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Global analysis of the E-learning scientific domain: a declining category?

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Abstract The scientific production in E-learning has an average annual growth rate of 16%, which along with the 3.9% annual increase in the number of virtual students worldwide present a very favorable prospect for the category. However, the growth in scientific production is not constant. The objective of this work was to analyze the behavior of scientific production in E-learning from a bibliometric perspective in the 2003–2015 period, to identify its evolution in relation to other areas of knowledge. The methodology used compared production in E-learning versus world production, production by regions and blocks of countries and production of related areas of knowledge. With these results, a visualization was generated in VOSViewer under the overlay mapping technique to identify the dynamics of the 81 existing scientific journals in the category. This analysis determined that the growth in production in E-learning is due to the contribution of the journals in Social Sciences and that the decrease during the years 2013–2015 is mainly due to the fact that Computer Science have decreased their contribution in conference papers and reviews. In conclusion, E-learning is on the decline, since the growth offered by the Social Sciences is not enough to counteract the decline in the contribution of Computer Science. The method used in this study is a contribution to bibliometric techniques to explain the behavior of scientific production in a certain area of knowledge.

Keywords E-learning · Bibliometric · Global analysis · Scientific production · SCOPUS · SCImago

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Introduction

Since it entered the world stage, E-learning has been considered as one of the elements of social and educational transformation. The United Nations has stated that, to ensure inclusive and quality education for all and promote lifelong learning, sustainable development goals "by 2020, substantially expand globally the number of scholarships available to developing countries, for enrolment in higher education, including information and communications technology", with the percentage of young people and adults with ICT skills (United Nations 2016) as the indicator. For its part, the OECD has the employability rate of trained adults. In this case, in the member countries of this body this indicator is at 88% for those who graduated in ICT (OECD 2017a, b), also promoting educational innovation with technology as a necessary element to achieve quality educational results (OECD 2017a, b).

Against this, since 2010 there has been an increase in enrollment in virtual programs at the tertiary level, with an annual growth rate of 3.9%. In the United States, 1 of 4 students have taken a virtual course, reaching in 2016 the figure of 6 million students who have had academic experience in virtual learning environments, and in higher education the learning outcomes obtained under this modality are 70% equal to or higher than classroom education (Allen and Seaman 2016). This puts pressure on the education system in the offer of new virtual programs that is already suffering a drop-in student in tertiary education on campus of 5% per year (Allen and Seaman 2017).

Massive Open Online Courses are also contributing to the increase of students with academic experience in virtual learning environments, reporting in 2016 more than 58 million students worldwide (Shah 2016) and with contributions in courses of more than 700 universities, especially in America, Europe and Asia. Although this is a very promising scenario, there is evidence that E-learning is including new fields of action not necessarily linked to formal or non-formal education. For example, according to the Global Learning Technology Investment Patterns (Adkins 2017), the investment has focused on 8 specific products: Self-paced learning (courseware), Digital Reference-ware, Collaboration-based learning, Simulation-based learning, Game-based learning, Cognitive learning, Mobile learning and Robotic tutors, representing more than $75 billion. This report also shows that the most benefited sector from investments has been primary consumers, followed by companies and schools (K-12) and lastly the Higher Education sector.

We found then a very determined commitment of the universities to participate in MOOC, with the investment directed to the consumer and the business sector, with results that demonstrate its effectiveness in the learning process. Therefore, we can call this evidence as a social growth of E-learning.

Now, how is this social growth of E-learning reflected in the world scientific production of the category?

As a research area, Conole and Oliver (2006) determined that E-learning, since it has a growing scientific community that has verifiable scientific production, was in an "emerging" state within its proposal to develop knowledge areas. Regarding scientific production in E-learning, some researchers have conducted studies to determine the research fronts of the category. Shih and others (2008) began reviewing 5 journals, Maurer and Khan (2010) also reviewed 5 journals and 2 conference proceedings, Chiang et al. (2010) focused on 7 journals to identify their thematic relationships with other areas of knowledge and Hung (2012) analyzed 689 articles to determine the research fronts of the category. On the other hand, Tibaná-Herrera et al. (2017) categorized E-learning, using the combination of the bibliometric approach with visualization techniques to determine the existence of a set of 218 scientific publications that present a high degree of cohesion between bibliometric indicators of citation, co-citation and coupling on the subject, of which 137 are conference proceedings and 81 are journals, representing 34,345 articles in the period 2003–2015.

