A Bibliometric Analysis of Mobile Assisted Second Language Learning

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Abstract—This article reviews mobile assisted second language learning (MASLL) with a bibliometric method. The authors collected data of papers related to MASLL from Web of Science and then analyzed the sources, authors, papers, and conceptual structure. The result suggests that: the effects of technology on learning, vocabulary, personalized learning, learning environment, and learner attitudes are popular topics in this field; the attention on themes related to "technology" is fading away and the focus of MASLL research is shifting to themes related to "students". Most-cited journals, authors, and papers are also presented in this article.

Keywords—literature review, mobile learning, second language learning, bibliometric analysis, MASLL

1 Introduction

Mobile learning has grown from a minor research interest to widespread practice in schools, workplaces, museums, cities and rural areas around the world [1]. Mobile technologies are widely applied in learning nowadays. One of the most important features of mobile learning is that learners can enter a personalized world at any place and at any time according to their needs [2]. It offers new possibilities and opportunities for both teachers and students [3]. It is possible to expand learning environment through the development of mobile learning [4]. Mobile learning, sometimes called "ubiquitous learning", "m-learning", or "u-learning", is the experience and opportunities brought about by the evolution of educational technologies. Mobile learning has become an umbrella term for the integration of mobile computing devices within teaching and learning [5]. The essence of "mobile" in mobile learning is often related to the mobility of physical space, mobility of technology, mobility of conceptual space, mobility of social space and learning dispersed over time [1].

As mobile technologies are more and more widely applied in second language learning, mobile assisted second language learning (MASLL) research has become an area that attracts more and more researchers' attention. For newcomers into a research field, it is important to know which topics have been discussed, which researchers to follow,

which journals and articles are highly influential, etc. The answer to these questions can help researchers better understand the status quo of the field. One of the methods to provide answers to these questions is bibliometrics.

1.1 Bibliometrics

Bibliometrics originated from the study of large number of bibliographic materials in the field of library and information science [6]. The term "Bibliometrics" was coined by Alan Pritchard and was defined as: "The application of mathematics and statistical methods to books and other media of communication" [7]. Long before the term appeared, there had been studies on quantitative analysis of publications [8, 9]. Cole and Eales [8] published a statistical analysis of more than three centuries of comparative anatomy literature (1543–1860), in which they assessed the growth rate of research in this field and the contribution of each European country to the field. Bibliometric method not only makes finding bibliographic information easier and faster, but also makes it possible to quantitatively evaluate the influence of journals, authors, researchers, projects and research institutions [10, 11]. It is now firmly established as a scientific specialty and an integral part of research evaluation methodology within the scientific and applied fields [12].

A plenty of bibliometric studies of mobile learning have been published [13–17]. However, in the field of MASLL, only a few bibliometric research have been carried out. Chen, et al. [18] employed a social network analysis method to investigate the collaboration relations among countries/regions, affiliations, and authors in technology-enhanced language learning research from 2008–2017. Goksu, et al. [19] analyzed the Computer Assisted Language Learning (CALL) journal a bibliometric mapping method, revealing the keyword trend and the countries, universities, and authors that made the highest contribution to CALL journal between 2008 and 2019. Liu and Zhang [20] conducted a bibliometric analysis of computer-assisted English learning literature indexed in EI Compendex database from 2001 to 2020 with VOSviewer and revealed hotspots and frontiers of computer-assisted English learning. This research attempts to present a more comprehensive review of MASLL with a bibliometric analysis.

1.2 Research questions

This research aims to answer the following questions about MASLL.

a) Sources: Which sources are most influential in the field?
b) Authors: Which researchers are the most influential in field of MASLL?
c) Papers: Which papers about MASLL are most cited?
d) Conceptual structure: What are the most popular topics in MASLL research? How the themes of MASLL evolved?

2 Research methods

2.1 Source of data

Web of Science (WOS) core collection is the source of data for this research, including SCIE, SSCI, A&HCI, ESCI, and CPCI. The Web of Science core collection contains multidisciplinary research materials from more than 18,000 high-impact academic journals, more than 180,000 conference papers, and more than 80,000 academic books around the world [21]. Among them, the Science Citation Index Expanded (SCIE) covers more than 9,300 mainstream journals in 178 disciplines; The Social Sciences Citation Index (SSCI) covers more than 3,400 journals in 58 social science disciplines; The Arts & Humanities Citation Index (A&HCI) covers more than 1,800 journals in the arts and humanities, as well as excerpts from more than 250 natural science and social science journals; The Emerging Sources Citation Index (ESCI) contains more than 5,000 journals in the fields of natural sciences, social sciences and humanities; The Conference Proceedings citation indexes include the published literature of the most significant conferences, symposia, seminars, colloquia, workshops, and conventions in science, social sciences, and humanities across 256 disciplines.

