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E-learning experiences in tertiary education: patterns and trends in research over the last 20 years

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ABSTRACT

This article presents a review of the literature about e-learning experiences in tertiary education over the past 20 years, since the 2000s. At this point, an increasing use of web-based technologies started to affect the spread of e-learning. The methodological approach used in the study was quantitative. The main results showed that the development of information technology and the spread of Internet applications in the field of education drove a significant increase in the number of publications in the period 2016–2020. Approximately 50% of the total number of documents analysed were published during this period, more than 100 documents per year. The main research themes in the last 20 years showed four different periods, with leading and emergent themes in each. Our study also suggests that the recent phase of e-learning may be extended in future towards a reframed concept, so-called hybrid learning.

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E-learning; distance education; literature review; bibliometrics; science mapping

1. Introduction

E-learning is a system based on digital technologies capable of promoting the acquisition of knowledge and skills by users and students (Bernuy and García 2006; Hashim and Tasir 2014) and supporting and improving the learning processes (McConnell 2005; Gentile et al. 2019; Rodrígues et al. 2019; Gentile et al. 2020). Over recent years, many institutions have combined traditional forms of face-to-face learning activities with those implemented online (McKenzie et al. 2022). E-learning has therefore become a fundamental part of students' learning experience in a higher education context (Ellis, Ginns, and Piggott 2009; Margalina, De-Pablos-Heredero, and Montes-Botella 2017). Several universities have also created e-learning systems to provide online lectures and materials, and offer Internet-based degree programs. Recently, the health emergency resulting from the SARS-CoV-2 pandemic has forced universities worldwide to suspend traditional classroom activities (Ebner et al. 2020; García-Peñalvo et al. 2021). This has encouraged the spread of distance and online learning.

Although the term e-learning was coined at the end of the 1990s (Moore, Dickson-Deane, and Galyen 2011), distance education has a very long history (Harasim 2006; Corbeil and Corbeil

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2015). Successive generations of distance education have spread as different types of communication channels were adopted by universities (Keegan 1994; Taylor 2001). Before the Internet, distance learning relied on alternative media matched to the stage of technological evolution. The first generation was correspondence courses offered via mail, popularised from the end of the nineteenth century (Bergmann 2001). The second generation began when printed communication was joined by other media, with learning activities provided through audiotapes, videotapes and other digital channels. The third generation mainly leveraged teleconferencing systems and radio/TV broadcasting. E-learning, in its strictest sense, started in the fourth generation (Lauzon and Moore 1989). During this period, distance education was mainly via computer-mediated communication and web-based technologies, with synchronous or asynchronous virtual environments (Bates and Bates 2005). The advent of the fourth generation was primarily characterised by the adoption of a flexible learning model. With the launch of the fifth generation of distance education in the 2000s, essentially an upgrade of the previous generation, there was a substantive enrichment in the educational offer of universities and other post-secondary institutions. Nevertheless, in many cases, the fourth phase began only 'theoretically', in the sense that these technologies were only implemented from the beginning of the new millennium, even though there were already ICT systems able to deliver online courses (National Center for Education Statistics 2003; Organisation for Economic Co-operation and Development 2005). The sixth generation of distance learning has established the delivery and support of teaching and learning activities through advanced management systems, enriched with file transfer and storage services, with a prominent use of mobile technologies, social media, and open educational resources (OER) as in the huge open online courses (MOOC) proposed by Coursera or developed on Moodle platforms (Kimani 2019).

Most recently, a new phase of distance education has started. Universities had to reshape their educational strategies following the worldwide health emergency from the beginning of 2020. Several studies have been published that contribute to the debate about the implementation of online learning activities in tertiary education (e.g. Dhawan 2020; Rapanta et al. 2020; Wotto 2020). A number of studies have discussed e-learning trends (Köhler 2003; Fischer et al. 2015), and some even tried to forecast the future of a digitised education system (Köhler, Wollersheim, and Igel 2019).

In this continuously changing framework, it is crucial to highlight the main issues discussed in the e-learning literature, focusing on its real-world use in universities and colleges. The different experiences recently investigated offer a good starting point to assess future global trends in distance education. Starting from these cues, this paper aims to provide an overview of studies about e-learning experiences in tertiary education across the last 20 years. As mentioned above, this period is particularly relevant because it includes the emergence and diffusion of the last two generations of distance learning, with the increasing use of web-based technologies. In this context, technology plays an increasingly predominant role, and we can identify development paths and future trends. Thus, for example, some scenarios of Technology Enhanced Learning (TEL) and Technology Enhanced Teaching (TET) in academic training are outlined for the next decade, in which teaching staff will have to know how to use multiple devices to provide lessons.

The paper is organised as follows. The methodology is briefly presented in Section 2. After describing the data retrieval and pre-processing in Section 3, we show the main findings in Section 4. Sections 5 and 6 contain a discussion of the most valuable results and some final remarks.

2. Methodology

Literature reviews are commonly used to assess the current state of progress and trends in a research domain. Grant and Booth (2009) tried to classify the different approaches used by scholars, considering the different scopes and techniques used to explore the literature systematically. The majority of these approaches rely on qualitative techniques, but more and more quantitative analyses are considered. Thanks to the availability of online databases and computer tools capable of performing

automatic analyses, this task can be accomplished using a statistical approach within a bibliometric framework (Pritchard 1969; Broadus 1987). The primary methods used in these studies are *performance analysis* (Peters and van Raan 1991; White and McCain 1998) and *science mapping* (Noyons and van Raan 1998; Börner, Chen, and Boyack 2003). The first method aims to use bibliographic data to evaluate both productivity and impact of those involved in a field, including authors, institutions, and countries. The second method tries to depict the cognitive patterns of the analysed domain, visualising the major topics with a synchronic (Callon et al. 1983) or diachronic view (Garfield 1994; Cobo et al. 2011).

Network tools – developed in the context of graph theory – can be used to explore data in both performance analysis and science mapping, looking at the social, intellectual and conceptual structure of the analysed domain. The social structure can be represented by using collaboration networks among countries, institutions, and authors, and having a macro-, meso – or micro-view on scientific cooperation (Glänzel 2002). In each network, the relations among the different actors are built considering joint publications (Katz and Martin 1997). They reflect the degree of connection of regular study groups and hidden clusters of scholars. The intellectual structure aims to estimate the impact and influence of the actors. It can be deduced from co-citation networks. These kinds of networks visualise the relations among sources, publications or authors, depending on the extent of the analysis (Marshakova 1981). The conceptual structure can be highlighted by mapping the research front of the domain using co-word networks. Each scientific field or topic can be characterised by a set of keywords assigned by publications' authors or indexing databases, e.g. the *KeyWord Plus* coding used by Web of Science (Garfield and Sher 1993). From this set of keywords and its representation as a term co-occurrence network, it is possible to visualise the knowledge base embodied in a document collection and explore the themes developed into a domain of interest (Leydesdorff 1989; He 1999).

2.1 Thematic analysis and thematic evolution

Reading a vast collection of documents to discover recurring meaning patterns is a time-consuming activity. Several scholars have used a qualitative approach to literature reviews, and this is still preferred in many research fields. Highlighting the key concepts running through a document can increase understanding of that document, but this task is challenging without prior knowledge of the document. Interpretive researchers have widely used qualitative text analysis on the principle that reality can be decoded through a 'sense-making process' (Weick 1979; Kuckartz 2014). Methods like *content analysis* (Berelson 1952; Krippendorff 1980) tried to offer a systematic way of working on the qualitative approaches used to investigate social phenomena. However, Ignatow (2016) suggested that a statistical approach to text analysis is justified by the realist constructionist position that discourses are real entities that can be studied like any other empirical phenomenon.

