Pedagogia Jurnal Ilmu Pendidikan

Journal homepage: http://ejournal.upi.edu/index.php/pedagogia

21st-Century Skills Research Trends Over the Last 10 Year: Bibliometric Review and Analysis

*Hanandita Veda Saphira, Iqbal Ainur Rizki, Isna Zakhiyah, Salsabila Putri Saharani, Mukhayyarotin N.R. Jauhariyah

*Physics Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Surabaya, Indonesia

*Correspondence: E-mail: hanandita.19049@mhs.unesa.ac.id

ABSTRACT

The development of the 21st-century research world that responds to the current challenges presents a new status for trends in this field. Therefore, efforts need to be made to understand and focus on the status of these trends. The purpose of this research is to review several top-cited publications using bibliometric analysis on document type, source document, contributed country, language, top affiliation, sponsorship funding, top source title, source title, research citations, as well as visualization of mapping research trends across and top 50 cited publications for the last ten years on 21st-century skills research. The metadata used is the Scopus database and mapping application using VOSviewer with 428 documents. The bibliometric results show that the trend of 21st-century skills research in the last ten years is 1) 21st-century skills focused on students; 2) the subjects studied are computing and engineering; 3) teaching for 21st-century skills; 4) the most researched skill is critical thinking; 5) based on e-learning or learning system.

ARTICLE INFO

Article History:
Submitted/Received 20 Dec 2021
First Revised 15 February 2022
Accepted 19 March 2022
First Available Online 28 March 2022
Publication Date 01 April 2022

Keyword:
Education,
Educational Research,
Bibliometrics.

1. INTRODUCTION

Currently, many countries are starting to move from an industry-based economy to an information-based economy. This has resulted in the education system adapting this change according to the Assessment and Teaching of Twenty-First Century Skills Project (ATC21S), launched at the Learning and Technology World Forum in London in January 2009 (Griffin et al., 2012). As a result, a more complex and comprehensive concept of skills was created to meet these demands, namely 21st-century skills (Johan et al., 2020; Roemintoyo & Budiarto, 2021). The 21st-century skills are known as 4C (Critical thinking, Creativity, Collaboration, Communication), which students must possess when studying at school to compete in the future world of work.

21st-century skills are used to understand the impact of digitalization on the skills of individual workers for both education and the world of work (Arifin & Setiawan, 2020; Sarkar & Arya, 2020; Soleh et al., 2020; Tandika, 2022). The Partnership for 21st-Century Skills has developed a framework for 21st-century learning by combining knowledge, specific skills, expertise, and literacy skills in various fields to help practitioners integrate their skills with academic subject content to be successful in life and career (Anagün, 2018; Anderson-Levitt, 2021; Herawan & Suryadi, 2019).

The trend of 21st-century skills is considered exciting, continues to grow, and has potential. A simple method that can be done to prove it is to do a search on Scopus with the keywords "21st Century Skills" it found 16 documents in 2016 and 84 documents in 2021. This shows that the trend of century skills research 21 continues to develop. So, there needs to be an effort to find out and understand the status and trends of 21st-century skills research to be developed (Li et al., 2020). Bibliometric studies can be one solution to understanding research trends, patterns, novelty, and impactful studies (Du et al., 2021; Zyoud, 2021). This study can also assess the contribution of research to developing 21st-century skills and knowledge using a statistical approach. It can deepen understanding of a scientific discipline at a relatively low cost (Zakhiyah et al., 2021). Previous research by Khodabandelou et al. (2018) has conducted a bibliometric analysis and systematic review of 21st-century educational trends in early childhood education. Thus, the information obtained needs to be more comprehensive and represent 21st-century skills research trends. In addition, Hufiah et al. (2021) research has conducted a bibliometric analysis of 21st-century skills, which is limited to discussing the main domains. However, based on the description above, the researcher understands the importance of mapping the trends of 21st- century skills research within the last ten years to be studied more broadly and get representative results.

Therefore, bibliometric research on 21st-century skills in the last ten years (2012-2021) uses Scopus metadata and the VOSviewer application. This research is expected to find patterns, research trends, novelty, and future research in 21st-century education. Specifically, the research objectives are as follows:

1. Analyzing document types, document sources, and countries' contributions in 21st-century skills research over the last ten years.
2. Analyzing languages, authors, top affiliations, and sponsorship funding on 21st-century skills research over the last ten years.
3. Analyzing top source titles, source titles, and research citations on 21st-century skills research over the last ten years.
4. Identify the mapping results of research trends in 21st-century skills over the last ten years.
5. Identify the results of visualizing research trends mapping in the top 50 cited publications on 21st-century skills research over the last ten years.

