

Bibliometric Analysis of Studies Based on Context-Based Learning Method in Science Teaching Fen Öğretiminde Bağlam Temelli Öğrenme Yöntemine Dayalı Çalışmaların Bibliyometrik Analizi

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Abstract: Although the studies on Context-Based Learning (CBL) within the scope of science are increasingly blooming in recent years, original studies offering new perspectives still remain limited in numbers. This shows that in order to increase the quality of studies on CBL in science, physics, chemistry, and biology teaching, there is a need for more inclusive studies and to ensure these new studies are original in their content. The aim of this study is to emphasize the need for CBL in high school science teaching by making a bibliometric review of the literature on CBL within the scope of science on the Web of Science (WOS). Performing a search in WOS by limiting "Science education and education research" with the title filter and "Context-based" keyword, a total of 545 studies were found. These studies were visualized using the VOSviewer 1.6.18 program. In this study descriptive statistical analysis, citation analysis, co-occurrence analysis, co-citation analysis, co-authorship analysis, and bibliographic matching analysis methods were used. The findings show that CBL is recorded in six main research areas: "Context-Based Learning", "Context-based approach", "Context-based problems", "Chemistry teaching", "Context-based responsibilities" and "Professional development of teachers". Although there have been intensive studies on CBL in the last 7 years, more qualified studies are needed within the scope of science education. There is a need for qualified studies on CBL for teachers to improve their teaching techniques and to overcome the gap in studies that facilitate students' learning.

Keywords: Context-based learning, bibliometric analysis, science teaching, visualization

Öz: Son yıllarda fen bilimleri kapsamında Bağlam Temelli Öğrenme (BTÖ) ile ilgili çalışmalar artış gösterse de yeni bakış açıları sunan özgün çalışmaların yeterli düzeyde olmadığı vurgulanmaktadır. Bu durum fen bilimleri, fizik, kimya ve biyoloji öğretiminde BTÖ'ye yönelik çalışmaların niteliğini artırmak için daha kapsayıcı çalışmalara ve bu yeni çalışmaların içerik olarak özgün olmasını sağlamaya ihtiyaç olduğunu göstermektedir. Bu çalışmanın amacı, Web of Science'ta (WOS) fen bilimler eğitimi kapsamında BTÖ ile ilgili literatürün bibliyometrik bir incelemesini yaparak lise fen öğretiminde BTÖ'de araştırma boşluğunu ortaya koymaktır. WOS'ta "Fen Bilimleri Eğitimi ve Eğitim Araştırmaları" başlık filtresi ve "Bağlam Tabanlı" anahtar kelimesi ile sınırlandırılarak arama yapıldığında toplam 545 çalışma ortaya çıkmıştır. Bu çalışmalar VOSviewer 1.6.18 programı kullanılarak analiz edilip görselleştirilmiştir. Bu çalışmada betimsel istatistiksel analiz, atf analizi, birlikte oluşum analizi, ortak atf analizi, ortak yazarlık analizi ve bibliyografik eşleştirme analizi yöntemleri kullanılmıştır. Elde edilen bulgulara göre BTÖ'nün altı alt başlıkta sınıflandırıldığını göstermektedir: Bunlar, "Bağlam Temelli Öğrenme", "Bağlam Temelli Yaklaşım", "Bağlam Temelli Problemler", "Kimya Öğretimi", "Bağlam Temelli Sorumluluklar" ve "Profesyonel Öğretim Uygulamaları" olarak ortaya çıkmaktadır. Son yedi yılda BTÖ konusunda yoğun çalışmalar yapılmasına rağmen fen bilimleri eğitimi kapsamında öğretmen ve öğrencilerin güncel ihtiyaçlarının belirlenip bu ihtiyaçlar doğrultusunda oluşan araştırma boşluğuna yönelik nitelikli çalışmalara ihtiyaç duyulmaktadır.

Anahtar Kelimeler: Bağlam temelli öğrenme, bibliyometrik analiz, fen öğretimi, görselleştirme

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Introduction

In academic studies, the number of citations of scientific publications has an important place as an indicator of the quality of the studies. The higher the citation history of the studies, the higher the impact level of the research is considered (Aksnes, Langfeldt & Wouters, 2019). The high number of citations alone is not sufficient to determine the quality of the research. Some of the important determinants of the number of citations are the methods used by the authors in their research, the original approaches they brought to the academic field, and the solution approach they developed while researching new and current issues (Moravcsik & Murugesan, 1975). In recent years, when calculating the impact values of the journals, the direct association of the articles with the citation numbers has been the subject of a debate among researchers (Lariviere & Sugimoto, 2019). The quality of over-cited articles is not adversely affected by these discussions. The reason for this situation can be explained by the fact that the studies with the highest number of citations identify current problems and develop effective solutions

(Waltman, 2016). In order for researchers to identify current problems and develop original conclusions, all the previous studies should be reviewed within the relevant systems and the proposed conclusions should be evaluated effectively.

Physics, chemistry, and biology, as the three main sub-disciplines within science field, aim to explain the complexity and mysteries in nature and living beings with logical patterns. While the conceptual contents in these three disciplines are being presented in learning environments, the comprehensiveness is ensured by bringing daily life examples and technological contents to the fore (Kumaş, 2022). One of the most important features of science education is that it pioneers scientific and technological developments and presents developments in this field to learners in an understandable language (Kumaş & Kan, 2019). With this feature, it would not be wrong to say that different methods used in science education also affect other disciplines.

Science literacy is defined as presenting new scientific and technological developments clearly by giving daily life examples within the scope of aforementioned three sub-

disciplines of science and adopting this information for the students by associating it with inquiry, critical approach, and daily life problems (Kumaş & Kan, 2021). By placing their sense of curiosity at the center during the learning process, the individuals ensure lifelong learning in terms of their science literacy improvement. This acquisition offers learners the opportunity to take scientific attitudes, skills, and questioning to the next level (Ardiyanti, Suyanto & Suryadarma, 2019). It is an inevitable fact that improving science literacy will contribute not only to the learners but also to the development of upcoming qualified generations who are supposed to add value to the education of their prospective countries. Therefore, it is necessary to provide qualified teaching concepts in terms of science. It is known that students might have some misconceptions before taking science courses in high school (Ecevit & Şimşek, 2017; (Gödek, Polat & Kaya, 2018). To improve students' scientific literacy and positive attitudes toward science learning, and to eliminate these misconceptions, studies on Context-based learning (CBL) are recording an increasing trend in the last two decades (Febrianti, 2022).