Text analysis allows researchers to extract knowledge from documents written in natural language by analysing the unstructured data embodied in the texts (Misuraca and Spano 2020). Besides the set of terms used to write a paper, it is possible to consider high-level latent entities expressing the different concepts or themes underlying the text. Science mapping helps to extract and visualise the topics covered by a research domain, defining the most relevant ones. Comparing the conceptual structure across different time sub-intervals allows examination of the evolution of themes over time. The basic idea is that the different terms frequently appearing together in a document – e.g. keywords, terms extracted from titles or abstracts – can be used to identify a topic.

After pre-processing textual data in a document collection, a *document* × *terms* binary matrix **X** with n rows and p columns is built. The marginal column distribution represents the so-called *vocabulary* of the document collection. Each generic element x_{ij} ($i = 1, \dots, n; j = 1, \dots, p$) assumes a value of 1 or 0 depending on whether a term j appeared in document i. From **X**, it is then possible to derive a p-dimensional *terms* × *terms* matrix **A**, whose generic element $a_{jj'}$ ($j \neq j'$) represents the number of documents in which terms j and j' co-occur (i.e. they are both present). The elements a_{jj} on the

principal diagonal count the number of documents containing a term *j*. This matrix can be graphically depicted as a network, where each node represents a term used in the document, and each link between two terms expresses their connection. In a bibliometric framework, van Eck and Waltman (2008) showed that the co-occurrence of two terms could be expressed as a normalised measure called *association strength*. A value equal to 0 means that terms do not both appear in any document, and a value equal to 1 means that two terms co-occur in all the documents in the collection.

This network can then be used for *community detection*, a method similar to clustering that group nodes in highly cohesive sub-networks. This allows researchers to identify groups of terms representing different themes or topics in the analysed collection. The *multilevel* algorithm proposed by Blondel et al. (2008) showed high effectiveness in comparison with other competing proposals for both small and large networks (Yang, Algesheimer, and Tessone 2016). The topics obtained through the community detection can be visualised in a *strategic* or *thematic diagram* (Cahlik 2000), showing the *Callon centrality* and *Callon density* of each topic. These measures express the participation of a theme in the organisation of the domain's conceptual structure. Callon centrality describes the importance of the theme in the whole research domain, and Callon density gives a measure of the theme's development. The thematic diagram depicts four typologies of themes, depending on the quadrant in which they are plotted:

- The motor themes have higher values of centrality and density. These are well developed and necessary for structuring the research domain;
- Basic themes have higher values of centrality and lower values of density. These themes are essential for the domain and transversal to its different research areas;
- Emerging or declining themes have lower values of centrality and density. They are weakly developed or of marginal interest in the domain;
- Niche themes have lower centrality values and higher values of density. These are strongly developed but marginal in the domain.

By analysing the conceptual structure of sub-periods of the reference period, it is possible to show both the thematic evolution of the domain and the trajectories of the different themes over time.

3. Data retrieval and pre-processing

In February 2021, we searched the *Web of Science* (WoS) indexing database to collect publications on e-learning experiences in tertiary education. WoS was initially developed by the Institute for Scientific Information (ISI) and is currently maintained by Clarivate Analytics. It is one of the primary databases used by scholars to explore scientific publications. It includes several citation databases focused on specific fields (e.g. the Social Science Citation Index for Social Science), and covers more than 20,000 journals, conference proceedings and books. Alternative databases can also be considered to retrieve bibliographic data, like *Scopus* or *Google Scholar*, and there is an intense debate about which data source is better (de Winter, Zadpoor, and Dodou 2014; Harzing and Alakangas 2016). However, the quality of information is often considered the highest in the WoS (Li, Rollins, and Yan 2018), so we decided to focus exclusively on this database.

To build an effective query and retrieve the set of reference publications for study, we first considered the possible synonyms of 'e-learning', including 'distance', 'online', and 'blended' together with 'learning' and 'education'. We also considered alternative spellings of these terms, including both multiword terms with and without hyphens. Secondly, the study focused on e-learning in tertiary education, so we also included the terms 'university' and 'college', and the multiword terms 'higher education', 'tertiary education', and 'post-secondary education'. We again considered the spelling of different terms with and without hyphens. Accessing the full scientific literature on any topic is an unattainable goal. Bibliometric analyses are usually limited by the availability, relevance and reliability of the information. To select only the publications specifically related to the

research questions, we used this articulated query on the TITLE field of WoS. This gave 2,074 documents. We then applied several filters to this raw dataset to establish the document set for the study.

In Figure 1, the PRISMA diagram (Moher et al. 2009) shows the information flow through the different steps of the search, highlighting the number of identified records, those included and excluded, and the reasons for exclusions. The initial dataset size was reduced by only considering publications written in English (1,923 documents), then only retaining publications that appeared as articles in journals, contributions in conference proceedings and chapters in edited or authored books (1,783 documents). The number of documents was further reduced by limiting the period to the last 20 years and retaining only the publications that appeared between 2001 and 2020. After this first stage, we focused on the keywords used by the authors to select only the documents with complete records. This provided a dataset of 1,360 documents for both performance analysis and science mapping analysis.

In the first case, we focused on the analysis of the publications, with reference to the authors and geographic relevance. In the second case, we used Callon's strategic diagram (Cahlik 2000). We have divided the initial period of work into five-year sub-periods (2001–2005, 2006–2010, 2011–2015 and 2016–2020) to analyze the development of the issues in a diachronic way. According to Callon's chart, the themes were divided into: motor, basic, emerging and niche.

Finally, we used the Sankey diagram to discuss the evolution of the main researches that emerged in the literature on e-learning, based on the four subperiods, and their distribution in terms of the contributions found (Wang, Ban, and Hong 2021).

The results in the following section were produced using the R library *bibliometrix* (Aria and Cuccurullo 2017), according to the pipeline shown in Figure 2.

4. Findings

4.1. Main figures about the collected publications

An interesting preliminary focus concerned the geographical localisation of the e-learning practices investigated by the publications analysed. Each document was manually checked to identify a geographical reference, allowing about 82% of the 1,360 publications to be tagged. The other publications were mainly focused on theoretical debates and technical proposals, rather than specific case studies.

Figure 3 shows the country distribution of the tagged publications, with a light blue colour shading into a dark blue colour showing the number of e-learning experiences in post-secondary education. The map highlights the higher concentration in Asia, particularly in China (5.17% of the tagged publications), Malaysia (3.66%), Turkey (3.03%) and Indonesia (2.94%). In Europe, Spain is a leading country in the implementation of e-learning (4.46%), together with Romania and UK

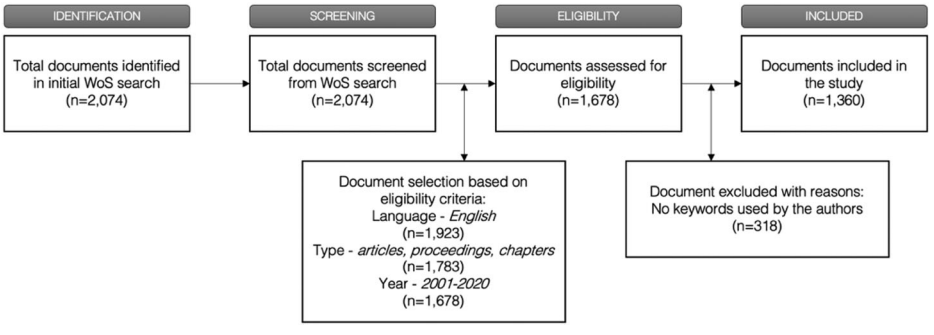

Figure 1. PRISMA flow diagram used in the study.