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

6. Review some of the top-cited publications on 21st-century skills research.

2. METHODOLOGY

The method used in this descriptive type of research is bibliometric analysis. In this study, metadata is needed to produce accurate and practical information to be processed in visualization, tracking, and analyzing publications. Therefore, the metadata used was retrieved via the Scopus database (www.scopus.com) because it is one of the academic databases containing quality articles and has been peer-reviewed (Beovich et al., 2021). Therefore Scopus can be used as a database for bibliometric analysis. There are five stages in this research procedure in its implementation, as shown in Figure 1.

Figure 1. Bibliometric Research Stage

The search string used in document search is "TITLE (21st AND century AND skills)," with a limit of the last ten years (2012-2021). Data mining was carried out on February 24, 2022, usingthe Scopus database. As a result, 487 documents appear according to the search words specified in the defining search keywords stage.

After the document is obtained, the document is re-selected to improve the data to be studied further. The documents used in this research are documents in journals and proceedings. This document was chosen because it contains primary research results that are more credible and up-to-date than books and book series. Furthermore, the journal and its proceedings in the publication process have undergone complex criteria and a peer-review process by experts before publication. After the selection process, 428 documents were obtained, consisting of journals and conference proceedings, to be extracted into files with .ris and .csv extensions.

At this stage, inserting documents using the .ris file in the VOSviewer application is carried out to generate statistical data used in mapping, visualization, and data analysis of 21st-century skills trends in the last ten years (2012-2021). The VOSviewer application was chosen because it can provide good visualization and enter data from various sources (Moral-Muñoz et al., 2020). This process results in document mapping based on publication, citation pattern, keywords, country, and authorship pattern. Then to get more detailed data results, further analysis will be carried out through the .csv file, which is opened using Ms. Excel.

The data were analyzed descriptively to determine the document type, source, language, country, top affiliation, sponsorship funding, top source title, field of study, research citation, authorship, and keywords in the 428 documents obtained. The analysis was carried out based on the results of mapping and visualization using the VOSviewer application by considering the node size and link strength. In addition, data analysis was cross-checked through the search results page on the Scopus web to ensure the validity of the data. Finally, the analysis was continued by reviewing the five articles with the highest citations based on their findings and recommendations.

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

3. RESULT & DISCUSSION

3.1. Publication Distribution, Document Type, Source, and Contributing Countries

The results of the Scopus database processing show that research publications related to 21st-century skills over the last ten years have only sometimes had stagnant results. As shown in Figure 2, research publications for 2012-2018 are still increasing and decreasing yearly. However, a very high number of publications increased in 2019, almost three times compared to 2018. Let us take a common thread this year. We can find the implications of the situation starting with the emergence of the Covid-19 pandemic in various fields of life, especially education which will be closely related to the demands of society. 21st-century skills that students and students must possess. In line with the results of Argaheni's research, online learning due to the adaptation to the Covid-19 situation has several impacts, including still confusing students, making students passive, less creative, less motivated, and can even make students psychologically disturbed (Argaheni, 2020).

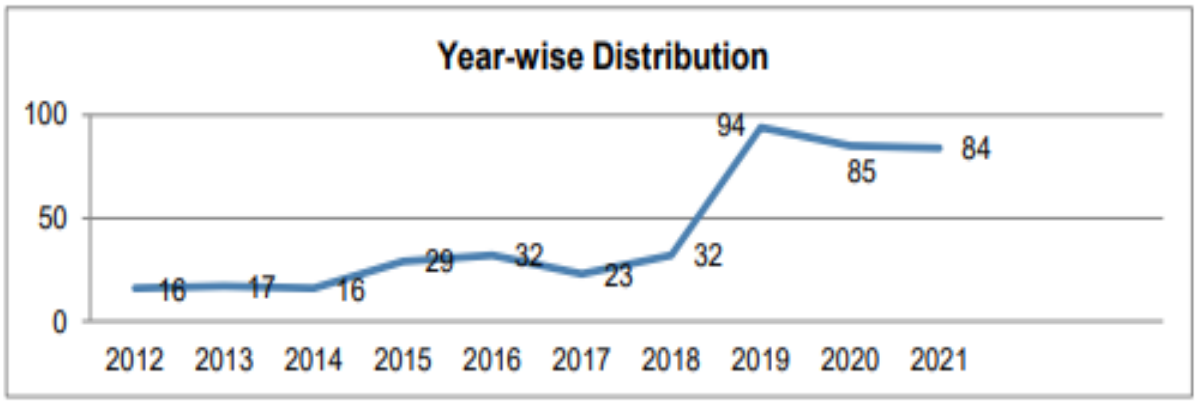

Figure 2. Distribution of 21st Century Skills Research Publications Over the Last 10 Year

This is contrary to the demands of the 21st-century skills that students should have, namely critical thinking, creativity, communication, and collaboration. By looking at the impact, research on this topic is also a concern to be studied more deeply in 2019. Two years after the emergence of the Covid-19 pandemic, 21st-century skills research publications have begun to decline. However, considering that the world's conditions are still affected until 2022, the opportunity for increasing research publications on this topic is still relatively large.

