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Podcast in Education: Performance and Co-Word Analysis in WoS

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Abstract: Podcasts have become a digital resource currently used as a means of transmitting information. In the educational area, podcasts have shown a great didactic potential that can be designed by both teachers and students for different purposes. The aim of this study is to analyse the concept of podcasts in the field of education. To do so, a bibliometric methodology has been used. This is based on a documentary analysis and scientific mapping by means of co-word analysis of the reported literature. The study focused on the Web of Science database. A unit of analysis of 439 documents was used. The results reveal that publications on the state of the art have been of interest to the scientific community in recent years. In addition, research is focusing on the pedagogical methods used for their application in learning spaces, the technological resources used for their development and the benefits they generate in students.

Key-words: podcast; literature review; scientific mapping; scimat; co-word analysis.

1. Introduction

Throughout its history, society has undergone major changes. In recent times, these changes have been marked, among other aspects, by the evolution of information and communication technologies, commonly known as ICT

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(Moreno-Guerrero et al., 2021). Thanks to this evolution, various technological resources have emerged, including podcasts.

Podcasts have their origin from the union of the terms "iPod", due to the audio system that Apple's iTunes system established in its beginnings; and the term "broadcast", related to the dissemination of content (Ferreira et al., 2020). Podcasts are defined as a multimedia resource for regular digital publishing (Kennedy et al., 2018; Shamburg, 2020). Such a resource is primarily in audio format, although it may also be available in video format (Mirza, 2020). Podcasts can be downloaded to any device, as long as there is an internet connection and an application for receiving, managing and listening or viewing (Wentzel and De Hart, 2020). In addition, podcasts can be included on a website or blog, but can also be listened to on platforms such as iTunes, Spotify, SoundCloud or Ivoox (Riddell et al., 2020). Podcasts should not be confused with radio, since podcasts can be listened to at any time, asynchronously. Radio programmes are played synchronously (McNamara and Drew, 2019; Rockhill et al., 2019).

Podcasts are mainly characterised as a digital resource, mainly audio, which allows combining voice, music and various sound effects (García-Marín and Aparici, 2020) and are usually free of charge (Konig, 2020). They can also be in various audio formats, although the most commonly used is mp3 (Barnes et al., 2020). They are often hosted on websites, for downloading or listening (Newsom et al., 2019). In addition, they have a wide variety of subject matter, ranging from news to the presentation of educational content (Woods et al., 2020). They are usually created by experts in a particular subject area (McNamara and Drew, 2019). To generate a podcast, a digital recording system is needed (Ibarra, 2019). In addition, podcasts offer a personal and even emotional link between the author and the listener (Blum, 2018).

In order to create a podcast, a series of steps or phases must be taken into account. Firstly, it requires pre-production, where the author identifies the subject to be dealt with, analyses it in depth and writes the content to be explained. Secondly, it requires production. In other words, the recording of the content, requiring a digital recording and editing system. Various resources and audio effects can be used in the recording. Thirdly and finally, post-production is needed, analysing the work done, retouching and publishing the content generated (Killean and Summerville, 2020; Tarchichi and Szymusiak, 2020).

In education, podcasts have not gone unnoticed. They can be created by the teachers themselves, or even by the students themselves. Everything will depend on the purpose of the teaching and learning processes established. As in any educational process, creativity plays a fundamental role in the use of podcasts in education (Ferrer et al., 2019; Kane et al., 2019; Leton et al., 2018; Rowell, 2019). Podcasts can be used with innovative methods such as

flipped classroom or project-based learning, among many others. It can also be used as a supplement to educational sessions or as reinforcement material for parents and learners. Or they can even be used to share experiences and resources in teacher networks. They can also be used by students for content creation (Besser et al., 2021; Celaya et al., 2020; Maher et al., 2020; Makina, 2020).

Educational research on the use of podcasts shows how they increase praise in students' behaviours, thus improving their predisposition towards learning (Miller and Uphold, 2021); improve student interest and motivation in teaching and learning processes (Berk et al., 2020; Elekaei et al., 2019; Rodman et al., 2021; Sendag et al., 2018); and are accepted by students as an educational resource (Bueno-Alastuey and Nemeth, 2020; Young et al., 2021).

Moreover, they improve students' academic performance (Bianchi-Pennington, 2018; Elekaei et al., 2019; Mnatzaganian et al., 2020); increase self-reflection, self-awareness and metacognition (Fouz-Gonzalez, 2019; Jeong, 2019; Matulewicz et al., 2020); enhance creativity and self-expression (De los Ríos, 2020; Kornieva and Vashchylo, 2019); consolidate learning and autonomous learning (Samuels et al., 2020; McNamara and Haegele, 2020; Wall, 2019); enhance students' listening skills (Stefancik and Stradiotova, 2020); and enable the generation of unique learning environments (McNamara and Drew, 2019).

In conclusion, podcasts in the field of education are a versatile and adaptable techno-pedagogical resource that can generate many benefits in the teaching and learning processes. This can be reflected positively in student learning (Dmytriieva, 2018).

2. Justification and Objectives

This paper is based on the importance that information and communication technologies (ICT) have reached nowadays (Blanco et al., 2015; Ortiz-Echeverri et al., 2018). This projection has been increased not only as a consequence of the technological evolution that society has experienced in recent years (Rodríguez-Reséndiz et al., 2012; Rodríguez-Ponce et al., 2015), but also due to the impact of COVID-19 on people's daily actions, as many processes have been digitised (García-Peñalvo and Corell, 2020). This study derives from the project entitled Study on pioneers and founders of Sociology (Code EXP 118/21).

In order to carry out this study on the projection of podcasts in the field of education (PODCAST-EDU), a bibliometric aspect of the research was used. That is, bibliometrics has been used to ascertain the state of the question. This research methodology focuses on the analysis of published scientific documentation (Carmona-Serrano et al., 2021). With this, a state of

the art on the subject under analysis can be revealed to the scientific community. All this thanks to the study of various variables such as authorship, keywords, journal, countries, language, source of origin, among the most important (Corell-Almuzara et al., 2021).

