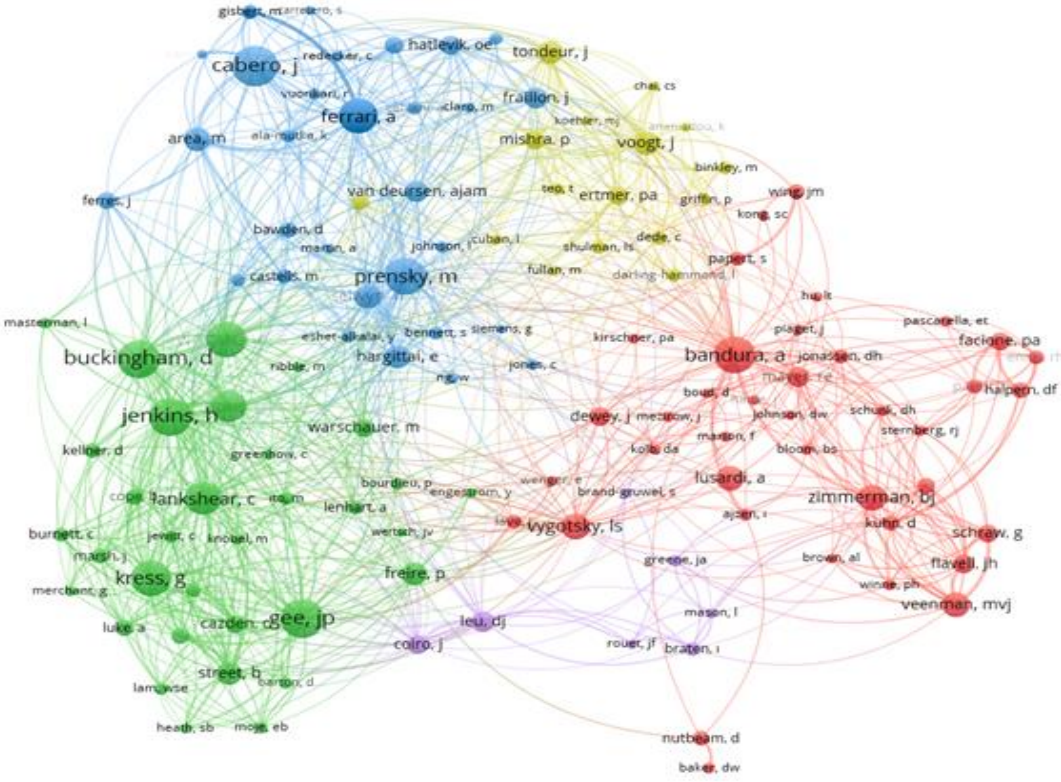
Ferrari, O.E. Hatlevik), digital literacy (J. Fraillon, D. Bawden, P. Gilster), digital skills (A. Van Deursen), and digital inequalities (E. Hargittai).

The green cluster contains various connected focal points gathered under the label "Media and Communication." This school of thought is comprised mainly of researchers in two different groups associated with densely related fields. Scholars in the larger first group—led by D. Buckingham, H. Jenkins, S. Livingstone, C. Lankshear, M. Knobel, G. Kress, R. Hobbs, and L. Matsterman—focus on media literacies. On the other hand, the second group of researchers—J. P. Gee, C. Cazden, S. B. Heath, M. Warschaurer, C. Greenhow, and W. S. E. Lam—have published articles on communication and language.

Finally, the red cluster, which is the largest and most populated one, appears at first glance to represent a group of important researchers from the field of educational psychology, including Bandura, Vygotsky, Zimmerman, Veenman, Kolb, Piaget, Dewey, Flavell, and Pintrich. However, when zooming out from the center of the cluster, additional researchers focusing on different subject areas become apparent as well. Therefore, the red cluster is more accurately represented as an "Eclectic" assemblage, comprised of nodes focusing on different areas. Apart from "Educational Psychology," this cluster represents several fields, including a group of researchers focusing on "Computational Thinking" (e.g., Wing, Kong, Papert); a second group occupying the right corner that focuses specifically on "Critical Thinking" (e.g., Facione, Halpern, Ennis); and a third group, distinctively dispersed from the others, including researchers associated with health literacy (e.g., Nutbeam, Baker).