Based on 428 documents from the Scopus database that have been processed, the most common types of documents found were journal articles, with 239 documents, then seminar articles, with 143, and the rest are reviews and notes. According to these results, the source documents with the most number of documents are journals, as many as 291 documents, followed by sources of seminar proceedings, as many as 137 documents, as in Figure 3 and Figure 4. This is because publication through journals is still the goal of most researchers related to 21stcentury skills. After all, it is the source with the highest quality compared to other document sources.

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

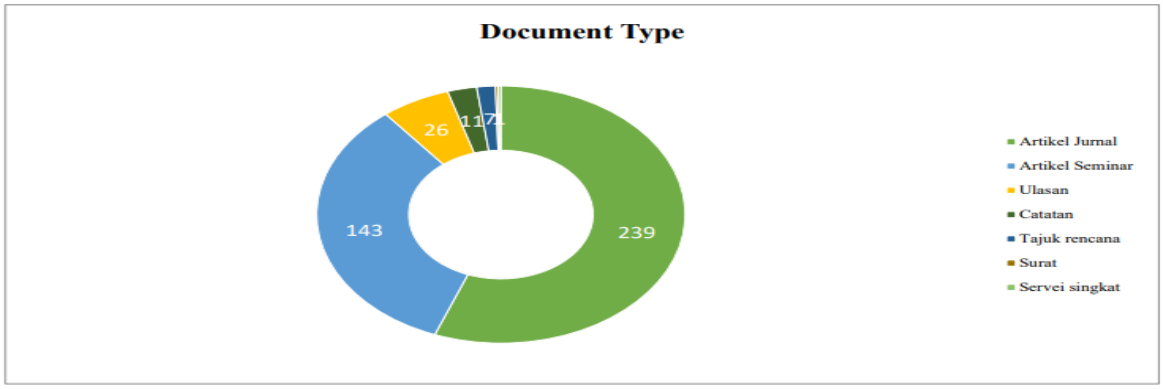

Figure 3. Types of 21st-Century Skills Research Documents for the Last 10 Years

Figure 4. Sources of 21st-Century Skills Research Documents for the Last 10 Years

Figure 5. Mapping of 10 Countries that Contributed to 21st-Century Skills Research Over the Last 10 Years

The ten countries contributing to 21st-century skills research over the last ten years are the United States (USA), with 109 documents. Indonesia is in second place with a total of 73 documents, followed by Turkey with the difference quite far, namely 28 documents and so on. The USA is the most productive country in this study. The USA believes that graduates

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

with 21stcentury skills are in high demand across a wide range of jobs. So they continue to focus much of their national, state, and local efforts on enhancing the student experience by integrating 21stcentury skills into school subjects (National Research Council, 2003). This research has become a research trend that is quite attractive to researchers in the USA. In the second place, Indonesia, which contributed 73 documents, shows that the productivity of Indonesian researchers in supporting 21st-century skills is just a little behind developed countries such as the USA. Likewise, compared to several other developed countries which are next in line, which have a total number of publications of no more than 30 documents.

3.2. Top 10 authors, affiliates, and funding sponsors

Based on the data shown in Table 1, the most productive authors are de Haan, J., van Deursen, AJAM, and van Dijk, JAGM, with six articles each, followed by other authors with a total of 3-5 articles. Meanwhile, based on its affiliation, Universitas Pendidikan Indonesia is recognized as an affiliate with the highest total number of publications, namely 15 documents, followed by Universitas Kebangsaan Malaysia with 13 documents. This again shows that both Indonesia and Malaysia, as developing countries, are not inferior in terms of their affiliation contributions to the trend of 21st-century skills research compared to developed countries in the world. 5 out of 10 affiliates with the most contributions to this research trend are Indonesian affiliates.

Table 1. Top 10 Authors, Affiliates, and Sponsorship Funding Trends For 21st-Century Skills Research Over the Last 10 Year