In light of this new categorization that highlights the need for a new revision of bibliometric indicators, this paper aims to analyze in detail the evolution of the scientific production of the E-learning category to establish if there is a relationship between its social growth and its scientific production, and then determine if the subject category has matured sufficiently to move from an “emerging” state to a “diversified” one, for which it requires the consolidation of different schools of thought and alignment with other areas of knowledge already established (Conole and Oliver 2006).

The indicator of scientific production is the number of documents that can be cited (NDoc). This has been used as a unit of analysis in research work at different levels, for example, global studies on environmental issues (Jingqing et al. 2015), drinking water (Fu et al. 2013), the microRNA (Mallik and Mandal 2014). At the country level, it has been used to study influenza in Mexico (Castillo-Pérez et al. 2015), science and technology in Singapore (Rana 2012).

In addition, bibliometric analysis of scientific production can be complemented with visualization techniques. Leydesdorff et al. (2017) propose visualization by knowledge maps as an instrument to provide new interpretations of the data from the direct comparison of various variables (e.g. countries and areas of knowledge) by orienting their differences in terms of strengths and weaknesses (Leydesdorff et al. 2017). Another technique used in conjunction with the bibliometric analysis is mapping overlay to chart scientific fields (Waaijer et al. 2011).

Materials and methods

The data to answer the raised question were obtained from the SCImago Journal and Country Rank—SJR (SCImago 2007), a platform developed by SCImago Research Group[1] based on data from scientific publications in the SCOPUS database during the period 2003–2015.

> Scopus is the largest abstract and citation database of peer-reviewed research literature including: Over 21,500 titles, with 4,200 Open Access journals from more than 5,000 international publishers (Elsevier 2017).

In SJR the scientific production is classified in 27 subject areas and 313 subject categories (SCImago 2007). For this study, the primary literature was used (Romo-Fernández et al. 2013). The methodology prompts the analysis of data with different levels of granularity, starting with the world scientific production, then the scientific production grouped by blocks of countries and regions, finally, the scientific production of the 5 knowledge areas related to E-learning, according to the SCOPUS query on the term “E-learning”. The indicator used to make the comparisons and the analysis was the number of documents published in SCOPUS (NDoc).

E-learning evolution comparison in relation to the world scientific production

To know the behavior of the category in front of the world scientific publication trend (Guerrero-Bote and Moya-Anegón 2015).

[1] www.scimagolab.com.

E-learning evolution comparison versus the scientific production of the main blocks of countries

In order to visualize in a different way, the production in E-learning present in different groups of countries and regions (Falagas et al. 2006), these are: OECD member countries, the European Union, BRIICS countries (Brazil, Russia, India, Indonesia, China and South Africa), Eastern and Western Europe, Asia, Middle East, the Pacific region, Northern America, Latin America and Africa.

E-learning evolution comparison with related knowledge areas

To know the contribution of the different knowledge areas with which E-learning is related, we need to measure the NDoc in scientific communication channels. The comparison areas are: Social Sciences, Computer Science, Engineering and Business, Management and Accounting.

Analysis of worldwide production in E-learning

To differentiate world scientific production by source type, among journals, conference proceedings, reviews and editorials. First, we compared the evolution of production in the area between source type. Second, we analyzed the distribution of source type among Social Sciences and Computer Science areas. Third, the growth rate of production for each journal was classified in a scale of 4 states (Superior Growth, Normal Growth, Decline and Drop). Fourth, the mapping overlay technique (Leydesdorff et al. 2015) was used to know the evolution in the growth of the journals of the category in front of the knowledge areas and to determine the relation of this evolution with the above comparisons. Leydesdorff, Moya-Anegón and Guerrero-Bote also demonstrated that the VOSViewer[2] visualization tool guarantees the understanding of node labels on the map.

These comparisons and the subsequent analysis allow determining the worldwide evolution in the production of the category and the contribution of different knowledge areas to this evolution.

Results and analysis

During the period 2003–2015 the world scientific production in E-learning has had a sinusoidal behavior, with a remarkable growth until 2012, going from 654 documents in 2003 to 5418 in 2012 and then, it shows a pronounced decrease to the 3879 documents in 2015 (Fig. 1). The category shows a growth of 493%, with an average annual growth rate of 16%. When comparing this behavior with the world scientific production it is observed that there is evidently a decrease in 2015 in this one, but in general, the behavior of the category does not correspond to the world behavior, particularly in 2012 where the peak of production is presented with a worldwide share of 0.21%.

