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Review

Bibliometric Study of Scientific Production on the Term Collaborative Learning in Web of Science

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Abstract: Currently, more and more teachers decide to follow active teaching methods, leaving behind traditional teaching methods. Among the most used pedagogical methods in the educational field is the collaborative learning. The general objective of the present investigation is to know the performance and academic development of the term "collaborative learning" in the documents collected in the Web of Science database. The research method developed was based on a bibliometric study, identifying academic performance and conceptual development, through a co-word analysis. Particularly, we have pursued four main objectives: (a) To determine the degree of performance of documents collected from collaborative learning; (b) to identify the scientific development of so-called collaborative learning; (c) to analyze the most incidental aspects of collaborative learning; and (d) to value the most representative authors who are experts in the use of collaborative learning. The total number of manuscripts studied is 3295. The results show the manuscripts are written mainly in English by researchers who belong from the United States. The main area of knowledge is Education Educational Research. As a conclusion, it can be said that the collaborative learning pedagogical method is at a turning point in the scientific field. Its scientific evolution, focused on its principles in the students themselves, has extended to other branches. At present, studies are oriented towards technological resources, co-regulation, and the academic achievements of students. Furthermore, in the coming years the terms innovation, design, patterns, collaboration, and communication will probably be the new lines of study in this scientific field.

Keywords: collaborative learning; education; bibliometric analysis; scientific production; scientific mapping; web of science

1. Theoretical Background

Roughly speaking, globalization has led to developments in various social areas [1]. In turn, this evolution has not only had consequences in the economic, political, or social spheres; in the educational sphere, the implementation of innovation processes in the different educational institutions has also experienced a great evolution [2]. In order to update and offer quality and innovative training, it is necessary to abandon traditional teaching–learning approaches [3], as well as passive training methods [4]. For this reason, the line of action in the educational and pedagogical field must be directed towards the development of new innovative practices. This can have a positive influence on the overall development of students [5–10], increasing their motivation and satisfaction [11]. However,

the inclusion of these innovative practices in the teaching–learning processes requires an effort and coordination of all the players involved. This implies both teachers [12] and those agents involved in managing educational institutions [13]. It is essential to begin by rethinking teaching processes [14], where information and communication technologies (ICT) facilitate the development and application of innovative teaching methods [15,16].

Currently, the lines of pedagogical innovation [17–19] focus on different educational aspects, among which the so-called collaborative teaching methods receive greater attention. This educational practice has become one of the most widely used methods in the field of education [20], since they allow a high educational potential to be achieved [21]. Considering the needs to be worked on and the evolution of society and education, collaborative learning is a method of teaching that occurs through the interaction of two or more people [22] who share certain resources at certain moments of their learning [23]. It may be necessary to bring into play the different skills of the group members [24] in order to achieve improvements in academic performance through the relationship between individuals [25], the exchange of experiences [26], or the change of roles among group members [27]. It should not be forgotten that the actions of the group members affect the acquisition of the educational objectives of the other components of the group [28]. In general terms, collaborative learning requires a group project [29], teamwork for problem solving [30], pedagogical debates [31], and work teams [32].

Some research shows that established social relationships do not appear at the time of learning but require a period of adaptation to achieve it adequately [33]. Clearly, an updated teacher training is essential [34] to provide pre-service teachers with the necessary didactic and methodological tools to be able to face new learning situations and assume and put into practice their life-long learning processes. In this sense, some limitations or disadvantages of this method would be the possible lack of involvement among students in the group [35]. This aspect must be taken into account if the training process is to be successful [36] and highly coordinated. Any didactic process always requires a previous didactic planning and a coordination of all its members to achieve the best results [37].

Among the advantages shown by recent research is that the teaching and learning process based on collaborative learning is positively valued by students [38,39], improves their interactions and communications [40,41], promotes communication among equals, increases their attitude [42], motivation [43], sense of community [44,45], the realization of pedagogical exercises [46], the mental situation of the student [47], and autonomy [48], actively involving him in his pedagogical acts to improve his interaction [49]. Some authors indicate that this method can contribute to improve students' behavior and attitudes, and can influence their monitoring of learning [50,51]. In turn, it allows the creation of monitored teaching–learning situations where group reactions, the type of adaptive regulation and behavior can be analyzed (monitoring target, valence, and phase). This method allows the creation of opportunities and limitations in the different monitoring dimensions [28,52,53].

It is essential to always create a good learning environment, a social climate in the classroom that allows the student to feel at ease. Collaborative learning also contributes to regulation. Thus, the student has more tools to face the challenges of learning, participating in different didactic situations. This allows them to learn to manage their attitudes and emotions [54]. Collaborative learning also presents enormous advantages in relation to its use with digital competence, that is, the use of educational technologies [55]. It favors socialization and social interaction processes, the student's satisfaction in learning acquisition, and promotes the use of innovative didactic models that confer a leading role to students. Even in learning environments where the use of Google Docs is prevalent, it is considered a good method [56–59].

On the other hand, some authors indicate that this method also favors intercultural competence by promoting collaborative learning environments with heterogeneous groups of students [60]. Traditional teaching–learning approaches do not allow for a focus on improving certain skills in the student training process. An example derived from recent research [61] shows that the collaborative learning allows for the articulation of the so-called buzz groups, thus improving the effectiveness of the student-centered approach. This also contributes to improving the student's motivation by sharing

their centers of interest. Innovation, the development of processes of creativity, critical thinking, and problem-solving allow for the development of collaborative learning together with experiential learning [62,63]. Other research indicates that this method has been beneficial for improving reading comprehension. Collaborative learning allows the development of didactic strategies that have a high positive impact on students, such as the use of peer collaboration in the analysis of complex texts [64].