Top Author		Top Affiliate		Top Sponsor Funding	
Author	**Total**	**Affiliate**	**Total**	**Sponsor Funding**	**Total**
de Haan, J.	6	Universitas Pendidikan Indonesia	15	National Science Foundation	9
Van Deursen, A. J. A. M.	6	Malaysian National University	13	*Nederlandse Organisatie voor Wetenschappelijk Onderzoek*	7
van Dijk, J. A. G. M.	6	University of Twente	8	European Commission	3
Osman, K.	5	Universitas Sebelas Maret	8	European Regional Development Fund	2
van Laar, E.	5	Universitas Negeri Padang	7	Horizon 2020 Framework Programme	2
Greiff, S.	4	Universitas Negeri Malang	6	Kasetsart University	2
Woods-Groove, S.	4	Educational Testing Service	5	Kementerian Pendidikan Malaysia	2
Wulan, A. R.	4	Universiti Tun Hessein Onn Malaysia	5	Ministerio de Educación, Gobierno de Chile	2
Choi, T.	3	Ita-Suomen Yliopisto	5	Ministry of Higher Education, Malaysia	2
Haviz, M.	3	Universitas Negeri Jakarta	5	Universiti Pendidikan Sultan Idris	2

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

3.3. Top 10 Source Titles, Fields of Study, and Author Citations

This research also filters top title source, the top field of study, and top research citation over the 21st century researches publications over ten years to deepen the identity of tren of the 21st-century researches publication over ten years, shown in Table 2.

Table 2. Top 10 Sources, Fields of Study, and Research Citations on 21st-Century Skills Research Trends Over the Last 10 Years

Top Title Source		**Top Field of Study**		**Top Citation Research**	
Source Title	**Total**	**Field of Study**	**Total**	**Research Citation**	**Total**
Journal Of Physics: Conference Series	41	Social Sciences	279	Mishra, P	70
ACM International Conference Proceeding Series	12	Computer Science	111	Fadel, C	68
AIP Conference Proceeding	10	Technique	75	Trilling, B.	66
ASEE Annual Conference And Exposition Conference Proceedings	6	Physics and Astronomy	56	Claro, M.	64
Computers in Human Behavior	6	Arts and humanities	51	Care, E.	64
Ceur Workshop Proceedings	5	psychology	40	Dede, C.	63
Internasional Journal Of Emerging Technologies In Learning	5	Business, management & accounting	20	Voogt, J.	59
Internasional Journal of Instruction	5	Environmental Science	15	Griffin, P.	58
Internasional Journal Of Learning Teaching And Educational Research	5	Mathematics	13	Erstad, O.	56
Industrial And Organizational Psychology	4	Energy	11	Greiff, S.	52

Table 2 shows the top 10 source titles, fields of study, and author citations for 21st-century skills research trends over the last ten years. The top title of the source document, Journal Of Physics: Conference Series, is the primary source of 21st-century skills research with 41 documents. So the Journal Of Physics: Conference Series is the destination of most researchers on 21st-century skills trends. The second place is the ACM International Conference Proceeding Series, with almost one-third of the total Journal Of Physics: Conference Series, 12 documents. The AIP Conference Proceeding has ten documents and the following sources with 4-6 documents.

Meanwhile, when viewed from the field of study, Social Science (279), Computer Science (111), and Engineering (75) are the top 3 relevant fields of study associated with 21st-century skills. Other top fields of study are Physics and Astronomy (56), Arts and Humanities (51), Psychology (40), Business, Management, and Accounting (20), Environmental Science (15), Mathematics (13), and Energy (11).

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

Based on the author's top research citation, Mishra P. is recognized as the author with the most citations on 21st-century skills research over the past ten years, with 70 out of 428 publications. Next was Fadel, C with 68 citations, Trilling, B. with 66 citations, Claro, M. and Care, E. with 64 citations each, followed by authors in the order of 6-10, which had 52-59 citations. In line with these results, Figure 6. also shows the visualization of several research citation clusters with dominant clusters in red, green, blue, yellow, and purple nodes. In the yellow cluster, it can be seen clearly that Mishra P. has the most significant node, which shows the highest number of citations in its cluster. In the red cluster, there is Fadel, C., then in the green cluster, there is Claro, M., and in the purple cluster is Care, E.