The selection of the database in this type of study is essential. Specifically, for this work, the Web of Science (WoS) database has been selected as a repository that covers a large volume of documents referring to the Social Sciences and due to the relevance of this database in the Journal Citation Reports (JCR) (López-Belmonte et al., 2020; Martín-Martín et al., 2018).

The purpose of this research is to analyse the concept of PODCAST-EDU in WoS publications. After this analysis, it will be possible to generate new knowledge about the projection of this concept. This will allow readers to reflect on the path already travelled, as well as to draw new lines of action, based on what has already been collected in the published literature. Due to the novelty of this study, this work is positioned under an exploratory aspect. In short, the objectives of this research are the followings: (1) To find out the documentary performance in WoS on PODCAST-EDU; (2) To determine the scientific evolution in WoS on PODCAST-EDU; (3) To reveal the most significant topics in WoS on PODCAST-EDU; (4) To locate the most influential authors so far in WoS on PODCAST-EDU; and (5) To predict the most important topics and authors in WoS on PODCAST-EDU.

3. Method

In this research, an analysis of the literature concerning PODCAST-EDU is carried out, from the analysis of documentary development to a co-word analysis as an innovative approach based on scientific mapping. In order to carry out the study correctly, the guidelines of experts in this particular spectrum of bibliometrics were followed (Carmona-Serrano et al., 2020; Segura-Robles et al., 2020). Likewise, the analytical model presented in previous impact studies has been used. All this has been done in order to produce and present an analysis of the state of the art in a relevant and unbiased manner (López-Belmonte et al., 2021; Marín-Marín et al., 2021).

3.1. Research Design

Bibliometrics has enabled the development of various processes (literature search, registration, analysis and prediction) (Mac Fadden et al., 2020). These processes are necessary for the achievement of the objectives. In addition to these actions, an analysis of co-words (Hirsch, 2005; López-Belmonte et al., 2019) and various indices such as h, g, hg and q2, was carried out. All this gave rise to different maps with nodes representing subdomains

with the reported concepts. Also, these maps reveal the evolution of the topics addressed in the literature over time (Moreno-Guerrero et al., 2020).

3.2. Procedure

Based on previous studies (Moreno-Guerrero et al., 2022), the research has followed a series of actions: 1-Selection of the database (WoS); 2-Definition of the search concept (podcast); 3-Development of the search equation ("podcast*") for its application in the metadata title of the publications; 4-Concretion of the search, to refine the results, selecting the categories of education (Education Educational Educational Research, Education Scientific Disciplines, Education Special and Psychology Educational). In addition, various WoS indexes were covered (SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI, CCR-EXPANDED, IC).

These actions allowed a report of 457 publications. In order to refine the volume of documents, various criteria were used for both inclusion (all years except 2021, where one document was found because it had not been finalised) and exclusion (repeated or poorly indexed documents = 17). This produced a final unit of analysis of 439 documents.

Similarly, the sequence of processes articulated in the PRISMA protocol for this type of study was used as a reference.

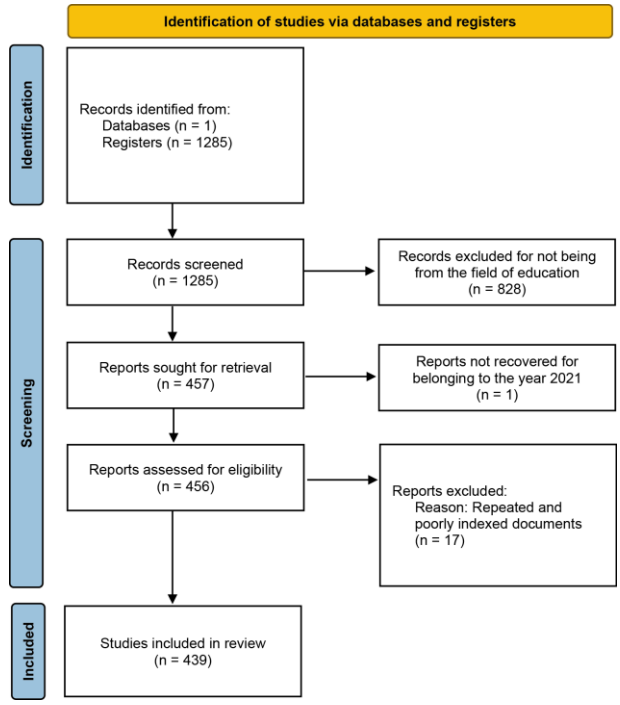


Figure 1. Flowchart according to the PRISMA declaration.

Due to the large amount of information reported and the limitations to reflect all data in a single document, several requirements have been established for a correct representation of production and performance: language ($x \geq 2$); areas of knowledge ($x \geq 16$); type of documents ($x \geq 30$); institutions ($x \geq 6$); authors ($x \geq 4$); sources of origin ($x \geq 8$); country ($x \geq 11$); and the four most cited documents.

3.3. Data Analysis

The data analysis was carried out using three applications. In order to know the authorship, country, type of document, institution, language, medium and most cited documents, two WoS tools integrated in its platform (Analyze Results, Creation Citation Report) were used. SciMAT was used to carry out the structural and dynamic longitudinal development of the extracted documents. This programme also allowed the co-word analysis to be carried out. For optimal use of the software, the considerations of experts and previous studies (Soler-Costa et al., 2021) were taken into account.

In order to develop the co-word analysis, the following processes were carried out:

- Recognition: 1035 keywords were analysed from the document volume. After a purification process, 982 keywords were identified. Then, maps of co-occurrence nodes and a normalised network of contiguous words were drawn up. Finally, using a clustering algorithm, the most prominent themes and concepts were identified.
- Reproduction: the thematic connections and strategic maps were designed. The latter are articulated in four zones. The upper right zone compiles the relevant and driving themes. The upper left zone contains the isolated and entrenched themes. The lower left zone sets out the disappearing or projected themes. The lower right zone reflects the cross-cutting or underdeveloped themes. In all these actions carried out in this process, the principles of density (internal strength of the network) and centrality (level of terminological connection) have been taken into consideration.
- Determination: the volume of documents was divided into three time periods (P1 = 2005-2010; P2 = 2011-2015; P3 = 2016-2020). For the authors' analytics, a single period (PX = 2005-2020) was configured. The strength of association between the periods is extracted through the number of common keywords or themes.
- Achievement: in order to carry out this process it is necessary to establish the output indicators together with their inclusion criteria (Table 1).