2.2 Data collection

To include relevant literature as much as possible, and at the same time to make sure the retrieved papers are closely related to MASLL, the search was done in the following procedure. First, the researchers searched in WOS with six terms in topic field: "ubiquitous language learning", "mobile language learning", "mlearning", "m-learning", "ulearning" and "u-learning", with a time span set from 1985 to December 31, 2021. The logical operator between these terms is "or". This produced 5547 records. Then, the researchers reviewed the titles and abstracts of the papers and found that many are not related to foreign language learning at all, such as many ones in the field of computer science. As MASLL research are mainly related to fields of linguistics, education, and some other social sciences, the researchers then refined the results by narrowing them down to the fields of "Education Educational Research" (2341), "Education Scientific Disciplines" (333), "Linguistics" (326), "Language Linguistics" (247), "Social Sciences Interdisciplinary" (126), "Psychology Educational" (45), and "Education Special" (6). This narrowed the literature down to 2744 results. Afterwards, the terms "foreign language" (611 results) and "second language" (336 results) were used separately to filter the 2744 results to obtain documents related to second language learning research. After removing the duplicates (144) in the two filtered results, a total of 803 articles were obtained finally. All the above searches were done on January 15, 2021.

2.3 Data analysis

This study employs Bibliometrix for the analysis of retrieved data. Bibliometrix is an open-source R-package for quantitative research in bibliometrics and scientometrics, providing the functions of data collection, data analysis and data visualization [22]. It can be used for executing a comprehensive science mapping analysis of scientific literature.

3 Research results

3.1 General information

The 803 retrieved papers are published in 352 sources (journals, conference proceedings, books etc.). These papers have been cited a total of 6615 times (with an average citation of 8.24) and cited a total of 20,601 references. The trend of MASLL research articles is shown in Figure 1. The first paper about MASLL appeared in 2002, which reviewed the hardware and research on m-learning and discussed future work with mobile foreign-language study [23]. From 2002 to 2015, the number of MASLL research articles showed a trend of slow growth; after 2015, the number of papers published each year rose rapidly, reaching a peak in 2019 and then going downward.

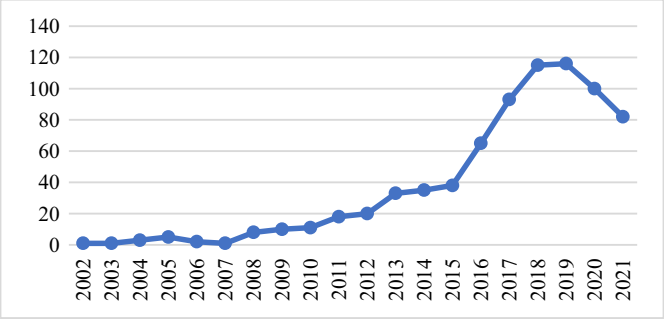

Fig. 1. Annual production of MASLL articles

3.2 Sources

The influence of sources of publications are measured here by h-index, which was proposed by Hirsch [24] to characterize the scientific output of a researcher, defined as h number of papers with citation number ≥h, where h is an integer. H-index can also be applied to the productivity and impact of scholarly journals. For example, if a researcher has four published papers, with 6, 3, 3, and 2 citations respectively (ordered from greatest to least), then the researcher's h-index is 3 as the researcher has 3 publications with 3 or more citations. However, if the researcher has four publications with 6, 3, 2, and 2 citations respectively, then the researcher's h-index is 2 as the researcher has less than 3 publications that have been cited more than 3 times and the largest integer for h-index is 2.

The top 10 most influential sources in the field of MASLL are listed in Table 1. The list is ordered by local h-index calculated by Bibliometrix, then total citations (TC) and then number of publications (NP). Local h-index is the h number of articles published in a source that have been cited at least h number of times recorded in the data in this research.

A total of 140 articles were published in the top 10 journals, accounting for 17.4% of all articles included in this research. These articles have been cited a total of 4392 times, accounting for 66.4% of the total of 6615 citations. *Computer Assisted Language Learning* is the source with the highest numbers of total citations (TC, 1506), the highest number of publications (NP, 45) and the highest local h-index of 20. The journal with

the highest SJR H-index is *Computers and Education* (179), with a local h-index of 9, which means that this journal is the most influential globally among the top 10 journals listed here but its influence is relatively lower (ranked the third) in the field of MASLL.