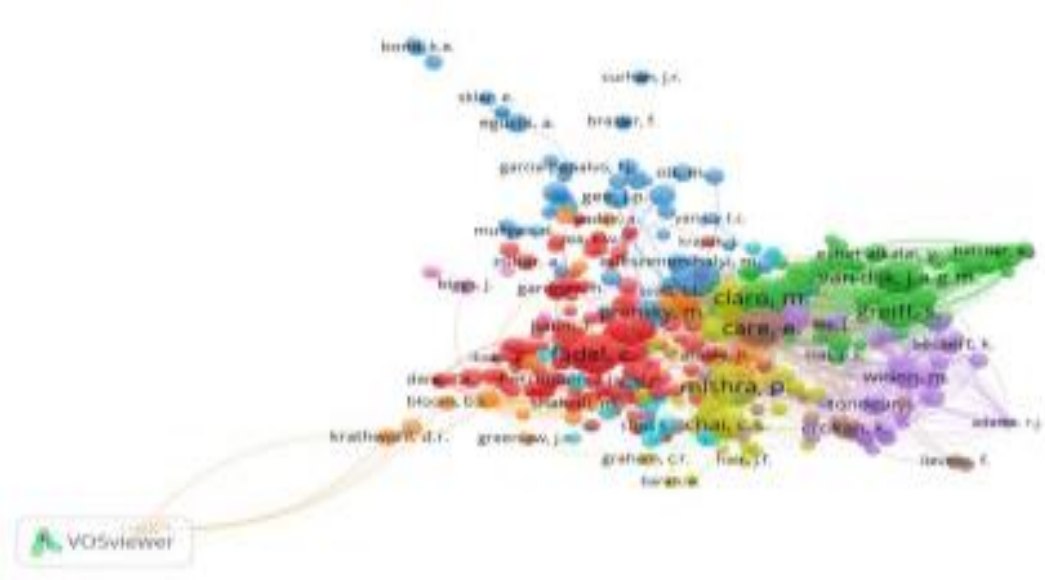

Figure 6. Mapping of Author Citation Visualization in 21st-Century Skills Research

3.4. Mapping the Visualization of 21st Century Skills Research Trends

First, an analysis of the occurrence of the keywords in 21st-century skills research is carried out, and a comparison is made for the top 50 cited articles on this research topic (see Table 3). The most widely used keyword is 21st-century skills, with 126 occurrences. In addition, there are also 105 students and 39 21st-century skills. Then followed are education computing, teaching, critical thinking, engineering education, e-learning, and learning systems. Based on this pattern, it can be seen that: 1) 21st-century skills are focused on students; 2) the subjects studied are computing and engineering; 3) teaching for 21st-century skills; 4) the most researched skill is critical thinking;

Table 3. Top 10 keywords for Overall 21st Century Skills Research and 50 Cited-Research

Overall 21st-Century Skills Research			Top 50 Citation Research Related to 21st Century Skills		
Keywords	**Appearance**	**Total Link Strength**	**Keywords**	**Appearance**	**Total Link Strength**
21st century skills	126	239	21st century skills	14	17

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

Overall 21st-Century Skills Research			Top 50 Citation Research Related to 21st Century Skills		
Keywords	**Appearance**	**Total Link Strength**	**Keywords**	**Appearance**	**Total Link Strength**
students	105	456	Problem Solving	9	29
21st-century skills	39	68	21st-century skills	9	22
Education computing	34	182	Education	9	21
Teaching	33	161	Creativity	8	23
Critical Thinking	32	109	students	8	20
Education	31	142	Critical Thinking	6	20
Engineering Education	29	133	Digital Skills	6	17
E-learning	29	126	Human	5	18
Learning Systems	24	126	Teaching	4	10

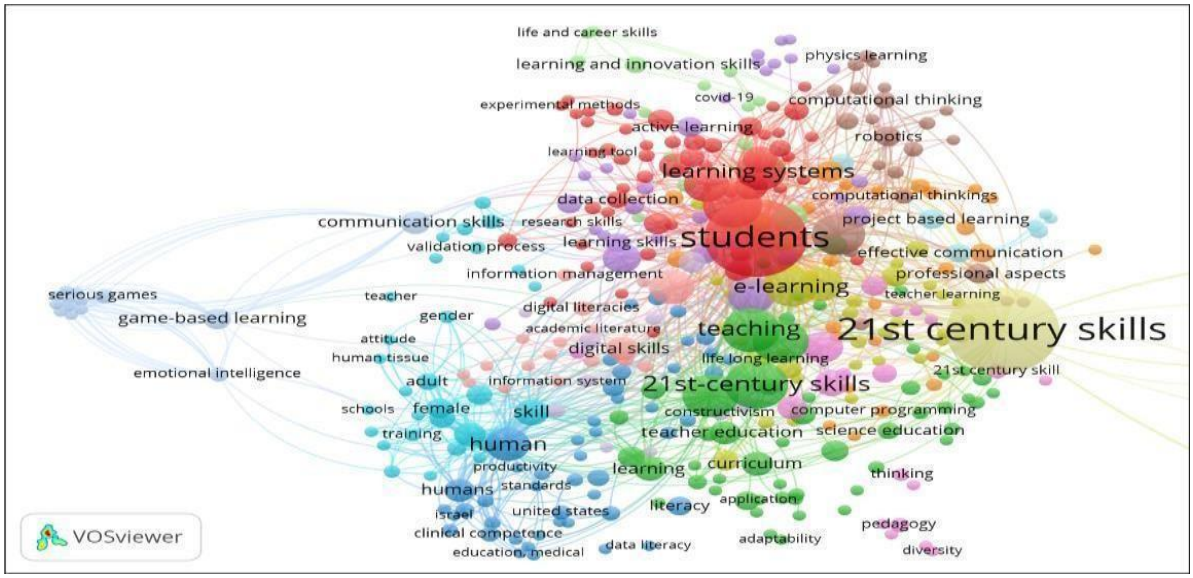

Figure 7. Visualization Mapping Based on Keyword Occurrences Throughout the Research 21st Century Skills Over the Past 10 Years

While the keywords in the top 50 citation research are relatively different from the research, 21st century skills and 21st-century skills remain the most frequent occurrences, respectively 14 and 9. In this top 50 research, the majority discussed abilities themselves, such as problem-solving, creativity, critical thinking, and digital skills. So it can be seen that these keywords are used by researchers who get many citations and the most influential research (impactful research).