Configuration	Values
Analysis unit	Keywords authors, keywords WoS
Frequency threshold	Keywords: P1 = (2), P2 = (2), P3 = (2) Authors: PX = (2)
Network type	Co-occurrence
Co-occurrence union value threshold	Keywords: P1 = (1), P2 = (1), P3 = (1) Authors: PX = (2)
Normalization measure	Equivalence index: eij = cij2 / Root (ci - cj)
Clustering algorithm	Maximum size: 9; Minimum size: 3
Evolutionary measure	Jaccard index
Overlapping measure	Inclusion rate

Table 1. Production indicators and inclusion criteria.

4. Results

4.1. Scientific output and production

The scientific research collected in WoS on PODCAST-EDU began in 2005. From that date to the present day, its production has been constant although irregular. There are different stages in its scientific production. In the first stage, between 2005 and 2008, both inclusive, the production is increasing, although with a reduced volume of production. During this period, the number of manuscripts produced did not exceed twenty per year. The second stage runs from 2009 to 2011. This is the period with the highest volume of production. During these three years, scientific production remained constant, with a volume of approximately 50 manuscripts per year. The third stage runs from 2012 to 2020. During these years, the output has experienced many ups and downs, with several peaks and troughs. The highest peaks of production in this period occurred in the years 2013, 2016 and 2020. The lowest peaks of production in this period occurred in 2015 and 2018. The highest volume of all scientific output was generated in 2009 (Figure 2).

Figure 2. Evolution of scientific production

The language selected by the scientific community to present the results of their manuscripts is English, which accounts for the majority of scientific productions. The other languages do not have a significant presence in WoS (table 2).

Languages	**n**
English	418
Spanish	21
Portuguese	7
French	5

Table 2. Scientific language used

The main area of knowledge in PODCAST-EDU is Education Educational Research, and its production is very high compared to the rest of the areas of knowledge. In addition to the field of education, it can be seen that the areas of computer science, health and linguistics carry out research in this line of research (table 3).

Denomination	**n**
Education Educational Research	375
Education Scientific Disciplines	97
Computer Science Interdisciplinary Applications	33
Healthcare Science Services	28
Linguistics	18

Table 3. Areas of knowledge

The main type of manuscript used by the scientific community to present their research is research articles. Other documents have a much lower volume than research articles (table 4)**.**

Denomination	**n**
Article	296
Proceedings Paper	103
Book Chapter	36
Editorial material	32

Table 4. Type of document

In PODCAST-EDU's field of study there is no institution of reference, as far as the production volume is concerned. In this case, the number of productions from the principal's institutions show similar stocks. The first two institutions are the State University System of Florida and University of Leicester, with 9 productions each (table 5).

Denomination	**n**
State University System of Florida	9
University of Leicester	9
University of Virginia	8
Islamic Azad University	7
Pennsylvania CommonWealth System of Higher Education (PCSHE)	7

Table 5. Institutions

There are two principal authors in scientific production different from the institutions: Abdous, M. and Facer, B.R. Both of them have a production volume of 14 manuscripts each. The rest present lower stocks than these two authors (table 6).

Authors	**n**
Abdous, M.	14
Facer, B.R	14
Kennedy, M.J.	8
Lee, M.J.W.	7
Chan, A.	5
Thomas, C.N.	5

Table 6. Most prolific authors

In the PODCAST-EDU field exists a variety related to the origin. In the first place, if the volume of production is taken into account, there are scientific magazines and conference proceedings books. In this case, the scientific magazines' head is Computer & Education, while the principal conference proceeding book is INTED Proceedings (table 7).

Source titles	**n**
Computers & Education	18
British Journal of Educational Technology	14
INTED Proceedings	14
Edulearn Proceedings	13
Medical education	9
Medical Teacher	9

Table 7. Source of origin

The country with the most volume production related to PODCAST-EDU is the United States. Its production is superior to the rest of the countries (table 8).

Countries	n
USA	152
England	67
Australia	35
Canada	26
Spain	26

Table 8. Country

The most cited manuscripts in the investigation line of PODCAST-EDU is Evans' manuscript (2008) with 300 quotes. In this manuscript is analyzed the m-learning effectiveness related to the podcasting in students of the undergraduates in higher education. The next manuscript most quoted is Coples' (2007) with more than 200 quotes. This research analyzes the effectiveness of a video podcast production method by using basic software. The next more quoted documents are McGarr (2009) and McKinnery, Dyck and Luber (2009), with 151 and 133 quotes (table 9).

Reference	Citations
Evans, C. (2008). The effectiveness of m-learning in the form of podcast revision lectures in higher education. *Computers & Education*, 50(2), 491-498. doi: 10.1016/j.compedu.2007.09.016	355
Copley, J. (2007). Audio and video podcasts of lectures for campus-based students: production and evaluation of student use. *Innovations in Education and Teaching International*, 44(4), 387-399. doi: 10.1080/14703290701602805	208
McGarr, O. (2009). A review of podcasting in higher education: Its influence on the traditional lecture. *Australasian Journal of Educational Technology*, 25(3), 309-321. doi: 10.14742/ajet.1136	151
McKinney, D., Dyck, J.L., y Luber, E.S. (2009). iTunes University and the classroom: Can podcasts replace Professors? *Computer & Education*, 52(3), 617-623. doi: 10.1016/j.compedu.2008.11.004	133

Table 9. Most quoted articles.