In addition, it should be noted that studies indicate that the collaborative learning method favors sustainability, especially if this method is developed digitally [65] In addition, collaborative learning, associated with specific sustainability programs such as the European Project Semester (EPS), promotes multicultural and multidisciplinary teamwork, communication, problem solving, creativity, leadership, entrepreneurship, ethical reasoning, and global contextual analysis [66]. The collaborative learning method has been applied in the training of students of various kinds, especially students of interior design [67], administrative studies [68], or agro-food systems [69], with a view to sustainable development.

2. Justification and Objectives

The innovative topic we deal with in this paper is the so-called "collaborative learning". Current theories prove it to be successful and spread in different research areas. In fact, it has been analyzed in the documents collected in the Web of Science (WoS). That analysis has allowed us to carry out a scientific mapping. To achieve this objective, different bibliometric indicators were analyzed, as well as the study of the performance and evolution of the term. However, we have also considered other documents in the Journal Citation Reports [70–72]. Hence, we provide updated models to contribute to the dissemination of knowledge.

The overall objective of this study is to identify the performance and conceptual development of "collaborative learning" in the documents collected in WoS. This formulation of the objective of the research and its creation arises from the fact that there are not enough studies developed using this bibliometric technique of documentary analysis. The aim of this study is to show researchers the new findings regarding this use of the term "collaborative learning". In this way, the knowledge researchers require in this field are covered.

Particularly, four objectives were formulated in this research: (a) To determine the degree of performance of documents collected from collaborative learning; (b) to identify the scientific development of so-called collaborative learning; (c) to analyze the most incidental aspects of collaborative learning; (d) to value the most representative authors who are experts in the use of collaborative learning.

As research questions, the following issues are established: What is the academic performance of the term collaborative learning in the scientific production of Web of Science? What is the scientific evolution and the most relevant topics in the research developed on collaborative learning in Web of Science?

3. Method of Investigation

3.1. Structure of the Investigation

Once the objectives of the research were established, the methodology to be adopted was determined. The methodological option that best fits the characteristics of this research is bibliometrics [73,74]. This decision was agreed upon by evaluating the potential of scientometrics developed in the processes of locating, recording, identifying, and forecasting academic production [75]. In addition, what has been developed by other researchers in this method was taken as a reference as the backbone of this research [76].

More specifically, this research also includes the study of joint words [77], as well as other bibliometric indicators (h, g, hg, q2) [78]. The inclusion and analysis of these aspects makes it possible to obtain various conceptual maps that indicate the development and location of issues related to

"collaborative learning" (COLE). It should also be noted that graphic design allows us to observe the evolution of COLE-related topics in WoS [79]. For this reason, the analysis of these aspects was considered key to the choice of research methodology.

3.2. Procedure and Data Analysis

It is worth mentioning in detail the steps that this research has been experiencing. Firstly, the choice of the database to be analyzed (WoS) was made. The Web of Science, owned by the company Clarivate Analytics, is the collection of databases of bibliographic references and citations from periodicals that collect information from 1900 to the present. The WoS is composed of the Core Collection which covers the Science, Social Science, and Arts and Humanities indexes, as well as the Proceedings of both Science and Social Science and Humanities along with tools for analysis and evaluation, such as the Journal Citation Report and Essential Science Indicators. Secondly, the key words to be analyzed were specified ("collaborative learning"). Thirdly, the search equation was elaborated ("collaborative learning" (TITLE)). Fourthly, the term was searched in the title of the various publications. As a result, a total of 3411 publications were initially collected. It is significant that the concept of collaborative learning has existed in the scientific literature since 1970. Therefore, we proceeded in this research with a diachronic perspective analyzing the 49-year-old literary volume, including 2019. In this sense, the publications related to 2020 (n = 67) were eliminated since they did not end the calendar year. Note that repeated documents or those that were wrongly indexed (n = 49) were also deleted. This represents a final analysis of 3295 documents. To reflect all the actions assumed in this study, a process based on the PRISMA protocol was followed (Figure 1).

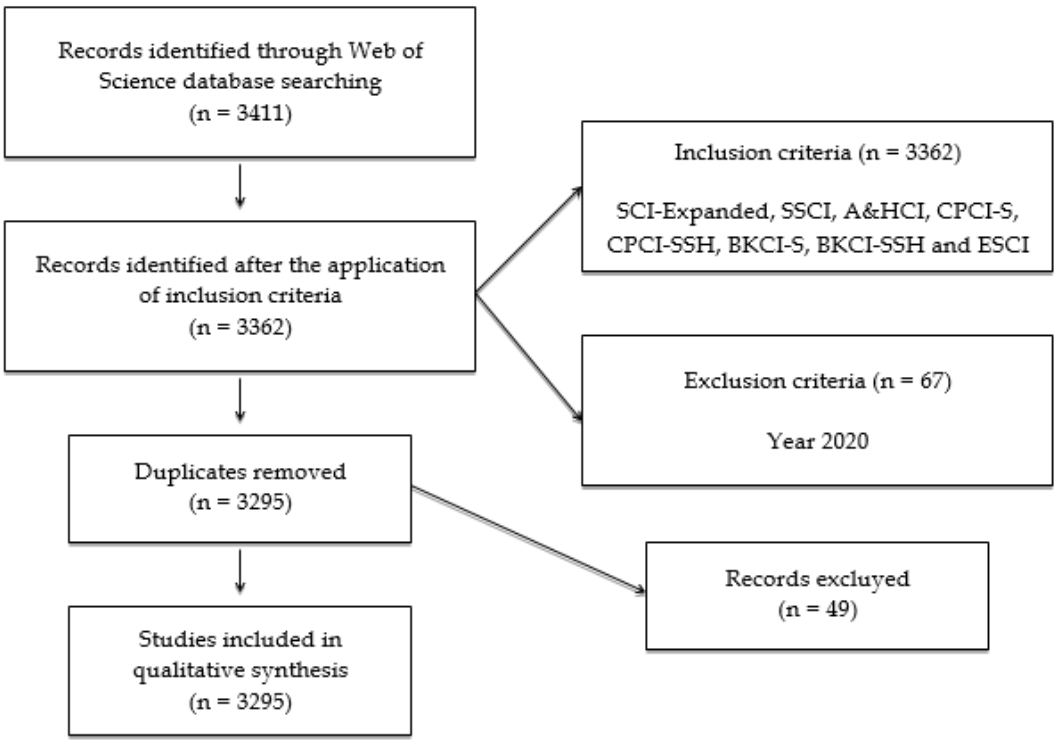


Figure 1. Flowchart according to the PRISMA Declaration.