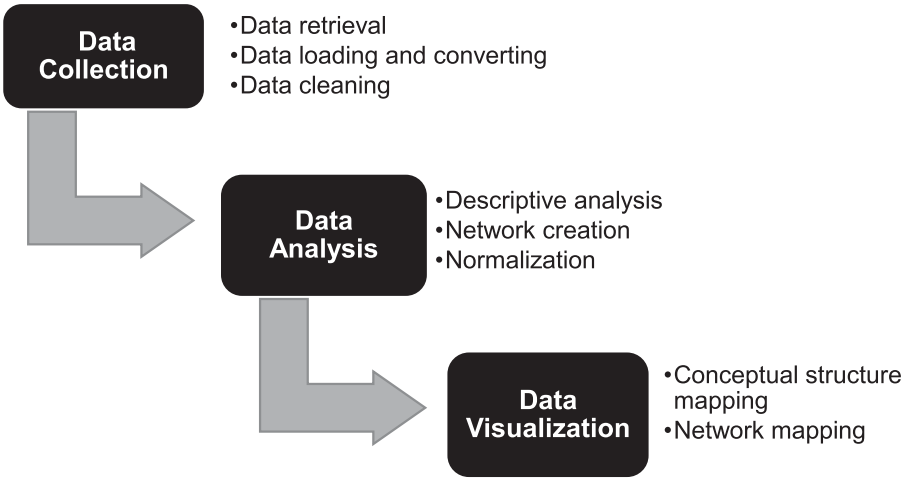

Figure 2. The three phases of bibliometric analyses according to Aria and Cuccurullo (2017).

(both countries with 3.30%). There was also a significant awareness of e-learning in Africa, particularly South Africa (4.19% of the publications) and in several countries in the Northern and Western regions of the continent. In the Americas, there were publications studying US institutions (3.30%), and a remarkable number of experiences in Brazil (2.05%) and Canada (1.34%). It is interesting to underline that about 3.12% of tagged publications contained comparative studies involving more than one country.

Table 1 shows the main descriptive statistics about the studies analysed, considering the different elements usually considered in bibliometric studies.

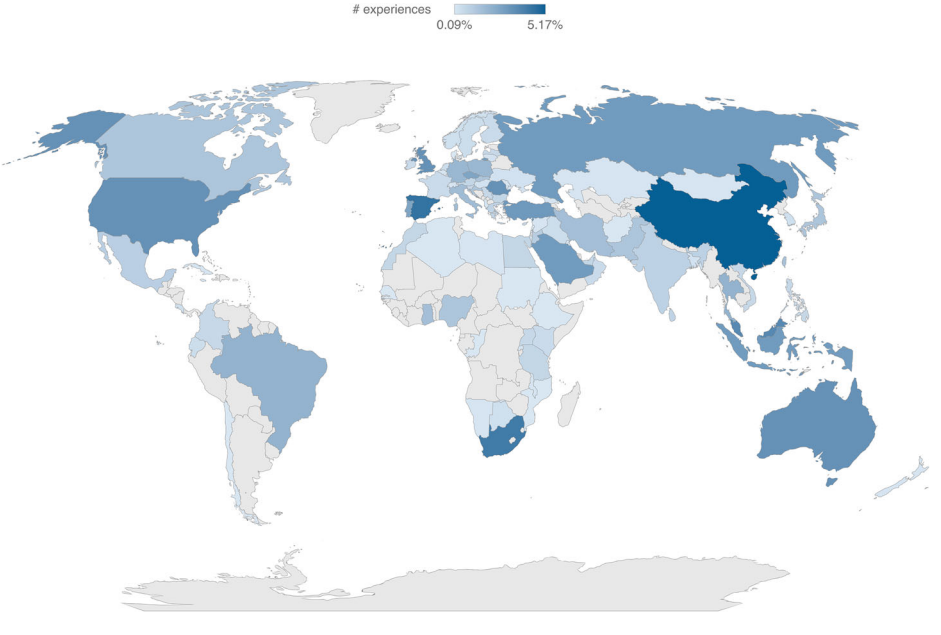

Figure 3. Country distribution of the e-learning experiences from 2001–2020.

Table 1. Main statistics about the studies analysed.

Documents	1,360	Authors	3,270
– *articles*	489	Author appearances	3,629
– *proceedings papers*	865	Authors per document	2.41
– *book chapters*	6	Documents per author	0.42
Sources (journals, books)	710	Single-authored documents	328
Average documents per year	68	Authors of single-authored documents	313
Average citations per document	4.95	Multi-authored documents	1,032
References	26,621	Authors of multi-authored documents	2,957
Authors' keywords	3,237	Co-authors per document	2.67
Keywords Plus (WoS)	600	Collaboration index	2.87

Figure 4 shows the year-wise cumulative distribution of documents published during 2001–2020. On average, 68 documents were produced each year over the last 20 years (with a standard deviation of ±52.40 documents). The annual average growth rate was 123.5%, revealing an increasing interest in e-learning.

Importantly, the development of computer technology and the diffusion of Internet applications in the field of education meant that the number of publications has significantly increased in the last five years. In total, about 50% of the documents appeared from 2016 to 2020, with an average of more than 100 documents per year. The graphical representation shows a strong goodness-of-fit of the production growth curve with a power-law ($R^2 = 0.995$). The observed power-law tendency is undoubtedly a consequence of research propagation in a scale-free system, suggesting that the domain under investigation is currently extremely relevant. This trend in scientific publications on real-world case studies about e-learning in tertiary education will probably continue to increase considerably in the future. This follows the increasing interest in online education, particularly since the changes driven by the SARS-CoV-2 pandemic in teaching and learning.

4.2 Performance analysis

The first trait to consider was the type of publication. About two-thirds of publications appeared in conference proceedings, suggesting that scholars mainly presented and discussed the different

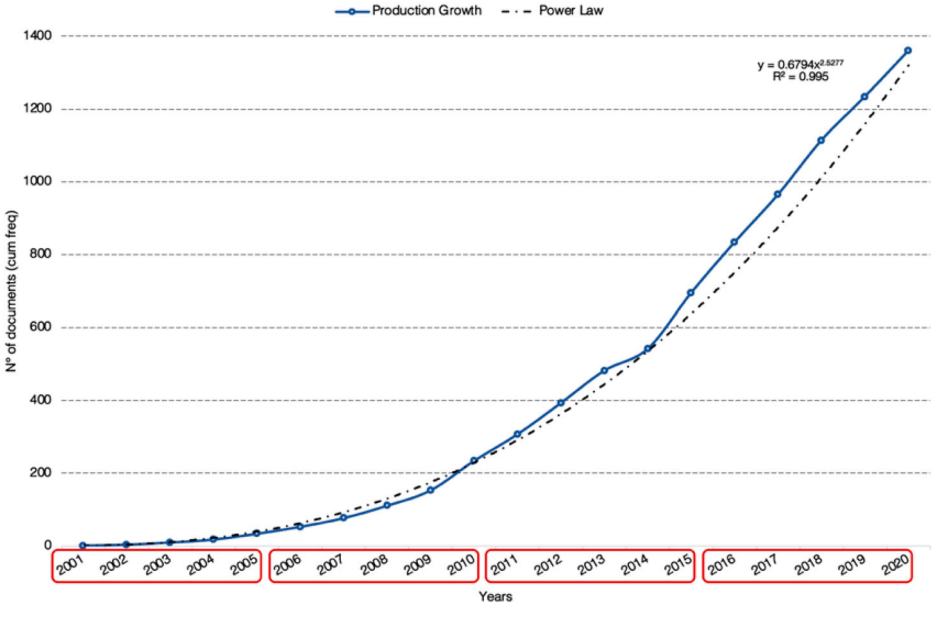

Figure 4. Year-on-year growth and correlation of publications' production from 2001–2020.

experiences of using e-learning in tertiary education during scientific meetings with other colleagues.