4.2. Structural and thematic develop

The evolution in the keywords in a field of study allows us to see whether there is an established line of research on a given topic. Or if on the contrary there is a no defined research base and new proposals are being created. Before analysing the Figure 3, we have to take into account several elements in order to properly interpret the information. The circles represent the number of keywords in a given period. The upward lines show the keywords that are dropping out of one period in relation to the next. The ascending line indicare new keywords added in a given time period. The horizontal lines indicate the percentage of keywords that match between contiguous periods. In this particular case, the field of study of PODCAST-EDU is at the limit. There is a 30% overlap between the first period (2005-

2010) and the second period (2011-2015), and between the second period (2011-2015 and the third period (2016-2020). This means that there is a line of research that has been established over time, but is not consolidated. New lines of research can be investigated.

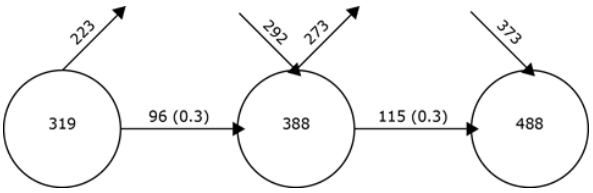
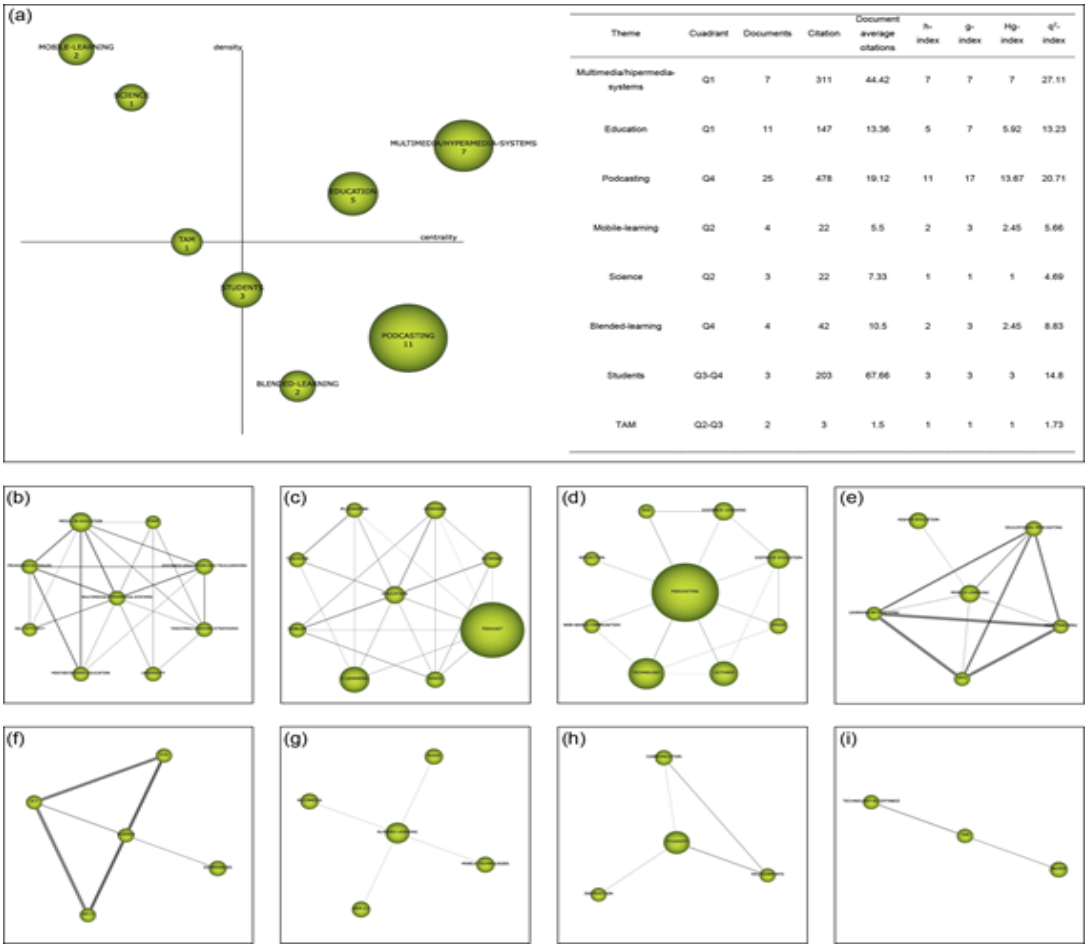


Figure 3. Keywords' sequence between consecutives intervals.

The following figures show different types of information. The information is relevant but also is complementary to the rest of the data that conform the figure itself. These figures represent pre-established time periods. three elements must be taken into account. First element, interval diagrams. These are located in the top left of the figure. The diagram shows the themes derived from the applied co-word analysis. According to their location, they will be more relevant in this specific period. In order to establish the diagraman's position, we have to take into account the Callon's index. This index is classified by density and centrality. Density is based on the strength of the connection between internal links. Centrality is based on the strength of the connection between external links. The second element is the performance analysis. This is located at the top right of the figure. The performance analysis shows information on various bibliometric indicators of the topics resulting from the co-word analysis. The third and last element is the cluster' network. These elements are represented in the rest of the figure, below the interval diagrams and the performance analysis. These cluster networks show the interrelation between a topic and other topics or keywords. Cluster' networks are used to find out lines of research on a specific theme.

Starting with the first period (2005-2010), 'podcasting' is the subject with the highest bibliometric value, with an h-index of 11. If its position in the interval diagram is analysed, its position indicates that the period was considered a basic and transversal issue. So what were the themes in this period? In this case, are 'multimedia/hipermedia systems' that relates with 'media-in-education', 'form', 'distance-education-and-telelearning', 'teaching/learning-strategies', 'university', 'postsecondary-education', self-efficacy' and 'pedagogical-issues'; and 'education', in relation with 'm-learning', 'learning', 'internet', 'podcast', 'wikis', 'e-learning', 'weblog' and 'teaching'. In this period the relevance in the field of study of PODCAST-EDU is considered to focus on pedagogical methods related to distance learning, teaching and learning strategies for the application of podcasts in the

pedagogical act and in several educational stages, especially in higher education and secondary education (Figure 4).