As can be seen, a number of inclusion criteria were taken into account in the total number of documents submitted in the descriptive analysis of the scientific output. For this purpose, the program Analyze Results and Creation Citation Reports (tools integrated in the WoS platform), for academic performance, was used. These results were presented taking into account certain levels of inclusion (year of publication = all production except 2020; language ≥ 20; area of publication ≥ 200; type of

documents ≥ 50; organizations ≥ 34; authors ≥ 23; sources of origin ≥ 50; countries ≥ 190; citation: the four most cited documents ≥ 390).

The SciMAT program ver.1.1.04 (Granada, Spain, 2016) is used to identify the scientific evolution of the term, taking into account the assessments given by specialists [80–82]. The phases followed in this analysis are (Figure 2):am

- Detection of research topics: Of the 6189 keywords collected on the subject of study in WoS, a total of 5741 keywords were analyzed. This is due to the creation of a network of co-occurrence through nodes. Keywords are connected when two of these words co-appear in different scientific texts, generating a standardized network of co-words. Using the clustering algorithm, the research topics were located, thus showing the strongly related keywords. The keywords given by the authors and those created by WoS were used, according to the type of document. In addition, all the scientific production was analyzed to check that there were no repeated documents, and certain documents that appeared in the search that were not strictly related to the subject matter, using the IBM SPSS Statistics ver. 20 program (Armok, NY, USA, 2011), which, by means of the frequency tables, locates the repeated documents.
- Representation of the research topic: For this purpose, a strategic diagram and a thematic network were used, formed by two dimensions (centrality and density), where the key words are shown in four sectors: Upper right sector, where the motor and fundamental topics in the research topic are located; upper left sector, where the connections are weak and they are nodes with little relevance in the topic; lower left sector, where the topics are relevant but they do not have a pressing development; and lower right sector, where the nodes lack development or relevance, although those that appear in that area can be emerging topics.
- Location of thematic areas. This is determined by the chronological evolution shown by the nodes from one period to another. The strength of the relationship is based on the number of key words they have in common. The analysis begins in 1970 and ends in 2019. The periods established were P1 (1970–2006), P2 (2007–2011), P3 (2012–2015), and P4 (2016–2019).
- Performance analysis. Each of the keywords has, in turn, a chain of connections that mark the trend of that node, offering data on the use that the scientific community makes of it. For this purpose, analysis protocols were established (Table 1).

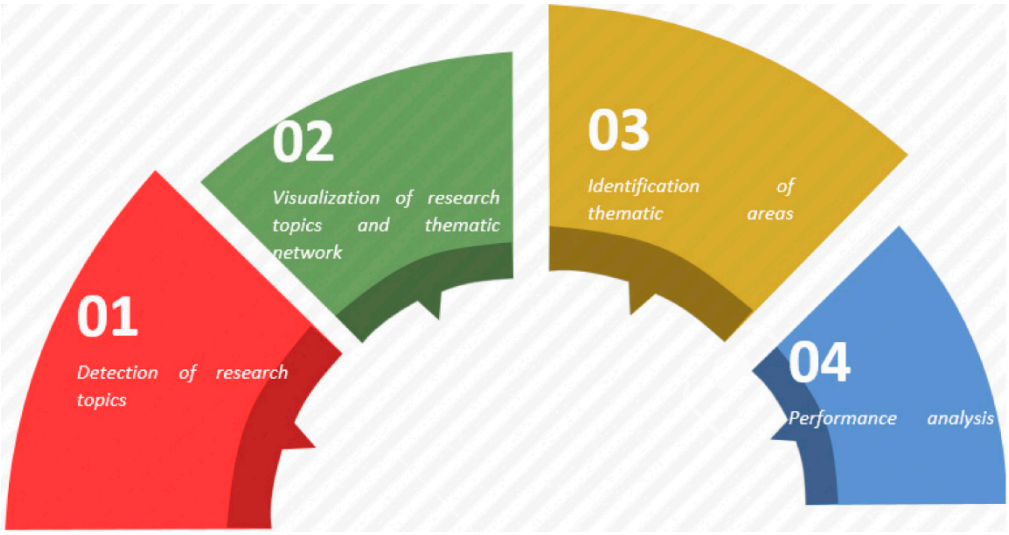


Figure 2. Phases of co-word analysis using SciMAT. Recovered from [83].

Table 1. Production indicators and inclusion criteria.

Configuration	Values
Analysis unit	Keywords authors, keywords WoS
Frequency threshold	Keywords: $P_1 = (2)$, $P_2 = (4)$, $P_3 = (4)$, $P_4 = (4)$ Authors: $P_X = (4)$
Network type	Co-occurrence
Co-occurrence union value threshold	Keywords: $P_1 = (2)$, $P_2 = (2)$, $P_3 = (2)$, $P_4 = (2)$, $P_5 = (2)$ Authors: $P_X = (4)$
Normalization measure	Equivalence index
Clustering algorithm	Maximum size: 9; Minimum size: 3
Evolutionary measure	Jaccard index
Overlapping measure	Inclusion Rate

4. Results

4.1. Scientific Production Performance

Research over time on collaborative learning was composed of 3295 documents. The evolution of the term in scientific production has been irregular. From 1970, when the first document was published in WoS, until 2001, scientific production was scarce. This evolution is not constant over time, given that there are years in which the scientific community has not produced content related to the topic. From 2002 to 2013, the scientific production has been growing constantly. In 2014, it breaks the upward trend, and will grow again in 2015. This year is when the highest production peak occurs. From 2016 to 2019, the production on collaborative learning has been gradually decreasing (Figure 3).