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

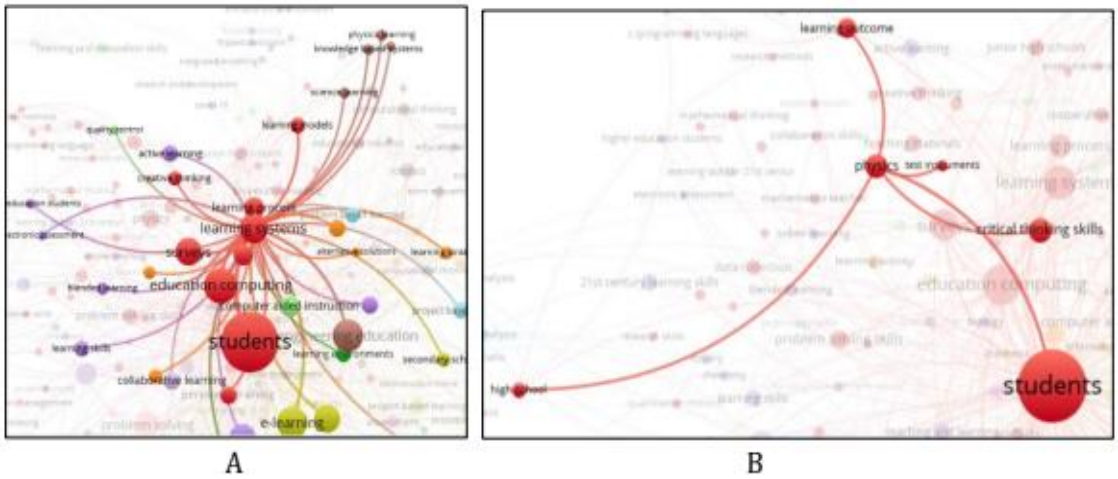

Figure 8. Some Examples of More Specific Mapping on Keywords Are (A) Learning System and (B) Physics

While the keywords in the top 50 citation research are relatively different from the research, 21st-century skills, and 21st-century skills remain the most frequent occurrences, respectively 14 and 9. In this top 50 research, the majority discussed abilities themselves, such as problem-solving, creativity, critical thinking, and digital skills. So it can be seen that these keywords are used by researchers who get many citations and the most influential research (impactful research).

3.5. Top 5 Most Citation Articles Overview

The review was conducted on the top 5 cited publications that impacted 21st-century educational research over the last 15 years. Table 4 states that each article was analyzed based on the findings in that article and the number of citations that the article obtained. The mapping results show that there are 16 clusters of topics for this research. The central cluster with red nodes (n=55) focuses on learning aspects, such as the learning process, learning system, learning model, and learning outcomes. The second cluster, with green nodes (n=53), focuses on educational content, such as education, curriculum, teaching, design, and knowledge. The third cluster with blue nodes (n=47) focuses on people, such as medical education, health, productivity, competence, and psychology. Other clusters have less keyword occurrence and research focus.

The way to find novelty based on mapping results is to look at the strength of the links between smaller or fewer keywords. For example, there has been much research about student focused 21st-century skills, learning systems, e-learning, and technical education over the past ten years because many keywords have been found, and link strength is firm. Meanwhile, little research has been done on analyzing 21st-century skills in learning strategies or gender because relatively few keywords related to this have been found. This is an opportunity and potential for research on current and future 21st-century skills that can be done.

