Context and Characteristics of Software Related to Ecuadorian Scientific Production: A Bibliometric and Content Analysis Study

Marcos Espinoza-Mina(✉), Alejandra Colina Vargas, and Javier Berrezueta Varas

Ecotec University, Samborondón, Ecuador
mespinoza@ecotec.edu.ec

Abstract. In view of the predominance of Information Technologies in different contexts, it is known that the use of software and data in the field of scientific research has increased; however, it is not possible to clearly determine the environment and the use given to them. The present study proposes a bibliometric and content analysis of publications with Ecuadorian affiliation, which allows us to recognize the characteristics and context of the use of software as a work tool. The study was developed in four stages: selection of documents, bibliometric analysis, network analysis and content analysis. A total of 4028 documents were extracted from the WoS and Scopus databases, analyzing 117 at the content level. Among the main tools used were R Studio, VOSviewer and QualCoder. Among the institutions generating this production are the Universidad Politécnica ESPOL, the Universidad Politécnica Salesiana and the Universidad de las Fuerzas Armadas ESPE. There is a high rate of collaboration with Spanish authors. Finally, the studies are strongly oriented towards "Professional, scientific and technical activities", are of the "Experimental" type, and have mainly referred specifically to proprietary software.

Keywords: Ecuadorian research · software · authorship · affiliation

1 Introduction

Today's environment is dominated by Information Technology (IT). Specialists have the central task of strategically and accurately identifying those areas that can potentially improve their efficiency, with the support offered by hardware, software or new IT-related value-added services [1].

In the field of scientific research, the use of software and digital data has increased significantly in recent years. There are many domain-specific peculiarities in the use of software by researchers; both the amount and the purpose of its application vary significantly [2]. Unfortunately, although citation standards exist, there is no rigor in software citation practices in scientific production [3]. This makes automatic detection and unambiguous removal of software mentions a problem for your study [2].

Bibliometrics provides information on a topic, the trend of future research, critical points of research, scientific collaborations, among other things [4]. However, it is

H. Florez and M. Leon (Eds.): ICAI 2023, CCIS 1874, pp. 369–389, 2024.
https://doi.org/10.1007/978-3-031-46813-1_25

not enough to know only the bibliometric attributes of a subject when conducting a tecnological assessment, or the assessment of other disciplines [5].

Content analysis is a research technique that provides answers to open-ended questions. The words and phrases mentioned in a document reflect important contents; however, they may also involve multiple meanings. Therefore, in order to achieve the reliability of this technique, it is necessary to ensure the correct organization of the significant contents in codes and categories, together with an adequate structuring of the results of this process [6]. The objective of this research was to carry out a bibliometric study strengthened with the content analysis of publications with Ecuadorian affiliation, which allows the recognition of the characteristics and the context of the use of software as a technological and scientific tool.

2 Methodology

According to the topic of interest to be worked on, a method for the development of the research is established. Based on the definitions and adoptions of [7] and [8], the scheme and steps required for the development of a bibliometric study with content analysis are shown in Fig. 1. Several computer tools were used in the different stages. For document selection and bibliometric analysis, mainly the R Studio software and the Bibliometrix package were used. VOSviewer software was used for network analysis and QualCoder for content analysis.

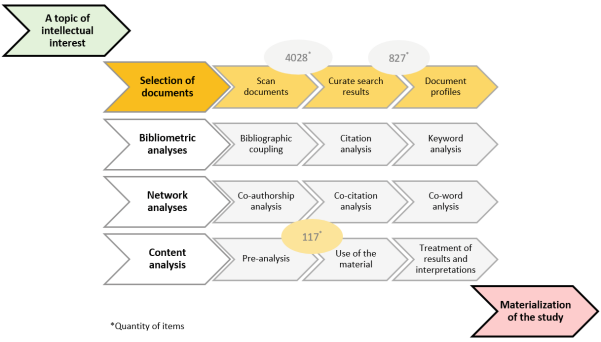


Fig. 1. Method for bibliometric study with content analysis

3 Results

The results of the study are organized below according to the four stages defined in the method, which are: document selection, bibliometric analysis, network analysis, and content analysis.

3.1 Selection of Documents

3.1.1 Scan Documents

In February 2023, the records of the scientific production of Ecuador related to software were consulted from the Web of Science (WoS) and Scopus databases. The word "software" was searched for in the title, abstract and keywords, of the scientific production of the last ten years, that is, from 2013 to 2022, with the filter by country of Ecuador. This search generated 1691 results in WoS and 2337 in Scopus.

3.1.2 Curate Search Results

Two filters were added to the extracted documents, the first by "type of document", restricting it exclusively to articles, and the second by "type of access", so that only open access documents would be shown in the list. Finally, a total of 377 WoS articles and 450 Scopus articles remained, whose references were exported to files with ".bib", ".csv" and ".txt" extensions for further processing.

3.1.3 Documents Profiles

Within the study period from 2013 to 2022, it can be observed that the annual production recorded is variable, and there is a positive trend (see Fig. 2). The growth rates were: for WoS 45.74%, and for Scopus 44.81%. The latter database regularly surpasses WoS in the number of annual papers.

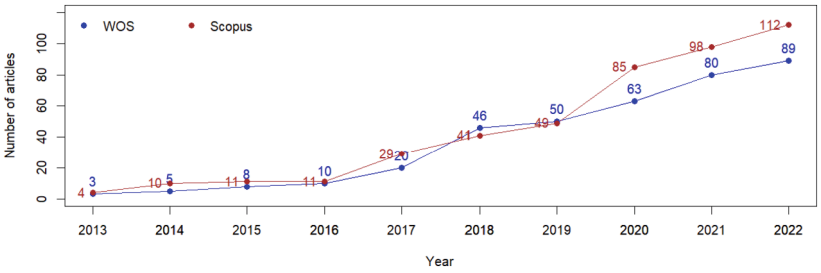


Fig. 2. Total articles per year for WoS and Scopus

Although the scientific production analyzed was selected with a filter by country of Ecuador, affiliations from 39 other countries were identified. Due to the filter, Ecuador heads the list of the country with the highest number of articles. Likewise, the rest of the countries have a solid international collaboration (inter-country index above 0.50), i.e. with Ecuador. Spain, USA, Chile and Mexico stand out in terms of number of articles. See details in Table 1.

Table 1. Top ten countries by number of articles

WoS						Scopus					
A	B	C	D	E	F	A	B	C	D	E	F
Ecuador	217	0.57713	94	123	0.567	Ecuador	208	0.5826	71	137	0.659
Spain	61	0.16223	0	61	1.000	Spain	50	0.1401	0	50	1.000
Usa	14	0.03723	0	14	1.000	Chile	15	0.0420	0	15	1.000
Chile	11	0.02926	0	11	1.000	Usa	11	0.0308	0	11	1.000
Mexico	7	0.01862	0	7	1.000	Mexico	7	0.0196	0	7	1.000
Argentina	5	0.01330	0	5	1.000	Italy	6	0.0168	0	6	1.000
Peru	5	0.01330	0	5	1.000	Argentina	5	0.0140	0	5	1.000
Colombia	4	0.01064	0	4	1.000	Brazil	5	0.0140	0	5	1.000
United Kingdom	4	0.01064	0	4	1.000	Colombia	5	0.0140	0	5	1.000
Brazil	3	0.00798	0	3	1.000	Cuba	4	0.0112	0	4	1.000

(A) Country (B) Articles (C) Frequency (D) Intra-country collaboration index (E) Inter-country collaboration index (F) Inter-country relationship.

A total of 1296 different affiliations are reported for WoS and 1262 in Scopus. Table 2 shows the 10 institutions with the highest number of registered articles. The count depends on the affiliation of each of the authors involved in a scientific production; due to this, the list also includes foreign institutions, in addition to the Ecuadorian ones. Among the Ecuadorian institutions are ESPOL Polytechnic University, Universidad Politécnica Salesiana, Universidad de las Fuerzas Armadas ESPE, Universidad de las Américas, Universidad San Francisco de Quito, and Universidad de Cuenca.