Looking at the authorship pattern, the 1,360 documents were written by 3,270 scholars, with an average value of 0.42 documents per author. Only 24.12% of these documents were written by a single author. Valuable preliminary reflections can also be made by looking at the *authors per document ratio*, the *co-authors per document ratio* and the *collaboration index* (Aria, Aria, Misuraca, and Spano 2020). The authors per document ratio shows that each document in the collection was written on average by 2.41 authors. The co-authors per document ratio – the number of times an author appeared in the collection over the total number of documents – showed that there were, on average, 2.67 authors per document. However, the complex nature of interactions arising from authors' collaboration over time means that the nature and magnitude of this cannot easily be interpreted. The average number of authors per document generally ranged between two and three. The difference in the results relies on the different way of counting authors. Authors who had written three different publications were counted only once in the authors per document ratio and three times in the co-authors per document ratio. The collaboration index can be used to avoid this dissimilarity. This index is given by the ratio between the authors of multi-authored articles and the number of multi-authored articles, excluding all publications in which there is no collaboration, i.e. all articles written by a single individual. In the collection analysed, the collaboration index was 2.87, consistent with the results obtained from the other measures.

Several countries have played a primary role in implementing e-learning at an academic level over the last 20 years. Only the countries of the corresponding authors' institution were considered in this evaluation. This was defined as the author's affiliation at the time of publication. Table 2 shows the productivity of the top ten most influential countries in terms of the total number of contributions. China was the leading country in terms of publications on the implementation of e-learning in an academic context (131 documents, 11.52% of the analysed collection), followed by Spain, Malaysia and the US (about 50 documents each). This is very interesting, because in the management field, the USA and UK are generally predominant. One possible explanation is that the growth in the Chinese e-learning market was really significant in the last 5 years, moving from 78.7 billion yuan in 2016–257 billion yuan in 2020 (Statista 2021).

All the leading countries presented a higher number of *single country publications* (SCP) than *multiple countries publications* (MCP), revealing a low propensity for trans-national collaboration. Looking at the *country collaboration rate* (CCR), calculated as the ratio between MCP and the total number of documents per country, we concluded that the UK was most open to scientific collaboration (CCR = 18.42%), followed by Indonesia (16.22%) and Malaysia (15.38%).

About two-thirds of documents appeared as proceedings papers. Table 3 shows the top ten journals and top ten conferences (by the number of publications in the dataset). Some of these sources (first part of the table) are electronic and open journals listed in the *Emerging Source Citation Index*

Table 2. Top ten most relevant countries: productivity and collaboration.

Country	Documents	Freq (%)	SCP	MCP	CCR (%)
China	131	11.52	122	9	6.87
Spain	53	4.66	49	4	7.55
Malaysia	52	4.57	44	8	15.38
USA	50	4.40	49	1	2.00
South Africa	43	3.78	40	3	6.98
Australia	41	3.61	36	5	12.20
Russia	40	3.52	35	5	12.50
United Kingdom	38	3.34	31	7	18.42
Indonesia	37	3.25	31	6	16.22
Romania	35	3.08	33	2	5.71

SCP = single country publication, **MCP** = multiple countries publication, **CCR** = country collaboration rate.

Table 3. Top ten journals and top ten conferences in the field.

Journals	**Documents**
Education and Information Technologies (IF 2.901)	21
International Journal of Emerging Technology in Learning †	21
International Review of Research in Open and Distributed Learning (IF 2.297)	21
Turkish Online Journal of Distance Education †	18
Computers & Education (IF 5.296)	14
International Journal of Advanced Computer Science and Applications †	9
Internet and Higher Education (IF 6.566)	9
Distance Education (IF 1.702)	7
Open Praxis †	7
Studies in Higher Education (IF 3.00)	7
Conferences	**Documents**
International Conference on Education and New Learning Technology (EDULEARN)	110
International Technology Education and Development Conference (INTED)	82
International Conference of Education Research and Innovation (ICERI)	59
European Conference on E-Learning (ECEL)	40
International Conference on E-Learning (ICEL)	27
World Conference on Educational Sciences (WCES)	15
International Conference on New Horizons in Education (INTE)	12
International Symposium on Educational Technology (ISET)	10
International Conference on E-Learning (ECONF)	10
International Multi-Conference on Society Cybernetics and Informatics (IMSCI)	9

†Indexed in the ESCI list.

(ESCI), so they are not included in the annual Journal Citation Reports published by WoS. These journals are mainly published by academic institutions or scientific associations.

The other journals, listed in the *Social Sciences Citation Index* (SSCI), showed a *two-year impact factor* (IF) for 2019 that was higher than the median value of 1,585 (computed by considering all 263 journals indexed in the 'Education & Educational Research' WoS category). Three major conferences in the list, EDULEARN, INTED and ICERI, were all promoted by the *International Academy of Technology, Education and Development*, an organisation devoted to promoting education and cooperation among universities in the technological and scientific sphere.[1]

The dataset was also used to identify the most cited publications related to e-learning and tertiary education, as shown in Table 4. The most cited publications in the dataset (Ozkan and Koseler 2009; Park 2009; López-Pérez, Pérez-López, and Rodríguez-Ariza 2011) all referred to students' acceptance and perceptions of the new technologies in an educational context. Other publications focused on implementing e-learning systems in practice (Graham, Woodfield, and Harrison 2013; Bernard et al. 2014; Porter et al. 2014). The discussion section of this paper includes an in-depth evaluation of the main contributions.

4.3 Science mapping analysis

For the thematic analysis, and to explore the thematic evolution of e-learning experiences in tertiary education across the last 20 years, we focused on the keywords used by authors in their publications. We preferred to look at this set of keywords rather than the keywords automatically attributed by the indexing databases, because this gave a broader spectrum of themes. Bibliographic catalogues need some standard keywords to allow users to search across disciplines, because different disciplines focused on similar phenomena may share part of the literature. Some information used by authors to categorise their work may be lost in this normalisation process. However, analysing authors' keywords requires careful pre-treatment to avoid unnecessary duplication of terms because of the use of alternative spellings, singular and plural, and acronyms for well-known approaches and techniques.

Table 1 shows that the studies analysed included 3,237 keywords chosen by the authors. We replaced acronyms (e.g. 'ICT' became 'information and communication technology') and normalised

Table 4. Top ten most cited publications.