With the developments in the field of information communication technology, countries have started to develop innovative approaches and make various updates to their curricula. Updating curricula in parallel with the developing technology enables students to take part in advanced technology at an early age, not only as a user but also as an actor, while at the same time developing their fundamental working principles (Muji et al., 2021). These approaches incorporate technological contents able to respond to countries' and individuals' specific needs, and give individuals the possibility to develop a high level of inquiry skills and to explain daily life and working principles of the advanced technology tools. The increase in the number of individuals who become software specialists at an early age is a good example of this situation. Thereby, CBL proves itself as an important education approach that triggers this development positively. CBL, the subject of this research, aims to establish contexts between the new and the old knowledge that students will learn within the science program and the situations encountered in daily life. Thus, students' desire to learn increases (Sözbilir, Sadi, Kutu, & Yıldırım, 2007).

The first applications of context-based education are encountered in the 1980s. A group of researchers working in the field of science at York University in England suggested the usage of CBL approach to develop high-level success and positive attitudes toward science among students. Here, "Context" is defined as the initial formation of the concept being taught or its relationship with daily life. These researchers have revealed that presenting the concepts within the scope of science with examples from everyday life will contribute to the teaching of science in a more interesting way and will help absorb future information more effectively (Nentwig & Waddington, 2006). In this approach, firstly, scenario-based problems that form the basis of problem-based learning are developed. Students are asked to associate them with the concepts by questioning the technology-containing contexts that are closest to them (Waddington, 2005). This learning approach activates their pre-knowledge and ensures that new knowledge is formed on a scientific basis. By doing this, students are allowed to construct new knowledge from the contexts they already know and to explain unknown contexts. In the classrooms where the context-based approach is applied, problem-solving proficiency in science lessons improves

remarkably, and students' interest, attitudes, and motivations towards these lessons increase accordingly (Demircioğlu, Bektaş & Demircioğlu, 2018; Yıldırım, 2015). Attention should be paid to the fact that the contexts presented to students in CBL consist of their own environment and the environments they can reach, and it should be ensured that they are related to new contexts. For this reason, possible misconceptions will be prevented by associating science concepts with daily life (Overton, 2007).

The points to be considered in the CBL process can be listed as follows (Yu, Fan & Lin, 2014).

- The concepts that are to be taught should be clearly defined.
- Scenarios, problems, process steps, and assessment-evaluation applications should be of a quality that overlaps with the educational applications.
- Defined scenario/problems should cover daily life and high technology contexts in a way that overlaps with problem-based learning applications.
- Educational activities should be included in the whole process. The content in these activities should be compatible with contextual applications.
- Prepared activities should include up-to-date and in-use technologies.
- Since cooperative group work in CBL environments improves students' problem-solving skills and has a positive effect on learning (Kumaş, 2022), group education should be given importance.

In many studies based on CBL, it has been concluded that teachers and students found this approach useful (Worrel & Profetto-McGrath, 2007; Vaino, Holbrooka & Rannikmäe, 2012; Yu, Fan & Lin, 2015) but challenging (Avargil, Herscovitz & Dori, 2012). The starting point of this approach is to try to transform learning into a need by associating the situations that students encounter in daily life with the course content (Koballa, Glynn & Upson, 2005; Acar & Yaman, 2011). Since this study does not focus on determining the advantages or disadvantages of CBL with an experimental method, it is limited to presenting the features of the approach stated in the literature.

Compared to classical learning environments, the roles of the teacher and students are different in CBL. In terms of students, learning activity turns into a scientific approach when appropriate (Yu, Fan & Lin, 2015). Particularly, when CBL is implemented in science classes, the role of the student can be described as quasi-scientist. The student is faced with a problem from daily life and tries to find the logical and most suitable solution. For this purpose, the path to be followed will not be different from the one of the scientist's (Worrell, & Profetto-McGrath, 2007).

Considering these features, it is necessary to analyze many different aspects of CBL in terms of teachers and students. From this perspective, in order to be teacher-oriented this approach should be developed and implemented very efficiently (Avargil, Herscovitz & Dori, 2012) and the following issues need more attention in the process.

1. Lesson planning skills suitable for this approach,
2. Designing course environments as required by the approach,
3. Develop scenarios suitable for this approach in order to increase the quality of conceptual teaching,

4. Implementation phases of the approach and carrying out the scientific processes should be done simultaneously, etc.

However, it can be seen that the studies in the literature mostly focus on the application of this approach and its effect on the learning process (Ex: O'Sullivan, 2006; Dewi & Primayana, 2019). While CBL is considered as an approach that offers wide application opportunities in the field of science education, there has been found no research that examines the extent and the content of its educational activities by using bibliometric method and pattern maps. Most of the research on CBL has been carried out using the systematic analysis method. Therefore, it is expected that this study sheds light on wide spectrum of literature in this area.

The main purpose of this research is to emphasize the need for CBL in science teaching by making a bibliometric review of the studies in the literature on CBL in WOS. In this context, the dependent variable of the study is science education, while the independent variable is Context-Based Learning. However, the fact that the research goals are examined on a wide scale has brought along various focuses other than the dependent variable. These include other areas of education in which CBL is associated with bibliometric analysis.

In this study, previous research published between 1986-2023 are examined. Since the authors limited the scope of this study to 'science education', other studies related to 'Context-based' were excluded. However, it is expected that the study provides an important data source for researchers who will conduct studies on CBL in science education in following years.

Method

Research Method

In this study, the bibliometric method was used. Bibliometric methods are auxiliary research methods used to confirm researchers' preliminary impressions about a subject and based on objective yet measurable results (Mingers & Leydesdorff, 2015, Nerur, Rasheed & Natarajan, 2008). This method assumes that, in order to establish qualified links between researched topics, data obtained from databases like Web of Science and Scopus is being analyzed using bibliometric methods. According to Mingers and Leydesdorff (2015), various links can be established between the articles scanned for the determined topic. Two purposes come to the fore in the bibliometric analysis method, namely, to determine the fundamental characteristics of the literature, and to establish a guidance for the following studies based on the previous ones (Atsız, Öğretmenoğlu & Akova, 2022).

Conceptual or scientific maps are frequently used to visualize studies in bibliometric methods. The purpose of these maps is to establish correlation of the studies in the literature with other connections. According to Cobo et al. (2011), when using maps, terms like author, article, journal, country, number of citations, or keywords can also be represented on the maps. Besides, the conceptual and quantitative characteristics of studies, examined sample, or effect values can also be included in these maps. While various software applications have been developed to do mappings, the way the maps are being represented mostly depends on the creativity of the authors. Hence, in order to uncover conceptual structures of the studies, aforementioned maps are also included in this study.

Data Collection Tools

Bibliographic data concerning CBL approach is obtained from the Web of Science database. In this study, the bibliometric parameters of the approach have been summarized. Moreover, citation analysis, co-citation analysis, co-authorship analysis, keyword co-occurrence analysis is determined, as well as bibliographic matching between keyword, document, author, source and country relations. The results are presented in the form of network maps using VOSviewer (version 1.6.18).

