A Bibliometric Analysis of 4Cs Implementation in Teaching and Learning

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Abstract: Bibliometric research offers a thorough picture of its study subject, identifies gaps in the field, encourages the development of new ideas, and makes contributions to research disciplines that are related to it. For the purpose of providing in-depth information regarding the development and direction of 4C research in the educational setting, this research was carried out. After doing a search for scientific publications on the 4Cs issue that were indexed by Scopus, the research was carried out using a bibliometric analysis approach. A total of 81 articles that were related to the topic were acquired, and these articles were then examined using Vos Viewer and visualized. 21st-century talents is the keyword that appears the most frequently in relation to the 4Cs, as indicated by the findings of the research, which shows that it appears 25 times. Research that has been carried out over the course of the past five years reveals an increase that is expected to continue to increase in the years to come. The utilization of digital learning environments is the research potential that can be created in relation to the 4C.

Keywords: Bibliometric analysis; 4Cs; Implementation; 21st century skills.

Introduction

Education in the current era of information and communication technology development has transformed to become more inclusive and interactive. The importance of relevance and real-world skills shifts the previous view which emphasized the importance of mastering only 3 skills, namely reading, writing and arithmetic (R's) (Smith & Hu, 2013). Many important skills and competencies are needed that are broader than just the transfer of knowledge to face developments in the 21st century (Chalkiadaki, 2018), as well as the challenges and demands of the modern world that continue to develop (Chu et al., 2016). Facing this, a learning environment that supports the development of 21st century skills need to be provided (Lavi et al., 2021; Teo, 2019), as well as teacher professional development to improve the quality of teaching 21st century skills needs to be given attention (Kim et al., 2019; Stehle & Peters-Burton, 2019).

21st century skills include several skills involved in modern learning and teaching, namely Communication, Collaboration, Critical thinking, and creativity (4Cs) (Soulé & Warrick, 2015). This skill is an important skill for adapting to the way of life in the 21st century (Gadhamshetty et al., 2016; van Laar et al., 2017). Apart from that, 4Cs skills can help someone prepare themselves to work in today's world of work, as well as quality individual and civic life (Jacobs, 2010; Soulé & Warrick, 2015). This emphasizes that current curriculum, philosophy, assessment, and learning methods should focus on mastering skills that can be used in the world of work and real situations (Drake & Reid, 2018; Wagner, 2008). The development of frameworks as a basis for integrating 4Cs in educational curricula has been carried out, such as the Framework for 21st Century learning which combines content knowledge, special skills, expertise, and literacy (Soulé & Warrick, 2015; Voogt & Roblin, 2012). Furthermore, the potential of this framework in supporting the 4Cs

has also been researched (Guo & Woulfin, 2016). Research related to the 4Cs will continue to develop along with dynamic information and communication technology.

Even though research on 4Cs has received attention among researchers, data regarding this research trend, especially regarding its application in learning and teaching, is still quite limited, especially the use of the bibliometric approach. Research with bibliometric analysis is important in expanding knowledge on topics of interest (Donthu et al., 2021). Bibliometric analysis can be a useful guide for researchers to obtain a comprehensive picture of their research field, gaps, stimulate new ideas, and contribute to related research fields (Donthu et al., 2021). The importance of mastering these skills requires the ability of teachers to be able to apply them in the classroom, such as by using appropriate technology to improve the 4Cs (Keane et al., 2016). Through bibliometric research on the 4Cs in teaching and learning, it can provide information, and improve educational practices that are relevant to current developments. This research aims to provide a comprehensive overview of the development and direction of 4C research in the educational context.

Method

This research was conducted using a bibliometric analysis approach which is known as one of the most widely used methods to assess the impact of previous research (Ellegaard & Wallin, 2015). Bibliometric analysis can be used as a tool to understand the potential of a scientific discipline (Wallin, 2005). In the bibliometric analysis carried out, a search was first carried out for scientific articles on the 4C's topic indexed by Scopus using publish or perish. There were 81 articles netted in the search carried out. The criteria used to select articles for analysis are shown in Table 1.