Figure 5

Author Co-citation Map (Threshold 20 Citations, 125 Authors)



Topical Foci of the Knowledge Base

Finally, we employed co-occurrence analysis to identify the main topics explored in the literature on 21st century skills. We set a threshold of 20 co-occurring cases of "author keywords," with a display of 125 among the total of 8594 co-occurring keywords in the network. The most frequently ten co-occurring keywords in the knowledge base were media literacy (444), digital literacy (374), digital competencies (246), digital technologies (212), teacher education (209), higher education (206), communication skills (166), adolescence (153), new literacies (148), and ICT (122). The keyword co-occurrence map identifies four different clusters, which are densely linked with each other:

•*Yellow cluster:* Media Literacy

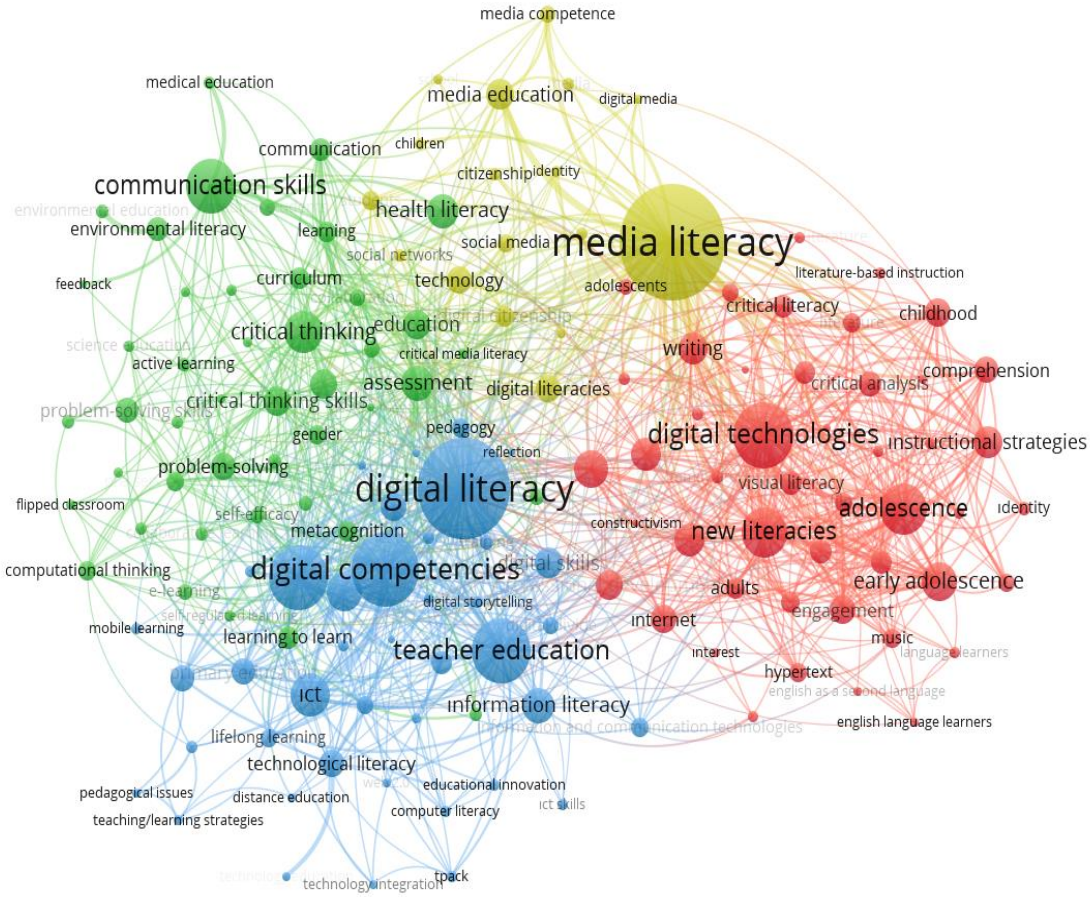
•*Red cluster:* New Literacies and Digital Technologies in Education