In order to perform bibliometric analysis, firstly the topic and then the keywords associated with it were determined. After this preliminary stage, in order to make a broad analysis of the topic it was necessary to conduct a literature review and to determine a good database concerning the content of the topic. Although different applications are in usage, Web of Science and Scopus are emerging as the best databases in this field (Pranctute, 2021). In this study, Web of Science, which has a large database in the field of social sciences and especially educational sciences, was preferred over the others. The data query was made on 24.12.2022.

In order to identify the studies published on CBL in the Web of Science database, the term "Context-Based Learning" was written in the "Title" section. The attention was given only to those publications that cover studies in the field of education. While searching the content, documents such as research and/or review articles, book chapters, publications in the process, publications with data content, and early access were included. As a result, the search showed that the first publication on Context-Based Learning was published in 1986 and the last one was in 2023. Performing the first search in this way, a total of 545 documents were found.

Data Analysis

Statistical data belonging to the sub-headings of the search made for the purpose of preliminary examination were collected for this study. In this sense, excel program was used for classifications of various parameters such as publication year, publication type, keyword, country of publication, number of documents, author, and bibliography. Citation analysis, co-citation analysis, co-authorship analysis, keyword, multiple literature analysis, and bibliographic matching analysis were performed to determine the relationships between the bibliometric elements of the publications. In order to enable the reader to reach more understandable data, visualizations in the form of network maps were used by using VOSviewer 1.6.18. This program was preferred because it has a strong visualization ability (van Eck & Waltman, 2010).

Within the scope of the research, the data was analyzed by following a systematic scheme determined by the authors. There was no suggestion in the literature to follow a certain order while performing analysis in bibliometric studies. In this study, it was found appropriate to apply the following order in order to present the data analysis of the bibliometric study more systematically, to improve the quality of the study, and to provide understandable information to the reader.

- 1) Variable Analysis
- 2) Impact (Citation) Analysis
- 3) Frequency (Statistics) Analysis
- 4) Keyword Analysis
- 5) Associated Multi-Literature Analysis
- 6) Author Analysis
- 7) Source and Country Analysis

The variable analysis focuses on the intersection of dependent and independent variables across studies. At this stage, the common points of the studies can be easily read. In Impact (Citation) analysis, the impact of a publication and the number of citations it receives are measured (Donthu et al., 2021). In this method, the relationships between the quoted and quoting items are evaluated (Szomszor, Pendlebury & Adams, 2020). Thus, it can be seen more easily which studies are accepted by the scientific community. Frequency analysis focuses on the numerical data of the studies. This stage provides ample room for authors to relate freely chosen quantitative data. In keyword analysis, the frequency of co-occurrence of two or more keywords is measured (Callon, Courtial & Laville, 1991).

The frequency of keywords in studies indicates a more intense relationship between studies (Zeng et al., 2022). Keyword analysis enables us to visually identify the themes in line with the conceptual structure of the studied subject and objectives (Cobo et al., 2011). The associated multiple literature analysis, on the other hand, shows the similarity between these focal articles when citations are made to the third or fourth articles to which more than one article refers (White & Griffith, 1981). Relational multiple literature analysis mainly refers to the contextual part of the literature review. The other stage of bibliometric analysis is author analysis. In some sources, this step is defined as a phase that occurs when two authors come together to write a document (Biscaro & Giupponi, 2014). However, in this study, author analysis also focuses on the relationships between an author's work on the same topic. The last stage of the bibliometric analysis is the analysis of the sources in the literature.

Findings

The findings of the research are presented considering the order determined in the analysis section.

Findings Obtained from Analysis of Variables

Literature-related data correlating Context-Based Learning, as an independent variable of this study, and science teaching, as a dependent variable is presented below.

A total of 545 studies in the field of science are examined. These studies have been separated into areas using an internal analysis via VOSviewer (version 1.6.18). 192 of these studies are in chemistry, 68 in biology, 55 in physics, 15 in physics-chemistry, 8 in chemistry-biology and 2 in physics-chemistry-biology. While the focus of the research is mainly on 'science' in some of the studies, most of them include other disciplines by implementing interdisciplinary approach.

50% of the research topics and citation choices in science and its sub-disciplines (physics, chemistry, biology) cover

education and training research. The research have also been conducted in knowledge engineering (7%) and medicine and health (6%). 84% of studies in the field of chemistry are related to education and training. 6% of the research done in the field of chemistry was associated with the fields of physics and astronomy. Other studies in the field of chemistry have been carried out within the scope of applied subjects. 64% of studies in physics are related to education and training, while other research in physics deals with the applications of physics in technology (21%) and laws and principles of physics (5%). The remaining physics research was carried out within the scope of applied subjects.

Findings Obtained from Impact (Citation) Analysis

In this context, 545 documents and the research of 1338 authors have been examined. 37 of the authors who conducted the reviewed studies have at least one citation. The top five most cited articles are Gilbert, Bulte & Pilot (2011), Choi and Johnson (2005), Ültay and Çalık (2012), King (2012), and Bennett, Holman, Lubben, Nicolson & Otter (2005) (Table 1).

The network map concerning publication/document citation clusters is shown in Fig. 1. Accordingly, seven citation clusters have been formed to create a descriptive map. The most cited cluster is shown in turquoise color. This cluster is described by Gilbert, Bulte & Pilot (2011). The second cluster is represented with yellow color. This cluster is managed by Choi and Johnson (2005). The third cluster is shown in green color and is managed by Ültay and Çalık (2012). It is also possible to see other clusters on the network map (Fig 1).

Findings Obtained from Frequency/Statistics Analysis

Examining the publications about Context-Based Learning, which is a more frequently used learning model specially in the field of science education, it can be seen that a total of 280 studies had been conducted. The first of these studies was published in 1986. It can be noticed that the publications in this field increased intensively between 2014-2018. Further investigation of the data in Graph 1 shows that a total of 160 studies have been conducted in 2018. The analysis identified that the type of publication with the highest frequency regarding Context-Based Learning was research articles (n=515, 94.50%) while, on the other hand, the lowest frequency was recorded at data paper (n=3; 0.5%).

Moreover, when evaluating the studies on Context-Based Learning on a subject basis, a similar intensity in research to that in Graph 2 has been detected. As it can be noticed, the studies in this field are mostly concentrated in education and training research, covering the following subjects: educational sciences and disciplines, methodology of computer science, chemistry, and multidisciplinary approach.