Table 2. Top ten institutions by number of articles

WoS			Scopus		
A	B	C	A	B	C
Espol Polytech Univ	83	0.02786	Espol Polytechnic University	57	0.02205
Univ Politecn Salesiana	45	0.01510	Univ Politécnica De Madrid	31	0.01199
Univ Fuerzas Armadas Espe	40	0.01342	Univ De Las Américas	30	0.01160
Univ Politecn Madrid	40	0.01342	Univ Fuerzas Armadas Espe	29	0.01121
Univ Cuenca	38	0.01275	Univ San Francisco De Quito	27	0.01044
Univ San Francisco Quito	35	0.01174	Universidad De Cuenca	26	0.01005
Univ Las Américas	26	0.00872	Univ Técnica Particular De Loja	24	0.00928
Univ Politecn Valencia	26	0.00872	Univ Politécnica Salesiana	23	0.00889
Univ Tecn Particular Loja	25	0.00839	Univ Técnica De Manabí	18	0.00696
Univ Tecn Manabi	21	0.00704	University Of California	17	0.00657

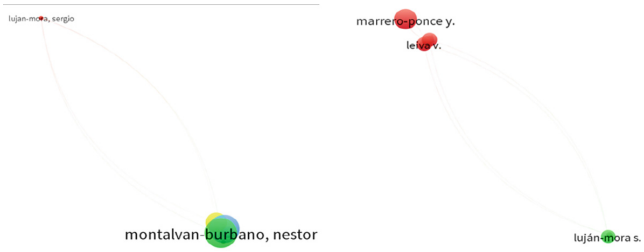
(A) Affiliations (B) Number of articles (C) Proportion.

3.2 Bibliometric Analysis

3.2.1 Bibliographic Coupling

The "Bibliographic Coupling Network Analysis" function of VOSviewer returns the number of citations received by an author, when using "author" as the unit of analysis [9]. For the required calculation the default author thesaurus of VOSviewer was used. Within the selection criteria, the minimum number of documents of an author is defined as five, and the minimum number of citations of the author's documents that have received citations is defined as one.

A total of 1577 authors were obtained in WoS and 1915 in Scopus, of which eleven and ten meet the specifications in the extracted data, respectively. Figure 3 shows "Montalvan-Burbano, Nestor" and "Marrero Ponce, Y." as the authors who most agree with others, citing one or more articles together, in WoS and Scopus, respectively.



(a) (b)

Fig. 3. Visualization of bibliographic coupling analysis by authors (a) WoS, (b) Scopus

Additionally, the "Bibliographic Coupling Network Analysis" utility is used in VOSviewer, selecting "Sources" as the unit of analysis; identifying in it the number of citations received from a source. The items to be obtained were limited to five as the minimum number of documents from a source, and one for the minimum number of citations received from a source. The result was 201 and 260 sources, of which fourteen and thirteen of them meet the guidelines already defined.

Of the sample obtained, thirteen and twelve sources from the two scientific databases used are strongly connected, being the most representative sources or journals "IEEE Access", followed by "Sustainability", as they show greater size in the circle and its label, both for WoS and Scopus, see Fig. 4.

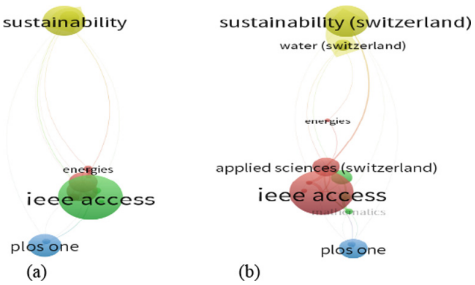


Fig. 4. Analysis of bibliographic coupling by source (journals): (a) WoS, (b) Scopus

3.2.2 Citation Analysis

Due to the filter applied, Ecuador has the highest number of citations by volume of related articles in the dataset; however, in the average number of citations of articles, the countries of Armenia, Estonia and Netherlands stand out in WoS, and Sweden, Italy and United Kingdom in Scopus, see Table 3.

Table 3. Top ten countries by number of citations

WoS			Scopus		
A	B	C	A	B	C
Ecuador	988	4.55	Ecuador	1280	6.154
Spain	330	5.41	Spain	286	5.720
Armenia	192	96.00	Italy	175	29.167
Usa	144	10.29	Chile	122	8.133
Netherlands	119	59.50	Sweden	101	33.667
Estonia	74	74.00	Usa	90	8.182
Chile	71	6.45	Argentina	85	17.000
United Kingdom	63	15.75	United Kingdom	64	21.333
Switzerland	51	25.50	Switzerland	59	19.667
Finland	47	15.67	Finland	58	19.333

(A) Country (B) Total Citations (C) Average Article Citations.

3.2.3 Keyword Analysis

The WoS publications have a total of 1764 keywords suggested by the author (Author's Keywords) and in the case of Scopus there are 1888. The keywords associated by the databases themselves (Keywords Plus) for WoS were 1185 and Scopus 3743. Discarding the keywords "Ecuador" and "software", the following terms should be highlighted: "COVID-19", "bibliometric analysis", "human", "performance", "article", "software engineering", "system", "education" and "female", see Table 4.

Table 4. Top ten relevant keywords

WoS				Scopus			
Author Keywords		Keywords-Plus		Author Keywords		Keywords-Plus	
A	B	A	B	A	B	A	B
Ecuador	15	Software	33	Ecuador	21	Software	91
Software	11	Design	17	Bibliometric Analysis	11	Human	83
Covid-19	9	Performance	17	Covid-19	9	Article	71
Software Engineering	9	System	17	Education	8	Female	64
Bibliometric Analysis	8	Model	15	Software Engineering	7	Ecuador	62
Monitoring	8	Management	14	Telemedicine	6	Humans	56
Cloud Computing	7	Diversity	11	Co-Occurrence	5	Male	51
Simulation	6	Quality	10	Latin America	5	Adult	42
Analysis	5	Conservation	9	Machine Learning	5	Controlled Study	35
Co-Occurrence	5	Identification	9	Simulation	5	Aged	24

(A) Keywords (B) Articles.

3.3 Network Analysis

3.3.1 Co-authorship Analysis

Co-authorship analysis comprises the identification and study of the generation of a link when two researchers appear in the same publication. As for the co-authorship maps, whose unit of analysis was the author, the minimum values of choice were defined as having five documents per author and one author citation, in order to identify the most visible author (WoS with 1177, and Scopus with 1815). Of which eleven and ten meet the criteria defined in WoS and Scopus.

From the sample obtained, five authors are strongly connected in WoS and four in Scopus, from which it is deduced that the node with the largest diameter of the network refers to the productivity per author; as well as collaboration with the number of links between the nodes of the network [10]. Being productive "Montalvan-Burbano, Nestor", followed by "Carrion-Mero, Paul" in both WoS and Scopus, see Fig. 5.

As for the co-authorship map, whose unit of analysis was countries, the minimum values of choice for an organization were defined as having five documents and one citation to the institution's documents in WoS and Scopus, in order to identify the most visible organization. The result was WoS with 64, and Scopus with 68, with research on the topic under study. There are 22 items linked in the resulting networks in WoS and 24 in Scopus; see Fig. 6.

In WoS and Scopus, it was found that, in the case of Ecuador, the country that stands out most for its productivity, relationship and assertive and frequent communication with authors from other countries [10], ivs Spain.

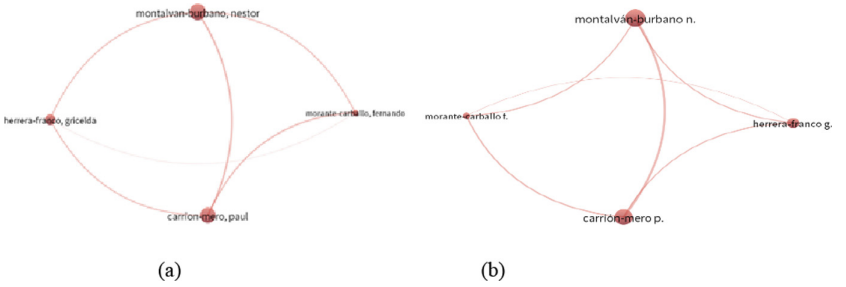


Fig. 5. Visualization of co-authorship analysis by author. (a) WoS, (b) Scopus

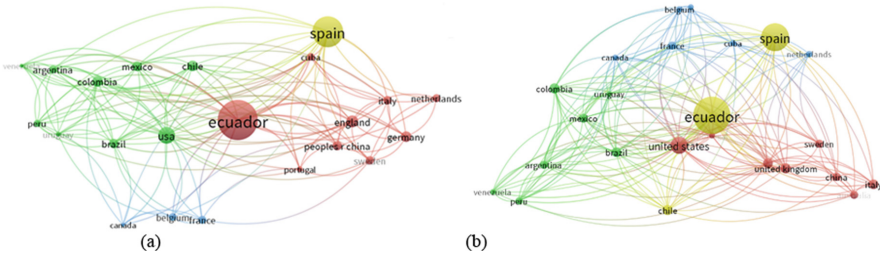


Fig. 6. Visualization of co-authorship analysis by countries (a) WoS, (b) Scopus

3.3.2 Co-citation Analysis

Co-citation analysis is also performed in VosViewer, to identify when two items are cited by the same document [9]. The author is established as the unit of analysis, the thesaurus of default authors is included and the minimum value of citations of an author is limited to ten, resulting in 14813 and 45566 authors, where 25 and 282 meet these criteria, both in WoS and Scopus, respectively. From the data reported in WoS, the most cited author was "Herrera-Franco, G.", while in Scopus the most cited author was "Montalvan-Burbano, N.", see Fig. 7.