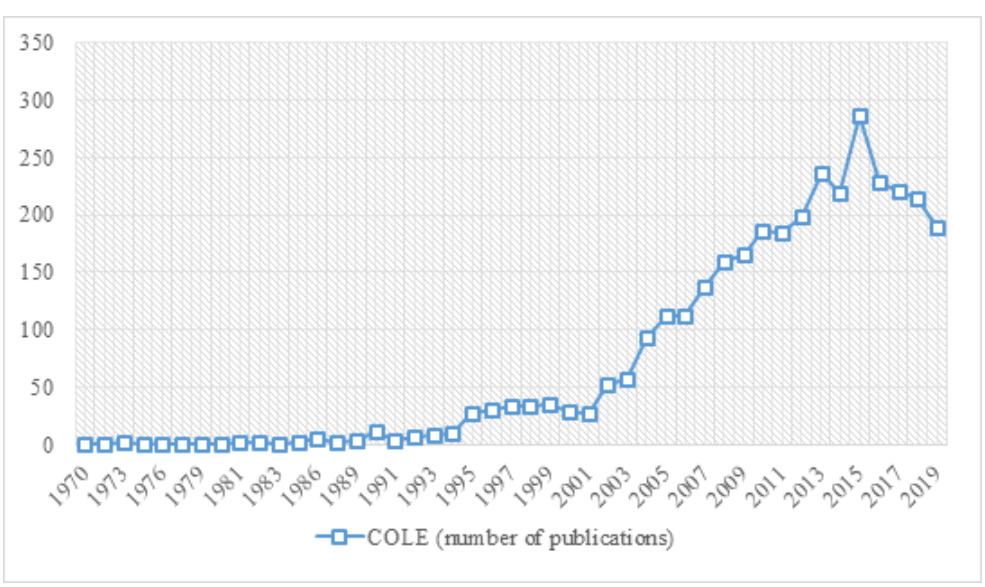


Figure 3. Evolution of the volume of production on collaborative learning.

The language used by the researchers to show their scientific results is English, being very distant from the other languages (Table 2).

Table 2. Language used in scientific production.

Languages	COLE (Number of Publications)
English	3180
Spanish	123
Portuguese	25

The main area of knowledge in which scientific findings about COLE are collected is Education Educational Research. The following knowledge areas are focused on the field of computing (Table 3).

Table 3. Areas of knowledge.

Areas of Knowledge	COLE (Number of Publications)
Education Educational Research	1659
Computer Science Interdisciplinary Applications	576
Computer Science Information Systems	469
Computer Science Theory Methods	416
Computer Science Artificial Intelligence	324
Education Scientific Disciplines	317

There are even production levels, if you bear in mind the type of document used. In this case, the articles slightly exceed the communications (Table 4).

Table 4. Type of document.

Document Types	COLE (Number of Publications)
Article	1625
Proceedings paper	1535
Book Chapter	151
Meeting abstract	94
Editorial Material	71

The main institution attending to the field of study presented is the UOC Universitat Oberta de Catalunya. Its level of production is slightly higher than that of the other institutions (Table 5).

Table 5. Institutions.

Organizations	COLE (Number of Publications)
UOC Universitat Oberta de Catalunya	43
Nanyang Technological University	39
Nanyang Technologucal University National Institute of Education NIE Singapore	39
Utrecht University	38
University of Oulu	35

In the studies on collaborative learning, two authors stand out above the rest, in terms of volume of production. These authors are Cabelle, S, and Jarvela, S. As can be seen in Table 6, there is not much distance, as far as production is concerned, with the rest of the authors.

Table 6. Most prolific authors.

Authors	COLE (Number of Publications)
Cabelle, S.	27
Jarvela, S.	27
Hayashi, Y.	24
Kirschiner. P.A.	24

The main source of production is Lecture Notes in Computer Science, which stands out considerably from other sources (Table 7).

The United States is the country with the highest volume of production on COLE. The next country is Spain, although its production level is far from the first (Table 8).

Table 7. Main sources of production on collaborative learning.

Source Titles	COLE (Number of Publications)
Lecture Notes in Computer Science	151
Computers Education	76
Computers in Human Behavior	73
Procedia Social and Behavioral Sciences	56

Table 8. Country.

Countries	COLE (Number of Publications)
United States	700
Spain	354
China	299
Japan	196

The most frequently cited document is that of Stahl, Koschmann, and Suther (2006), which presents a high number of citations, with a total of 658. It is closely followed by the manuscript of Kreijns, Kirschner, and Jochems (2003), with 635 citations. The rest of the documents are distant, in terms of the number of citations (Table 9).

Table 9. Collaborative learning (COLE): Most cited articles.

Reference	Citations
[84]	658
[85]	635
[86]	399
[87]	391

4.2. Evolution of COLE's Structure and Theme

The development of the keywords is evident, bearing in mind the established time intervals. In this case, it provides information on the keywords that are no longer used in the contiguous period, new keywords that appear in a certain period, and keywords that coincide between periods. It also shows the total number of keywords used in a given time period. As shown in Figure 4, the level of coincidence has been decreasing from the first time interval to the last one. In other words, the level of coincidence has gone from 37% to 29%. What we observed shows changes in the lines of study on COLE, so the focus of studies is likely to change in the coming years.