•*Blue cluster:* Digital Literacy and Competencies

•*Green cluster:* Multidimensional Cluster (Communication, Critical Thinking, and Problem-solving)

Figure 6

Co-occurrence Map of Keywords (N=8594 Keywords; Threshold 20 Co-occurrences, Display 125 Keywords)



The yellow cluster, which is the smallest but the most distinctive, is associated with one of the most popular subfields of this knowledge base: media literacy. This

cluster consisted of a strictly connected set of keywords about media. In addition to "media literacy," which is the biggest node both in this cluster and in the overall map, other interrelated keywords in this cluster include "media education," "media competence," "digital media," "social media," and "social networks." Regardless of their relatively small size, the existence of the "digital citizenship" and "identity" keywords reveals an important relationship among these concepts in the cluster.

The red cluster represents a dual focus on "new literacies" (e.g., content literacy, visual literacy, critical literacy) and "digital technologies in education" (e.g., internet-based educational innovations, hypertext). Moreover, some nodes in this cluster (e.g., childhood, early adolescence, adolescence, young adults, adults) highlight that these studies focused on individuals from a wide variety of age groups.

The blue cluster, located in the lower part of the map, surfaces themes related to "digital literacies and digital technologies in education." The central core of the map is occupied by "digital literacy," which includes a host of densely connected and interrelated concepts. The position of digital literacy points to its prominence as an anchoring component in the field. On the other hand, when zooming in on the keywords related to "digital technologies" and "teacher education," strong relationships emerge among concepts such as technological pedagogical content knowledge (TPACK), technological literacy, information and communication technologies, information literacy, and computer literacy.

Finally, the green cluster reflects a more multidimensional image of 21st century skills. The primary components of this cluster are "communication skills," "critical thinking skills," "problem-solving skills," and "computational thinking skills." Additionally, the inclusion of "environmental literacy" and "health literacy" within this cluster represents a less dominant set of emerging keywords associated with 21st century literacies.

Discussion and Conclusion

The results of this study illustrate that the knowledge base related to 21st century skills encompassed in WoS-indexed journals has been growing consistently over the past two decades. The capacity of this knowledge base is more remarkable when one remembers that the notion of "21st century skills" dates back only to the beginning of the new millennium. Especially significant is the growth trend and the number of studies over the past five years, which comprise 80% of the total, indicating swiftly expanding scholarly interest in this area (Charland, 2014; Voogt & Roblin, 2012). The findings regarding the volume of literature about 21st century skills take on even more importance when one notes that this review did not include other documents (e.g., conference proceedings, etc.) beyond articles and reviews. Especially in recent years, the fact that many different countries across the world have adopted 21st century skills while designing their national education policies, curricula, teacher training programs, learning outcomes, materials and instructional content to meet both the needs of societies and individuals (Ananiadou & Claro, 2009 Care, 2018; World Economic Forum, 2015) might trigger this increase in the number of studies as of late. In addition, 21st century skills are now not only included in the curriculum of pre-school, primary, secondary, high school and higher education levels, but also they are regarded as critical

skills in respect of lifelong learning (Altınpulluk & Yıldırım, 2021). This could be another the reason for this growing scholarly interest in the 21st century skills.