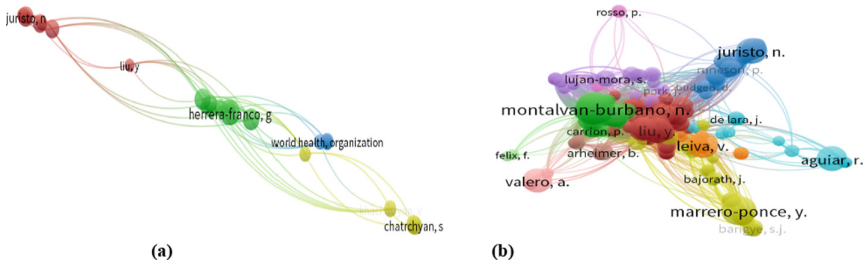
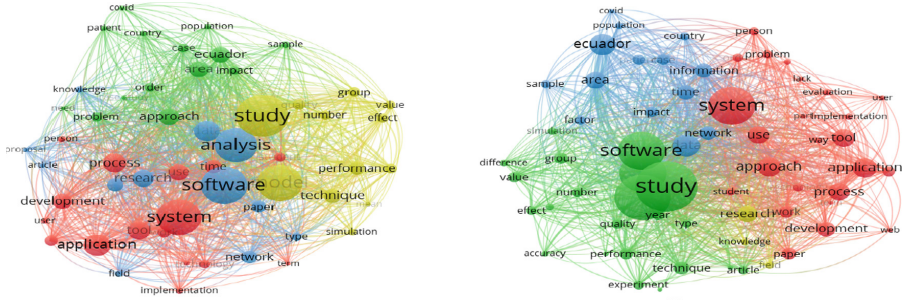


Fig. 7. Visualization of co-citation analysis by cited authors. (a) WoS, (b) Scopus

3.3.3 Co-word Analysis

From the execution of the algorithm of analysis and identification of trends in topic, creating maps based on Vosviewer data texts, criteria were established to simplify the visualization [11], where the unit of analysis was title and abstract, frequency greater than 30, counting method "Full counting", and the default thesaurus of topics. A total of 11559 and 13821 terms, respectively, were obtained from the total number of selected articles in the WoS and Scopus databases. The number of words appearing together are 54 for WoS and 64 in Scopus. The resulting word networks in Fig. 8, identifies the pairs of terms, showing a larger size those tags with a higher frequency of occurrences, for WoS "software", "analysis", "study" and "system". In the case of Scopus, "software", "study", "system" and "model" are located in the center of the map because they are highly interrelated.



(a) (b)

Fig. 8. Visualization of co-word analysis of keyword occurrences (a) WoS, (b) Scopus

3.4 Content Analyses

3.4.1 Pre-Analysis

The number of articles extracted in the bibliometric analysis was 377 from WoS and 450 from Scopus. By establishing a maximum acceptable error of 10%, the estimated sample percentage of 50%, and the desired confidence level of 90%, it is calculated that a content analysis should be performed on 58 and 59 documents, respectively.

The samples were taken from the total extracted from each database, following for WoS, the rule of representativeness, provided by the same database through the relevance of the articles, and for the Scopus sample, the rule of homogeneity considering articles from the last year of the study period.

After a first review, a repeated article was found in the databases, and through the reading of the abstracts, those that are not relevant to the study, which in the case of WoS were two and Scopus was only one. The respective documents are removed and other articles are taken from the extracted universe to complete the calculated sample numbers. Two objectives were defined for the study, their categories and codes, see Table 5. Finally, the files are downloaded in "pdf" format for the respective analysis of the summaries and conclusions.

Table 5. Code Table

Objectives	Categories	Associated codes
Identify the context of scientific research that makes use of software	Economic activities	According to page 19 in [12]
	Type research	According to page 110 in [13]
	Geographical region benefited	According to [14]
Recognize the characteristics of software referenced in scientific publications	Distribution software	Open Source Software, Free Software, Proprietary Software, Freeware
	Device Support	Server, Desktop, Mobile

3.4.2 Use of the Material

QualCoder open source software was used for the qualitative processing of the selected articles. The documents were reviewed one by one and the codes and their respective categories were created.

3.4.3 Treatment of Results and Interpretations

Within the categories covering the objective "Identify the context of scientific research that makes use of software", see Table 6, it was found that, of the 117 documents evaluated, the economic activities toward which the studies are mostly oriented are "Professional, scientific and technical activities" covering 38% of the total; somewhat distanced are "Human health care and social assistance activities" and "Agriculture, Forestry and Fishing", both with 11%.

The classification "Professional, scientific and technical activities" covers a wide range of research and development areas; these include forensic genetics focused on haplogroups, the development of new antibiotics through DNA regulation, the implementation of a robot based on the electronic communication interface for emerging countries, the use of CEINCI LAB in seismic engineering, data compression algorithms and electrical systems, lava flow monitoring in remote volcanoes, characterization of pathogen exposure through environmental pathways, interoperability of software systems, promising medicine for anticancer vaccines, code analysis in software repositories, quality control in software development, among other relevant topics.

The research was of the Experimental type, under this coding 32 studies were identified; in Case study and Descriptive 27 and 26 documents emerged, respectively. In the Experimental area, a number of studies have been carried out in various research areas. These include the analysis of bibliometrics, with the application of state-of-the-art technology, experiments with wind turbines, the search for new molecules, simulation of quadruped robots, development of robots for locomotion in small intestines, study of composite materials, quasi experiments with young people aged 11 to 13 years, biomass surveys, temperature analysis in asphalt replacement, electricity and statistical code studies, database identification, design of charging stations, use of neural networks, study of concrete structure when replacing sand, oil extraction, and controlled experiments for quality assessment in an IDE (Integrated Development Environment).

As expected, when delimiting the research to studies in Ecuador, the main beneficiary region of the production is South America, with 31 studies; then, it is necessary to

highlight the second region, which is Europe with 11 works. In Europe, several studies and research have been carried out in countries such as Italy, the Netherlands, France, Denmark, Germany and Spain. These studies cover a wide variety of areas, ranging from science and technology to medicine, engineering and social sciences.

Table 6. Coding result to identify the context of scientific investigations

A	B	C	D
Economic activities	Administrative and support services activities	2 (2)	[15, 16]
	Agriculture, Forestry and Fishing	13 (11)	[17–29]
	Arts, Entertainment and Recreation	2 (2)	[30, 31]
	Construction	2 (2)	[32, 33]
	Exploitation of mines and quarries	5 (4)	[34–38]
	Financial and insurance activities	2 (2)	[39, 40]
	Human health care and social assistance activities	13 (11)	[41–53]
	Information and Communication	12 (10)	[54–65]
	Manufacturing industries	10 (9)	[66–75]
	Professional, scientific and technical activities	45 (38)	[77–120]
	Supply of electricity, gas, steam and air conditioning	5 (4)	[121–125]
	Teaching	3 (3)	[126–128]
	Water distribution, Sewerage, Waste management and sanitation activities	3 (3)	[129–131]
Type research	Case study	27 (22)	[28, 31, 33, 37, 39, 43, 55, 62, 69, 70, 73, 75, 83, 86, 92, 94, 98, 103–105, 108, 109, 112, 114, 115, 117, 120]
	Correlational	17 (14)	[19, 23, 43, 47, 51, 53, 57, 66, 80, 82, 91, 111, 116, 119, 123, 128, 129]
	Descriptive	26 (21)	[15–18, 29, 30, 38, 41, 42, 44, 46, 54, 56, 64, 66, 76, 78, 79, 82, 84, 85, 87, 88, 99, 122, 130]
	Documental	13 (10)	[20, 22, 26, 50, 58, 59, 74, 87, 89, 93, 97, 126, 131]
	Experimental	32 (26)	[21, 24, 27, 32, 35, 36, 39, 40, 45, 48, 49, 52, 60, 61, 65, 67, 68, 71, 72, 75–77, 81, 88, 96, 101, 102, 106, 118, 121, 124, 125, 127]
	Explanatory or casual	2 (2)	[15, 78]
	Historical	8 (6)	[25, 63, 90, 95, 100, 107, 110, 113]
Geographical region benefited	Africa	1 (2)	[125]
	Asia	2 (4)	[84, 131]
	Europe	11 (22)	[18, 26, 31, 39, 44, 50, 68, 70, 73, 81, 99]
	North America	4 (8)	[39, 44, 81, 131]
	Oceania	1 (2)	[70]
	South America	31 (62)	[15, 17, 19–21, 23, 25, 26, 30, 32–34, 36, 38, 42, 43, 46, 47, 50, 73, 78, 81, 82, 85, 91, 97, 106, 113, 119, 127, 128]

(A) Categories (B) Associated codes (C) No. of studies (%) (D) Studies.