Table 1. Most cited articles about "context based"

Document	Citations	Document	Citations
Gilbert, Bulte & Pilot (2011)	116	Ramsden (1997)	49
Choi and Johnson (2005)	107	King, Bellocchi & Ritchie (2008)	43
Ültay and Çalık (2012)	69	Taasoobshirazi and Carr (2008)	39
King (2012)	60	King and Ritchie (2013)	33
Bennett et al. (2005)	58	Demircioğlu, Demircioğlu & Çalık (2009)	32
Wijaya, van den Heuvel-Panhuizen & Doorman (2015a)	57	Stolk et al. (2011)	28
Wijaya, van den Heuvel-Panhuizen & Doorman (2015b)	57		

Note. Documents with at least 28 citations

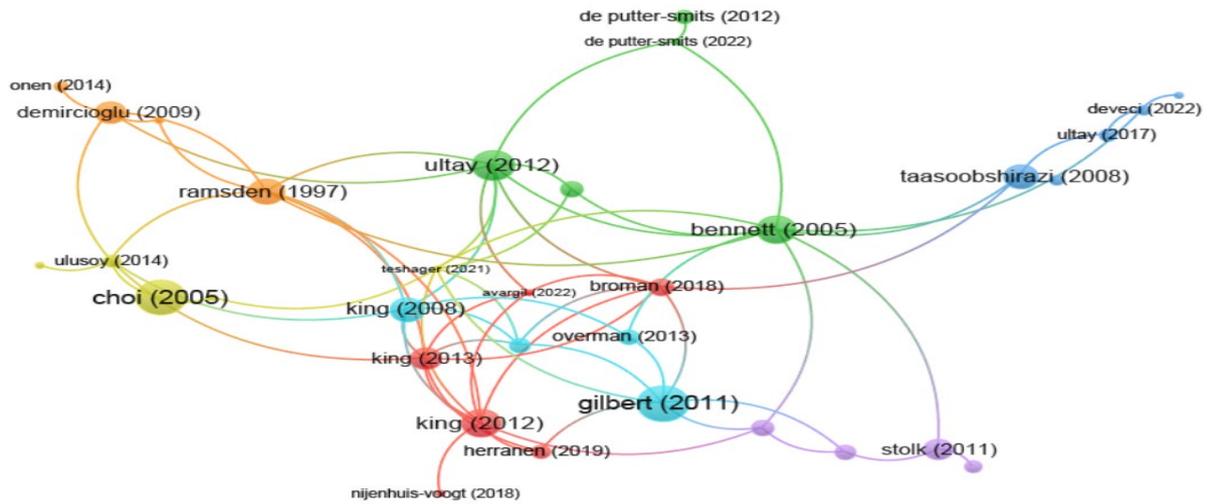
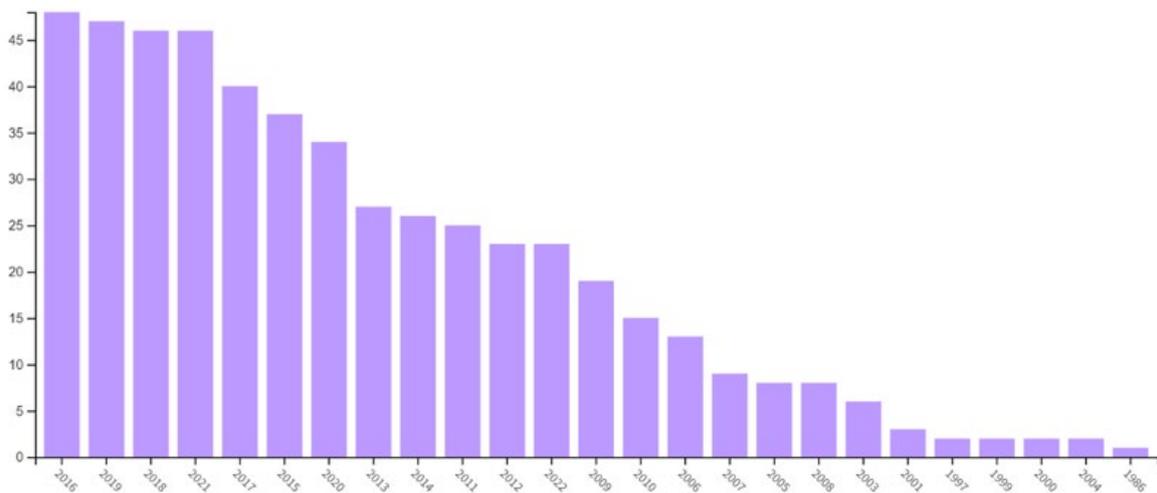


Figure 1. The network map that shows document citation sets about "context-based"



Graph 1. Number of publications related to Context-based (1986-2023)



Graph 2. Subject areas of research on Context-Based Learning

Findings Obtained from Keywords Analysis

As part of keywords analysis, scanning of the literature unveiled 134 keywords related to "Context-based" for the

1986-2023 period. At least 2 repetitions have been used as criteria for the co-occurrence analysis of the keywords and thus 18 keywords have been detected (Table 2).

Table 2. Keywords in the literature related to context-based

Keyword	Occurrences	Keyword	Occurrences
Context-based learning	10	Opportunity-to-learn	2
Chemistry education	6	Physics education	2
Context based approach	6	Secondary education	2
Context-based	2	Sociocultural	2
Context-based approach	2	Storyline	2
Context-based chemistry	2	Teacher professional development	2
Dialectics	2	Textbook analysis	2
Context-based problems	2	Thematic review	2
Context-based tasks	2	Chemistry	2

Note. Only those keywords that occur at least 2 times are shown.

In the analysis, five different themes emerged in the clusters related to the keywords within the scope of the research topic. These themes are context-based, context-based approach, context-based tasks, chemistry education, and context-based learning (Fig. 2). The red cluster is titled “Context-based” and consists of two keywords, namely, “Dialectics and sociocultural”. The green cluster is titled “Context-based approach” and consists of four keywords, namely, “Context-based problems, storyline, thematic review, physics education”. The dark blue cluster is titled “Context-based tasks” and consists of two keywords, namely, “Opportunity-to-learn, textbook analysis”. The purple cluster is titled “Chemistry education” and consists of five keywords, namely, “Teacher professional development, context-based learning, context-based, context-based approach, thematic review”. The blue cluster is titled “Chemistry” and consists of only one keyword, namely, “Context-based learning” (Fig. 2).

By showing the average process of occurrences of keywords, it is possible to understand the trend of context-based research. According to Figure 2 prepared for this purpose, purple and blue colors represent the first years, while the following years are shown in green, and the most recent

studies are in yellow. It can be noticed that the CBL method in science education has been used remarkably in the fields of chemistry and physics education, especially in recent period.

Findings Obtained from Associated Multi-Literature Analysis

As can be clearly seen from Table 1 and Figure 1, Gilbert, Bulte & Pilot's (2011) study titled “Concept Development and Transfer in Context-Based Science Education” is the most cited pioneering work in the literature.

Findings from Author Analysis

From 1986 to 2023, the number of authors who pursued academic studies on context-based is 95. The top five most cited authors are Bulte, Astrid M.W. (5 research/paper; 170 citations), Gilbert, John, K., (1 research; 116 citations), Choi, Hee (1 research, 107 citations), Johnson, Scott (1 research; 107 citations) and King, Donna (2 research; 103 citations) (Table 3).