Table 1. The most influential sources in the field of MASLL

Rank*	Title	Local h-Index	TC	NP	Type	SJR h-Index
1	Computer Assisted Language Learning	20	1506	45	journal	48
2	ReCALL	12	501	17	journal	52
3	Computers and Education	9	621	11	journal	179
4	Educational Technology and Society	9	316	13	journal	88
5	Language Learning and Technology	8	264	12	journal	73
6	Journal of Computer Assisted Learning	7	545	9	journal	93
7	British Journal of Educational Technology	7	264	10	journal	95
8	Interactive Learning Environments	6	151	11	journal	44
9	System	5	128	6	journal	77
10	Foreign Language Annals	5	96	6	journal	49

Note: *Ranked in the order of local h-index, TC and NP.

3.3 Authors

The influence of authors, the geographical information of authors and collaboration between first-author countries are analyzed here.

The influence of authors is also measured here by local h-index, the h number of articles that have been cited at least h number of times in the data collected for this research. Of the 1,552 authors recorded in this research, 865 have an h-index value larger than 1. The top 20 high h-index authors are listed in Table 2, in the order of h-index, then total citations (TC), and then number of publications (NP). The authors with the highest local h-index are Hwang, W. and Hwang Y, both having a local h-index of 9.

Table 2. Author impact

No.	Author	h-Index	TC	NP	No.	Author	h-Index	TC	NP
1	Hwang, W.	9	377	12	11	Yang, S.	4	110	4
2	Huang, Y.	9	292	11	12	Liu, T.	4	96	5
3	Chang, C.	8	369	10	13	Cardoso, W.	4	67	5
4	Shadiev, R.	8	321	10	14	Zheng, D.	4	65	4
5	Liu, G.	7	153	10	15	Wang, H.	4	60	4
6	Hwang, G.	5	261	7	16	Chen, Y.	4	41	7
7	Chen, C.	5	185	6	17	Lin, V.	4	31	4
8	Hsu, C.	4	279	5	18	Viberg, O.	3	194	4
9	Ogata, H.	4	218	5	19	Burston, J.	3	158	3
10	Wu, W.	4	192	4	20	Chen, H.	3	129	3

To find out the geographical information of the authors and the collaboration between different countries, corresponding author's country analysis is carried out here. The top 20 countries with the largest number of articles published is presented in Figure 2, ordered by the number of articles published, then Multiple Country Publication (MCP), and then Single Country Publication (SCP). Multiple Country Publication means publications in which authors belong to different countries and such publications represent inter-country collaboration i.e., international collaboration; Single Country Publication means publications in which all authors belong to the same country, indicating that such publications are intra-country collaboration. Authors from China are the most productive, contributing a total of 182 articles, in which 156 are single-country publications and 26 are multiple-country publications, with a MCP ratio of 14.29%. Authors from UK represent the highest ratio of multiple country publications, contributing a total of 25 articles, in which 17 are single-country publications and 8 are multiple-country publications, with a MCP ratio of 32%, the highest among all countries.