In the first category "Distribution software", which covers the objective "Recognize the characteristics of software referenced in scientific publications", see Table 7, it is evident that most of them have referenced "Proprietary Software" with 69% of the total.

In the study, several proprietary software tools and programs were used to carry out the analysis and research. These included databases such as Scopus, modeling and simulation programs such as MATLAB/Simulink, SureDesign, LeDock and Adsorption V10. In addition, data visualization and analysis tools such as ArcGIS and Rockworks were used. In the case of the second category, the studies give almost no direct reference to the type of equipment on which the software operates, among the few that could be recognized there is a greater presence of "Mobile" devices, comprising 47% of the total.

Table 7. Coding result to recognize the characteristics of the referenced software

A	B	C	D
Distribution software	Freeware	1 (3)	[48]
	Open Source Software	8 (28)	[17, 20–22, 74, 77, 79, 81]
	Proprietary Software	20 (69)	[18, 23, 27, 34, 39, 48, 49, 51, 66, 69, 76, 77, 79, 80, 97, 121, 123, 124, 129, 131]
Device Support	Desktop	5 (29)	[16, 54, 58, 63, 105]
	Mobile	8 (47)	[42, 54, 56–59, 62, 108]
	Server	4 (24)	[41, 77, 85, 88]

(A) Categories (B) Associated codes (C) No. of studies (%) (D) Studies.

4 Conclusions

For the recognition of the characteristics of the software and the context in which it is applied, within the scope of Ecuadorian scientific production, two significant scientific content databases were used, WoS and Scopus.

When applying the search and filters in the defined databases, 377 references of articles were obtained in WoS and 450 in Scopus. With these references the bibliometric analysis is performed, within the period 2013 to 2022, which has the following results:

From 2013 to 2022 there is a positive growth in the number of research papers referring to software, in WoS (45.74%), and Scopus (44.81%). The countries of Spain, USA, Chile and Mexico stand out for the number of articles and international collaboration in the development of studies with Ecuadorian affiliation. Among the Ecuadorian institutions with the greatest production in the subject matter addressed are: ESPOL Polytechnic University, Universidad Politécnica Salesiana and Universidad de las Fuerzas Armadas ESPE.

The analysis of bibliographic coupling networks presented "Montalvan-Burbano, Nestor" and "Marrero Ponce, Y.", as those authors who most coincide with others, citing one or more articles together for WoS and Scopus, respectively. Another result raises the most representative sources; by coupling with other journals, are "IEEE ACCESS", followed by "Sustainability". For the average number of citations of articles, the countries of Armenia, Estonia and Netherlands stand out in WoS and Sweden, Italy and United Kingdom in Scopus.

In the word analysis, terms such as "COVID-19", "bibliometric analysis", "human", "performance", "article", and "software engineering" stand out. Montalvan-Burbano, Nestor" followed by "Carrion-Mero, Paul", are the authors with the highest productivity due to their strong connection in the co-authorship analysis. Under this same analysis, it was obtained that, among the authors from Ecuador and Spain, they stand out for the relationship they have. The co-citation analysis shows "Herrera-Franco, G." for WoS and "Montalvan-Burbano, N." for Scopus. The trend of terms obtained through co-word

analysis were “software”, “analysis”, “study” and “system” for WoS, and “software”, “analysis”, “study” and “model” for Scopus.

The content analysis of a sample of 117 documents was carried out, following rules of representativeness and homogeneity. Two objectives were set: “Identify the context of scientific research that makes use of software” and “Recognize the characteristics of software referenced in scientific publications”. The most significant results are presented below: The economic activities towards which the studies are oriented are “Professional, scientific and technical activities”, “Human health care and social assistance activities” and “Agriculture, Forestry and Fishing”.

The research was mainly of the “Experimental”, “Case study” and “Descriptive” type. The beneficiary regions of the productions are “South America”, since Ecuador is part of it, and “Europe”. The studies have mostly referred to “Proprietary Software”. Although very little is stated about the type of equipment used in the studios, it was found that they make use of “Mobile” devices. Due to the rapid evolution and use of information technologies, added to the increase in scientific production of the characteristics defined in this work, there is interest in carrying out a new study in the short term, which will allow the evaluation of new areas of application.

References

1. Alt, R., Leimeister, J.M., Priemuth, T., Sachse, S., Urbach, N., Wunderlich, N.: Software-defined business: implications for IT management. Bus. Inf. Syst. Eng. **62**(6), 609–621 (2020). https://doi.org/10.1007/s12599-020-00669-6
2. Schindler, D., Bensmann, F., Dietze, S., Krüger, F.: The role of software in science: a knowledge graph-based analysis of software mentions in PubMed Central. PeerJ Comput. Sci. **8**, e835 (2022). https://doi.org/10.7717/peerj-cs.835
3. Kruger, F., Schindler, D.: A literature review on methods for the extraction of usage statements of software and data. Comput. Sci. Eng. **22**(1), 26–38 (2020). https://doi.org/10.1109/MCSE.2019.2943847
4. Li, J., Hou, Y., Wang, P., Yang, B.: A review of carbon capture and storage project investment and operational decision-making based on bibliometrics. Energies **12**(1), 23 (2018). https://doi.org/10.3390/en12010023
5. Soehartono, A.M., Khor, K.A.: Critical assessment of technological development: what can bibliometrics reveal? Sch. Assess. Rep. **2**(1), 4 (2020). https://doi.org/10.29024/sar.11
6. Takahashi, Y., Uchida, C., Miyaki, K., Sakai, M., Shimbo, T., Nakayama, T.: Potential benefits and harms of a peer support social network service on the internet for people with depressive tendencies: qualitative content analysis and social network analysis. J. Med. Internet Res. **11**(3), e29 (2009). https://doi.org/10.2196/jmir.1142
7. Khanra, S., Dhir, A., Mäntymäki, M.: Big data analytics and enterprises: a bibliometric synthesis of the literature. Enterp. Inf. Syst. **14**(6), 737–768 (2020). https://doi.org/10.1080/17517575.2020.1734241
8. Bardin, L.: El análisis de contenido, 2a edn. Akal Ediciones, Madrid (1996)
9. van Eck N.J., Waltman, L.: VOSviewer Manual, p. 54 (2022)
10. Rodríguez Gutiérrez, J.K., Gómez Velasco, N.Y.: Redes de coautoría como herramienta de evaluación de la producción científica de los grupos de investigación. Rev. Gen. Inf. Doc. **27**(2), 279–297 (2017). https://doi.org/10.5209/RGID.58204