Table 1. Article selection criteria

Criteria	Including	Excluding
Languange	English	Other languages
Period	2013-2023	Before 2013
Database	Scopus	Other sources
Keyword	"Teaching 4C's in science class", "4C Skills in education"	Preceding paper

After obtaining articles that meet the criteria in Table 1, the data is analyzed for trends and patterns, as well as the journals that most actively publish research on 4Cs in learning and teaching, then visualized using the VOS viewer application. The overall bibliometric

analysis procedure in this study was presented in Figure 1.
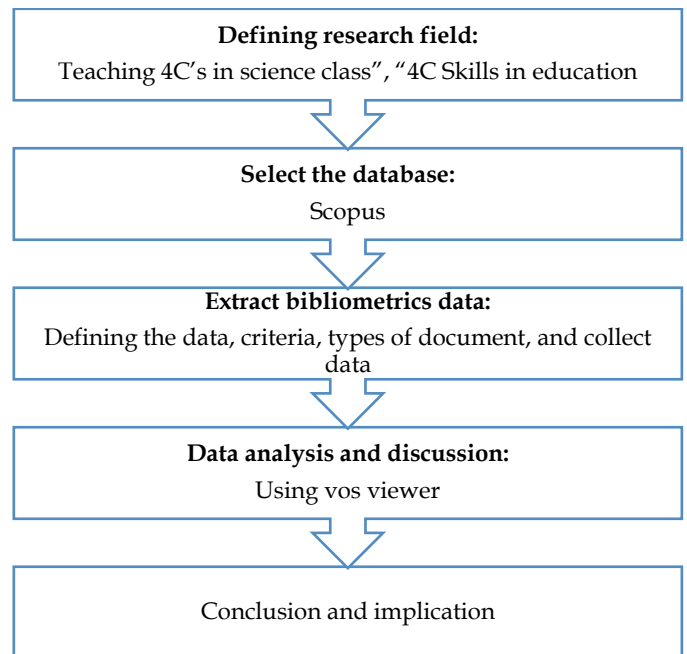
Figure 1. Research Procedure (Adaptation form: Dong, Li, & Chang (2023)

Result and Discussion

From a total of 81 articles there were 1544 terms, where the occurrence of a term was at least 5, so that 92 met the threshold. For each of the 92 terms, a relevance score will be calculated. Based on this score, the most relevant terms will be selected. The default choice is to select the 60% most relevant terms, therefore 55 terms selected. The 15 terms showed in the tables and figures below.

Table 2. The term appears frequently

Term	Occurrences
21st century skills	25
Ability	20
Activity	19
Aspect	17
Attitude	16
Classroom	16
Competency	16
Context	15
Creative thinking	15
Critical thinking skill	15
Digital learning	14
Environment	13
Game	12
Group	11
Higher education	10

The visualization of the most frequently terms using VOS viewer application was shown in figure 2, the latest research conducted (2019-2023) in figure 3, the latest research potential that can be developed shown in the Figure 4.

The analysis of papers that can be taken for analysis and published in scientific journals is known as bibliometric analysis. Researchers can determine the number of people researching a topic or the significance of the author's contribution from this bibliometric data. They can also identify trends and patterns in the research as well as the journals, institutions, and researchers who are most active in publishing research

The term analysis maps the keywords used by researchers and then constructs and visualizes them using Vos Viewer software, so that data on the