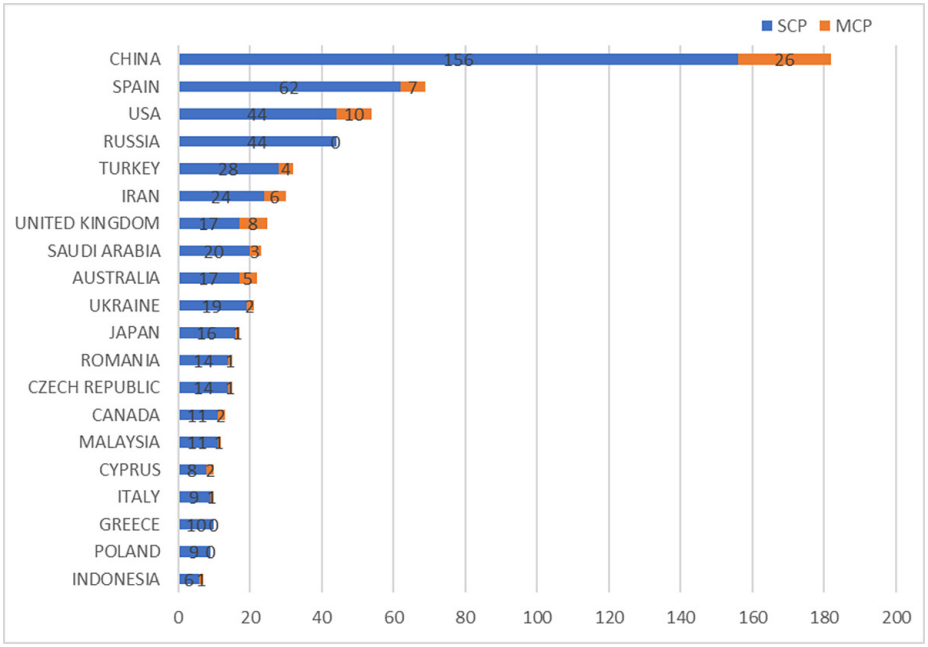

Fig. 2. Corresponding author's country and between-country collaboration

3.4 Papers

The most cited papers are listed in Table 3, sorted first by global citation score (GCS) and then by local citation score (LCS). GCS is the total citations that an article has received from documents indexed in the Web of Science database. LCS is the citations that an article has received from documents included in this research (all the bibliographies of the articles in this research).

The most locally cited paper is *Using Mobile Phones in English Education in Japan* published in 2005. In the research, the authors investigated Japanese university students regarding their use of mobile devices. An experiment carried out by the authors found that students learning English vocabulary through e-mail with their mobile phones performed better than their peers learning with the same material on paper or web [25].

The most globally cited paper is *Technologies for Foreign Language Learning: A Review of Technology Types and Their Effectiveness* published in 2014, which reviewed over 350 studies and found that despite an abundance of publications available on the topic of technology use in FL learning and teaching, evidence of efficacy is limited. A strong support is found for the claim that technology made a measurable impact in foreign language learning with computer-assisted pronunciation training. The literature revealed moderate support for claims that technology enhanced learners' output and interaction, affect and motivation, feedback, and metalinguistic knowledge [26].

Among the top 10 most cited papers, four are closely related to vocabulary learning (1, 2, 3, and 5). It can be concluded that "vocabulary" is one of the hot topics of MASLL. Besides, a content analysis of the titles and abstracts of these papers infers that in the field of MASLL, technology on learning effects, vocabulary learning, personalized learning, learning environment, learner attitudes, etc. are popular topics among researchers.

Table 3. Most cited papers

Rank*	Title	Source	Author(s)	Year	LCS	GCS
1	Using Mobile Phones in English Education in Japan	Journal of Computer Assisted Learning	Thornton, P; Houser, C	2005	65	305
2	Effectiveness of Vocabulary Learning Via Mobile Phone	Journal of Computer Assisted Learning	Lu, M	2008	39	167
3	Mobile English Learning: An Evidence-Based Study with Fifth Graders	Computers & Education	Sandberg, J; Maris, M; de Geus, K	2011	29	162
4	Technologies for Foreign Language Learning: A Review of Technology Types and Their Effectiveness	Computer Assisted Language Learning	Golonka, EM; Bowles, AR; Frank, VM; Richardson, DL; Freynik, S	2014	21	306
5	A Comparison of Undergraduate Students' English Vocabulary Learning: Using Mobile Phones and Flash Cards	Turkish Online Journal of Educational Technology	Basoglu, EB; Akdemir, O	2010	20	90
6	A Mobile-Assisted Synchronously Collaborative Translation–Annotation System for English as a Foreign Language (EFL) Reading Comprehension	Computer Assisted Language Learning	Chang, CK; Hsu, CK	2011	20	86

(Continued)

Table 3. Most cited papers *(Continued)*

Rank*	Title	Source	Author(s)	Year	LCS	GCS
7	A Personalized Recommendation-Based Mobile Learning Approach to Improving the Reading Performance of EFL Students	Computers & Education	Hsu, CK; Hwang, GJ; Chang, CK	2013	17	134
8	Cross-Cultural Analysis of Users' Attitudes Toward the Use of Mobile Devices in Second and Foreign Language Learning in Higher Education: A Case from Sweden and China	Computers & Education	Viberg, O; Gronlund, A	2013	12	100
9	Context-Aware Support for Computer-Supported Ubiquitous Learning	2nd IEEE International Workshop on Wireless and Mobile Technologies in Education	Ogata, H; Yano, Y	2004	7	196
10	Using The Flipped Classroom to Enhance EFL Learning	Computer Assisted Language Learning	Hsieh, JSC; Wu, WCV; Marek, MW	2017	5	122

Note: *Ranked by LCS and then GCS.