Theme	Cuadrant	Documents	Citation	Document average citations	h-index	g-index	Hg-index	q²-index
Multimedia/hipermedia-systems	Q1	7	311	44.42	7	7	7	27.11
Education	Q1	11	147	13.36	5	7	5.92	13.23
Podcasting	Q4	25	478	19.12	11	17	13.67	20.71
Mobile-learning	Q2	4	22	5.5	2	3	2.45	5.66
Science	Q2	3	22	7.33	1	1	1	4.69
Blended-learning	Q4	4	42	10.5	2	3	2.45	8.83
Students	Q3-Q4	3	203	67.66	3	3	3	14.8
TAM	Q2-Q3	2	3	1.5	1	1	1	1.73

Figure 4. (a) Strategic diagram (h-index) and performance from 2005 to 2010. Themes are shown as follows: (b) "multimedia/hypermedia-systems"; (c) "education"; (d) "podcasting"; (e) "mobile-learning"; (f) "science"; (g) "blended-learning"; (h) "students"; (i) "TAM".

In the second period (2011-2015) the subject with the highest bibliometric value is 'podcasting', with an index h of 7. In this case, this theme is very close to themes such as 'podcast' and 'university'. A temporal continuity can be observed if the performance analysis is taken into account. Nevertheless, as in the previous period, this theme is not considered a principal theme in this period. This privilege belong to 'video-podcast' themes which is related to "geography", "flexible-learning-spaces", "cognitive-load", "ICT", "support", "streaming-video", "social-constructivism" and "implementation"; "university", that is related to "instructional-tool", "classroom", "audio", "students", "portability", "mobile-

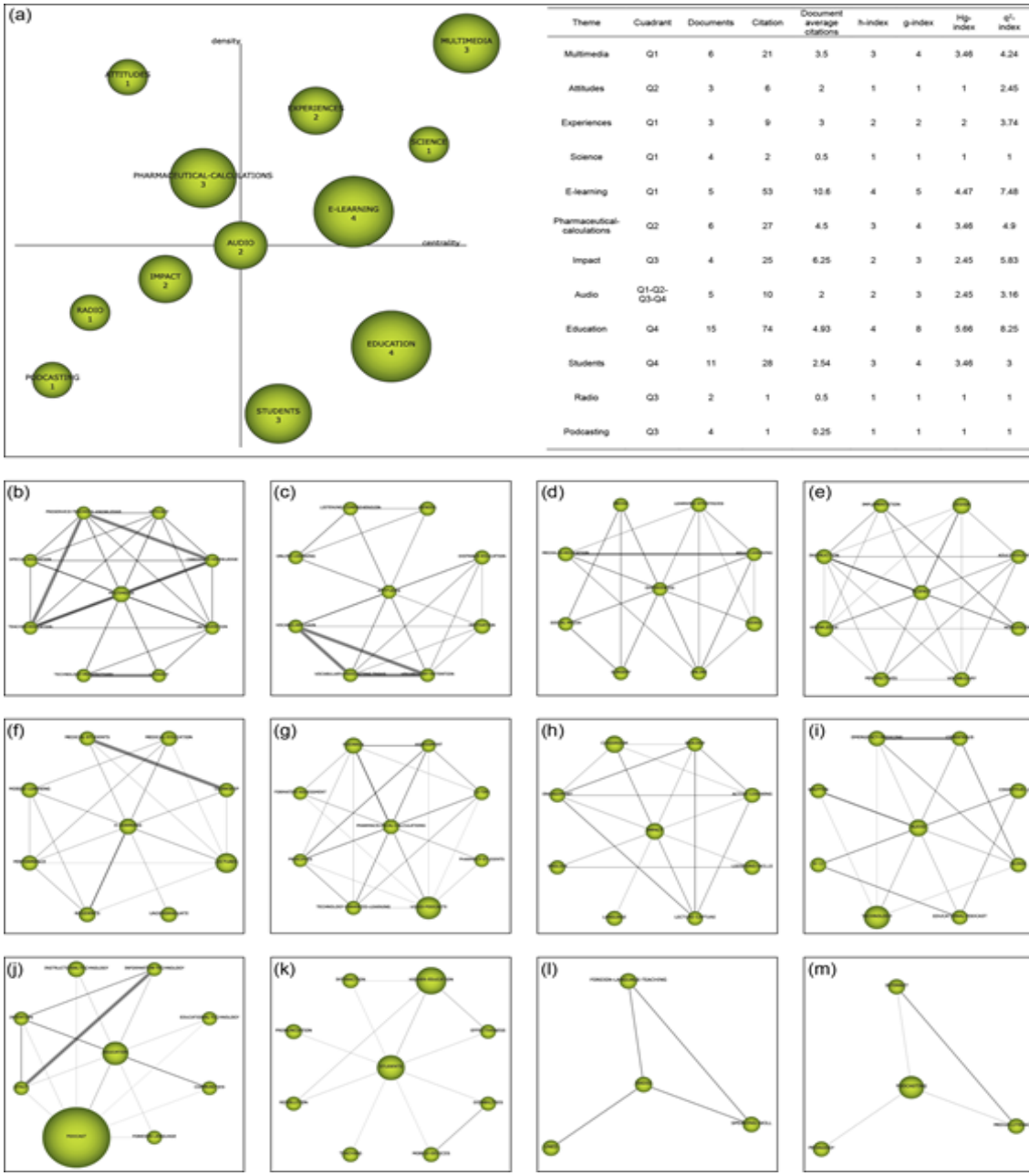
assisted-learning", "lifelong-learning" y "itunes-u"; "perceptions", that is related to "internet", "college", "beliefs", "blogs", "lectures", "performance", "needs" and "medical-education"; and "knowledge", related with "multimedia", "education", "assessment", "ipods", "technology", "vodcasts", "pedagogy" and "online-learning". This period is notable because the most relevant lines of research focus on the educational media used for the presentation of podcasts. The use of video associated with podcasts, in students' perceptions in order to use the podcast as a way to develop learning and pedagogical methods applied in the teaching and learning processes (Figure 5).