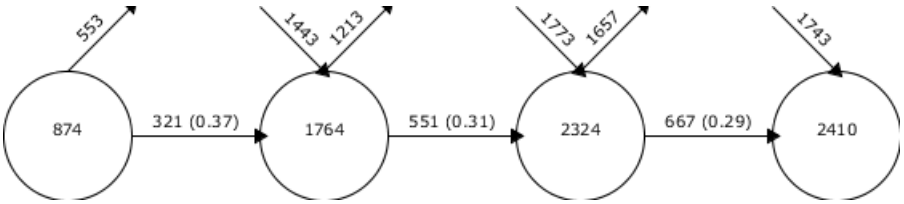


Figure 4. Continuity of keywords between contiguous intervals.

The analysis of the keywords used by the authors in their research, taking into account the established time intervals, provides information on the various bibliometric indices. In this case, the most relevant subjects with the best indicators are shown. The h index is a system that simultaneously measures the quality (based on the number of citations received) and the quantity of scientific output and is very useful for detecting the most outstanding research personnel within a knowledge area [88]. The g index is calculated from the distribution of citations received by the publications of a given researcher. It is similar to the h index, more complex in its calculation, but as it is larger and more variable, it allows us to distinguish between authors with a similar h index [89]. The hg index tries to

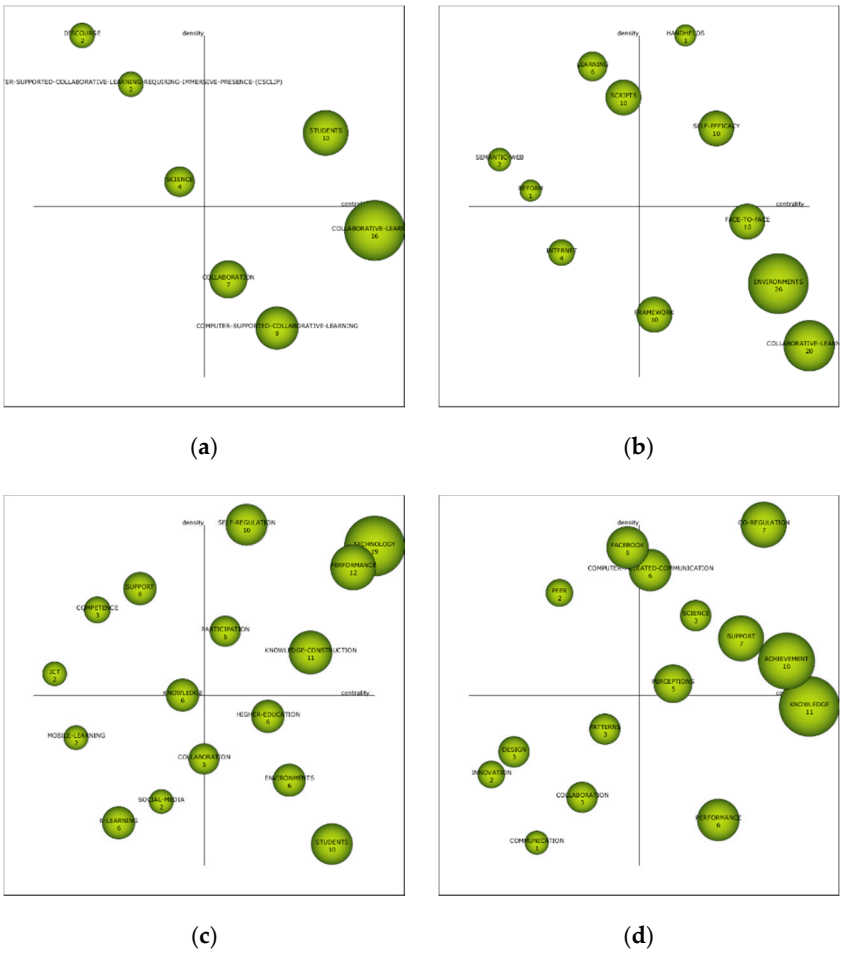
avoid the great influence that a single publication with many citations can have on the g index [90]. In the first interval (1970–2006), the topic with the best bibliometric value is "collaborative-learning". In the second period (2007–2011), it is "environments". In the third period (2012–2015), it is "technology". Lastly, in the fourth period (2016–2019), it is "knowledge", followed very closely by "achievement". If the periods are analyzed as a whole, it can be seen that there is no continuous line in the field of study of COLE, and that there are changes in trends. The themes have been ordered according to index h. (Table 10).