3.5 Conceptual structure

Two types of analysis are carried out here to map the conceptual structure of MASLL research: keyword co-occurrence and thematic evolution.

Keyword co-occurrence analysis is a method for understanding the main themes or main topics in a research field. Co-occurrence means that two pieces of information appear together in a set of data. Each keyword (a piece of information) in the data is treated as a node, and the co-occurrence of a pair of keywords is regarded as a link. The number of times that a pair of keywords appear together is the strength of the link [27]. A simple keyword co-occurrence network is illustrated in Figure 3. In the figure, A, B, and C are key words in article 1; A, C, and D are keywords in article 2. As keywords B and D appear once only in articles 1 and 2 respectively, the link strengths of B-A, B-C, D-A, and D-C are 1. However, keywords A and C appeared in both articles, i.e. A and C co-occurring 2 times. Therefore, the link strength between A and C is to 2. The higher the link strength between keywords, the more likely these keywords are hot topics.

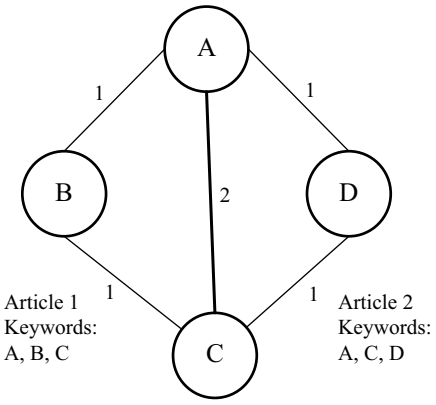

Fig. 3. Example of a simple keyword co-occurrence network

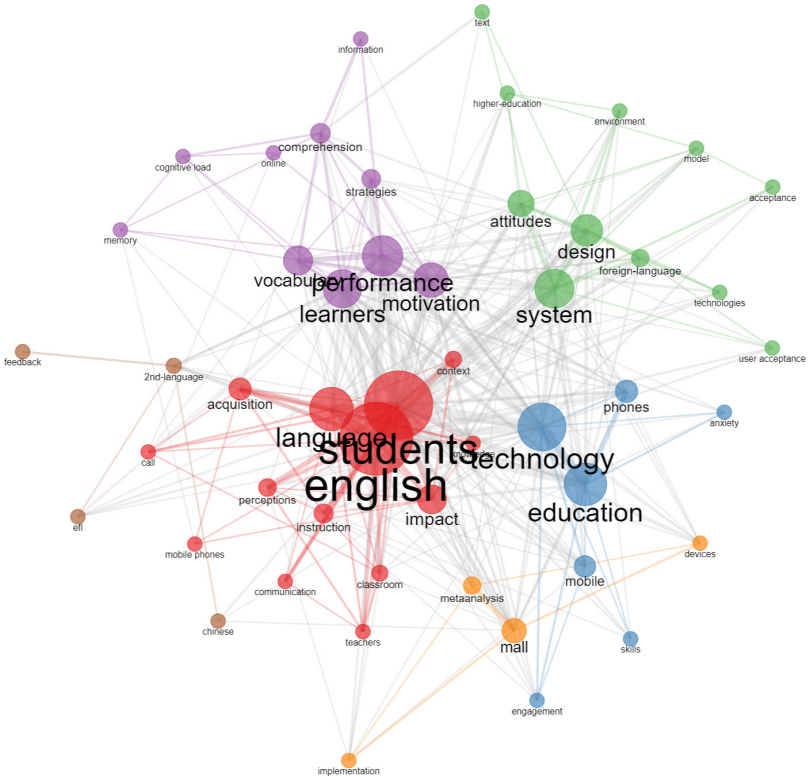

Fig. 4. Keywords plus co-occurrence network

Keywords Plus keywords are chosen in this research for keywords co-occurrence analysis. Keywords Plus keywords are keywords automatically generated by a special algorithm unique to Clarivate Analytics databases. The keywords of MASLL research

falls into 6 clusters represented by six different colors (Figure 4). In the figure, each circle is a keyword and the lines between the circles are links between the keywords. The keywords of the same color belong to the same cluster. The size of a circle in the figure is proportional to the frequency of the keyword: the larger the circle, the higher the frequency; the smaller the circle, the lower the frequency. The top 50% keywords in each cluster are listed in Table 4, ranked first by cluster number and then betweenness score.