When changing the level of analysis, it was observed that the production in E-learning of the main blocks of countries and regions is consistent with the behavior in the production of the category (Fig. 2). Being a recent category, the growth rates of the blocs of countries and regions are in the order of hundreds and thousands, however, it can be

[2] www.vosviewer.com.

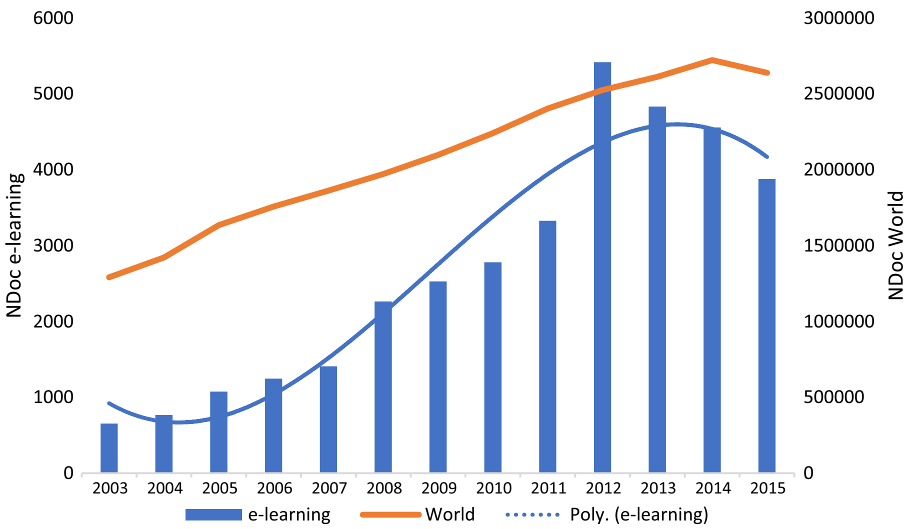


Fig. 1 Global scientific production in E-learning (*Data*: SCImago Journal and Country Rank. *Source*: self-made)

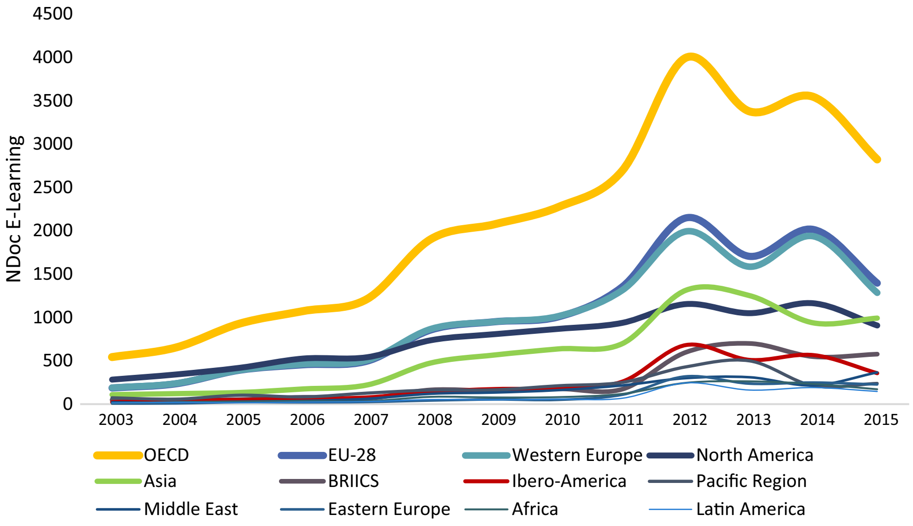
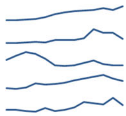


Fig. 2 Scientific production in E-learning in the main blocks of countries and regions (*Data*: SCImago Journal and Country Rank. *Source*: self-made)

mentioned that Eastern Europe has the highest average annual growth rate with 25.62% and on the other hand, the slower growth is presented by the Pacific Region with 2.33%. OECD member countries are the ones that contribute most to the growth of the category, thus responding to the innovation strategy that was proposed in this block of countries where technology and education are a policy priority (OECD 2015). As a result of this