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

Table 4. Review in the top 5 Most Cited Articles

Source	Citation	Finding	Recommendation
(van Laar et al., 2017)	424	The aspect of 21st-century skills is broader than digital skills, and the list of skills in demand is much more comprehensive. Different from digital skills, 21st- century skills are only sometimes supported by ICT.	Future research hopes to use the "Performance Test" to provide a more realistic view of skill level because various indicators can be achieved automatically.
(Qian & Clark, 2016)	353	The impact of Game-Based Learning (GBL) on 21st-century skill development profoundly states that the effectiveness of GBL depends on game design.	qualitative research on the effectiveness of GBL for statistical and practical analysis and further review of published articles on all the associated technologies may provide additional information.
(Saavedra & Opfer, 2012)	172	The transmission model to the 21st-century model has important implications for the entire education system. For example, changes to the curriculum,instructional instruction, and assessment systems have implications for teacher training, professional development, career mobility, and professional teaching culture.	Believing in 21st-century skills is critical to solving economic, societal, and global problems and engaging effectively in these fields, so we must trust these skills to improve our education system.
(Claro et al., 2012)	143	The majority of students can complete tasks related to the use of information. About three- quarters of students can search for information, and half can organize and manage digital information as consumers.	The researcher suggests in further research to give a questionnaire test regarding the information on students' family background (Examples: parents' education level, number of books at home, andso on).
(Eguchi, 2016)	100	. The hands-on, project- based, and goal-oriented learning experiences provided by educational robotics competitions have a long-lasting impact on students' learning and motivation to explore further STEM-related fields.	RoboCupJunior (RCJ) is dedicated to collaborating with educational organizations, educators, and schools interested in promoting RCJ in their country. Researchers believe RCJ can increase awareness of technology and capabilities in the younger generation.

DOI: https://doi.org/10.17509/pdgia.v2011.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

The results of the review state that aspects of 21st-century skills are broader than digital skills. This is in line with the fact that the 21st century gave birth to many new approaches to students' skills as the basis for academic experience and life success (Chalkiadaki, 2018). The review results also show that the integration of 21st-century education in learning shows positive results depending on the models, methods, and media used. Achieving 21st-century skills is done by updating the quality of learning, adapting personalized learning, encouraging communication and collaboration, emphasizing problem-based or project-based learning, using appropriate learning instructions, and designing learning activities relevant to the real world (Hidayatullah et al., 2021).

4. CONCLUSION

This research is the first bibliometric research that reviews top citations of 21st-century skills research publications for the last ten years using the Scopus database assisted by the VOSviewer application. This topic has become one of the high research interests with significant development in the era of society 5.0 with the demands of 21st-century skills that are so complex. The trend of 21st-century skills research in the last ten years increased significantly in 2019, with the number of publications almost three times from the previous year, experiencing a decline in 2020 and 2021 but not too significant; The most common types of documents are article journals (239) and proceedings (143) in line with the most sources of documents, namely from journals (291) and seminar proceedings (137), while the most productive country in 21stcentury skills research is the USA.

The most productive author in this research trend are de Haan, J., van Deursen, AJAM, and van Dijk, JAGM, with a total of 6 articles each, Universitas Pendidikan Indonesia being the top affiliate with a total of 15 documents and exciting things found are 5 of the top 10 affiliates from Indonesia. At the same time, the most sponsored funding is the National Science Foundation (9).

The primary source in the publication of 21st-century skills research is the “Journal of Physics: Conference Series” (41). The most widely studied fields are Social Science (279), Computer Science (111), and Engineering (75), and Mishra, P. is the author with the highest number of citations, namely 70 citations. The mapping of 21st-century skills research trends over the last ten years are: 1) 21stcentury skills focused on students; 2) the subjects studied are computing and engineering; 3) teaching for 21st-century skills; 4) the most researched skill is critical thinking; 5) based on elearning or learning system. The keywords with the most occurrences in the top 50 citation research were 21st-century skills (14). In addition, the majority discussed the abilities themselves, such as problem-solving, creativity, critical thinking, and digital skills, which also received the most citations and research. Influential (impactful research).

The review results on the top 5 citation research examine the complexity of 21st-century skills and their positive implications in the field of education and their integration with STEM to support their implementation in education. These studies form the basis for future research to have good quality citations and impact the development of 21st-century skills topics

REFERENCES

Anagün, Ş. S. (2018). Teachers’ perceptions about the relationship between 21st century skills and managing constructivist learning environments. *International Journal of Instruction*, *11*(4), 825–840.

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

Anderson-Levitt, K. (2021). 21st century skills in the United States: A late, partial and silent reform. *Comparative Education*, *57*(1), 99–114.

Argaheni, N. B. (2020). Sistematik review: Dampak perkuliahan daring saat pandemi COVID-19 terhadap mahasiswa Indonesia. *PLACENTUM: Jurnal Ilmiah Kesehatan Dan Aplikasinya*, *8*(2), 99-108.

Arifin, Z., & Setiawan, B. (2020). Exploring students' perceptions of information technology in profession –curriculum and learning basic course of higher education: Platforms and usage. *Pedagogia Jurnal Ilmu Pendidikan*, *19*(01), 77–88.

Beovich, B., Olaussen, A., & Williams, B. (2021). A bibliometric analysis of paramedicine publications using the Scopus database: 2010–2019. *International Emergency Nursing*, *59*, 101077.