11. Galvez, C.: Análisis de co-palabras aplicado a los artículos muy citados en Biblioteconomía y Ciencias de la Información (2007–2017). Transinformação **30**(3), 277–286 (2018). https://doi.org/10.1590/2318-08892018000300001
12. INEC - Ecuador, "Clasificación Nacional de Actividades Económicas," (2012)
13. Bernal, C.A.: Metodología de la investigación. Colombia: Pearson Educación (2010)
14. Homeland Security, "Geographic Regions," Homeland Security (2023). https://www.dhs.gov/geographic-regions
15. Romero-Subia, J.F., Jimber-del Rio, J.A., Ochoa-Rico, M.S., Vergara-Romero, A.: Analysis of citizen satisfaction in municipal services. Economies **10**(9), 225 (2022). https://doi.org/10.3390/economies10090225
16. Kostakis, V., Niaros, V., Dafermos, G., Bauwens, M.: Design global, manufacture local: exploring the contours of an emerging productive model. Futures **73**, 126–135 (2015). https://doi.org/10.1016/j.futures.2015.09.001
17. Veliz, K., Chico-Santamarta, L., Ramirez, A.D.: The Environmental profile of ecuadorian export banana: a life cycle assessment. Foods **11**(20), 3288 (2022). https://doi.org/10.3390/foods11203288
18. Del-Aguila-Arcentales, S., Alvarez-Risco, A., Carvache-Franco, M., Rosen, M.A., Yáñez, J.A.: Bibliometric analysis of current status of circular economy during 2012–2021: case of foods. Processes **10**(9), 1810 (2022). https://doi.org/10.3390/pr10091810
19. Grupo de Investigación en Energía, Universidad Politecnica Salesiana. Ecuador et al., "TRNSYS Modeling of flat plate and vacuum tube solar collector systems for residential use under equatorial middle altitude climate condition. Renew. Energy Power Qual. J. **20**, 121–125 (2022). https://doi.org/10.24084/repqj20.240
20. Arcentales-Bastidas, D., Silva, C., Ramirez, A.: The environmental profile of ethanol derived from sugarcane in Ecuador: a life cycle assessment including the effect of cogeneration of electricity in a sugar industrial complex. Energies **15**(15), 5421 (2022). https://doi.org/10.3390/en15155421
21. Iñamagua-Uyaguari, J.P., Green, D.R., Fitton, N., Sangoluisa, P., Torres, J., Smith, P.: Use of unoccupied aerial systems to characterize woody vegetation across silvopastoral systems in Ecuador. Remote Sens. **14**(14), 3386 (2022). https://doi.org/10.3390/rs14143386
22. Mejía, V.C., et al.: Automatic control system for cane honey factories in developing country conditions. Processes **10**(5), 915 (2022). https://doi.org/10.3390/pr10050915
23. Martínez-Balderramo, L.Á., Cheme-Rodríguez, S.D., Baquerizo-Crespo, R.J., Riera, M.A.: Simulation of an anaerobic digestion system for agricultural residuals generated in the province of Manabí. Afinidad J. Chem. Eng. Theor. Appl. Chem. **79**(596) (2022). https://doi.org/10.55815/400722
24. Quezada Moreno, W.F., Quezada-Torres, W.D., Mera-Aguas, M.C., Medina-Litardo, and R.C., Proaño Molina, M.Y.: The essential oil of Mentha viridis L, chemical characterization and the relationship with its biological activities. Afinidad J. Chem. Eng. Theor. Appl. Chem. **79**(596) (2022). https://doi.org/10.55815/401284
25. Fouet, O., et al.: Collection of native *Theobroma cacao* L. accessions from the Ecuadorian Amazon highlights a hotspot of cocoa diversity. Plants People Planet **4**(6), 605–617 (2022). https://doi.org/10.1002/ppp3.10282
26. Revelo, H.A., López-Alvarez, D., Landi, V., Rizzo, L., Alvarez, L.A.: Mitochondrial DNA variations in colombian creole sheep confirm an iberian origin and shed light on the dynamics of introduction events of african genotypes. Animals **10**(9), 1594 (2020). https://doi.org/10.3390/ani10091594
27. Espinoza, J., Pacheco, H.: Use of an unmanned aerial vehicle as an alternative to assess the nutritional status of thecotton crop. Rev. Fac. Agron. Univ. Zulia **39**(1), e223919 (2022). https://doi.org/10.47280/RevFacAgron(LUZ).v39.n1.19

28. Garcia, B.F., Bonaguro, Á., Araya, C., Carvalheiro, R., Yáñez, J.M.: Application of a novel 50K SNP genotyping array to assess the genetic diversity and linkage disequilibrium in a farmed Pacific white shrimp (Litopenaeus vannamei) population. Aquac. Rep. **20**, 100691 (2021). https://doi.org/10.1016/j.aqrep.2021.100691
29. Ortiz-Olivas, M., Hernández-Díaz, J., Fladung, M., Cañadas-López, Á., Prieto-Ruíz, J., Wehenkel, C.: Spatial Genetic Structure within and among Seed Stands of Pinus engelmannii Carr. and Pinus leiophylla Schiede ex Schltdl. & Cham, in Durango, Mexico. Forests **8**(1), 22 (2017). https://doi.org/10.3390/f8010022
30. Carpio-Arias, T.V., et al.: Relationship between perceived stress and emotional eating. A cross sectional study. Clin. Nutr. ESPEN **49**, 314–318 (2022). https://doi.org/10.1016/j.clnesp.2022.03.030
31. Ashrafzadeh, M.R., et al.: Assessing the origin, genetic structure and demographic history of the common pheasant (Phasianus colchicus) in the introduced European range. Sci. Rep. **11**(1), 21721 (2021). https://doi.org/10.1038/s41598-021-00567-1
32. Vásquez-Álvarez, P.E., Flores-Vázquez, C., Cobos-Torres, J.-C., Cobos-Mora, S.L.: Urban heat island mitigation through planned simulation. Sustainability **14**(14), 8612 (2022). https://doi.org/10.3390/su14148612
33. Merchán-Sanmartín, B., Aucapeña-Parrales, J., Alcívar-Redrován, R., Carrión-Mero, P., Jaya-Montalvo, M., Arias-Hidalgo, M.: Earth dam design for drinking water management and flood control: a case study. Water **14**(13), 2029 (2022). https://doi.org/10.3390/w14132029
34. Villalta Echeverria, M.D.P., Viña Ortega, A.G., Larreta, E., Romero Crespo, P., Mulas, M.: Lineament extraction from digital terrain derivate model: a case study in the Girón–Santa Isabel Basin, South Ecuador. Remote Sens. **14**(21), 5400 (2022). https://doi.org/10.3390/rs14215400
35. Pérez Bayas, M. Á., Cely, J., Sintov, A., García Cena, C.E., Saltaren, R.: Method to develop legs for underwater robots: from multibody dynamics with experimental data to mechatronic implementation. Sensors **22**(21), 8462 (2022). https://doi.org/10.3390/s22218462
36. Garcia-Troncoso, N., Baykara, H., Cornejo, M.H., Riofrio, A., Tinoco-Hidalgo, M., Flores-Rada, J.: Comparative mechanical properties of conventional concrete mixture and concrete incorporating mining tailings sands. Case Stud. Constr. Mater. **16**, e01031 (2022). https://doi.org/10.1016/j.cscm.2022.e01031
37. Viana Da Fonseca, A., Cordeiro, D., Molina-Gómez, F., Besenzon, D., Fonseca, A., Ferreira, C.: The mechanics of iron tailings from laboratory tests on reconstituted samples collected in post-mortem Dam I in Brumadinho. Soils Rocks **45**(2), 1–20 (2022). https://doi.org/10.28927/SR.2022.001122
38. Oleas, N.H., Meerow, A.W., Francisco-Ortega, J.: Genetic structure of the threatened Phaedranassa schizantha (Amaryllidaceae). Bot. J. Linn. Soc. **182**(1), 169–179 (2016). https://doi.org/10.1111/boj.12444
39. Rodriguez-Marin, M., Saiz-Alvarez, J.M., Huezo-Ponce, L.: A Bibliometric analysis on pay-per-click as an instrument for digital entrepreneurship management using VOSviewer and SCOPUS data analysis tools. Sustainability **14**(24), 16956 (2022). https://doi.org/10.3390/su142416956
40. Rodríguez-Insuasti, H., Montalván-Burbano, N., Suárez-Rodríguez, O., Yonfá-Medranda, M., Parrales-Guerrero, K.: Creative economy: a worldwide research in business, management and accounting. Sustainability **14**(23), 16010 (2022). https://doi.org/10.3390/su142316010
41. Ayala-Ruano, S., et al.: Network science and group fusion similarity-based searching to explore the chemical space of antiparasitic peptides. ACS Omega **7**(50), 46012–46036 (2022). https://doi.org/10.1021/acsomega.2c03398