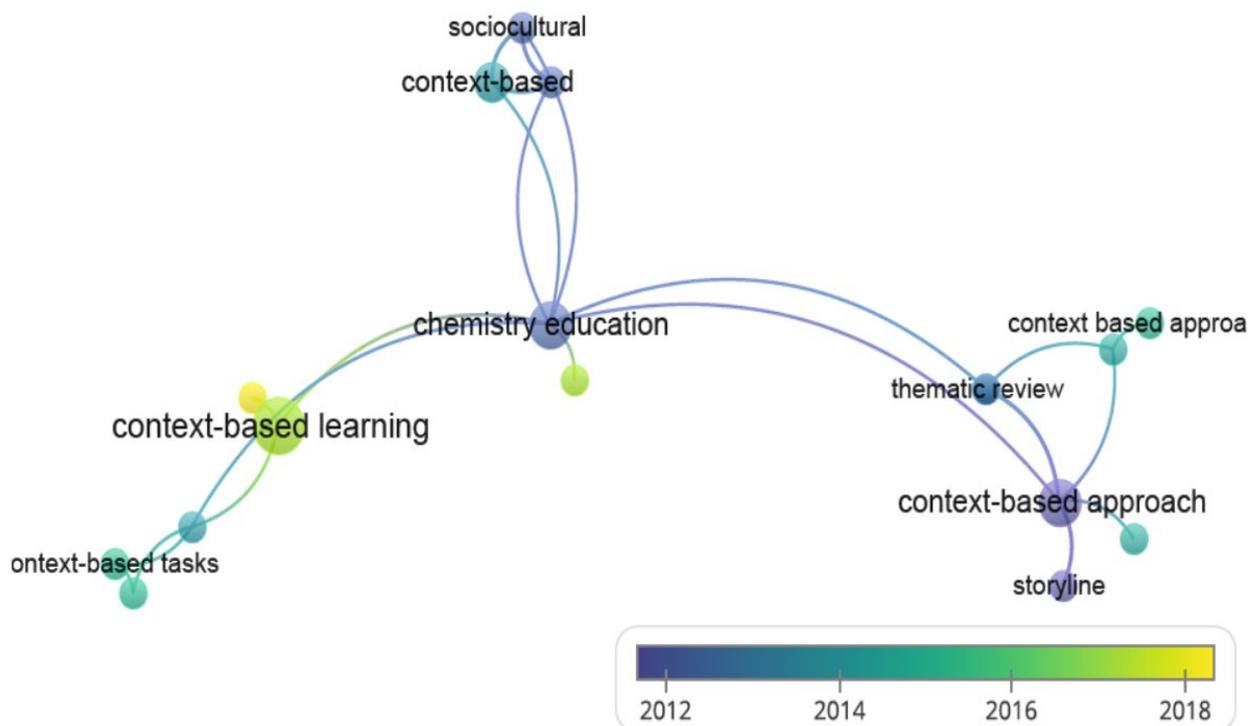


Figure 2. Network mapping of keyword associations in the context-based literature

Table 3. Most cited authors on context-based research

Author	Documents	Citations	Author	Documents	Citations
"Bulte, Astrid M. W."	4	170	"Parchmann, I."	1	58
"Pilot, Albert"	4	164	"Waddington, D."	1	58
"Gilbert, John K."	1	116	"Bellocchi, Alberto"	2	54
"Choi, Bee"	1	107	"Ramsden, Jm"	1	49
"Johnson, Scott"	1	107	"Carr, Martha"	1	39
"King, Donna"	2	103	"Taasobshirazi, Gita"	1	39
"Çalik, Muammer"	2	101	"De Jong, Onno"	2	35
"Ritchie, Stephen M."	3	87	"King, Donna Therese"	1	33
"Ultay, Neslihan"	2	77	"Demircioglu, Gokhan"	1	32
"Doorman, Michiel"	3	68	"Demircioglu, Hulya"	1	32
"Van den Heuvel-Panhuizen, Marja"	3	68	"Stolk, Machiel J."	1	28
"Wijaya, Ariyadi"	3	68	"Meijer, Paulien C."	3	27
"Bennett, J."	1	58	"Brekelmans, Mieke"	2	26
"Grasel, C."	1	58			

Note. Only authors who have published at least 1 document and have 26 citations are shown.

Co-citation analysis and bibliometric matching of authors have been performed to detect relationships between authors. For author co-citation analysis, data from authors with at least 1 publication and at least 26 citations have been used. Gilbert's research in this area receives the most citations (116) with one article. He is followed by Choi and Johnson, who received 103 citations to a study.

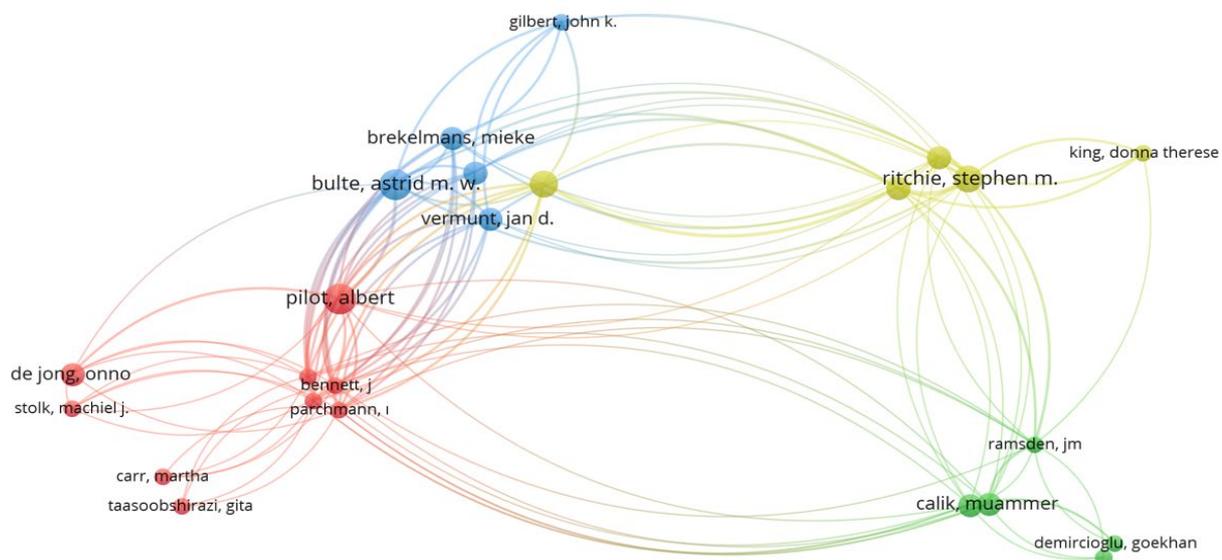
There are 4 clusters in the common citation network (Fig.3). The red cluster contains the largest group of authors (n=9). In the other three clusters, the number of author groups is equal (n=5). The most cited authors are in the blue group. The red and yellow clusters are the extensions of the blue cluster, which is led by Bulte. The red cluster is the second most cited cluster. The green cluster is the smallest cluster but is related to the blue and yellow clusters. Although the yellow cluster is also a small cluster, it is associated with the other three clusters.