Table 4. Top keywords of MASLL research

Keyword	Cluster	Betweenness	Keyword	Cluster	Betweenness
English	1	291.18	attitudes	3	6.49
students	1	184.51	foreign-language	3	0.98
language	1	26.48	model	3	0.49
acquisition	1	17.51	environment	3	0.46
impact	1	8.54	performance	4	61.11
CALL	1	6.88	learners	4	47.79
classroom	1	3.22	motivation	4	47.47
technology	2	87.14	vocabulary	4	15.38
education	2	25.15	comprehension	4	12.75
mobile	2	5.97	MALL	5	9.13
phones	2	1.51	meta-analysis	5	1.1
system	3	30.24	2nd-language	6	49.88
design	3	15.49	EFL	6	0.19

Betweenness is generally employed with the understanding that it captures the potential for control of communication between actors (keywords in this research) [28]. In a keyword co-occurrence network, a higher betweenness means a more important role for that keyword in the network [29]. From the above analysis, it is suggested that "English", "students", "language", "acquisition", "impact", "CALL", "classroom", "technology", "education", "mobile", "phones", "system", "design", "attitudes", "foreign-language", "model", "environment", "performance", "learners", "motivation", "vocabulary", "comprehension", "MALL", "meta-analysis", "2nd-language" and "EFL" are the most important topics in MASLL between 2002 and 2021.

While keywords co-occurrence analysis is a method for detecting important keywords during a period, thematic evolution analysis is for analyzing how the themes of a research field evolves. To investigate how the themes of MASLL research evolved during the past 20 years, the authors divided the collection of articles into 3 periods according to the trend of number of publications (see Figure 1. Annual production of MASLL articles). The first period is from 2002 to 2015, in which the yearly number of publications increased slowly, with a total of 186 articles. The second period is from 2016 to 2019, a period that saw soaring of publications, with a total of 389 articles. The last period is from 2020 to 2021, when the annual number of publications showed a downward trend, with a total of 228 articles.

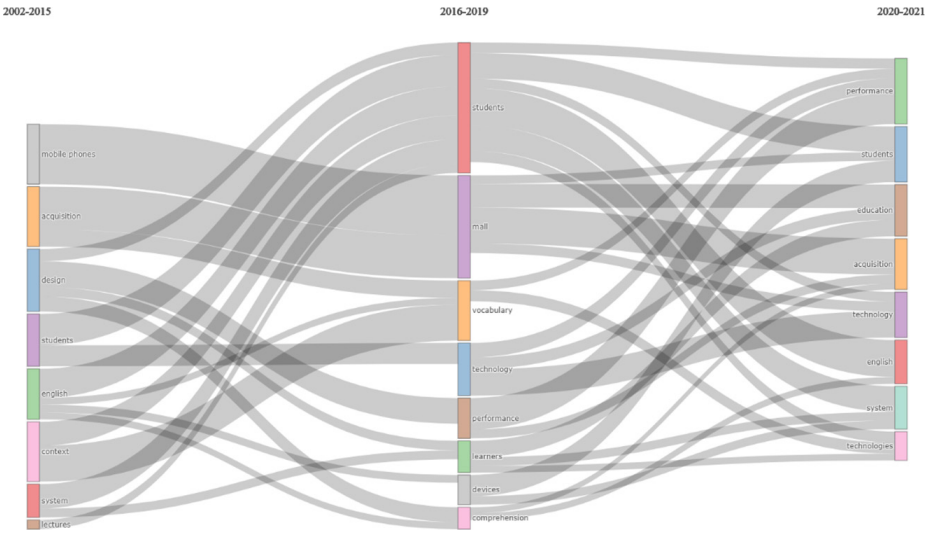

Fig. 5. Thematic evolution of MASLL research

The themes of MASLLA are visualized by two types of diagrams: thematic evolution diagram and strategic diagram. Thematic evolution diagram is a straightforward display of how the themes (clusters of keywords) in different periods relate to each other (see Figure 5). In the diagram, the vertical bars with names to their right represent the themes and the lines connecting the bars means how themes evolve from one to another. However, a more in-depth observation of theme evolution is realized in strategic diagrams. A strategic diagram is a set of research themes mapped in a two-dimensional diagram, which can be classified into four groups according to their centrality and density [30]:

(a) Themes in the upper-right quadrant are known as the motor-themes of a field, which are high in both centrality and density. These themes are well developed and important for the structure of a research field.
(b) Themes in the upper-left quadrant have well-developed internal ties but unimportant external ties and so, they are of only marginal importance for the field.
(c) Themes in the lower-left quadrant are both weakly developed and marginal. The themes in this quadrant mainly represent either emerging or declining themes.
(d) Themes in the lower-right quadrant are important for a research field but are not developed. This quadrant contains transversal and general, basic themes.