42. Beltrán-Iza, E.A., Noroña-Meza, C.O., Robayo-Nieto, A.A., Padilla, O., Toulkeridis, T.: Creation of a mobile application for navigation for a potential use of people with visual impairment exercising the NTRIP protocol. Sustainability **14**(24), 17027 (2022). https://doi.org/10.3390/su142417027
43. Bautista-Valarezo, E., Espinosa, M.E., Michels, N.R.M., Hendrickx, K., Verhoeven, V.: Culturally adapted flowcharts in obstetric emergencies: a participatory action research study. BMC Pregnancy Childbirth **22**(1), 772 (2022). https://doi.org/10.1186/s12884-022-05105-z
44. Rodríguez, S., Motta, F.D., Balbinotto Neto, G., Brandão, A.: Waiting list for liver transplantation: clinical and economic burden. Arq. Gastroenterol. (2022). https://doi.org/10.1590/s0004-2803.202204000-87
45. Yan, Y., Zhang, B., Páez Chávez, J., Liu, Y.: Optimising the locomotion of a vibro-impact capsule robot self-propelling in the small intestine. Commun. Nonlinear Sci. Numer. Simul. **114**, 106696 (2022). https://doi.org/10.1016/j.cnsns.2022.106696
46. Camacho-Leon, G., et al.: Attitudes towards depression of Argentinian, Chilean, and Venezuelan healthcare professionals using the Spanish validated version of the revised depression attitude questionnaire (SR-DAQ). SSM - Popul. Health **19**, 101180 (2022). https://doi.org/10.1016/j.ssmph.2022.101180
47. Rodríguez-Fernández, A., et al.: Maternal factors associated with non-exclusive breastfeeding in haitian immigrant women in Southern Chile. Nutrients **14**(15), 3173 (2022). https://doi.org/10.3390/nu14153173
48. Haider, M., Yousaf, S., Zaib, A., Sarfraz, A., Sarfraz, Z., Cherrez-Ojeda, I.: Diagnostic accuracy of various immunochromatographic tests for NS1 antigen and IgM antibodies detection in acute dengue virus infection. Int. J. Environ. Res. Public Health **19**(14), 8756 (2022). https://doi.org/10.3390/ijerph19148756
49. Aguiar-Salazar, E., Villalba-Meneses, F., Tirado-Espín, A., Amaguaña-Marmol, D., Almeida-Galárraga, D.: Rapid detection of cardiac pathologies by neural networks using ECG signals (1D) and sECG images (3D). Computation **10**(7), 112 (2022). https://doi.org/10.3390/computation10070112
50. Carrazco-Montalvo, A., et al.: Omicron sub-lineages (BA.1.1.529 + BA.*) current status in Ecuador. Viruses **14** (6), 1177 (2022). https://doi.org/10.3390/v14061177
51. Yousaf, M., Aslam, T., Saeed, S., Sarfraz, A., Sarfraz, Z., Cherrez-Ojeda, I.: Individual, family, and socioeconomic contributors to dental caries in children from low- and middle-income countries. Int. J. Environ. Res. Public Health **19**(12), 7114 (2022). https://doi.org/10.3390/ijerph19127114
52. Oubahmane, M., Hdoufane, I., Bjij, I., Jerves, C., Villemin, D., Cherqaoui, D.: COVID-19: In silico identification of potent α-ketoamide inhibitors targeting the main protease of the SARS-CoV-2. J. Mol. Struct. **1244**, 130897 (2021). https://doi.org/10.1016/j.molstruc.2021.130897
53. Alam, M.Z., et al.: Population genetics of Leishmania (Leishmania) major DNA isolated from cutaneous leishmaniasis patients in Pakistan based on multilocus microsatellite typing. Parasit. Vectors **7**(1), 332 (2014). https://doi.org/10.1186/1756-3305-7-332
54. Alpala, L.O., Quiroga-Parra, D.J., Torres, J.C., Peluffo-Ordóñez, D.H.: Smart factory using virtual reality and online multi-user: towards a metaverse for experimental frameworks. Appl. Sci. **12**(12), 6258 (2022). https://doi.org/10.3390/app12126258
55. Sharma, P., Singh, A.K., Leiva, V., Martin-Barreiro, C., Cabezas, X.: Modern multivariate statistical methods for evaluating the impact of whatsapp on academic performance: methodology and case study in India. Appl. Sci. **12**(12), 6141 (2022). https://doi.org/10.3390/app12126141
56. Molina Ríos, J.R., Honores Tapia, J.A., Pedreira-Souto, N., Pardo León, H.P.: Estado del arte: metodologías de desarrollo de aplicaciones móviles," 3C Tecnol. Innov. Apl. Pyme **10**(2), 17–45 (2021). https://doi.org/10.17993/3ctecno/2021.v10n2e38.17-45

57. Molina Ríos, J.R., Honores Tapia, J.A., Pedreira-Souto, N., Pardo León, H.P.: Comparativa de metodologías de desarrollo de aplicaciones móviles," 3C Tecnol. Innov. Apl. Pyme **10**(2), 73–93 (2021). https://doi.org/10.17993/3ctecno/2021.v10n2e38.73-93
58. Armijos Carrión, J.L., Morocho Román, R.F., Redrován Castillo, F.F., Torres Apolinario, D.A.: Estado del arte: métricas del desarrollo de software móvil. 3C Tecnol. Innov. Apl. Pyme **10**(3), 17–37 (2021). https://doi.org/10.17993/3ctecno/2021.v10n3e39.17-37
59. Cárdenas Villavicencio, O.E., Zea Ordóñez, M.P., Valarezo Pardo, M.R., Ramón Ramón, R.A.: Comparativa de tendencias de desarrollo de software móvil. 3C TIC Cuad. Desarro. Apl. Las TIC **10**(1), 123–147 (2021). https://doi.org/10.17993/3ctic.2021.101.123-147
60. Tello-Oquendo, L., Lin, S.-C., Akyildiz, I.F., Pla, V.: Software-Defined architecture for QoS-Aware IoT deployments in 5G systems. Ad Hoc Netw. **93**, 101911 (2019). https://doi.org/10.1016/j.adhoc.2019.101911
61. J. A. Herrera Silva, L. I. Barona López, Á. L. Valdivieso Caraguay, and M. Hernández-Álvarez, "A Survey on Situational Awareness of Ransomware Attacks—Detection and Prevention Parameters," *Remote Sens.*, vol. 11, no. 10, p. 1168, May 2019, doi: https://doi.org/10.3390/rs11101168
62. Martinez, D., Ferre, X., Guerrero, G., Juristo, N.: An agile-based integrated framework for mobile application development considering ilities. IEEE Access **8**, 72461–72470 (2020). https://doi.org/10.1109/ACCESS.2020.2987882
63. J. R. Molina Ríos, M. P. Zea Ordóñez, M. J. Contento Segarra, and F. G. García Zerda, "Comparación de metodologías en aplicaciones web," *3C Tecnol. Innov. Apl. Pyme*, vol. 7, no. 1, pp. 1–19, Mar. 2018, doi: https://doi.org/10.17993/3ctecno.2018.v7n1e25.1-19
64. R. Flores Moyano, D. Fernandez, N. Merayo, C. M. Lentisco, and A. Cardenas, "NFV and SDN-Based Differentiated Traffic Treatment for Residential Networks," *IEEE Access*, vol. 8, pp. 34038–34055, 2020, doi: https://doi.org/10.1109/ACCESS.2020.2974504
65. Chamba, J., Sánchez, M., Moya, M.J., Noroña, J., Franco, R.: Simulación de movimiento de un robot hexápodo en entornos de realidad virtual. Enfoque UTE **10**(1), 173–184 (2019). https://doi.org/10.29019/enfoqueute.v10n1.456
66. Mayacela, M., Rentería, L., Contreras, L., Medina, S.: Comparative analysis of reconfigurable platforms for memristor emulation. Materials **15**(13), 4487 (2022). https://doi.org/10.3390/ma15134487
67. Carrión-Coronel, E., Ortiz, P., Nanía, L.: Physical experimentation and 2D-CFD parametric study of flow through transverse bottom racks. Water **14**(6), 955 (2022). https://doi.org/10.3390/w14060955
68. Abad-Coronel, C., Palomeque, A., Mena Córdova, N., Aliaga, P.: Digital volumetric analysis of CAD/CAM polymeric materials after tooth brushing. Polymers **14**(17), 3499 (2022). https://doi.org/10.3390/polym14173499
69. Olivera-Montenegro, L., Bugarin, A., Marzano, A., Best, I., Zabot, G.L., Romero, H.: Production of protein hydrolysate from quinoa (chenopodium quinoa willd.): economic and experimental evaluation of two pretreatments using supercritical fluids' extraction and conventional solvent extraction. Foods **11**(7), 1015 (2022). https://doi.org/10.3390/foods11071015
70. Ortiz Lizcano, J.C., et al.: Colored optic filters on c-Si IBC solar cells for building integrated photovoltaic applications. Prog. Photovolt. Res. Appl. **30**(4), 401–435 (2022). https://doi.org/10.1002/pip.3504
71. Guaman, D., Delgado, S., Perez, J.: Classifying model-view-controller software applications using self-organizing maps. IEEE Access **9**, 45201–45229 (2021). https://doi.org/10.1109/ACCESS.2021.3066348
72. Minchala, L.I., Peralta, J., Mata-Quevedo, P., Rojas, J.: An approach to industrial automation based on low-cost embedded platforms and open software. Appl. Sci. **10**(14), 4696 (2020). https://doi.org/10.3390/app10144696