- The strategic diagrams by index h show the level of relevance and importance of the different themes. This was done by means of grouping techniques, bearing in mind Callon's index. This value presents the level of connection of the various thematic networks, taking into account centrality and density. Centrality identifies the strength of association of external connections between themes. Density analyses the internal association force, identifying all the key words related to a given theme.
- Bearing in mind the results achieved in the different diagrams (Figure 5), there is no theme that is repeated in all the established time intervals. In this case, the themes vary between the different periods. In the first period (1970–2006), only "students" appears as the driving theme, which is related to "performance", "mathematics", "work", "classroom", "environments", "motivation", and "achievement". In other words, the beginning of research on COLE focused on students.
- In the following time frame, established between 2007 and 2011, the driving themes are "hand-heeds", related to "participatory-simulation" and "gestures"; and "self-efficacy", related to "collective-efficacy", "engagement", "beliefs", "classroom", "achievement", "performance", "mathematics", and "work". In this period, the focus of the study is on the self-efficacy of the method and the use of technological devices.
- In the third period (2012–2015), the number of driving themes increases considerably with respect to the previous periods. In this case, the driving themes are "self-regulation", which is related to "social-shared-regulation", "instruction", "metacognition", "perspective", "strategies" " co-regulation", "motivation", and "self-regulated-learning"; "technology", which is linked to "design", "acceptance", "user-acceptance", "systems", "tools", "collaborative-learning", "education", and "information"; "performance", which is based on "conflict", "self-efficacy", "computer-mediated-communication", "interactive-learning-environment" "achievement", "impact", "science", and "group-decision-making"; "participation", which relates to "engagement", "efficacy", "interactive", "school", "visualization", "patterns", "issues", and "satisfaction"; and "knowledge-construction", which relates to "content-analysis", "scaffolding", "interaction-analysis", "project", "scripts", "on-line", "computer-supported-collaborative-learning", and "time". In this period, it can be seen that the focus of research is on more concrete aspects of learning. Examples of this are knowledge acquisition, self-regulation, and student involvement in the teaching and learning process. In addition, technology is beginning to be taken into account.
- In the last period (2016–2019), the driving themes are "computer-mediated-communication", related to "self-efficacy", "satisfaction", "teaching/learning-strategies", "communities", "interactive-learning-environments", "learning-communities", "perspective", and "work"; 'science', linked to 'inquiry', 'peer-learning', 'gender', 'environments', 'game', 'gender-differences', 'scripts', and 'knowledge-construction'; 'perceptions', based on 'pedagogy', 'educational-innovation', 'networking-sites', 'experiences', 'university', 'higher-education', 'social-presence', and 'acceptance'; "co-regulation", related to "group-engagement", "interplay", "self", "motivation", "video-data", "socially shared-regulation", "self-regulation", and "metacognition"; "support", linked to "participation", "computer-supported-collaborative-learning", "construction", "mobile-devices", "systems", "wiki", "moodle", and "quality"; and "achievement", based on "impact", "skills", "academic-performance", "classroom", "group-performance", "students", "meta-analysis", and "group-work". In this last period, it is also necessary to take into account the themes "innovation", "design", "patterns", "collaboration", and "communication", because its location in the diagram

places it as an unknown subject. In other words, they may disappear from the context of study on COLE or be the next driving force. In this period, as can be seen, the focus of studies begins to be on the co-regulation of learning, student achievement, the field of science, students' own perceptions, and the use of technological resources.

Table 10. Thematic performance in COLE.

Interval 1970–2006						
Denomination	**Works**	**Index h**	**Index g**	**Index hg**	**Index q^2**	**Citations**
Collaborative-learning	30	16	24	19.6	24	1153
Students	11	10	11	10.49	23.45	1053
CSCL	15	9	11	9.95	25.46	1609
Collaboration	10	7	9	7.94	15.87	821
Science	4	4	4	4	8	226
Discourse	2	2	2	2	11.66	71
CSCLIP	3	2	3	2.45	7.75	36
Interval 2007–2011						
Denomination	**Works**	**Index h**	**Index g**	**Index hg**	**Index q^2**	**Citations**
Enviroments	53	26	44	33.82	35.69	2018
Collaborative-learning	71	20	43	29.33	34.93	1874
Self-efficacy	12	10	12	10.95	28.28	784
Scripts	13	10	12	10.95	24.08	726
Framework	14	10	12	10.95	18.17	627
Face-to-face	12	10	11	10.49	20.25	599
Learing	17	6	8	6.93	8.12	77
Internet	4	4	4	4	10.58	79
Semantic-web	2	2	2	2	4.24	13
Handhelds	4	1	1	1	1.41	2
Reform	3	1	1	1	2.24	5
Interval 2012–2015						
Denomination	**Works**	**Index h**	**Index g**	**Index hg**	**Index q^2**	**Citations**
Technology	67	19	31	24.27	26.15	1117
Performance	23	12	21	15.87	21.07	458
Knowledge-contruction	26	11	20	14.83	15.2	427
Self-regulation	15	10	14	11.83	20.74	387
Students	19	10	17	13.04	17.89	546
Knowledge	1	6	11	8.12	10.1	163
Higher-education	14	6	10	7.75	11.22	111
E-learning	16	6	9	7.35	8.83	88
Enviroments	12	6	11	8.12	11.49	212
Support	7	6	7	6.48	10.39	111
Participation	10	5	10	7.07	11.83	336
Collaboration	21	5	10	7.07	9.22	103
Competence	4	3	4	3.46	6.46	22
Social-media	4	2	3	2.45	7.48	57
ICT	4	2	2	2	4	11
Mobile-learning	4	2	3	2.45	6.93	35
Interval 2016–2019						
Denomination	**Works**	**Index h**	**Index g**	**Index hg**	**Index q^2**	**Citations**
Knowledge	84	11	19	14.46	17.23	492
Achievement	34	10	14	11.83	12.25	254
Co-regulation	18	7	10	8.37	9.17	118
Support	24	7	11	8.77	9.17	137
Facebook	18	6	10	7.75	7.75	101
Performance	16	6	8	6.93	8.12	79
Computer-mediated-communication	9	6	7	6.48	12.49	130
Perceptions	24	5	8	6.32	6.32	72
Science	15	3	7	4.58	5.48	53
Collaboration	15	3	3	3	3	20
Patterns	9	3	6	4.24	5.48	39
Design	6	3	3	3	6	50
Peer	3	2	3	2.45	3.46	9
Innovation	5	2	4	2.83	4.9	17
Communication	4	1	1	1	1	1



(**a**) (**b**)

(**c**) (**d**)

Figure 5. COLE's h-index strategy diagram; (**a**) range 1970-2006; (**b**) range 2007–2011; (**c**) range 2012–2015; (**d**) range 2016–2019.

4.3. Evolutionary Development of COLE's Themes

The development of the various themes presents the strength of the relationship between them. This connection occurs between the time intervals indicated above. The index used to identify the relational strength is the Jaccard index. This force is established by the number of keywords coinciding between the different themes. There are two types of connections that can be established: Conceptual connection, represented by a continuous line; and keyword connection, identified as a non-continuous line.