relationship between one keyword and other keywords is obtained. This relationship is shown by differences in letter size, color and thickness of connecting lines. A total of 1544 related keywords were obtained which were then reduced according to the minimum limit of occurrence that had been set, namely a minimum of 5 times, to obtain 92 that met the criteria. Table 2 shows the most frequently used keywords in this research topic. Based on the results obtained, it can be seen that 4Cs research is very often associated with 21st century skills with the highest frequency of appearance being 25, followed by ability and activity which appear 20 and 19 times respectively. Another result obtained is that the 4Cs also show that there are keywords related to attitude that appear 16 times.
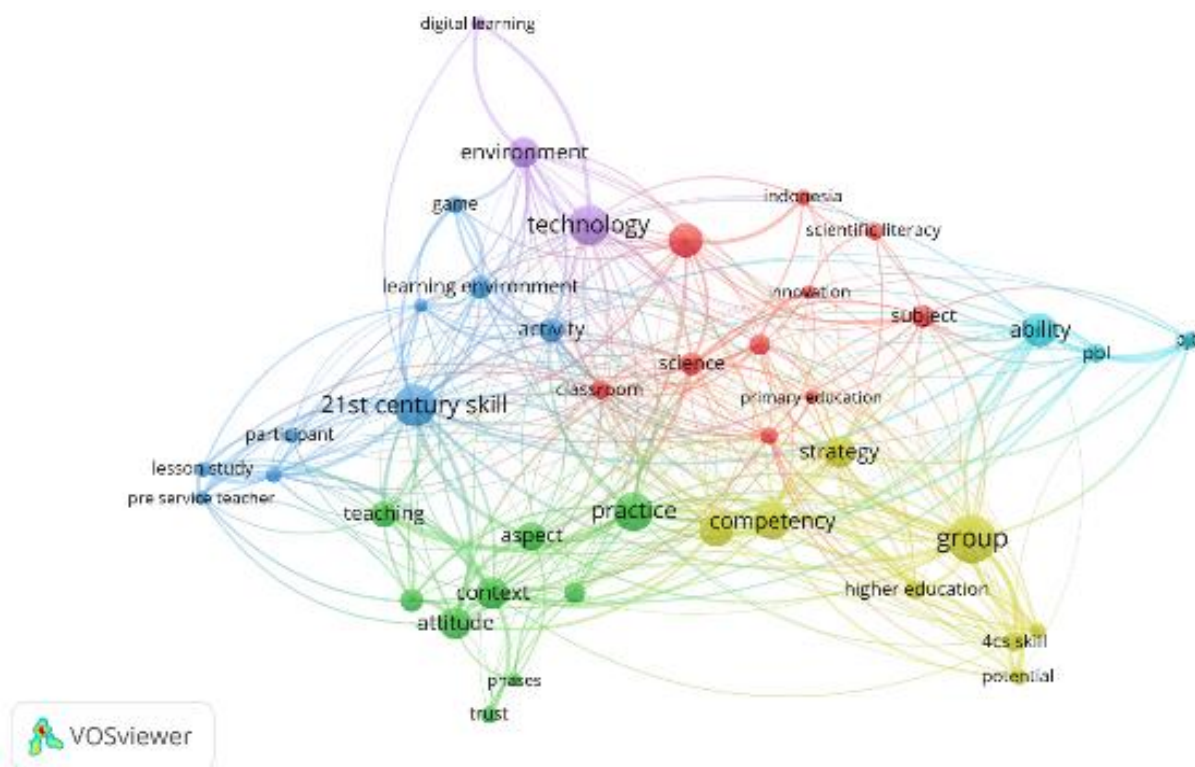
Figure 2. Visualization of most frequently terms

The results of the analysis of 4Cs research carried out from 2019 to 2023 (Figure 3) show an increase in the number of studies over the last 5 years and an increase since 2021 which is marked in green with a grid which shows that the 4Cs research that was raised is related to scientific literacy, problem based learning, project based learning and also associated with digital learning environments.

Problem-Based Learning (PBL) is an instructional approach that emphasizes experiential, active learning focused on the exploration and resolution of complex,

real-world issues (Zhang et al., 2022). The bibliometric analysis conducted by Zhang et al., (2022) reveals that 2,790 papers and reviews were examined, indicating a consistent rise in publications within the domain of PBL in 1981-2021. This increase was partially due to the fact that, according to (P21, 2007), PBL is the appropriate learning model for the development of life skills in the 21st century, including 4C's skill. Likewise with the Project-based Learning (PjBL) model. Project-based learning (PjBL) is characterized as an individual or collaborative endeavor conducted over an extended