To perform the author bibliographic match analysis, the minimum number of documents set as a criterion is at least 2 published documents by an author. According to this, 3 clusters are formed for a total of 23 authors (Fig. 4). For author co-citation analysis, data from authors with at least 1 publication and at least 26 citations have been used for 23 authors. The blue cluster is fixed in the center of the map of the five most cited authors, such as Pilot, Taconic, De Putter-

Smits. The green cluster is near the center, and it consists of the five second most cited authors. The red cluster, on the other hand, consists of eight authors who are highly connected with other clusters. However, this cluster draws attention with its slightly smaller number of citations. This indicates a finding that is generally consistent with the results of the "co-citation analysis".

Findings Obtained from Source and Country Analysis

Studies on context-based learning are being found in 29 different journals. Table 4 presents 25 journals that have published at least 1 article on the topic. The journals that published the highest number of articles are International Journal of Science Education (14 papers), Journal of Baltic Science Education (5 papers) and Chemistry Education Research and Practice (3 papers). In terms of citations, the most influential journals are recorded in International Journal of Science Education (348 citations), American Journal of Distance Education (107 citations) and Research in Science Education (71 citations).

**Figure 3.** Network map showing authors' common citation clusters

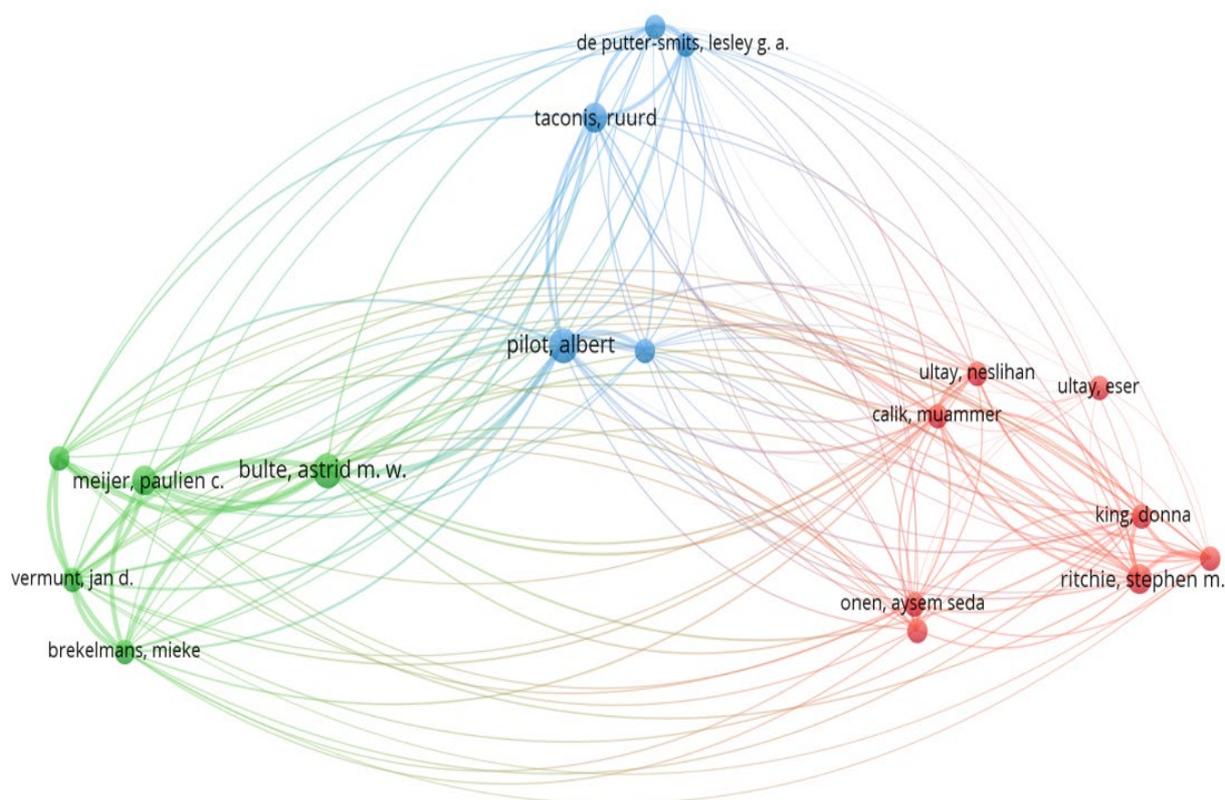


Figure 4. A network map showing the author bibliographic link clusters related to context-based

Table 4. Sources related to Context-based learning

Source	Documents	Citations
International Journal of Science Education	14	348
Journal of Baltic Science Education	5	22
Chemistry Education Research and Practice	3	49
7th World Conference on Educational Sciences	2	2
Research in Science Education	2	71
American Journal of Distance Education	1	107
Journal of Science Education and Technology	1	69
Studies in Science Education	1	60
Educational Studies in Mathematics	1	57
Educational Research Review	1	39
Mathematics Education Research Journal	1	11
Eurasia Journal of Mathematics Science and Technology Education	1	8
University Journal of Education	1	8
Journal of Biological Education	1	4
Active Learning: Models from The Analytical Sciences	1	3
Activity-Centered Design: An Ecological Approach to Designing Smart Tools and Usable Systems	1	3
Communication Education	1	3
International Journal of Mathematical Education in Science and Technology	1	3
Journal of Applied Security Research	1	2
12th Education and Training in Optics and Photonics Conference	1	1
4th World Conference on Educational Sciences (Wces-2012)	1	1
Curriculum Journal	1	1
Energy Education Science and Technology Part B-Social and Educational Studies	1	1
Professional Development in Education	1	1
Wpsee'18: Proceedings of the 13th Workshop in Primary and Secondary Computing Education	1	1