Table 1 Distribution of scientific production in E-learning. (*Data*: SCImago Journal and Country Rank. *Source*: self-made)

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Articles	491	531	588	733	1042	1475	1761	1997	2128	2243	2466	2181	2851
Conference papers	19	42	234	262	173	632	667	614	1000	2941	2168	2194	886
Review	115	171	224	198	133	47	36	47	81	107	61	49	49
Editorial	21	15	25	52	46	47	57	73	84	96	112	84	68
Others	8	8	5	2	15	5	8	16	35	31	26	50	25



comparison, two sets of countries and regions were identified with regard to their level of contribution to the category, on one hand, those making a higher contribution (OECD, EU-28, Western Europe, Asia and BRIICS), and on the other hand those that make an expected normal contribution in scientific production in E-learning (Ibero-America, Pacific Region, Middle East, Eastern Europe, Africa and Latin America).

Still in the world order, data broken down by document type of scientific publication (Table 1) show that the production of articles and editorials has maintained a permanent growth within the category, not the conference papers and reviews.

The decrease in reviews indicates that since 2008 the scientific community has reduced its interest in describing E-learning, this can be answered by many reasons, for example, there is no responsiveness to the pace that advances in technology propose, considering that the subject is sufficiently described or because there have been no substantial changes in its content, methods and results, the latter is also reinforced by the decrease in the conference proceedings, which shows that the scientific community has stopped presenting its advances and leading edge research in E-learning through these channels.

By changing the focus of analysis to the knowledge areas, production in E-learning compared to production in the knowledge areas to which it is related (Fig. 3) was compared. It can be observed that none of them has a behavior similar to E-learning.

On the other hand, it is striking that the production in Computer Science has a constant behavior from 2010, unlike the other areas that continue its growth, so that a cross-data was performed between the type of publication and the production in E-learning of the most representative knowledge areas (Fig. 4) to establish the existence of a direct relationship between the decrease in production, the knowledge areas and the type of publication. Only the last 5 years were used for this visualization, corresponding to the main changes in the evolution of the subject category.

It was determined with this analysis that the greatest contribution to the production in E-learning is made by the journal articles related to Social Sciences.

It was observed that the production of journal articles related to Computer Science is kept constant in this channel of scientific communication and that the peak in the production in E-learning presented in 2012 is mainly due the contribution made by the Conference Proceedings, both in Computer Science and in Social Sciences, however, this situation reverses in the following years with a clear decrease of the two areas in terms of their publications in Conference Proceedings.

This analysis provides elements to establish that Computer Science has stopped contributing to the growth and consolidation of the E-learning category in the last 3 years.

In order to verify this finding, an analysis was performed on the growth of the scientific journals of the E-learning category, applying the technique of overlay mapping (Leydesdorff et al. 2015), which allows representing a subset of information on a global base map.

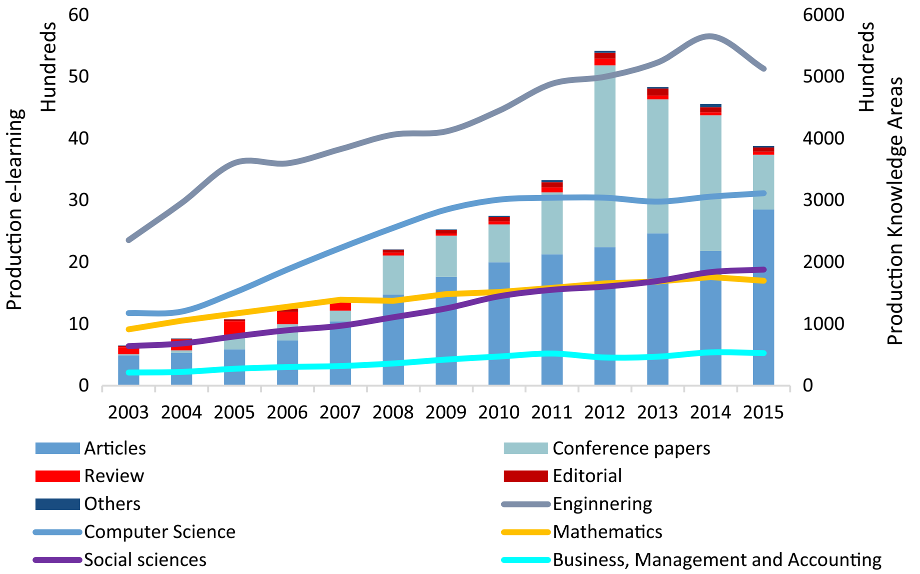


Fig. 3 Scientific production in E-learning versus the production of other knowledge areas (*Data*: SCImago Journal and Country Rank. *Source*: self-made)