The earliest articles in the corpus (published between 2000–2006), which mainly provide a theoretical basis for the new skills necessitated by the 21st century, are limited in number due to the nascent nature of the field during this period. However, the increase in the number of articles between 2007–2013 and 2014–2020 can be interpreted as a product of the growing dominance of information and technology across all areas of life; during this period the initial discussions turned more urgent, leading to a significant increase in the amount of research and number of publications on this subject. This increasing scholarly interest since 2000 could be related to the emergence and rapid transformation of teaching and learning technologies (Silber-Varod et al., 2019). Moreover, the development of 21st century skill and literacy frameworks (e.g., European Parliament 2007; P21, 2017; WestEd, 2018), based on the growing concerns for the competencies needed for global civic, economic, and educational engagement, could also have triggered an increase in such studies.

Contrary to the broad trends of knowledge production represented above, the geographical distribution of the studies in this area seems relatively limited. Although more than a hundred countries were represented in the corpus, only five of them constitute half of the literature. This situation signifies that the findings are massively skewed to Europe and North America, indicating that the corpus on 21st century skills, at least that which is available in the international literature, broadly fails to account for cultural and structural differences in the field of education. The emergence of the general framework of the concept of 21st century skills, which was regarded as the main source and policy guide in the literature for a long time, took place in the United States of America (USA) through a leading organization called the Partnership for 21st Century Skills. Also, the classification studies of these skills such as EnGauge (North Central Regional Educational Laboratory [NCREL], 2003), DeSeCo (Organisation for Economic Co-operation and Development [OECD], 2005), Key Competences for Lifelong Learning (European Parliament, 2007), Common Core State Standards (National Governors Association Center [NGA Center], 2010), ATC21S (Binkley et al., 2012), etc., which are frequently referenced in the related literature, were have been carried out by the USA, European Union member countries and OECD countries. These attempts could have made the 21st century skills more visible across the countries before mentioned. Similarly, considering the ranking of the countries producing the most scientific knowledge, research, and articles in the fields of social sciences and education (SJR, 2021), these results regarding the distribution of the articles on 21st century skills are not surprising.

As illustrated in Figure 4, WoS provides little to no information about the educational policies, classroom practices, and developments related to the 21st century skills in Africa, Oceania, South America, and select Asian nations. Moreover, the representation of nations within the continent in the dataset was similarly unbalanced. Only one or two top countries are featured in each continent. Regardless of the rapid overall growth of the corpus in terms of knowledge production, especially over the last five years, there are still “missing pieces” of the puzzle on the global map. This reprises the same argument that, although the number of studies within this area is growing steadily, the knowledge base remains limited and compressed in terms of geographical

distribution (UNESCO & The Brookings Institution, 2020). The geographical distribution of the most influential and prolific authors was strictly limited to Europe, the USA, and a handful of Asian countries. Surprisingly, many regional leader countries did not have any scholars on these top author lists. Based on the findings, it can be concluded that the distribution of influential researchers is uneven and quite restricted. The main reason why the vast majority of researchers are from the countries mentioned in the previous finding is actually quite heavily related to the explanations in the former paragraph. However, in addition to the aforementioned reasons, the factors such as the low number of researchers interested in research on 21st century skills in "the missing countries on the map", the low amount of resources allocated to these studies, and the low visibility of these studies in databases due to the fact that the publications written in different languages except for English can also be considered as explanatory for this finding.

When examining the timeframes of the most cited studies on 21st century skills, it becomes apparent that the articles published between 2000–2012 had the highest number of citations due to the fact that these pioneering studies built the theoretical foundations of the subject. In addition, the twenty most cited articles centered on closely linked themes, namely teachers' professional development in the 21st century, ICT competencies, digital technologies and competencies, media, new literacies, and educational psychology. Also remarkable is the very strong overlap in research topics between the most influential authors and documents. This finding echo those of previous studies on 21st century literacies (e.g., Chalkiadaki, 2018; Voogt & Roblin, 2012)

ACA analysis revealed five interconnected schools of thought that form the intellectual structure of the knowledge base, demonstrating close linkages between the scholars and their research fronts. Co-citation analysis also showed that the scholars studying the digitization of education and those focusing on media and communication emerged as intellectual leaders in this research field. Moreover, even though educational psychology does not represent a subdimension of 21st century skills, a noteworthy number of important researchers from this field are represented in the co-citation map. This could have resulted from the close relationships between the focus points of these two research fields, because both center around learners and the factors that affect their learning process.