Author/s, Year, Source	Title	GC	LC	LC/GC ratio
Park 2009, Educ Technol Soc	*An analysis of the technology acceptance model in understanding university students' behavioral intention to use e-learning*	501	25	4.99
López-Pérez, Pérez-López, and Rodríguez-Ariza 2011, Comput Educ	*Blended learning in higher Education: students' perceptions and their relation to outcomes*	259	18	6.95
Ozkan and Koseler 2009, Comput Educ	*Multi-dimensional students' evaluation of e-learning systems in the higher education context: an empirical investigation*	254	15	5.91
Graham, Woodfield, and Harrison 2013, Internet High Educ	*A framework for institutional adoption and implementation of blended learning in higher Education*	183	22	12.02
Bernard et al. 2014, J Comput High Educ	*A meta-analysis of blended learning and technology use in higher Education: from the general to the applied*	152	8	5.26
Porter et al. 2014, Comput Educ	*Blended learning in higher Education: institutional adoption and implementation*	140	12	8.57
Owston R et al., 2013, Internet High Educ	*Student perceptions and achievement in a university blended learning strategic initiative*	124	10	8.06
Mahdizadeh H et al., 2008, Comput Educ	*Determining factors of the use of e-learning environments by university teachers*	99	5	5.05
Islam 2013, Comput Educ	*Investigating e-learning system usage outcomes in the university context*	98	5	5.1
Martinez-Torres MR et al., 2008, Behav Inform Technol	*A technological acceptance of e-learning tools used in practical and laboratory teaching, according to the European higher education area*	91	3	3.3

GC = global citations, LC = local citations.

the spelling of terms. We also altered terms' declension by changing plurals to singulars. Finally, we deleted keywords used in the query from the transformed vocabulary because they were present in more or less all the documents, and therefore had low informative power. This gave a set of 3,050 unique terms. Six publications were categorised only by keywords used in the query, leading to the exclusion of these documents.

The 20 years initially considered in the study were divided into four five-year subperiods (2001–2005, 2006–2010, 2011–2015 and 2016–2020) to analyze the conceptual framework and explore the evolution of themes across the periods. This subdivision into multiple time periods, in the context of scientific mapping, as we said before, allows us to capture the development of the field over time (Zupic and Čater 2015). It also allows us, for each time period, to separately analyze and compare bibliometric data to find changes in the structure of the field. This longitudinal analysis can reveal how particular groups within an intellectual structure emerge, grow or vanish.

Specifically in our survey, the themes were automatically labeled, using the Callon strategic diagram we talked about earlier, considering the most relevant term in each corresponding subnet, observing the number of connections with other terms. Resuming the subdivision of the topics covered in: engine, base, emerging / declining and niche, the following emerged.

Figure 5 shows the conceptual structure for 2001–2005. This period contained 34 publications, and provided a limited number of themes. Notably, *virtual university* and *computer-based training* were motor themes, and issues related to the Internet were niche themes in the domain. Figure 6 shows themes relating to e-learning and post-secondary institutions in 2006–2010. There were about five times more publications in this period than in the previous period (199 documents). The motor themes included issues related to the organisation of the infrastructure used in e-learning (e.g. *learning management system*, *online learning environment*).

The basic themes included creation of a *virtual learning environment* and the use of ICT. *Virtual university* and the use of the Internet shifted to the bottom-left of the diagram as emerging themes. Interestingly, the use of acceptance models to evaluate the impact of the new generation of distance learning appeared as a niche theme, together with a more general discourse on *knowledge society* and *collaborative learning*.

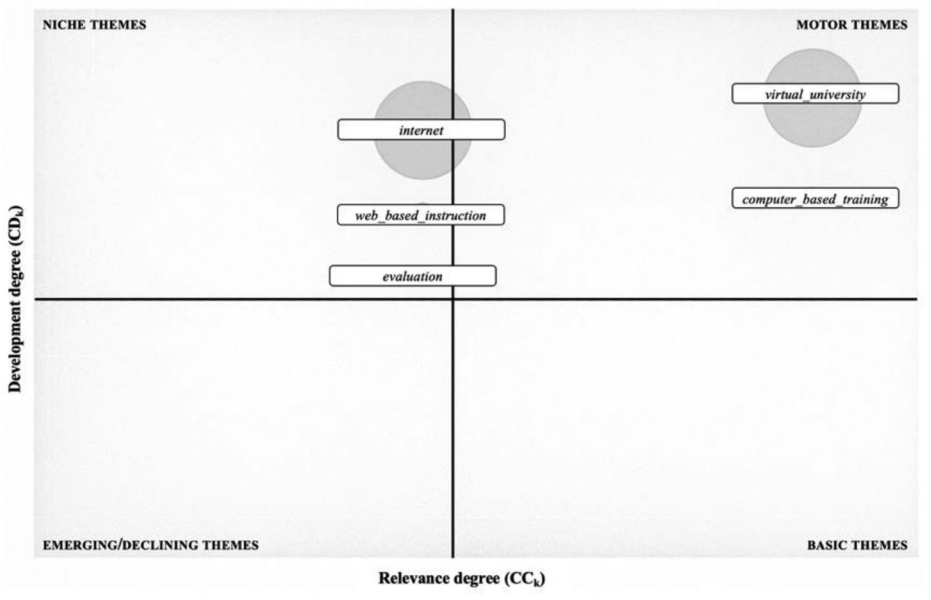

Figure 5. Strategic diagram for the 2001–2005 sub-period.

The following five-year period (2011–2015) is shown in Figure 7. This shows an increase in the complexity of conceptual structure. The 458 documents published in this period show the shift of the fifth generation of distance learning towards a new phase, with *web 2.0* as a motor theme covering the strengthening of Internet education and web-based ICT. The use of these technologies in the field of English teaching appeared as an emerging theme, and a reference to *cloud computing* and new strategies in teaching/learning was a niche theme.

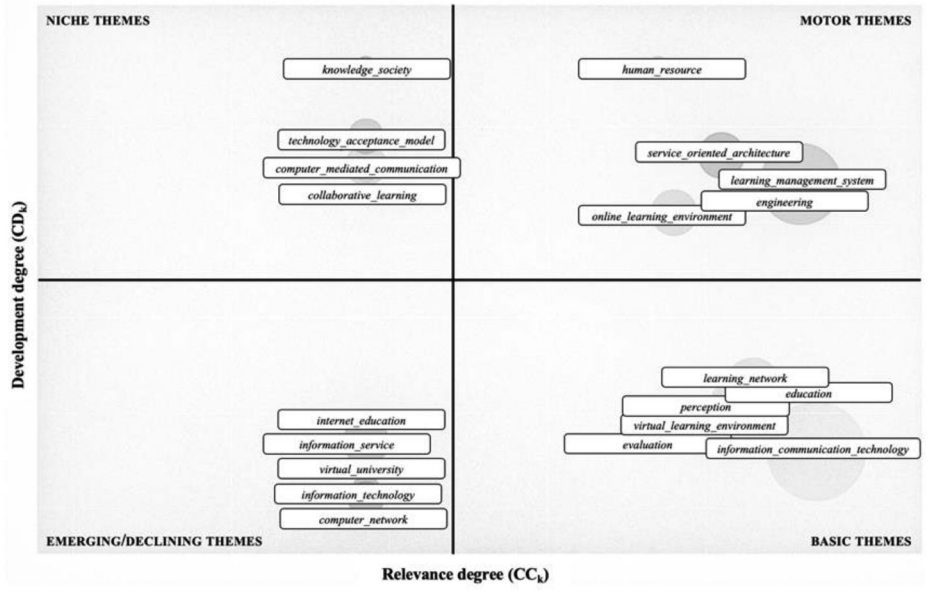

Figure 6. Strategic diagram for the 2006–2010 sub-period.