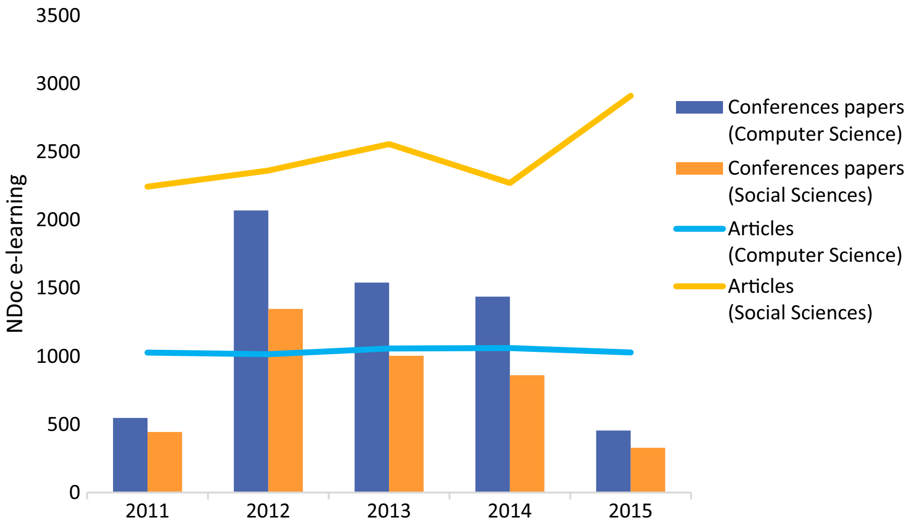


Fig. 4 Cross-graphing between publication types and knowledge areas (*Data*: SCImago Journal and Country Rank. *Source*: self-made)

The global science map by Tibaná-Herrera et al. (2017) was used to determine the existence of a cluster of journals using the combined indicator (citations, co-citations, coupling) used by SCImago[3] (Hassan et al. 2014).

[3] http://www.scimagojr.com/viztools.php.

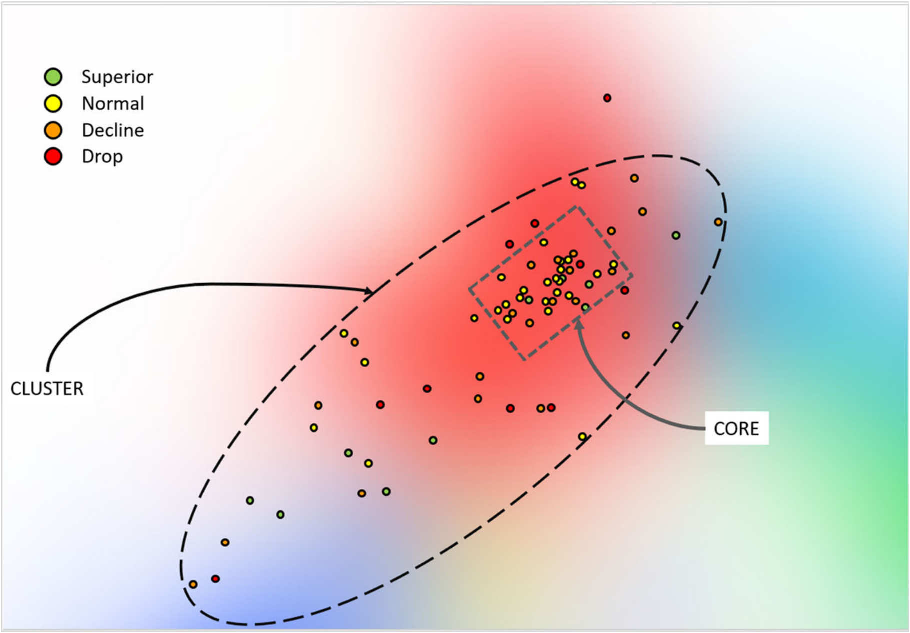


Fig. 5 Classification of journals related to E-learning, using the map superimposition technique using VOSViewer in its density map configuration (*Data*: SCImago Journal and Country Rank. *Source*: Own elaboration)