Note. Journals with at least one published article are being listed

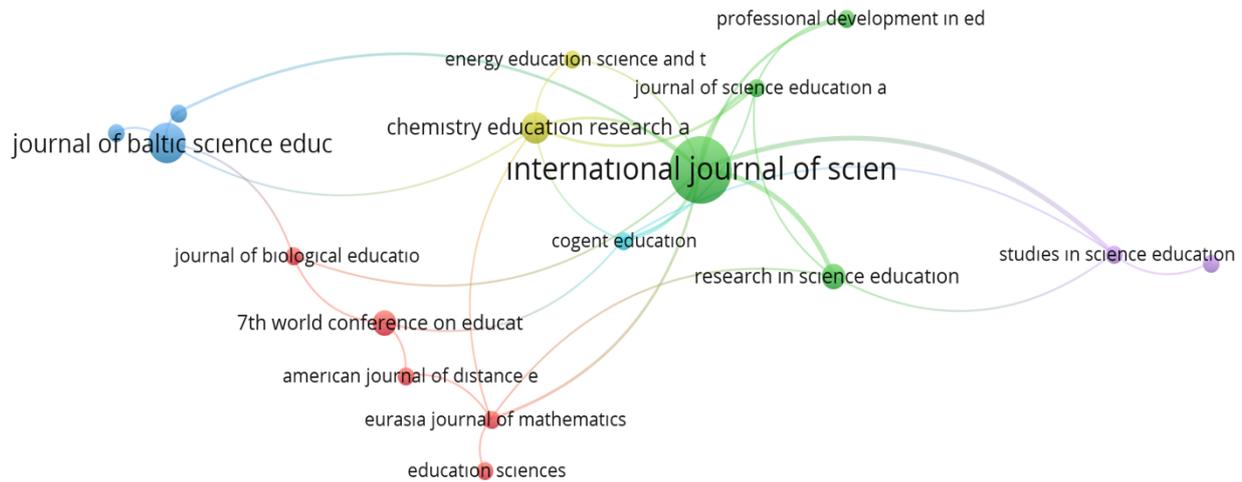


Figure 5. Network map showing source common citation clusters related to context-based learning

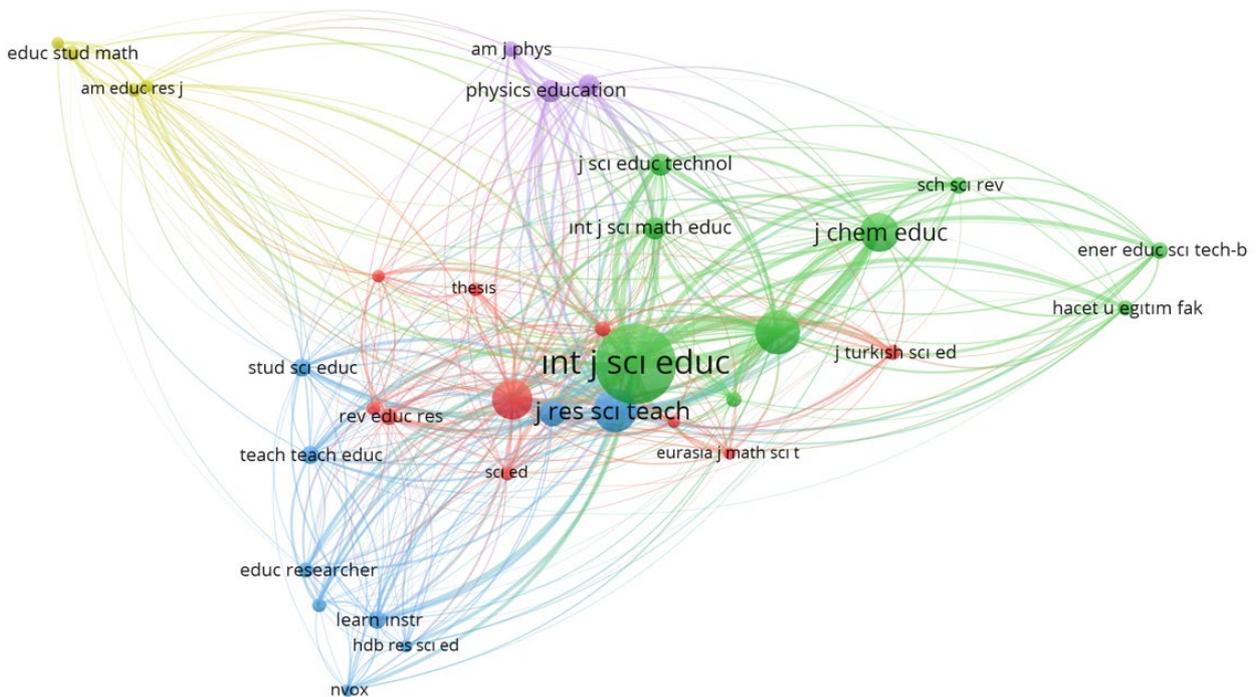


Figure 6. Network map showing source biographic match clusters related to context-based learning

16 countries participated in the publication of research on context based. Türkiye was the country that contributed the most to a sample by producing 15 articles. Türkiye is followed by Netherlands (12), England and Australia (5), respectively (Table 5).

The results of the common citation and bibliographic matching cluster analysis of the sources are presented in Figure 5 and Figure 6. In terms of co-citation, 29 journals with at least 7 citations were analyzed. There are 6 clusters identified in the source-co-citation network (Fig 5). The largest cluster is the green color cluster consisting of five items, while the smallest cluster is the turquoise color cluster consisting of just one item. Most of the clusters consist of resources published in the field of science. In that sense, with other colors are being represented chemistry, biology and mathematics resources as mostly science fields.

For the analysis of the biographical match of the sources, it has been set the condition that a source publishes at least 7

articles. With this condition, a total of 35 journals and 5 clusters are formed.

As it can be seen from Table 5, when the impact ratio (Cit./Doc.), introduced to measure the impact values of the published studies is considered, the first 3 countries are USA (49.7), England (38.4) and Australia (29.4). In order to determine the total publishing network of the countries, 16 countries with at least one published document have been evaluated. In this case, countries are divided into 5 clusters (Fig. 7). In the red color cluster, there are countries such as Australia, Spain and Russia under the leadership of Türkiye. The green color cluster includes the Netherlands, England, and Indonesia, while the blue color cluster includes America and Brazil. The purple color cluster includes Germany and Switzerland and the yellow color one includes Norway and Finland.

Table 5. Number of documents and citations related to Context based by country

Country	Documents	Citations	Impact (Cit./Doc.)
Türkiye	15,00	145,00	9,70
Netherlands	12,00	270,00	22,50
England	5,00	192,00	38,40
Australia	5,00	147,00	29,40
USA	3,00	149,00	49,70
Germany	3,00	75,00	25,00
Indonesia	3,00	68,00	22,70
Norway	2,00	11,00	5,50
Sweden	1,00	17,00	17,00
Spain	1,00	12,00	12,00
Finland	1,00	9,00	9,00
Slovenia	1,00	4,00	4,00
Brazil	1,00	3,00	3,00
Ethiopia	1,00	0,00	0,00
Russia	1,00	0,00	0,00
Israel	1,00	0,00	0,00

Note. Only countries that published at least one paper/document have been included.