duration with a specified timeframe to making authentic product (Elsamanoudy et al., 2021). The PBL and PjBL has been increasingly utilized by educators in Indonesia since its endorsement in the 2013 curriculum as an effective learning model. Numerous researchers, like Anggraeni et al., (2023), Hidayati et al., (2019), dan Lestari et al., (2019), have demonstrated that 4C skills can be enhanced through the PBL paradigm. Several scholars who have investigated PjBL and 4C's skills include Campo et al., (2023), Varas et al., (2023), dan Wijaya et al., (2021). These results show that research on 4Cs will continue to increase in the following year
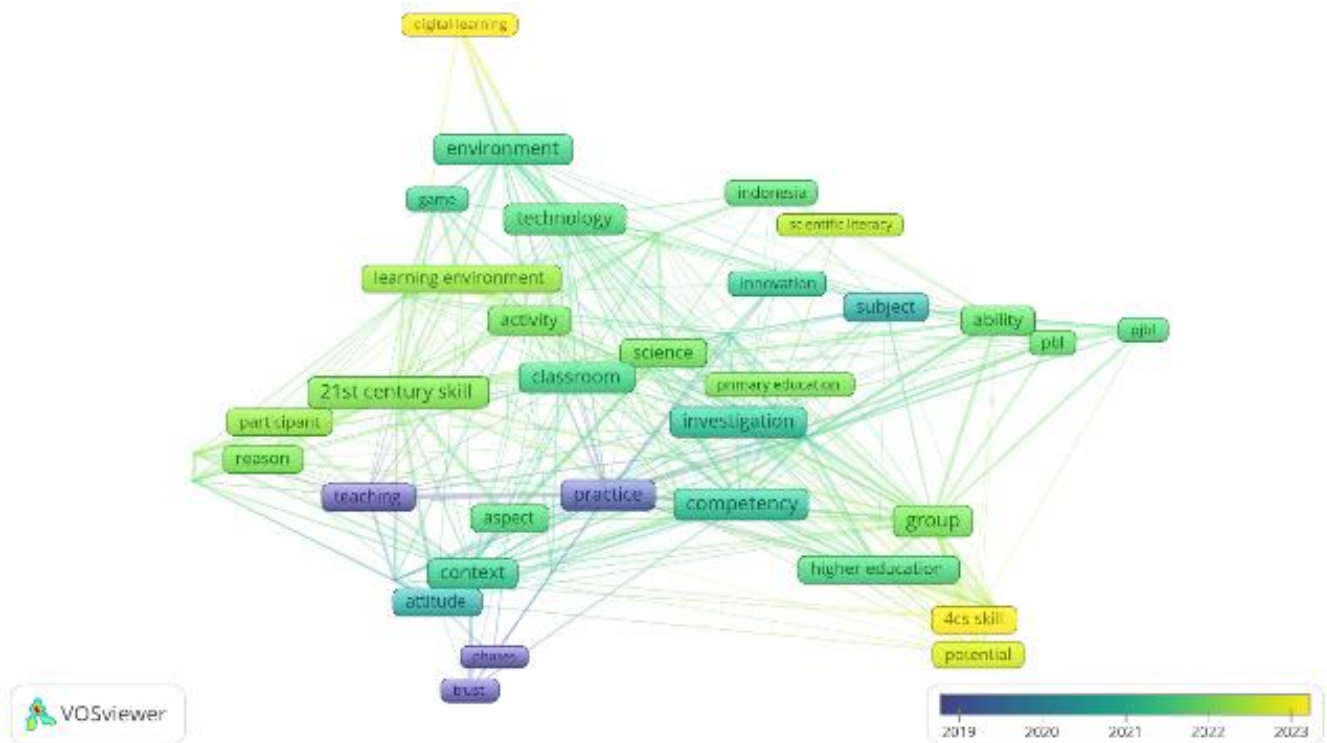