Bearing in mind what is established in Figure 6, it is possible to indicate that there is a conceptual gap. In other words, the same theme is not observed in the three time intervals. In addition, it can also be observed that there is no line of research that is settled in time, but rather that the field of study varies on the part of the scientific community. Another relevant aspect is the number of existing connections. The most common ones are established between the last and the penultimate period. There are also more thematic connections than conceptual ones. A thematic evolution can be seen, moving from a field of study focusing on students and the method itself, to the use of technological resources and specific and concrete aspects of learning, such as motivation, perception, knowledge, and self-regulation, among others. The thematic evolution confirms that there are constant changes in the lines of research of the scientific community.

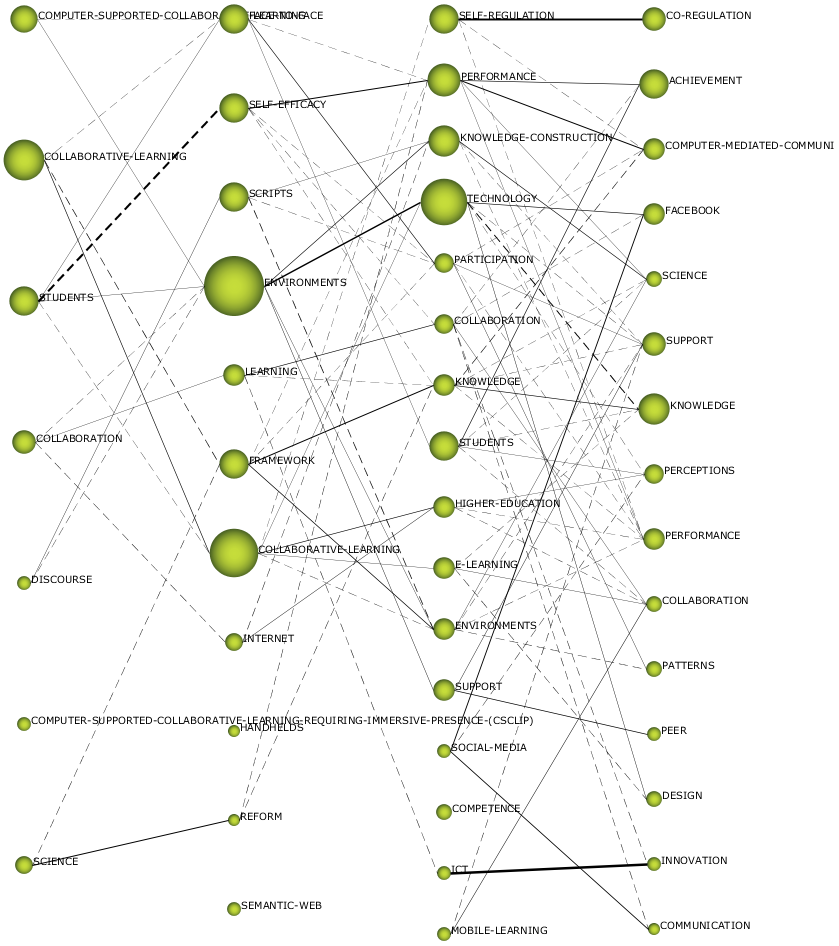


Figure 6. Thematic evolution by h-index.

4.4. Authors with the Highest Relevance Index

In relation to the authors, it is observed that Asensio-Pérez, J.I., Ruys, I., Redondo, M.A., and Hunger, A. are considered the driving forces in the field of COLE research. In addition, the authors Caballe, S., Collazos, C.A., and Fischer, F., should be taken into account, since they may be the driving forces in this field of study in the coming years (Figure 7).

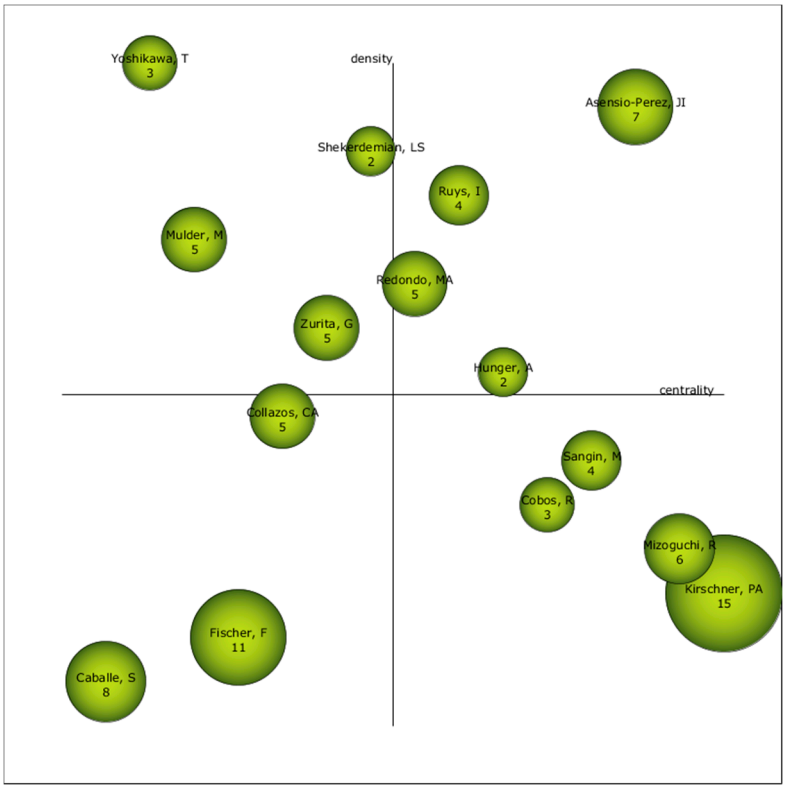


Figure 7. Diagram of authors producing COLE.