Theme	Cuadrant	Documents	Citation	Document average citations	h-index	g-index	hg-index	q²-index
Intention	Q1-Q2	3	89	29.66	2	2	2	13.19
University	Q1	9	137	15.22	6	9	7.35	10.39
Video-podcasts	Q1	5	163	32.6	4	5	4.47	14.7
Perceptions	Q1	4	44	11	3	4	3.46	5.74
Knowledge	Q1	8	74	9.25	4	7	5.29	8.49
Podcast	Q3	18	164	9.11	6	12	8.49	8.12
Podcasting	Q2-Q3	16	112	7	7	10	8.37	9.54
Higher-education	Q4	9	124	13.77	5	8	6.32	10.49
Active-learning	Q3	2	28	14	2	2	2	6
Advance-organizers	Q3	2	11	5.5	1	1	1	3.32

Figure 5. (a) Strategic diagram (h-index) and performance from 2011 to 2015. Themes are shown as follows: (b) "intention"; (c) "university"; (d) "video-podcasts"; (e) "perceptions"; (f) "knowledge"; (g) "podcast"; (h) "podcasting"; (i) "higher-education"; (j) "active-learning"; (k) "advance-organizers"

In the third and final period (2016-2020), “podcasting” ceases to be the theme with the best bibliometric value and assigns this position to two themes. This is particularly the case for “e-learning” and “education”. In this period, “e-learning” is also one of the themes considered as a driving force and the other ones are “experience”, “science” and “multimedia”. Undertaking a deep research on each of these, the theme “multimedia” seems to be related to “preservice-teaching-knowledge”, “efficacy”, “candidate-knowledge”, “intervention”; “literacy”, “technology-perspectives”, “teacher-education” and “special-education; “experiences” can be linked to “media”, “learning-strategies”, “adult-learning”, “video”, “online”, “surgery”, “social-media” and “media-in-education”; “science” is related to “implementation”, “design”, “adult-education”, “adolescent”, “vocabulary”, “perspective”, “knowledge” and “instruction”; and “e-learning” can be linked to “medical-students”, “medical-education”, “clerkship”, “lectures”, “undergraduate”, “residents”, “performance” and “mobile-learning”. This period stands out for the fact that the research focuses mainly on the inclusion of the podcast in the teaching and learning processes, on the different pedagogical strategies for its right implementation, its inclusion in the medical field and in the training of adults, and of students with learning difficulties. In addition, the themes "impact", "radio" and "podcasting" should be taken into account due to their position in the diagram. In this case, they are considered as unknown themes, because they may disappear from the research lines or they may be the next driving themes (Figure 6).

The table 10 is deduced from the data collected from the tables 4, 5 and 6. In this table, the themes are shown according to its location in the diagram in the different periods of time established. Based on the data obtained, we can say that the theme “podcasting” appears in every period. This shows that the area of study PODCAST-EDU presents a conceptual line. This does not mean that it is the most relevant theme of the set of research. Examples include the location of this theme in the different diagrams determined. In none of the periods has it been located as a driving theme.



Theme	Cuadrant	Documents	Citation	Document average citations	h-index	g-index	Hg-index	q²-index
Multimedia	Q1	6	21	3.5	3	4	3.46	4.24
Attitudes	Q2	3	6	2	1	1	1	2.45
Experiences	Q1	3	9	3	2	2	2	3.74
Science	Q1	4	2	0.5	1	1	1	1
E-learning	Q1	5	53	10.6	4	5	4.47	7.48
Pharmaceutical-calculations	Q2	6	27	4.5	3	4	3.46	4.9
Impact	Q3	4	25	6.25	2	3	2.45	5.83
Audio	Q1-Q2-Q3-Q4	5	10	2	2	3	2.45	3.16
Education	Q4	15	74	4.93	4	8	5.66	8.25
Students	Q4	11	28	2.54	3	4	3.46	3
Radio	Q3	2	1	0.5	1	1	1	1
Podcasting	Q3	4	1	0.25	1	1	1	1

Figure 6. (a) Strategic diagram (h-index) and performance from 2016 to 2020. Themes are shown as follows: (b) "multimedia"; (c) "attitudes"; (d) "experiences"; (e) "science"; (f) "e-learning"; (g) "pharmaceutical-calculations"; (h) "impact"; (i) "audio"; (j) "education"; (k) "students"; (l) "radio"; (m) "podcasting".

	P1(2006-2015)	**P2(2016-2018)**	**P3(2019-2020)**
Multimedia/hipermedia-systems	Q1(40.52/59.59)		
Education	Q1(23.23/0.62)		Q4(84.98/24.41)
Podcasting	Q4(38.8/9.14)	Q2-Q3(52.43/13.31)	Q3(11.57/9.66)
Mobile-learning	Q2(4.7/93.61)		
Science	Q2(0.25/78.33)		Q1(118.51/42.11)
Blended-learning	Q4(22.87/2.5)		
Students	Q3-Q4(13.72/12.04)		Q4(72.17/6.39)
TAM	Q2-Q3(8.04/13.89)		
Intention		Q1-Q2(67.85/125.2)	
University		Q1(102.23/75.79)	
Video-podcasts		Q1(74.31/91.85)	
Perceptions		Q1(84.24/31.43)	
Knowledge		Q1(68.19/25.04)	
Podcast		Q3(32.68/12.33)	
Higher-education		Q4(109.47/9.04)	
Active-learning		Q3(10.9/12.5)	
Advances-organizers		Q3(30.46/9.72)	
Multimedia			Q1(132.55/112.96)
Attitudes			Q2(39.8/69/44)
Experiences			Q1(75.64/48.92)
E-learning			Q1(80.2/32.82)
Pharmaceutical-calculations			Q2(64.4/34.66)
Impact			Q3(63.02/27.28)
Audio			Q1-Q2-Q3-Q4(70.59/31.14)
Radio			Q3(18.94/25)

Note: (X/Y), X=centrality; Y=density

Table 10. Principal research themes related to PODCAST-EDU from 2005 to 2020

The theme evolution of an area of study shows the link between the different themes resulting from the co-word analysis. The Jaccard index must be taken into account to establish this relation. The results shown in figure 7 show a variety of information. On the one hand, it provides the relationship between themes from attached periods. This relationship may be one of two types: the conceptual relationship, which is represented by a constant line and indicates that there is a common theme between two attached temporary themes, and non-conceptual relationship, which states that there is an overlapping keyword between two attached temporary themes. The width of

the lines, both continuous and discontinuous, shows the number of matching themes or keywords. The greater the width, the greater the number of matches. According to these aspects, it can be said that in the field of study of PODCAST-EDU there are several lines of research which have been established over time, but none of them is more relevant than the rest. Thus, in this case, it can be seen the research lines of "podcasting-podcasting-podcasting-e_learning", "podcasting-podcasting-podcasting", "science-advance_organizers-science", "mobile-learning-higher_education-students", among others. The data also indicate that there are more conceptual than non-conceptual links, which shows that there is a relationship between the several lines of research established on PODCAST-EDU.