In the first period (see Figure 6), the theme "design" is the most obvious motor theme. This means that keywords related to "design" are the most important and developed in MASLL during this period. The basic theme in this period are "system", "English" and "students". This indicates that keywords related to these themes are important but are not developed.

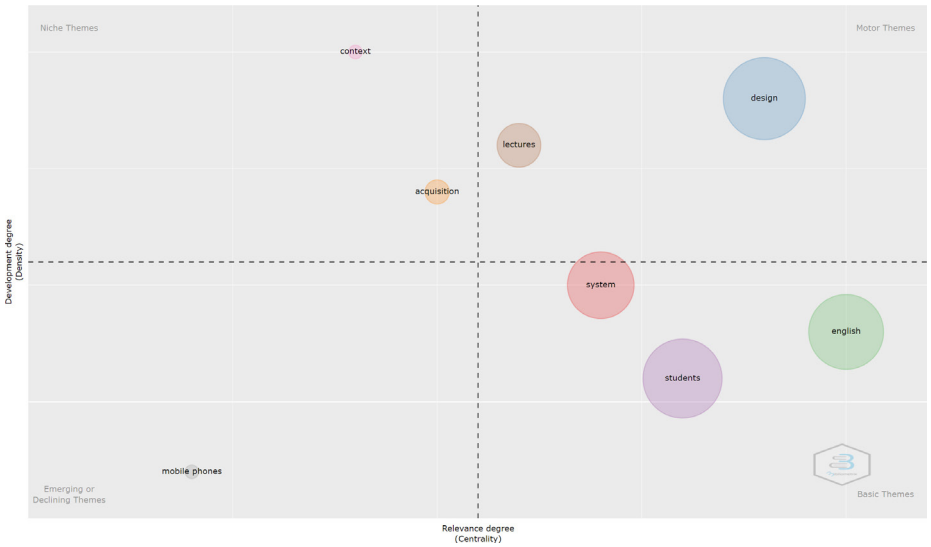

Fig. 6. Strategic diagram of MASLL research between 2002 and 2015

In the second period (see Figure 7), "technologies" emerges as the most obvious motor theme. This means that keywords related to "technology" become the most important and developed in this period. During the period, "learners", "students" and "mall" are the basic themes. However, it is obvious to notice that both the centrality and density of "students" become higher than the first period.

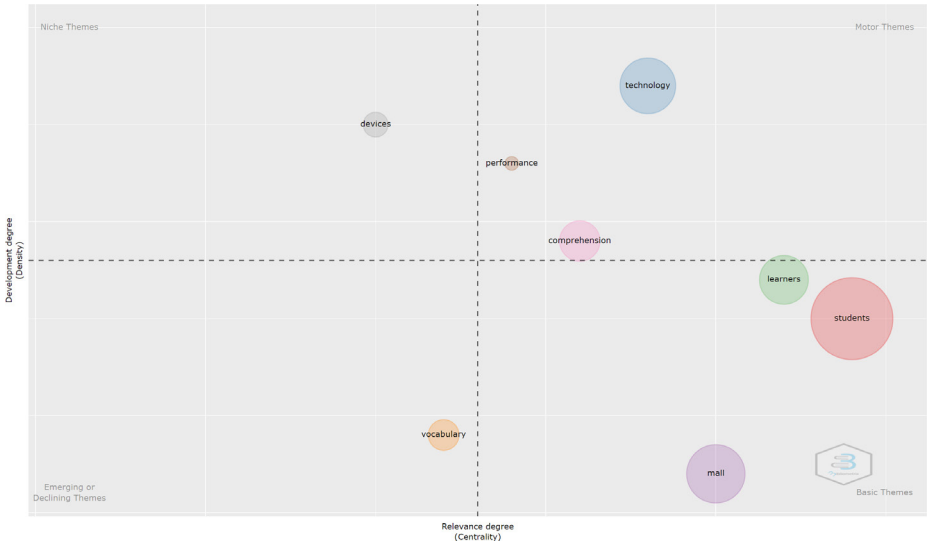

Fig. 7. Strategic diagram of MASLL research between 2016 and 2019

In the third period (see Figure 8), motor themes of MASLL are "acquisition", "students" and "technologies". The basic themes in this period are "technology", "performance", "education" and "English". It is easy to find that: (a) "students" has evolved from a basic theme in the previous two periods to a motor theme in the third period and (b) "technology" has evolved from a motor theme in the second period (2016–2019) to a basic theme in the third period.