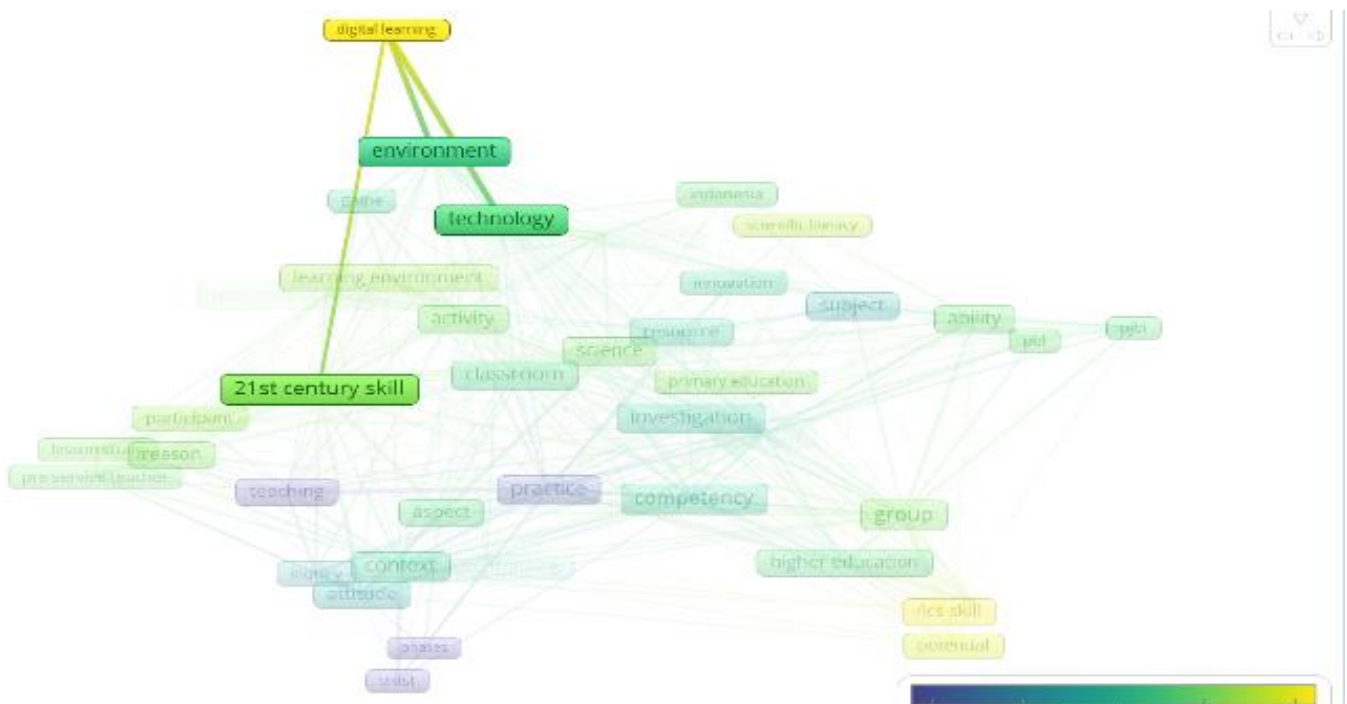**Figure 3.** Visualization of the latest research conducted (2019-2023)

Figure 4. Visualization of potential research

The potential research that can be developed regarding 4Cs can be seen in Figure 4. Based on this analysis, the thicker net lines between words, the more research has been carried out. On the other hand, the thinner the net between words shows that less research has been done. The results of the analysis using Vos Viewer visualization show that 4Cs research related to 21st century skills and utilizing digital technology is rarely carried out, especially since technological developments are currently very much needed in classroom learning (Chu et al., 2016). Digital technology in the classroom encompasses diverse applications and devices designed to assist students with specific accessibility requirements (Haleem et al., 2022). Digital learning that can be carried out can be in the form of media development, use of digital learning media for educators to support learning and other related research. Online learning environments contribute to the development of individuals possessing 21st-century abilities (Ilgaz, 2021).

The findings from this bibliometric analysis provide a roadmap for future research. The underrepresentation of studies exploring the intersection of 4Cs and digital technology suggests a need for more focused research in this area. Future studies should investigate how digital learning tools can be designed and implemented to foster 4Cs, addressing the current gaps and leveraging technology to enhance educational outcomes (Gikas & Grant, 2013). Additionally, the increase in research activity since 2021 indicates a growing interest in innovative teaching methodologies. Researchers should continue to explore and document effective practices in scientific literacy, problem-based learning, and project-based learning to provide educators with actionable insights (Hmelo-Silver, 2004).

Conclusion

Based on research that has been done, find that 21st-century talents is the keyword that appears the most frequently in relation to the 4Cs, as indicated by the findings of the research, which shows that it appears 25 times. Visualization using VOS Viewer reveals trends and patterns in research over the past five years (2019-2023). There has been an increase in the number of studies since 2021, with a focus on scientific literacy, problem-based learning, and project-based learning. This research also shows that studies related to 4Cs and 21st-century skills are expected to continue increasing in the coming years. Potential research areas are identified by examining the thickness of connecting lines between keywords. Thicker lines indicate that more research has

been conducted, while thinner lines suggest areas with less research. This analysis reveals that research related to 4Cs and the utilization of digital technology is still relatively sparse, despite the significant need for technology in classroom learning. Overall, the findings highlight the importance of ongoing research related to 4Cs and 21st-century skills, particularly in leveraging digital technology to support education.

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