5. Discussion

The new student's profile, that is to say, a competent student, is forcing teachers to apply active teaching methods, i.e., requiring more active student's involvement in the teaching–learning processes. In this case, teachers must become guides of this pedagogical act. The collaborative learning method is a clear example of an active teaching method [1–17]. This teaching methodology requires two or more people who, thanks to the sharing of various resources and skills, can acquire the curricular elements proposed. This methodology encourages the development of other skills in students, such as interaction, communication, problem solving, motivation, sense of community, and autonomy, among other aspects [38–49]. In addition, the collaborative learning method promotes and facilitates the acquisition of knowledge in areas of study where sustainable development is essential [65–69].

In the present study, the collaborative learning method has been analyzed in the WoS database. The beginnings of this theme in the database go back to 1970, but it is not until 2005 that scientific production begins to grow. That is to say, it is when this teaching method begins to have relevance for the scientific community, mainly due to the high pedagogical value it has. Considering the four overall research objectives, we may argue that with regards to a) degree of performance of documents collected from collaborative learning, we have conducted the present research has made it possible to establish an X-ray of the profile presented by the studies related to the collaborative learning method by the scientific community. In this case, it can be said that they are presented in articles written in English by researchers from the United States. They are gathered in the area of knowledge called Education Educational Research. The institution with the greatest scientific production is the UOC Universitat Oberta de Catalunya. The most prolific authors are Cabelle, S., and Jarvela, S., although the most relevant authors are Asensio-Pérez, J.I., Ruys, I., Redondo, M.A., and Hunger, A. The main source of production is Lectura Notes in Computer Science. The most cited article is the work of Stahl, Koschmann, and Suther (2006), called Computer-Supported Collaborative Learning. These data show us that the interest in the collaborative learning method goes back several years, but it is in recent years

where the interest has been growing considerably. These results may allow the scientific community to search, in a more efficient way, for studies related to collaborative learning.

The keywords of the analyzed manuscripts show us relevant and interesting information about the subject of the collaborative learning. In this case, we can see how the evolution of keywords during the different established time periods is decreasing. That is, as the years go by, the number of coincidences between the established periods is lower. This shows that there was a line of research established in the first time intervals, but currently new research perspectives are being established.

If we consider how the scientific development of the so-called collaborative learning has been identified (second research objective), we may say that the academic performance of the topics generated from these keywords shows that there is no coincidence in any of the established periods. That is, there are no themes that are repeated in the four periods. In the first period (1970–2006), the research was focused on the method itself, that is, on the collaborative learning. In the second period (2007–2011), on the learning environments. In the third period (2012–2015), on technology. In the fourth period (2016–2019), on knowledge. In other words, there is a variety of themes, all of them oriented to learning, to the environment where it takes place and to the technological resources.

Last but not least, with regards to the analysis of the most incidental aspects of collaborative learning and the value the most representative authors who are experts in the use of collaborative learning, we may consider the diagrams established and generated in each of the periods show us the really relevant topics for the educational community. In this case, in the first period (1970–2006), it was the students. In the following time frame (2007–2011), it was the portable resources and the self-efficacy of the training process.

In the third period (2012–2015), there was a change of trend, expanding the lines of research, oriented towards the acquisition of knowledge, self-regulation, and student's involvement in learning. In the last period (2016–2019), the focus is more on the co-regulation of learning, on the use of technological resources, and on the educational achievements of the students themselves. As it can be seen, the focus has shifted from the students themselves to the various branches of knowledge. In other words, studies are based on learning skills to develop the competence of learning to learn. All of this is associated with the use of technological resources.

Thematic developments in adjacent periods confirm the results achieved previously. In this case, no solid line of research is shown on the collaborative learning method, there being a conceptual gap in the research field. What the thematic evolution offers is the appearance of new lines of inquiry as time goes by. All these data facilitate and provide detailed information on the most relevant lines of research and trends in this field of study. With this, the scientific community, interested in studies on collaborative learning, will know, in a more concise way, the most interesting aspects for the scientific community. It will identify the topics of study most analyzed by the researchers. In addition, it provides a clear and concise image of all the lines of study established in the various years. In doing so, it offers more detail on the studies carried out in recent years.

6. Conclusions

Finally, the conclusion that can be drawn about the use of collaborative learning is somehow at a turning point in the scientific field. Its scientific evolution, focused on its principles in the students themselves, has extended to other branches. Currently, studies are oriented towards technological resources, co-regulation, and the academic achievements of students. Furthermore, in the coming years, the terms innovation, design, patterns, collaboration, and communication will probably be the new lines of research in this field of study. For this reason, the degree of performance of documents shows the relevance of collaborative learning. More precisely, this research aims to provide the scientific community with the most representative aspects of COLE studies. In addition, the aim is to offer the educational community a more in-depth knowledge of this teaching method. It also tries to offer the latest trends.

On the other hand, considering the scientific development of the collaborative learning we have shown that academic performance proofs no coincidence in any established periods. However, the analysis of the most incidental aspects of the collaborative learning lets us be aware of how authors generate knowledge based on the diagrams shown.

The prospective of this research is to provide the scientific community with updated information on the collaborative learning method. It also aims to be a reference point for teachers from different educational stages, so that they can learn about the latest trends and the different pedagogical applications of this teaching method. Finally, it was also presented to show that the collaborative learning method promotes training in students to face sustainability.

The present investigation has several limitations, including the adequacy of the database. This requires an in-depth analysis, to identify those scientific productions not related to the subject of study. In this case, the volume of production is high. Another aspect is determining the time periods. The researchers chose to follow the criterion of quantity, trying to accumulate a similar number of productions in each of the time periods. Thirdly, the indicators established in the SciMAT v.1.1.04 (2016) program are set by the authors themselves. If these values are modified, the results present in this study may change. For new lines of research in the future, we propose to identify the collaborative learning method in specific educational branches, such as Mathematics or Social Sciences. In addition, an analysis of the term collaborative learning can be carried out in other databases, such as Scopus or Google Scholar.

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