73. Vergara, A.M.C., et al.: A matrilineal study on the origin and genetic relations of the Ecuadorian Pillareño creole pig population through d-loop mitochondrial DNA analysis. Animals **11**(11), 3322 (2021). https://doi.org/10.3390/ani11113322
74. Minchala, L.I., Ochoa, S., Velecela, E., Astudillo, D.F., Gonzalez, J.: An open source SCADA system to implement advanced computer integrated manufacturing. IEEE Lat. Am. Trans. **14**(12), 4657–4662 (2016). https://doi.org/10.1109/TLA.2016.7816994
75. García, C., Castellanos, E., García, M.: UML-based cyber-physical production systems on low-cost devices under IEC-61499. Machines **6**(2), 22 (2018). https://doi.org/10.3390/machines6020022
76. Köksal, Z., et al.: Targeted Y chromosome capture enrichment in admixed South American samples with haplogroup Q. Forensic Sci. Int. Genet. Suppl. Ser. **8**, 97–98 (2022). https://doi.org/10.1016/j.fsigss.2022.09.034
77. Arévalo, J.M.C., Amorim, J.C.: Virtual screening, optimization and molecular dynamics analyses highlighting a pyrrolo[1,2-a]quinazoline derivative as a potential inhibitor of DNA gyrase B of Mycobacterium tuberculosis. Sci. Rep. **12**(1), 4742 (2022). https://doi.org/10.1038/s41598-022-08359-x
78. Flores-Vázquez, C., Angulo, C., Vallejo-Ramírez, D., Icaza, D., Pulla Galindo, S.: Technical development of the CeCi social robot. Sensors **22**(19), 7619 (2022). https://doi.org/10.3390/s22197619
79. Aguiar-Falconí, R.R., Cagua-Gómez, B.J.: Sistema Computacional 'CEINCI LAB' como una herramienta para la enseñanza de Ingeniería Sísmica-Estructural. DYNA **89**(222), 74–82 (2022). https://doi.org/10.15446/dyna.v89n222.101814
80. Amaya, L., Inga, E.: Compressed sensing technique for the localization of harmonic distortions in electrical power systems. Sensors **22**(17), 6434 (2022). https://doi.org/10.3390/s22176434
81. Vasconez, F.J., Anzieta, J.C.,. Vásconez Müller, A., Bernard, B., Ramón, P.: A near real-time and free tool for the preliminary mapping of active lava flows during volcanic crises: the case of hotspot subaerial eruptions. Remote Sens. **14**(14), 3483 (2022). https://doi.org/10.3390/rs14143483
82. Köksal, Z., et al.: Testing the Ion AmpliSeq^{TM} HID Y-SNP Research Panel v1 for performance and resolution in admixed South Americans of haplogroup Q. Forensic Sci. Int. Genet. **59**, 102708 (2022). https://doi.org/10.1016/j.fsigen.2022.102708
83. Ortíz, J.F., et al.: Pulvinar sign, stroke and their relationship with fabry disease: a systematic review and metanalysis. Neurol. Int. **14**(2), 497–505 (2022). https://doi.org/10.3390/neurolint14020041
84. Viera, R.T.: Lexical richness of abstracts in scientific papers in anglophone and non-anglophone journals, 3L Southeast Asian. J. Engl. Lang. Stud. **28**(2), 224–239 (2022). https://doi.org/10.17576/3L-2022-2802-15
85. Sosa-Moreno, A., et al.: Characterizing behaviors associated with enteric pathogen exposure among infants in rural Ecuador through structured observations. Am. J. Trop. Med. Hyg. **106**(6), 1747–1756 (2022). https://doi.org/10.4269/ajtmh.21-1099
86. Reyes, J., Fuertes, W., Arévalo, P., Macas, M.: An environment-specific prioritization model for information-security vulnerabilities based on risk factor analysis. Electronics **11**(9), 1334 (2022). https://doi.org/10.3390/electronics11091334
87. Computer and Decision Science Department, Universidad Nacional de Colombia, Medellín, Colombia, D. M. T. Ricaurte, M. K. V. Cabezas, Faculty of Electrical and Computer Engineering, Escuela Superior Politécnica del Litoral, ESPOL, Guayaquil, Ecuador, C. M. Z. Jaramillo, and Computer and Decision Science Department, Universidad Nacional de Colombia, Medellín, Colombia, "Representing Interoperability Between Software Systems by Using Pre-Conceptual Schemas," Int. J. Electr. Eng. Inform. **14**(1), 101–127 (2022). https://doi.org/10.15676/ijeei.2022.14.1.7

88. Romero, M., et al.: A novel network science and similarity-searching-based approach for discovering potential tumor-homing peptides from antimicrobials. Antibiotics **11**(3), 401 (2022). https://doi.org/10.3390/antibiotics11030401
89. Nina, H., Pow-Sang, J.A., Villavicencio, M.: Systematic mapping of the literature on secure software development. IEEE Access **9**, 36852–36867 (2021). https://doi.org/10.1109/ACCESS.2021.3062388
90. Corral, A., Sánchez, L.E., Antonelli, L.: Building an integrated requirements engineering process based on Intelligent Systems and Semantic Reasoning on the basis of a systematic analysis of existing proposals. JUCS - J. Univers. Comput. Sci. **28**(11), 1136–1168 (2022). https://doi.org/10.3897/jucs.78776
91. Arcos-Medina, G., Mauricio, D.: Identifying factors influencing on agile practices for software development. J. Inf. Organ. Sci. **44**(1), 1–31 (2020). https://doi.org/10.31341/jios.44.1.1
92. Santos, A., Vegas, S., Uyaguari, F., Dieste, O., Turhan, B., Juristo, N.: Increasing validity through replication: an illustrative TDD case. Softw. Qual. J. **28**(2), 371–395 (2020). https://doi.org/10.1007/s11219-020-09512-3
93. Sayago-Heredia, J., Pérez-Castillo, R., Piattini, M.: A systematic mapping study on analysis of code repositories. Informatica, 619–660 (2021). https://doi.org/10.15388/21-INFOR454
94. Rosero, R.H., Gomez, O.S., Rodriguez, G.: Regression testing of database applications under an incremental software development setting. IEEE Access **5**, 18419–18428 (2017). https://doi.org/10.1109/ACCESS.2017.2749502
95. Flores, P., Alvarez, M., Torres, J.: Identifying difficulties of software modeling through class diagrams: a long-term comparative analysis. IEEE Access **10**, 28895–28910 (2022). https://doi.org/10.1109/ACCESS.2022.3157290
96. Gomez, O.S., Aguileta, A.A., Aguilar, R.A., Ucan, J.P., Rosero, R.H., Cortes-Verdin, K.: An empirical study on the impact of an IDE tool support in the pair and solo programming. IEEE Access **5**, 9175–9187 (2017). https://doi.org/10.1109/ACCESS.2017.2701339
97. Palacios, K., Guerra, J.: Software aplicado en investigaciones científicas de las universidades del Ecuador: estudio de mapeo sistemático. Cienc. UNEMI **15**(39), 14–26 (2022). https://doi.org/10.29076/issn.2528-7737vol15iss39.2022pp14-26p
98. Longmore, S.N., et al.: Adapting astronomical source detection software to help detect animals in thermal images obtained by unmanned aerial systems. Int. J. Remote Sens. **38**(8–10), 2623–2638 (2017). https://doi.org/10.1080/01431161.2017.1280639
99. Guaman, D.S., Alamo, J.M.D., Caiza, J.C.: A systematic mapping study on software quality control techniques for assessing privacy in information systems. IEEE Access **8**, 74808–74833 (2020). https://doi.org/10.1109/ACCESS.2020.2988408
100. Ríos, J.M., Pedreira-Souto, N.: Approach of agile methodologies in the development of web-based software. Information **10**(10), 314 (2019). https://doi.org/10.3390/info10100314
101. Sandobalin, J., Insfran, E., Abrahao, S.: On the effectiveness of tools to support infrastructure as code: model-driven versus code-centric. IEEE Access **8**, 17734–17761 (2020). https://doi.org/10.1109/ACCESS.2020.2966597
102. Cruz, M., Bernárdez, B., Durán, A., Guevara-Vega, C., Ruiz-Cortés, A.: A model-based approach for specifying changes in replications of empirical studies in computer Science. Computing **105**(6), 1189–1213 (2023). https://doi.org/10.1007/s00607-022-01133-x
103. Bardier, C., Székely, D., Augusto-Alves, G., Matínez-Latorraca, N., Schmidt, B.R., Cruickshank, S.S.: Performance of visual vs. software-assisted photo-identification in mark-recapture studies: a case study examining different life stages of the Pacific Horned Frog (Ceratophrys stolzmanni). Amphib.-Reptil. **42**(1), 17–28 (2020). https://doi.org/10.1163/15685381-bja10025