Chalkiadaki, A. (2018). A systematic literature review of 21st century skills and competencies in primary education. *International Journal of Instruction*, *11*(3), 1–16.

Claro, M., Preiss, D. D., San Martín, E., Jara, I., Hinostroza, J. E., Valenzuela, S., Cortes, F., & Nussbaum, M. (2012). Assessment of 21st century ICT skills in Chile: Test design and results from high school level students. *Computers and Education*, *59*(3), 1042–1053.

Du, Y. Q., Zhu, G. D., Cao, J., & Huang, J. Y. (2021). Research supporting malaria control and elimination in China over four decades: a bibliometric analysis of academic articles published in chinese from 1980 to 2019. *Malaria Journal*, *20*(1), 1–12.

Eguchi, A. (2016). RoboCupJunior for promoting STEM education, 21st century skills, and technological advancement through robotics competition. *Robotics and Autonomous Systems*, *75*, 692–699.

Griffin, P., McGaw, B., & Care, E. (2012). Assessment and teaching of 21st century skills. In *Assessment and teaching of 21st century skills* (Vol. 9789400723).

Herawan, E., & Suryadi. (2019). Efektivitas manajemen mutu pembelajaran guru bidang produktif di sekolah menengah kejuruan. *Pedagogia Jurnal Ilmu Pendidikan*, *17*(1), 179–189.

Hidayatullah, Z., Wilujeng, I., Nurhasanah, N., Gusemanto, T. G., & Makhrus, M. (2021). Synthesis of the 21st Century Skills (4C) Based physics education research in Indonesia. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *6*(1), 88-97.

Hufiah, A., Afandi, & Wahyuni, E. S. (2021). Analisis bibliomterik domain keterampilan berpikir tingkat tinggi dalam pendidikan abad 21 menggunakan VosViewer. *Jurnal Sekolah PGSD FIP Unimed*, *6*(1), 1–10.

Johan, R. C., Sutisna, M. R., Rullyana, G., & Ardiansah, A. (2020). Developing online learning communities. In *Borderless Education as a Challenge in the 5.0 Society* (pp. 145-153). CRC Press.

Khodabandelou, R., Mehran, G., & Nimehschisalem, V. (2018). A bibliometric analysis of 21st century research trends in early childhood education. *Revista Publicando*, 5, 137-163.

Li, Y., Wang, K., Xiao, Y., Froyd, J. E., & Nite, S. B. (2020). Research and trends in STEM

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045

education: A systematic analysis of publicly funded projects. *International Journal of STEM Education*, *7*(1).

Moral-Muñoz, J. A., Herrera-Viedma, E., Santisteban-Espejo, A., & Cobo, M. J. (2020). Software tools for conducting bibliometric analysis in science: An up- to-date review. *El Profesional de La Informa- Ción*, *29*(1), 1–20.

National Research Council. (2003). *Strategic education research partnership*. Washington DC National Academies Press.

Qian, M., & Clark, K. R. (2016). Game-based Learning and 21st century skills: A review of recent research.*Computers in Human Behavior*, *63*, 50–58.

Roemintoyo, R., & Budiarto, M. K. (2021). Flipbook as innovation of digital learning media: Preparing Education for facing and facilitating 21st century learning. *Journal of Education Technology*, *5*(1), 8-13.

Saavedra, A. R., & Opfer, V. D. (2012). Learning 21st-century skills requires 21-st century teaching. *Kappanmagazine.Org*, 8–13.

Sarkar, A., & Arya, K. (2020, July). Teaching marker-based augmented reality in a PBL based online robotics competition. In *2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT)* (pp. 338-340). IEEE.

Soleh, A. M., Oka, I., & Kristiawan, M. (2020). Kondisi literasi media digital dalam aktifitas kerja pegawai politeknik penerbangan palembang. *Ilmu Pendidikan: Jurnal Kajian Teori Dan Praktik Kependidikan*, *5*(2), 51–62.

Tandika, P. B. (2022). Instructional materials and the development of young children's 21st century skills: Perspectives from early educators in Ukerewe, Tanzania. *Journal of Research in Childhood Education*, *36*(1), 31–45.

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2017). The relation between 21st-century skills and digital skills: A systematic literature review. *Computers in Human Behavior*, *72*, 577–588.

Zakhiyah, I., Suprapto, N., & Setyarsih, W. (2021, November). Prezi mind mapping media in physics learning: A bibliometric analysis. In *Journal of Physics: Conference Series* (Vol. 2110, No. 1, p. 012015). IOP Publishing.

Zyoud, S. H. (2021). The Arab region's contribution to global Covid-19 research: Bibliometric and visualization analysis. *Globalization and Health*,*17*(1), 1–10.

DOI: https://doi.org/10.17509/pdgia.v20i1.45263
p- ISSN 2528-1410 e- ISSN 2527-8045