Table 2 Classification of journals in E-learning according to their growth (*Data*: SCImago Journal and Country Rank. *Source*: self-made)

	Superior	Normal	Decline	Drop
Journals	14	29	22	16
Core	4	17	12	0
Cluster	6	14	9	6
Outside	0	4	2	7

The overlapping element corresponds to the classification of the journals according to their growth rate in 4 states: Superior, Normal, Decline and Drop (Fig. 5).

Of the 81 scientific journals included in the E-learning category according to the SJR, 53% show a growth between superior and normal. 25% of the total growth is in the core of the category, the biggest decrease is located in the cluster and the biggest drop is located outside the cluster (Table 2).

This analysis allows knowing in detail the behavior of the journals of the E-learning category, whose core, located in the Social Sciences, maintains its growth and constitutes the main contribution to the production in E-learning. On the contrary, the decline and drop in production are distributed by and outside the cluster, thus corroborating that the decline in scientific production in E-learning in the case of journals is due to the decrease in contribution of the related areas, where Computer Science remain constant and in second order the production in Engineering and Business, Management and Accounting decline.

This study demonstrates that through bibliometric techniques and using various frames of reference at a global level, it is possible to establish the elements in scientific communication that determine the growth or descent of the subject categories according to their scientific production in a certain period of time, understanding the behavior of their evolution.

However, these results are affected by the constant updating of the scientific communication indexes, as in this case SCOPUS, since it affects the production indicators of the subject categories, through the entry and/or withdrawal of publications and documents in the index. In the same order, the grouping of the Conference Proceedings as a series of publications will facilitate the analysis of this type of publication and provide complementary data on the evolution of the subject categories.

Though, recognizing that the decrease is presented in the Conference Proceedings of Computer Science, it is possible to go deeper into the taxonomy and the thematic content that the scientific community has published, for example, through knowledge maps, which could establish all the thematic that have ceased to be of interest to the scientific community investigating E-learning, similar to the establishment of artifacts in Big Data by Akoka et al. (2017). These knowledge maps can also be used to analyze the revisions of the subject (Pauyo et al. 2015) in the period 2003–2010 and verify the approach to the issue, whether it is sufficiently covered or not. In addition, they can help in the identification of the thematic that were addressed from Computer Science and Social Sciences in the conferences proceedings of 2012 that produced such a remarkable growth in the scientific production. It is also possible to analyze the production by countries and languages such as the Monge and Nielsen study on Biology (Monge-Nájera and Nielsen 2005) or the contribution of countries in journals of General Psychiatry (Patel and Kim 2007). Other bibliometric indicators can also be analyzed to establish the nature of the category in its production, citation and performance.

Conclusions

Through comparisons at global, regional and subject area levels, this study has presented a method to explain from bibliometrics, the changes that occur in the scientific production related to a knowledge area or subject category. Applied to the E-learning subject category, it was verified that the growth in the production of this subject category depends mainly on the contribution yield by journals in Social Sciences and that Computer Sciences have diminished their contribution in the last years, especially in conference proceedings and reviews.

Through the mapping overlay technique, it was determined that the core of journals in the category, located in Social Sciences, has been in permanent growth and this has facilitated the consolidation of E-learning as a category of study present in the academic discourses. However, at the global level, the category is decreasing, since the growth offered by Social Sciences is not enough to counteract the decline in the contribution of Computer Science, so it is not yet possible to establish whether E-learning as category is at the "diversified" level.

Because the relations of E-learning with other knowledge areas have been transformed in recent years, it is necessary to deepen the behavior of scientific communication to determine the transformations that have been presented in the taxonomy of the category, especially in front to technological topics such as learning platforms, standards and topics related to Web 2.0. At the same time, establish the current research fronts and the new relationships with other knowledge areas.

This study contributes to the characterization of E-learning, in its nature and dynamics of growth in Social Sciences, as well as in the behavior of related knowledge areas.

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Author contributions GT-H: Primary author, MTF-B, FM-A: Analysis and review.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Availability of data and materials Data related to this research were provided by SCImago Research Group. These are protected by licensing and copyright.

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