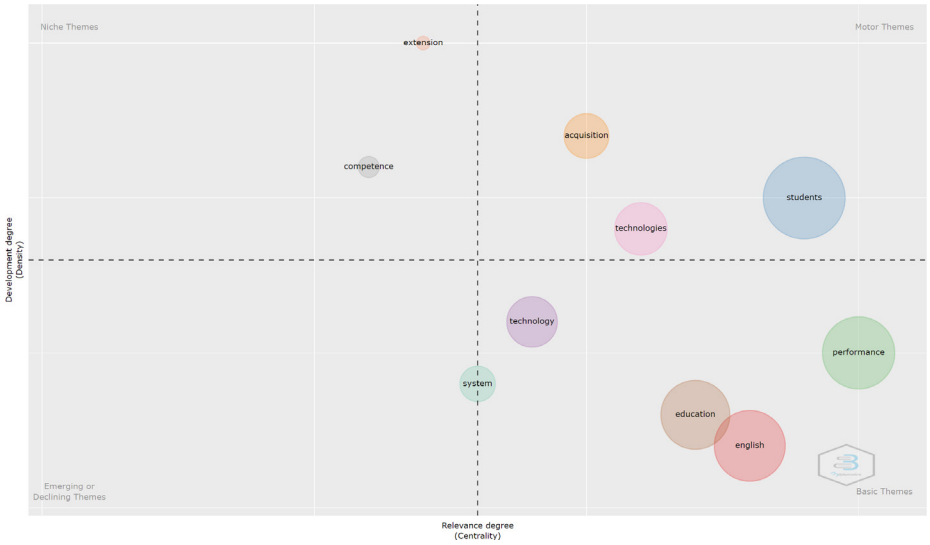

Fig. 8. Strategic diagram of MASLL research between 2020 and 2021

From the above thematic evolution analysis of MASLL research, it is suggested that the focus of attention in the field of MASLL is shifting towards "students" and the attention on "technology" is fading away. Although this conclusion may seem simplistic, it provides a panoramic view of how the themes of MASLL research evolved during the past 20 years.

4 Conclusion and discussion

In this research, the authors apply Bibiometrix to analyze the research articles in mobile assisted second language learning (MASLL). It is found that annual production of MASLL research articles increased slowly between 2002 and 2015, surged between 2016 and 2019 and then went downward after 2020. The trend suggests that the enthusiasm for MASLL is possibly fading away. The reason for this is yet to be studied.

Secondly, the top 10 most influential journals are presented by analyzing the data from this research, using local h-index as the indictor for measuring their influence. These journals are *Computer Assisted Language Learning, ReCALL, Computers and Education, Educational Technology and Society, Language Learning and Technology, Journal of Computer Assisted Learning, British Journal of Educational Technology, Interactive Learning Environments, System*, and *Foreign Language Annals*.

In terms of authors, researchers from China contributed most to this area, with the highest number of research papers published and the highest number of citations. Authors from UK represent the highest ratio of multiple country publications.

Besides, the top 10 most cited papers are listed in this research. A further keyword co-occurrence analysis suggested that "English", "students", "language", "acquisition", "impact", "CALL", "classroom", "technology", "education", "mobile", "phones", "system", "design", "attitudes", "foreign-language", "model", "environment", "performance", "learners", "motivation", "vocabulary", "comprehension", "MALL", "meta-analysis", "2nd-language" and "EFL" are the most important topics in MASLL during the past twenty years. A thematic evolution analysis suggests that in the field of MASLL, the focus of attention is moving towards "students" and the attention on "technology" is fading away.

The most important thing about using technology in learning is not the technology itself, but how to use technologies and how to design a suitable learning environment for learners to enhance their performance and learning outcome. However, it is important that both learners and teachers should familiarize themselves with technologies and learn how to apply these technologies in their learning and teaching. Otherwise, the opportunities offered by technologies to enhance performance may not be perceived by learners or teachers.

The result of this research serves as an important reference for understanding the current situation of MASLL research. However, this study also has some limitations. First, this study takes only one database, the Web of Science, as the source of data, even though it is a comprehensive data platform. Second, the papers in this study are all written in English and no other languages are included. Therefore, it is suggested that future research include multiple data sources and papers written in other major languages.

5 Acknowledgment

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