Figure 7. Theme progress by h-index

4.3. Authors with the highest index of relevance

Among the various authors who carry out research on PODCAST-EDU, Armstrong, G.R. stands out as a leading author in this field of study. Moreover, Kennedy, M.J. should also be borne in mind, as he is not just the one with the highest bibliometric indicator, but also ranks as an anonymous author. This means that he can be a reference in this field of study in the coming years (figure 8).

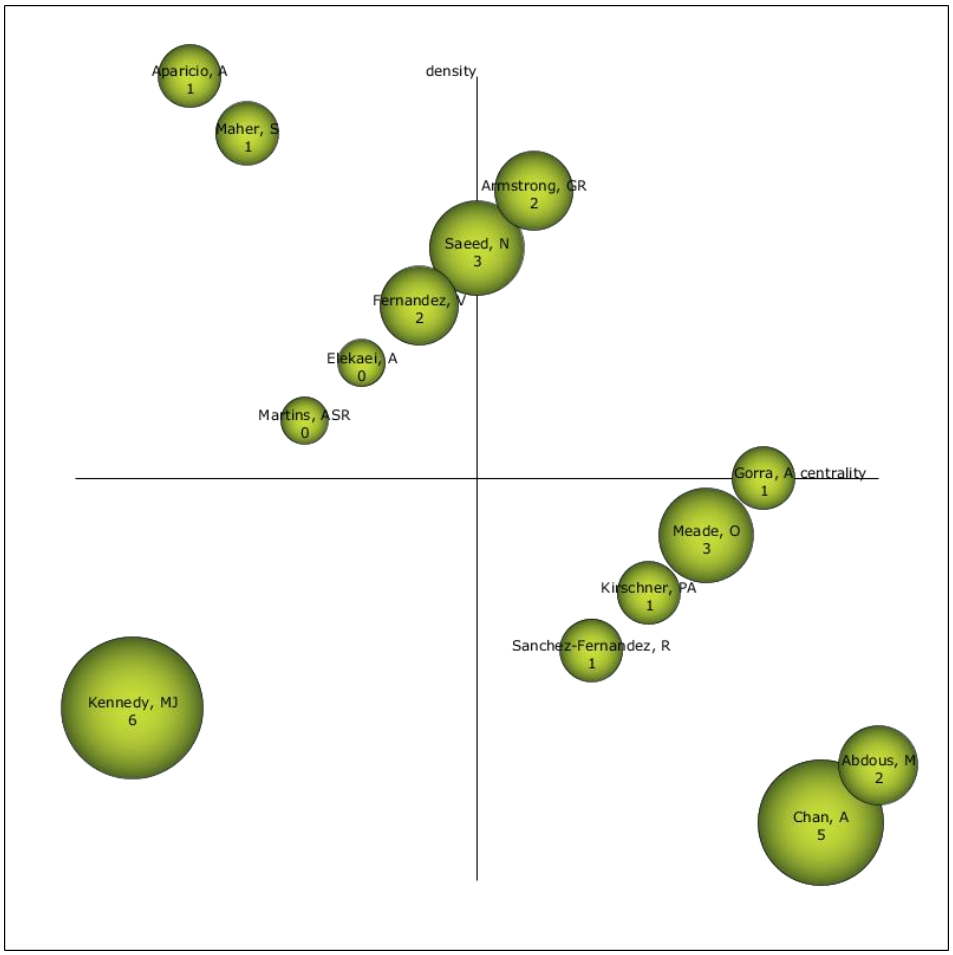


Figure 8. Strategic diagram of authors of all scientific production.

5. Discussion

Research on PODCAST-EDU in the WoS database began in 2005. In this case, it can be said that this line of research is relatively recent in the scientific field. Furthermore, if we analyse the studies on podcasts over the same period, we can see that research focused on the educational sphere

accounts for 35.56% of the total number. That is, of all the research on podcasts (n=1285), a total of 457 are education-oriented. From its beginnings until 2020, its progress has been very irregular, as three periods have been identified – the first period, from 2005 to 2008, with a relatively low but steadily increasing production volume; the second period, with the highest volume of production in its existence, from 2009 to 2011; and the third period with ups and downs in scientific production. This evolution points that the theme shows relevance depending on the time and the year. Nowadays, the media and various music playback applications – such as Spotify – are constantly including this resource, both from an informative and educational perspective. This suggests that this field of research is likely to become highly relevant to the scientific community. Analysing the academic output of the scientific production on PODCAST-EDU, it can be seen that the language selected by the scientific community to present their studies is English. This is a common fact in WoS analyses, because this database is mainly based on research carried out in the English-speaking world. In addition, it should be noted that Journal Citation Reports (JCR) is fed by this database, so the scientific community is aware that in order to reach as many researchers as possible, they must make use of English.

The knowledge area that collects studies on PODCAST-EDU is Education Educational Rersearch followed by Education Scientific Disciplines. This is normal due to the fact that this study is focused on the educational domain of the podcast. However, other areas of expertise, such as computing, health and linguistics, can be seen. This allows us to discern that these areas are aware of the use of podcasts in their training processes.