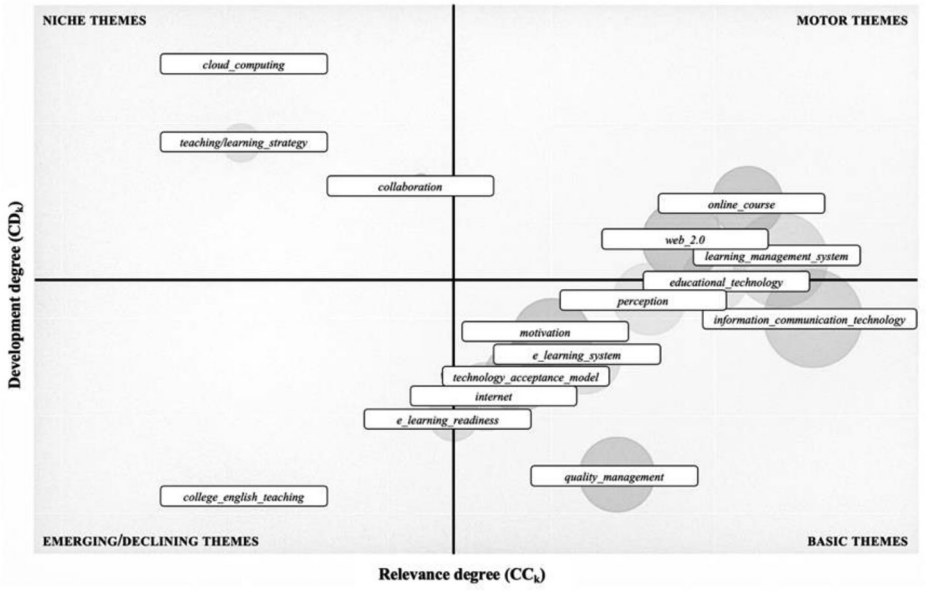

Figure 7. Strategic diagram for the 2011–2015 sub-period.

The most recent period, covering 2016–2020, is shown in Figure 8. This is probably the most noteworthy for several reasons. First, this period produced about half of the studies analysed (663 documents). This period also covered the consolidation of the sixth generation and the dawn of a new stage of distance education. The worldwide COVID-19 crisis (a motor theme in the 2016–2020 strategic diagram) meant that many institutions had to improve their ICT infrastructures and rethink their teaching/learning strategies. Basic themes of the period were the use of *moodles* (one of the

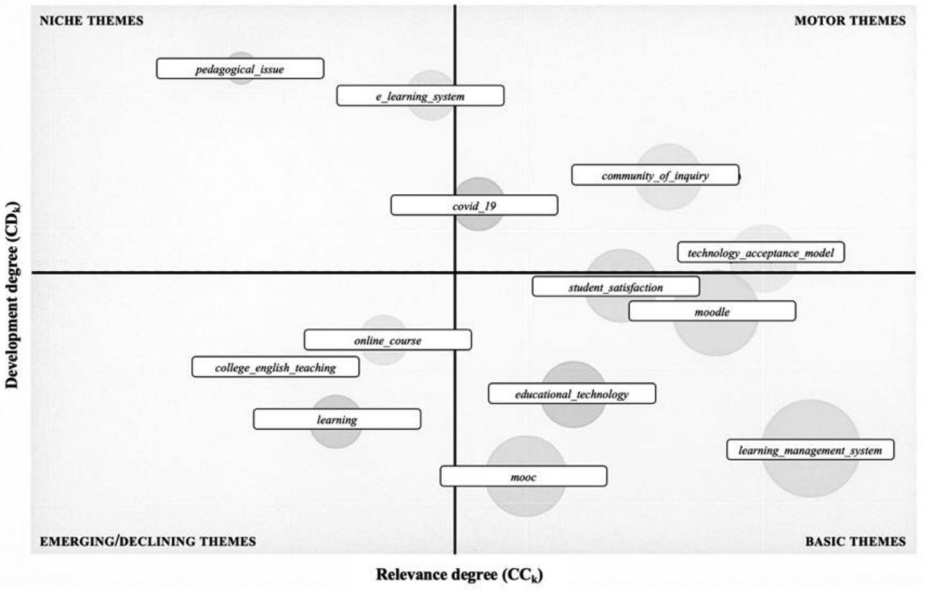

Figure 8. Strategic diagram for the 2016–2020 sub-period.

most popular *learning management systems*) and other systems, within the framework of the latest concept in online courses, or MOOCs. The use of e-learning systems in language education was an emerging theme, with a very light increase in the density of the topic. The presence of *online course* in this part of the diagram highlights the transformation led by massive courses. Finally, the debate about the pedagogical aspects of e-learning was a niche theme in the period.

5. Discussion

5.1 Sankey's diagram

Figure 9 shows a Sankey plot linking the four sub-periods (2001–2005, 2006–2010, 2011–2015, and 2016–2020). It shows the development of the different themes discussed in the literature and the distribution of the research topics developed (Wang, Ban, and Hong 2021). The extent of each flow connecting two themes graphically represents the magnitude of their conceptual nexus.

Given that Sankey diagrams are an effective way to see the volume of flow through a multistep process or system (Brath and Jonker 2015) and to show how different data elements are connected (Ramasubramanian and Singh 2017). Streams are conventionally arranged left to right, and the width of a link indicates the volume of the flow (Brath and Jonker 2015). Inbound links always enter a node on the same side at right angles and outbound links go out the same way on the opposite side. On each side of the node, the links are stacked at the entry and exit points to represent the total volume in and out.

Specifically, we used the Sankey diagram as shown in Figure 9 following the reasoning logic indicated below.

First of all, for each sub-period (2001–2005, 2006–2010, 2011–2015 and 2016–2020) the main issues identified from a quantitative point of view and their relevance were presented. These individual themes reappeared or not in the following period or were split in the further phases into new lines of research. In the first case, the same argument was repeated in a slavish manner in the following moment or it did not really emerge. In the second, the connection of one topic to another is attributable to the fact that a topic in the following period was included in the context of another, broader topic in terms of dissemination.

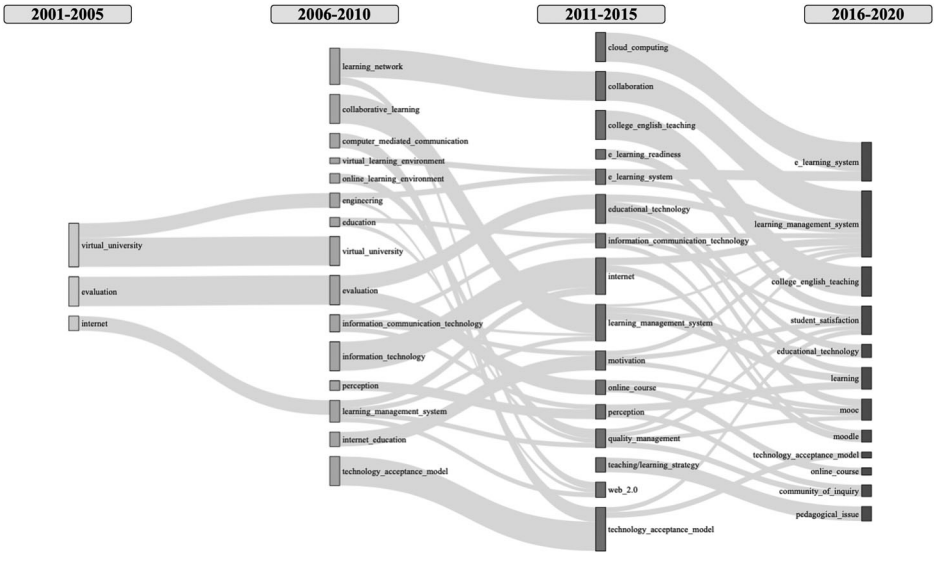

Figure 9. Thematic evolution across the four sub-periods from 2001–2020.