104. C. E. Anchundia, C.E., Fonseca, C.E.R.: Resources for reproducibility of experiments in empirical software engineering: topics derived from a secondary study. IEEE Access **8**, 8992–9004 (2020). https://doi.org/10.1109/ACCESS.2020.2964587
105. J. R. Valdés-Martiní *et al.*, "QuBiLS-MAS, open source multi-platform software for atom- and bond-based topological (2D) and chiral (2.5D) algebraic molecular descriptors computations," *J. Cheminformatics*, vol. 9, no. 1, p. 35, Dec. 2017, doi: https://doi.org/10.1186/s13321-017-0211-5
106. Gaviria, A., et al.: Genetic polymorphisms of 12 X-STRs in the Ecuadorian population. Forensic Sci. Int. Genet. Suppl. Ser. **7**(1), 677–679 (2019). https://doi.org/10.1016/j.fsigss.2019.10.135
107. Mejia, P., Martini, L.C., Grijalva, F., Larco, J.C., Rodriguez, J.C.: A survey on mathematical software tools for visually impaired persons: a practical perspective. IEEE Access **9**, 66929–66947 (2021). https://doi.org/10.1109/ACCESS.2021.3076306
108. Rodas-Silva, J., Galindo, J.A., Garcia-Gutierrez, J., Benavides, D.: Selection of software product line implementation components using recommender systems: an application to wordpress. IEEE Access **7**, 69226–69245 (2019). https://doi.org/10.1109/ACCESS.2019.2918469
109. García-Jacas, C.R., et al.: Choquet integral-based fuzzy molecular characterizations: when global definitions are computed from the dependency among atom/bond contributions (LOVIs/LOEIs). J. Cheminformatics **10**(1), 51 (2018). https://doi.org/10.1186/s13321-018-0306-7
110. Santos, A., Gomez, O., Juristo, N.: Analyzing Families of Experiments in SE: A Systematic Mapping Study. arXiv, Aug. 02, 2018. Accessed 03 June 2023. http://arxiv.org/abs/1805.09009
111. Martínez-Santiago, O., et al.: Exploring the QSAR's predictive truthfulness of the novel *N* -tuple discrete derivative indices on benchmark datasets. SAR QSAR Environ. Res. **28**(5), 367–389 (2017). https://doi.org/10.1080/1062936X.2017.1326403
112. Cuesta, S.A., Mora, J.R., Márquez, E.A.: In silico screening of the drugbank database to search for possible drugs against SARS-CoV-2. Molecules **26**(4), 1100 (2021). https://doi.org/10.3390/molecules26041100
113. Urquía, D., Gutierrez, B., Pozo, G., Pozo, M.J., Espín, A., Torres, M.D.L.: Psidium guajava in the Galapagos Islands: population genetics and history of an invasive species. PLoS ONE **14**(3), e0203737 (2019). https://doi.org/10.1371/journal.pone.0203737
114. Larco, A., Peñafiel, P., Yanez, C., Luján-Mora, S.: Thinking about inclusion: designing a digital app catalog for people with motor disability. Sustainability **13**(19), 10989 (2021). https://doi.org/10.3390/su131910989
115. Cuadros, J., Dugarte, N., Wong, S., Vanegas, P., Morocho, V., Medina, R.: ECG multilead *QT* interval estimation using support vector machines. J. Healthc. Eng. **2019**, 1–14 (2019). https://doi.org/10.1155/2019/6371871
116. Crespo-Martinez, E.: Análisis de vulnerabilidades con SQLMAP aplicada a entornos APEX 5. Ingenius **25**, 104–113 (2020). https://doi.org/10.17163/ings.n25.2021.10
117. Abad-Coronel, C., et al.: Analysis of the mesh resolution of an. STL exported from an intraoral scanner file. J. Esthet. Restor. Dent. **34**(5), 816–825 (2022). https://doi.org/10.1111/jerd.12889
118. García-Jacas, C.R., Contreras-Torres, E., Marrero-Ponce, Y., Pupo-Meriño, M., Barigye, S.J., Cabrera-Leyva, L.: Examining the predictive accuracy of the novel 3D N-linear algebraic molecular codifications on benchmark datasets. J. Cheminformatics **8**(1), 10 (2016). https://doi.org/10.1186/s13321-016-0122-x
119. Poulakakis, N., et al.: Description of a New galapagos giant tortoise species (chelonoidis; testudines: testudinidae) from cerro fatal on santa cruz Island. PLoS ONE **10**(10), e0138779 (2015). https://doi.org/10.1371/journal.pone.0138779

120. Congacha Aushay, E.P., Santillán Castillo, J.R., Guerra Salazar, J.E., Barba Vera, R.G.: Empleo de una aplicación informática como estrategia didáctica para el desarrollo de aptitudes académicas," Rev. Educ. 398–413 (2018). https://doi.org/10.15517/revedu.v42i2.27472
121. Ochoa, D., Martinez, S., Arévalo, P.: Extended simplified electro-mechanical model of a variable-speed wind turbine for grid integration studies: emulation and validation on a microgrid lab. Electronics **11**(23), 3945 (2022). https://doi.org/10.3390/electronics11233945
122. Universidad Politécnica Salesiana, Sede Guayaquil. Ecuador Grupo de Investigación en Energías, Universidad Politécnica Salesiana, Cuenca. Ecuador, D. Segovia-Muñoz, X. Serrano-Guerrero, and A. Barragán-Escandon, "Predictive maintenance in LED street lighting controlled with telemanagement system to improve current fault detection procedures using software tool). https://doi.org/10.24084/repqj20.318
123. Lema, M., Pavon, W., Ortiz, L., Asiedu-Asante, A.B., Simani, S.: Controller coordination strategy for DC microgrid using distributed predictive control improving voltage stability. Energies **15**(15), 5442 (2022). https://doi.org/10.3390/en15155442
124. Tamay, P., Inga, E.: Charging infrastructure for electric vehicles considering their integration into the smart grid. Sustainability **14**(14), 8248 (2022). https://doi.org/10.3390/su14148248
125. Pillay, E., Kumarasamy, M., Adu, J., Thirumuruganandham, S.P., Paruk, A., Naidoo, M.: Feasibility analysis of energy recovery using PATs in water distribution networks. Water **14**(7), 1150 (2022). https://doi.org/10.3390/w14071150
126. Vairinhos, V.M., Pereira, L.A., Matos, F., Nunes, H., Patino, C., Galindo-Villardón, P.: Framework for classroom student grading with open-ended questions: a text-mining approach. Mathematics **10**(21), 4152 (2022). https://doi.org/10.3390/math10214152
127. Universidad Técnica Estatal de Quevedo, Ecuador and J. Coutinho Dos Santos, "Improving Speaking Fluency Through 4/3/2 Technique and Self-Assessment. Teach. Engl. Second Foreign Lang.-TESL-EJ, vol. 26, no. 4 (2022). https://doi.org/10.55593/ej.26102a1
128. Cruz Pérez, M.A.: Propuesta metodológica para el empleo del software educativo como recurso didáctico en la formación investigative. Rev. Cienc. PEDAGÓGICAS E Innov. **7**(2), 21–30 (2019). https://doi.org/10.26423/rcpi.v7i2.288
129. Escuela de Ingeniería Química, Facultad de Ciencias Químicas, Universidad de Cuenca, Cuenca, Ecuador, M. Vera, S. Astudillo, Centro de Estudios Ambientales, Departamento de Química Aplicada y Sistemas de Producción, Facultad de Ciencias Químicas, Universidad de Cuenca, Cuenca, Ecuador, D. M. Juela, and Centro de Estudios Ambientales, Departamento de Química Aplicada y Sistemas de Producción, Facultad de Ciencias Químicas, Universidad de Cuenca, Cuenca, Ecuador, "Estudio experimental y simulación dinámica de la adsorción de Cd+2 y Pb+2 utilizando cáscara de cacao en columna de lecho fijo," Tecnol. Cienc. Agua, vol. 13, no. 6, pp. 56–97 (2022). https://doi.org/10.24850/j-tyca-13-06-02
130. Morante-Carballo, F., Montalván-Burbano, N., Arias-Hidalgo, M., Domínguez-Granda, L., Apolo-Masache, B., Carrión-Mero, P.: Flood models: an exploratory analysis and research trends. Water **14**(16), 2488 (2022). https://doi.org/10.3390/w14162488
131. Herrera-Franco, G., Carrión-Mero, P., Montalván-Burbano, N., Mora-Frank, C., Berrezueta, E.: Bibliometric analysis of groundwater's life cycle assessment research. Water **14**(7), 1082 (2022). https://doi.org/10.3390/w14071082