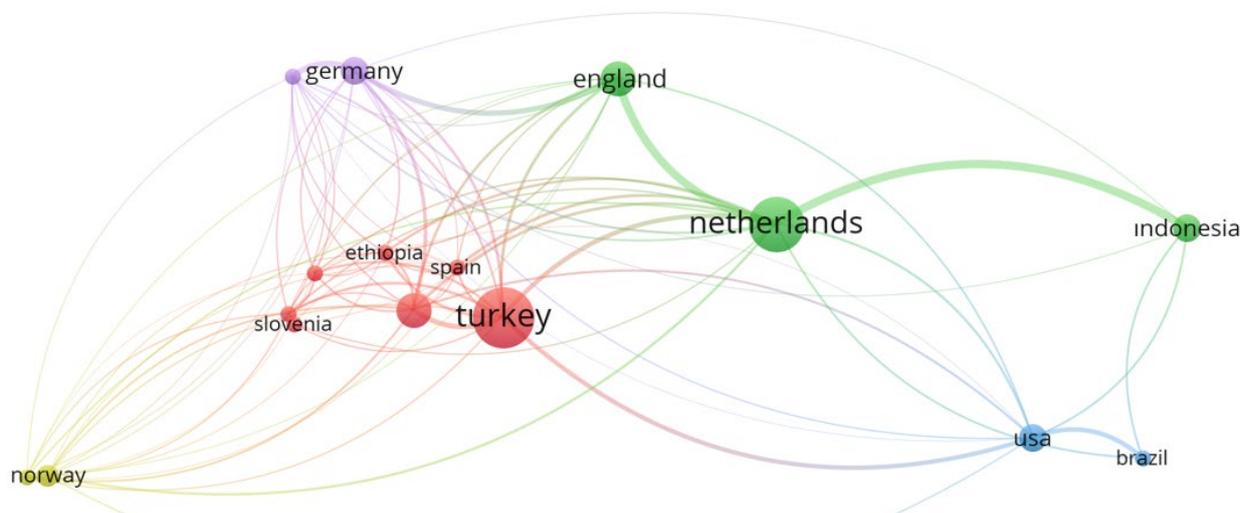


Figure 7. Network map showing citation clusters related to Context based by countries

Discussion and Conclusions

This study offers a comprehensive review on context-based research by analyzing the context-based learning literature published between 1986 and 2023 within the scope of science courses. One of the most important findings that came to the fore in the research is related to the fact that CBL as a method has been the subject of intense research in science teaching. It could be seen that until the date of this research, 545 studies have been carried out worldwide in this field, 160 of which were in 2018. This result is drawn from the findings of a number of disciplinary techniques that form the basic system for bibliometric research.

This study emphasizes that the context-based learning strategy is a popular research topic among science educators. Within the scope of the research findings, although intensive studies are carried out in the field of science education and chemistry education, it is recorded that sufficient studies are not carried out in physics, where technology and contextual applications are the closest discipline. The explanation for this situation can be found in prominence of technology-supported applications in the explanation of the subjects in physics and in insufficient contextual relationship.

In this research, the two most cited studies on context-based learning come forward, namely, Gilbert, Bulte & Pilot (2011) and Choi and Johnson (2005). The reason why they are

cited more than other studies is that the content richness and context-based learning approach in these studies are being examined in depth. Especially Gilbert, Bulte & Pilot (2011) can be considered as pioneer research with a value of 116 in terms of impact (number of citations/publication) among the studies conducted in this field.

It has been recorded that the studies based on the Context-Based learning method have been highly concentrated in 2018 with 160 studies conducted in total. One of the explanations for this is thought to be the increase in the number of general studies in educational sciences. This period coincides with the spread of experimenting different methods not only in this subject, but also in other fields of education. Although publishing related to Context-Based learning was not significantly intense in the first years, the number of publications considerably increased especially during 2015-2020 period.

In our research, it appears that concepts of "Context-based learning, chemistry education, context-based approach" are being the most common keywords. Moreover, the results indicate that CBL is the most applied model in Chemistry education. The source that records the most publication of these studies is the International Journal of Science Education. While during the initial years of research on the concept of "Context based" has been carried out focusing on thematic

analysis methods of the "Context based approach" concept, in the following years these studies were replaced by storytelling and context-based activities. However, in recent years, they have turned to content analysis techniques. This indicates that the method in question has evolved into a conventional field of study in educational sciences.

Furthermore, one of the important results of this research is taking into consideration the country distribution of the publications on CBL. While undertaking this analysis, the number of studies published in the countries and the citation rates to these studies were taken into account. Although Türkiye is the country with the highest number of publications in this evaluation, USA ranks first in terms of impact.

Considering the impact value, Türkiye with the highest number of publications is in the 10th place. The fact that the countries with the highest impact rate (USA, England, Australia, Germany) are developed countries is another important outcome of the study. The possible explanation of this situation could be the implementation of curriculum development and implementation studies based on the CBL curriculum in physics, chemistry, and biology courses within the scope of science high schools in Türkiye after 2004. The introduction of the CBL-based curriculum in science courses in Türkiye without completing scientific and academic studies in this topic, was the main reason for deficiencies in terms of quality of the research although quantitatively number of publications rose significantly.

Although intensive studies have been done within the scope of science at high school level in the last 20 years on CBL, there are research gaps in some areas, and it is important for researchers to fill this gap in the future. Among these are CBL-based research in experiments, observations and field studies in physics, chemistry and biology courses, CBL-based research in online and hybrid learning environments that emerged as popular learning environment after COVID-19, metaverse-based education that has started to take an active place in education in recent years, etc. Besides, associated with CBL are also CBL applications for individuals with special needs who do not have the opportunity to follow their lessons in classroom environment.

In this research, it was determined that bibliometric methods provide a broad and in-depth analysis opportunity. This result is compatible with the research conducted by Sai (2022). On the other hand, as stated by Battal and Taşdelen (2023), the database used in scans is very important in bibliometric analysis. Accordingly, researchers can obtain a wide perspective by using different databases.

In order to restructure the curricula of countries on the basis of CBL, it is of utter importance to conduct pilot applications first. CBL applications can be developed with a scientific-based approach, considering the local dynamics of the countries in the light of the research-based nature of these pilot applications and the findings obtained. Thus, it will make possible the achievement of targeted results. Otherwise, CBL studies that appear to be quantitatively positive will remain weak studies that have significant flaws in terms of quality and without meaningful acceptance in educational sciences.

Author Contributions

All authors equally took part in all processes of the article. All authors had read and approved the final version of the work.

Ethics Declaration

The authors declare that their work is not subject to ethics committee approval and that the rules set by the Committee on Publication Ethics (COPE) were followed throughout the study.

Conflict of Interest

The authors declare that there is no conflict of interest with any institution or person within the scope of the study.

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