Secondly, the use of the Sankey diagram in this study was not to present a summary of our results. Instead, we would like to discuss some general and relevant issues that emerge from our data. Our findings are too extensive to allow us to explore specific individual topics in depth, so instead we want to offer an overview and discuss some critical issues.

Some fundamental elements emerge from the analysis of the diagram in its entirety used by us (Figure 9) in this survey.

First of all, the first three lines of research on e-learning in the academic context that spread during the first sub-period (2001–2005) expanded in the second (2006–2010) and third (2011–2015) phase and then narrowing into quantitatively very significant categories during the last phase (2016–2020). This could indicate a path of the discipline which, after a first phase of growth towards very different paths, has tried to focus on the issues considered most relevant.

Secondly, it should be noted that the Learning Management System category that begins to develop during the second (2006–2010) and third period (2011–2015) constitutes the most consistent area in the fourth phase (2016–2020) where in-depth studies converge on collaboration and on e-learning and ICT systems and on the concept of motivation and quality management.

Thirdly, the role of managerial contributions emerges both in terms of strategy and quality in the third period (2011–2015), and in terms of organisational behavior (eg user reaction, student satisfaction).

Finally, a theme that emerges as central is that of evaluation (which we are currently dealing with in phase 1 and 2 but without continuity). This topic converges in the third period into two areas which are educational technology and online course.

5.2 Main findings

The Sankey diagram in Figure 9 therefore highlights the main issues relating to e-learning in the academic field in the four sub-periods, as we have already anticipated, characterised by a five-year cycle. Specifically, the major trends that have been studied and highlighted in this context have been reported in Figure 10.

PHASE 1: 2001–2005. Two main trends of the study emerged at this early stage: virtual university and evaluation. The Virtual University theme appeared in the contribution of Cochard and Marquie (2004). These authors highlighted the importance of offering specific e-learning study programs in the Information Systems Engineering curriculum at a university in France. This allowed students who worked or were unable to continue in person to attend training courses virtually. This research clearly explains how a distance teaching program called International E-Miage (IEM) was implemented, giving a better understanding of the functioning of the virtual university.

The second theme in this sub-period was the issue of e-learning evaluation. For example, the study by Gnudi, Lorenzi, and Malvisi (2004) proposed an evaluation of the two ways of delivering teaching activities: face-to-face and online, using the example of didactic activity carried out through blended learning within a computer science course for students of the economics faculty of an Italian university. The study showed that the adoption of blended learning was associated with some changes among students, in terms of autonomous learning and a shift towards a collaborative community where the teacher is not at the centre, but participates as a colleague. These two lines of research (Virtual University and Evaluation) in this first sub-period allow us to introduce the general theme of e-learning within the international scientific community.

PHASE 2: 2006–2010. The main areas of study in this second cycle focused on: Evaluation; Learning Network; Collaborative Learning; and the Technology Acceptance Model (Figure 10). We can see how the issue of e-learning evaluation was taken up from a different point of view in this second sub-period. The study by Ozkan and Koseler (2009) proposed a conceptual hexagonal model of evaluation of e-learning and the learning management system (LMS). This type of evaluation focuses on the overall satisfaction with e-learning based on the perceptions of the students.

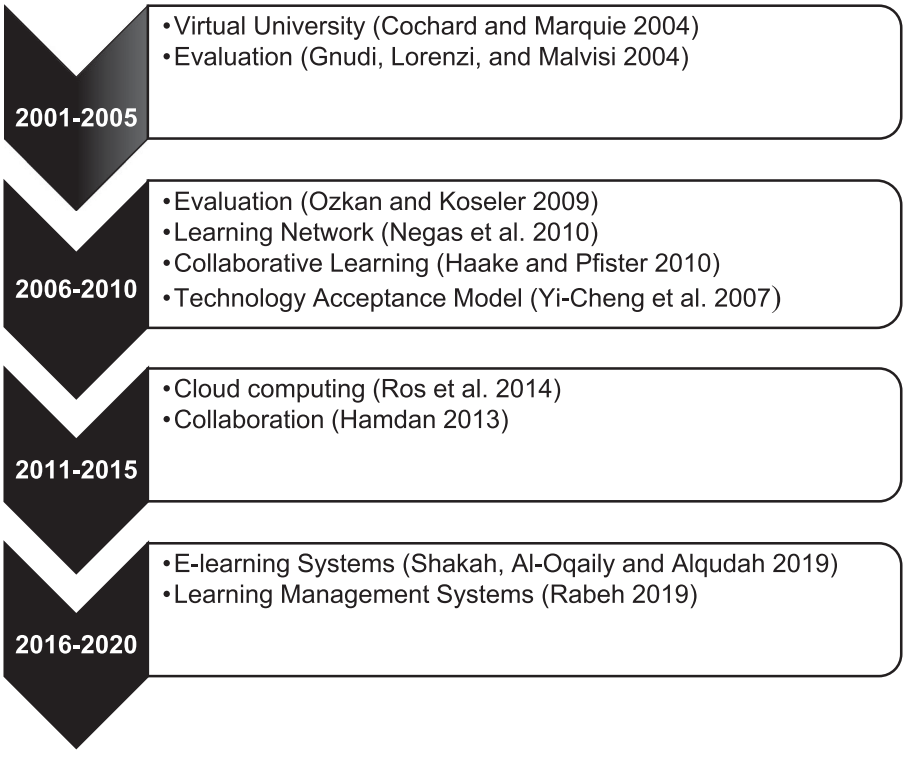

Figure 10. Main research studied based on Sankey diagram data.

In the same period, studies began to consider the use of the Learning Network in academic contexts. For example, Negas et al. (2010) used a consolidated review to demonstrate the pedagogical potential of an e-learning model that uses social networking. These tools can create awareness among students of learning through a new teaching method that allows them to share information and resources originally developed for their own use.

This sub-period also saw themes connected to Collaborative Learning become widespread. These studies included Haake and Pfister's (2010) experimental research on collaborating with scripts for network-based learning as part of a six-month university course on operating systems. In this scripted collaboration, the activities of the learners were coordinated and guided according to particular rules, implemented through tools in the learning environment. The survey focused on the students' use of three types of collaborative tasks: brainstorming, clustering and essay writing. The findings suggest that scripting may provide slightly more support in more complex tasks such as essay writing, than in undemanding tasks such as brainstorming.

Finally, the theme of the Technology Acceptance Model (TAM) also emerged in this second phase. Yi-Cheng et al. (2007) attempted to extend this model into an asynchronous e-learning system for university students. The empirical results showed that perceived pleasure and self-efficacy on the part of learners had the most significant direct effects on the perceived usefulness and perceived ease of use of e-learning. This suggests that universities need to deliver pleasurable content and effectively design and implement e-learning systems with care to avoid the risk of reducing students' interest and attention. The four contributions in this second sub-period all shared a common feature: the type of stakeholder selected as the sample of the empirical survey. All the interviews were conducted with the users of the e-learning services, i.e. university students.

PHASE 3: 2011–2015. Research in this further period research focused in particular on issues related to cloud computing and collaboration (Figure 10). For example, Ros et al. (2014) presented

a cloud computing-based web application management architecture, which combined local and public cloud resources to be implemented within universities' e-learning services. This infrastructure allowed universities to reduce inefficiencies and electricity costs resulting from the adoption of traditional e-learning systems.