Research articles are the main type of manuscript used by the scientific community to present their scientific results. This shows that this field of study is becoming established in the scientific community. This fact is contrasted in other research (Carmona-Serrano et al., 2021), given that when a field of study is generating new lines of research, it tends to present a high volume of proceedings papers. Among the journals with the highest volume of output are *Computer & Education*, and the *British Journal of Educational Technology*. Both journals are ranked in the top quartiles of both JCR and Scimago Journal & Country Rank (SJR) databases, being a reference in the field of social sciences. INTED Proceedings is one of the most important conferences for PODCAST-EDU research.

There is no institution that stands out above the rest. Moreover, the top posts are not occupied by institutions from the same country, so there is diversity. The institutions with the highest production volumes are the State University System of Florida and the University of Leicester. This states the wide dissemination and scientific interest it creates at an international level. It is true that the United States is the largest producer, but there are a number of other countries that provide knowledge and data through their research.

Analysing the authors with the highest volume of production, two authors can be observed: Abdous, M. and Facer, B.R. Despite their large production volume, they are not considered to be the most relevant ones. This achievement belongs to Amstrong G.R., who is considered to be the main author in this field of study. Furthermore, looking ahead to the future, Kennedy M.J., who may be a referent in the coming years, should be kept in mind. Additionally, this author has the highest h-index. In any event, all these authors are a reference and a guarantee for researchers willing to analyse and study the use of PODCAST-EDU.

Among the most cited works, Evans (2008) is the most noteworthy, showing a relatively large citation volume by comparison with others studies developed in the field of education (Moreno-Guerrero et al., 2021). That work analyses the effectiveness of podcasting in the formation of undergraduated. It strengthens the data obtained in this study, in which one of the main interests in the scientific community on PODCAST-EDU is the effectiveness of using podcasts in the teaching-learning process. Other studies, such as Copley (2007), McGarr (2009) and McKinney et al. (2009) have a medium-large citation volume. Consequently, they should be considered by the scientific community when developing and analysing studies about PODCAST-EDU.

The evolution of keywords shows how studies on PODCAST-EDU on the threshold between establishing lines of research and appearance of new ones. This indicates that, in forthcoming years, new research in new areas will be generated while still studying aspect already relevant to the scientific community.

The three periods analysed have revealed that there were diverse trends, though following a guiding thread, as in the case of podcasting. This subject has been the one with the highest bibliometric indicator, in the first period (2005-2001) and in the second ones (2011-2015). Nevertheless, it has not been the most relevant in any of the three periods. In the first period (2005-2010), the analysis of pedagogical methods focusing on distance learning, the variety of teaching and learning strategies used for the development and implementation of didactic processes and the educational stages of secondary education or university have been the main focus of the scientific community, particularly in terms of relevance. In the second period (2001-2015), this tendency changed slightly, due to the relevance of researches of PODCAST-EDU were more oriented towards the technological resources used to introduce and show podcasts to students and students´ perceptions about the use of these resources in teaching and learning processes. In this period, the analysis of pedagogical methods used in didactic procedures continued. In the third period (2016-2020), the pedagogical methods used for the implementation of podcasts in educational processes continue to be important, but also, the use of PODCAST-EDU in the medical FIELD and in treatment of students with learning difficulties begins to gain relevance. In other words,

the relevance in the field of PODCAST research has evolved from the importance and identification of the pedagogical methods used for the application and implementation of teaching-learning processes to the interest and implications that the use of podcasts generates in students.

Among the diverse lines that could be observed throughout the various periods in PODCAST-EDU studies, it is not possible to determine or indicate that there is one line of research that highlights above the rest. There are several current lines of research, including "podcasting-podcasting-e_learning", "podcasting-podcasting-podcasting", "science-advance_ organizers-science", "mobile-learning-higher_education-students" ...

This confirms what was already indicated previously. Therefore, it is a field of study that has established lines but it is settling in the scientific community. It should also note that there is a relation between the diverse lines of researches established, which means that there is a common thread in this field of study.

6. Conclusion

The conclusion is that research on PODCAST-EDU has been relevant and interesting for the scientific community relatively recently, from 2005 to the present, although its evolution and interest has been fluctuating abruptly. The main area of interest is the pedagogical methods used for its application in the teaching and learning processes, although the scientific community continues to be interested in the technological resources used for its development and use in the classroom, as well as in the implications and benefits that this resource generates for students. In recent years, its use with students with difficulties is gaining importance and relevance, as well as gaining relevance in medical formation.

The limitations of this study lie in several aspects. Firstly, only the WoS database has been analysed, so the results obtained are only based on this database. Additionally, database cleaning is a major challenge for researchers, who must analyse the documents collected from the database one by one. On some occasions, duplication is possible in the database or documents on other subjects are included. For this reason, a meticulous cleaning of the database is necessary in order to ensure that the analysis is successful. Finally, other aspects to keep in mind in the limitations are the values applied to the SciMAT statistical programme due to variation in the data may lead to different results. For these reasons, the data provided in this study should be taken as a reference, but with caution. Future lines of research include a similar study in other databases, such as Scopus and Google Scholar.

6.1. Study implications

This study generates a number of implications, both theoretical and practical, that need to be considered. Some of the theoretical implications include the fact that this study offers results that expand the field of knowledge. There are no similar studies in the internationally relevant PODCAST-EDU database. Furthermore, this study provides a more detailed knowledge of authors, countries, journals, international conferences, most cited papers, etc., which facilitates access to the most relevant information for any scientist interested in this field of study. This research also allows us to identify the most relevant lines of research for the scientific community and the current trends in PODCAST-EDU. This fact could help researchers' chances of success in publishing their scientific results in the most relevant international journals, as well as focusing their studies on lines of research of relevance to the scientific community.

In terms of practical implications, this study offers an overview of the needs of the diverse educational administrations in the field of PODCAST-EDU studies. The results obtained revealed the need for pedagogical formation by teachers in the application and use of podcasts in the educational field. It is evident in the PODCAST-EDU studies, as they focus their research on learning processes. Moreover, this research shows the existence of studies that focus on the design and presentation of podcasts in education. Finally, this study shows research that can be a pedagogical reference for other teachers who want to apply podcasting in teaching-learning processes. Ultimately, this research offers the real necessities of teacher formation, as well as promoting or offering references on real and viable pedagogical models in order to include podcasts in the pedagogical process.

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