The findings showed that digital literacy is located at the center of the knowledge base, indicating its role in integrating and interpreting different topical foci. Furthermore, media literacy, new literacies and digital technologies in education (Lankshear & Knobel, 2011), and digital competencies constituted the most prominent themes beyond the broad umbrella of digital literacy (Jansen & Van Der Merwe, 2015). Additional emerging topics included ICT skills, critical thinking skills, problem-solving skills, computational thinking skills, and health literacy. Taken together, these findings draw a picture of the current literature, which encompasses the kinds of skills, competencies, and literacies that are hot topics in this field (e.g., Joynes et al., 2019; Van Laar et al., 2020).

The theoretical debates in the literature mention a multitude of current skills associated with the 21st century. However, it is noteworthy that literacy skills, which emerged because of advancements in information and communication technologies, are

the most common themes in the published articles. When this result is evaluated together with the significant increase in knowledge production on 21st century skills over the years, it confirms the interpretation that these theoretical discussions emerge from the shifting demands of workers and citizens necessitated by the development of information communication technologies and their proliferation in day-to-day life, thus leading to a significant increase in the number of publications on the subject (Silber-Varod et al., 2019). Finally, the emergence of numerous studies examining 21st century literacies stemming from information and communication technologies has inevitably led to the preference for technology-themed WoS journals that publish such articles. This could explain Prensky's popularity in the knowledge base of this research, as well as the prominence of other scholars such as Gee, Cabero, Jenkins, Buckingham, and Livingstone.

Implications

This bibliometric study yields several important implications for research and policy. The results of this research seem to indicate a lack of interest in 21st century skills in some countries. This situation could be caused by language barriers, insufficient financial support provided to scholars by their institutions, inadequate value or time allocated to scientific research, or lack of theoretical and/or methodological knowledge and experience. Based on the findings of the geographical distribution of the publications, language or region-specific review studies (e.g., in Africa, South America, or Arabic-speaking regions) could be conducted and published in English to highlight the state of 21st century literacies in these areas in the international literature. Such studies could also provide the opportunity to verify the findings of the present research. Conducting such reviews would not only enable comparisons between the schools of thought and topical foci of the knowledge base of these places; it would also amplify the analyses to illustrate the "big picture" of 21st century skills in greater detail, because different societies develop unique sets of characteristics based on their educational policies, practices, and needs. Future reviews focusing on different specific regions may also reveal "hidden scholars" who can provide important contributions to the related literature. Such studies will complement, expand, verify, and deepen the findings of this review and provide powerful insights to understand socio-cultural influences on the intellectual structure and the topical foci of the knowledge base, so that policymakers, researchers, and practitioners may apply new trends and approaches in the context of 21st century skills. Such studies could also be replicated to analyze one of the schools of thought revealed in this review, providing additional insights into the historical evolution of a more specific field.

Finally, future review studies should combine the articles indexed in different databases and published in different languages. While we uncovered the structural characteristics of the global literature from different perspectives based on the research questions in this review, this work was still limited to academic articles published in English. Alternative research methods could be employed to analyze the related knowledge base from different perspectives. Moreover, more nuanced findings could be generated by reviewing other forms of scholarly publications, including book chapters, conference proceedings, and theses.

Statement of Responsibility

Mustafa Polat and Bahadır Erişti contributed equally to the design and implementation of the research, to the analysis of the results and to the writing of the manuscript.

Conflicts of Interest

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