Hamdan's article (2013) introduced an inter-dependent strategic collaborative model to enable academic and professional needs to be met. The article suggests that well-organised professional development workshops, micro-training sessions and continuing education programs are needed to bridge the digital divide between digitally savvy students and unskilled professors, and to guide students into cyberspace. This need of supporting competency development is most recently addressed as well when societies are becoming aware the linkage of eLearning and eScience and focus on the development of Training towards a society of data-savvy information professionals to enable open leadership Innovation (Apaolaza et al. 2021).

Two fundamental elements emerge from these two studies. They introduce a new concept, cloud computing, as a way to improve performance within academic contexts. Hamdan's (2013) article revived the idea of collaboration from previous periods, but with a new look. In this sub-period, the collaboration was between the teaching staff and the technicians providing the e-learning services.

PHASE 4: 2016–2020. For the past five years, it is worth mentioning studies that focused on E-learning Systems and Learning Management Systems (Figure 10). The main objective of the study by Shakah, Al-Oqaily, and Alqudah (2019) was to explore students' motivation to use the e-learning system in Jordanian universities. The results show the importance of avoiding various difficulties of e-learning systems to improve students' motivation to use these systems. The study showed that students will use e-learning systems if they are able to guarantee low technical requirements, high level of interactive communication with teachers and reduction of learning time and effort compared to traditional teaching.

Rabeh's (2019) study showed teachers' tendencies to use the e-learning management system and identified the main obstacles that limited their use of the system. The results showed that there must be a concerted effort between decision makers and teachers to enable students to use e-learning management systems, and a focus on its speed of use, as well as more training courses on its use.

These last two studies raised two fundamental questions. First, both studies show a focus on the importance of the use of e-learning systems and Learning Management Systems. Second, the empirical surveys were aimed at two different types of users. Shakah, Al-Oqaily, and Alqudah (2019) analysed university students. However,Rabeh's (2019) survey sample was faculty members at the university.

5.3 Final theoretical reflections

We suggest that two aspects are particularly relevant. The first is related to the perspective adopted for thinking about e-learning. The second concerns the role of e-learning in the future, and the adoption of hybrid learning. On the first point, the change of paradigm is really interesting. Using a managerial lens, it is clear that researchers moved from considering the teacher as the central player in the e-learning process (at the beginning of the 2000s) to focus on the student. This idea is clear in consideration of issues such as perception, motivation or satisfaction.

The thematic evolution of e-learning, and particularly its implementation and the experiences in a tertiary education context, cannot be seen merely as a result of technological innovation. In the early 2000s, classic learning models were driven towards a blended learning paradigm, with successful and less successful educational approaches realised by using ICT as a learning environment. In the initial phase, e-learning mainly focused on teacher-centred approaches (González 2010; Scott 2016). It then started to shift to different frameworks more oriented towards learners, from the *open and distance learning* (ODL) approaches to the novel concepts of telecommunication (Köhler 2003).

Obviously, it makes sense to sort the development of e-learning across different phases in chronological order. However, the thematic development cannot be seen only as the result of the arrival of new digital technologies. In the early phases, e-learning focused on the classic teacher-centred model of education. However, the research accelerated and started to focus on new paradigms of education, especially more learner-centred approaches. Reese (2015) suggested that for online learning to be effective and meaningful, it must provide students with something more than data transmission. Students must have the opportunity to become participants and creators, just as in everyday life, through connectivism.

On the second issue, Fischer et al. (2015) reported interesting findings of a trend study on e-learning frontiers and trends in academic teaching. They suggested that e-learning is only one of the major tendencies in digital education. It is surrounded (and will eventually be substituted) by further developments like MOOCs, mobile learning portfolios or virtual worlds. The COVID-19 pandemic has produced a new wave of e-learning implementations, but has not changed all the various formats in the same way. For example, video-based content and data-driven online assessments have shown slight progress, while classic e-learning appears to have reached its maximum innovation potential. It would be desirable to provide a further in-depth analysis of the last phase of the study period at the end of the global health crisis, when it will be possible to evaluate the impact of these technologies in all sectors of education.

E-learning is changing how we look at the traditional learning process. It is influencing choices through the benefits of mixed methods, especially in higher education. We recommend that the latest phase should be interpreted when the pandemic's first wave is ended. We expect to see an everyday implementation of e-learning in almost every education sector by that point. However, this may also be seen as a further extension of the recent phase of e-learning towards a reframed concept of so-called hybrid learning.

6. Conclusions

The aim of this research was to examine the main studies on e-learning experiences in tertiary education in the last 20 years from 2001 to 2020. The analysis began in the 2000s, because this allowed us to explore the emergence and dissemination of the last two generations of distance learning, with their specific use of information technologies. There had been six generations of distance learning at that stage, based on the type of ICT used within the academic context (Kimani 2019; Taylor 2001). Over the period, there have been numerous studies on e-learning in tertiary education (Hwang and Arbaugh 2006; McKenzie et al. 2022). However, the advent of the health emergency resulting from the SARS-CoV-2 pandemic meant that universities and colleges have been forced to rapidly and widely implement new strategies for distance and online learning (Ebner et al. 2020; García-Peñalvo et al. 2021).

This has resulted in the emergence of a new epoch of distance learning: the seventh generation characterised by the use of blended learning. Yet the New Media Consortium Horizon Report in the 2017 publication had already identified among the short-term emerging trends for the use of technology in higher education: Blended Learning Designs and Collaborative Learning (Adams Becker et al. 2017). The pandemic situation has reinforced this use of blended learning and collaborative learning in educational context.

Furthermore, these reflections lead to some fundamental directions. First of all, the 20-year research period was divided into four five-year sub-periods (2001–2005, 2006–2010, 2011–2015, and 2016–2020) to examine the evolution of the topics identified on e-learning. Of the 1,360 documents found on e-learning in the academic context, no less than 663 were from the most recent period: 2016–2020. This is about 50% of the total number of documents examined, and more than 100 studies per year.

Secondly, since the majority of articles were from 2016–2020, there are some obvious conclusions. The basic themes of this last five years were the use of learning management systems (such as

Moodle) and other systems (such as MOOCs). An emerging theme related to the use of e-learning systems in language teaching. The niche theme was the debate on the pedagogical aspects of e-learning.

Specifically, the attention of the studies towards newly opened technologies is obtaining a great diffusion in practical terms, since it would allow anyone to use the teaching material without having to demonstrate the access requirements or to obtain an authorisation (Marquet and Köhler 2017). The focus would be on interest in a topic or object, which is like a freely accessible library, but without the need for organisational commitment (enrolment in a university course).

Finally, our study has some limitations, mostly related to the bibliometric approach itself. In bibliometric analyses, there are often false positives and false negatives, because it is almost impossible to generate a complete and comprehensive query. We decided to retrieve only publications indexed in WoS, because of the perceived quality of information. Clearly, an integration with other sources (e.g. Scopus) could enrich the results. However, the higher cost in terms of data preparation and processing do not necessarily ensure that the analysis will have greater informative power. Furthermore, some publications might have been published in resources that are not yet indexed, and therefore cannot be retrieved. The survey was limited to publications in English, potentially missing relevant contributions in publications in other languages. The studies analysed might therefore not precisely reflect the sum of the research activity on e-learning implementation in the last two decades. However, our data have provided significant insights into the current state of the field and possible future developments of e-learning in an academic context.

Note

1. The impact factor of a journal for year *t* is calculated as the ratio between the total citations in *t* of documents that appeared in *t−1* and *t−2* and the total citable documents in the same time interval.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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