**Supplementary Material A1:** Discontinued journals from Scopus or those they are categorized as predatory.

* *Asian EFL journal*
* *Asian ESP Journal*
* *Journal of Language Teaching and Research*
* *Theory and Practice in Language Studies*
* *English Language Teaching*
* *International Journal of Applied Linguistics and English Literature*
* *World Journal of English Language*
* *International Journal of Innovation Creativity and Change*
* *World Journal of Educational Technology*
* *Cypriot Journal of Educational Sciences*
* *Journal of Language and Linguistics Studies*

**Supplementary Material A2:**

**CALL-core journals:**

*CALICO, ReCALL, Computer Assisted Language Learning, and LL&T.*

**Non-core CALL journals:**

*CALL-EJ, JALT CALL, Teaching English with Technology (TEwT), International Journal of Computer Assisted Language Learning and Teaching.*

**Supplementary Material A3:**

*Computers & Education, British Journal of Educational Technology, Educational Technology Research & Development, Journal of Educational Computing Research, Interactive Learning Environments, Educational Technology and Society, Journal of Computer Assisted Learning, Education and Information Technologies, Australasian Journal of Educational Technology, International Journal of Educational Technology in Higher Education, Journal of Computers in Education, Turkish Online Journal of Educational Technology, International Journal of Computer-Supported Collaborative Learning, Behaviour and Information Technology, Technology, Pedagogy and Education, Computers and Education: Artificial Intelligence.*

**Supplementary Material B1: Adapted from Lim and Aryadoust (2022) with slight modifications (we added the terms pronunciation and spelling)**

Edu Tech

TITLE-ABS-KEY ( reading ) AND EXACTSRCTITLE ( computers AND education ) OR EXACTSRCTITLE ( british AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE ( journal AND of AND computer AND assisted AND learning ) OR EXACTSRCTITLE ( journal AND of AND educational AND computing AND research ) OR EXACTSRCTITLE ( journal AND of AND educational AND technology AND society ) OR EXACTSRCTITLE ( educational AND technology AND research AND development ) OR EXACTSRCTITLE ( interactive AND learning AND environments ) OR EXACTSRCTITLE ( international AND journal AND of AND educational AND technology AND in AND higher AND education ) OR EXACTSRCTITLE ( australasian AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE (Education and Information Technologies) OR EXACTSRCTITLE (International Journal of Educational Technology in Higher Education) OR EXACTSRCTITLE (Journal of Computers in Education) OR EXACTSRCTITLE (Turkish Online Journal of Educational Technology) OR EXACTSRCTITLE (International Journal of Computer-Supported Collaborative Learning) OR EXACTSRCTITLE (Behaviour and Information Technology) OR EXACTSRCTITLE (Technology, Pedagogy and Education) OR EXACTSRCTITLE (Computers and Education: Artificial Intelligence) AND ( LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) OR LIMIT-TO ( DOCTYPE,"re" ) ) AND ( EXCLUDE ( PUBYEAR,2022) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) )

TITLE-ABS-KEY ( listening ) AND EXACTSRCTITLE ( computers AND education ) OR EXACTSRCTITLE ( british AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE ( journal AND of AND computer AND assisted AND learning ) OR EXACTSRCTITLE ( journal AND of AND educational AND computing AND research ) OR EXACTSRCTITLE ( journal AND of AND educational AND technology AND society ) OR EXACTSRCTITLE ( educational AND technology AND research AND development ) OR EXACTSRCTITLE ( interactive AND learning AND environments ) OR EXACTSRCTITLE ( international AND journal AND of AND educational AND technology AND in AND higher AND education ) OR EXACTSRCTITLE ( australasian AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE (Education and Information Technologies) OR EXACTSRCTITLE (International Journal of Educational Technology in Higher Education) OR EXACTSRCTITLE (Journal of Computers in Education) OR EXACTSRCTITLE (Turkish Online Journal of Educational Technology) OR EXACTSRCTITLE (International Journal of Computer-Supported Collaborative Learning) OR EXACTSRCTITLE (Behaviour and Information Technology) OR EXACTSRCTITLE (Technology, Pedagogy and Education) OR EXACTSRCTITLE (Computers and Education: Artificial Intelligence) AND ( LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) OR LIMIT-TO ( DOCTYPE,"re" ) ) AND ( EXCLUDE ( PUBYEAR,2022) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) )

TITLE-ABS-KEY ( speaking ) AND EXACTSRCTITLE ( computers AND education ) OR EXACTSRCTITLE ( british AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE ( journal AND of AND computer AND assisted AND learning ) OR EXACTSRCTITLE ( journal AND of AND educational AND computing AND research ) OR EXACTSRCTITLE ( journal AND of AND educational AND technology AND society ) OR EXACTSRCTITLE ( educational AND technology AND research AND development ) OR EXACTSRCTITLE ( interactive AND learning AND environments ) OR EXACTSRCTITLE ( international AND journal AND of AND educational AND technology AND in AND higher AND education ) OR EXACTSRCTITLE ( australasian AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE (Education and Information Technologies) OR EXACTSRCTITLE (International Journal of Educational Technology in Higher Education) OR EXACTSRCTITLE (Journal of Computers in Education) OR EXACTSRCTITLE (Turkish Online Journal of Educational Technology) OR EXACTSRCTITLE (International Journal of Computer-Supported Collaborative Learning) OR EXACTSRCTITLE (Behaviour and Information Technology) OR EXACTSRCTITLE (Technology, Pedagogy and Education) OR EXACTSRCTITLE (Computers and Education: Artificial Intelligence) AND ( LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) OR LIMIT-TO ( DOCTYPE,"re" ) ) AND ( EXCLUDE ( PUBYEAR,2022) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) )

TITLE-ABS-KEY ( writing ) AND EXACTSRCTITLE ( computers AND education ) OR EXACTSRCTITLE ( british AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE ( journal AND of AND computer AND assisted AND learning ) OR EXACTSRCTITLE ( journal AND of AND educational AND computing AND research ) OR EXACTSRCTITLE ( journal AND of AND educational AND technology AND society ) OR EXACTSRCTITLE ( educational AND technology AND research AND development ) OR EXACTSRCTITLE ( interactive AND learning AND environments ) OR EXACTSRCTITLE ( international AND journal AND of AND educational AND technology AND in AND higher AND education ) OR EXACTSRCTITLE ( australasian AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE (Education and Information Technologies) OR EXACTSRCTITLE (International Journal of Educational Technology in Higher Education) OR EXACTSRCTITLE (Journal of Computers in Education) OR EXACTSRCTITLE (Turkish Online Journal of Educational Technology) OR EXACTSRCTITLE (International Journal of Computer-Supported Collaborative Learning) OR EXACTSRCTITLE (Behaviour and Information Technology) OR EXACTSRCTITLE (Technology, Pedagogy and Education) OR EXACTSRCTITLE (Computers and Education: Artificial Intelligence) AND ( LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) OR LIMIT-TO ( DOCTYPE,"re" ) ) AND ( EXCLUDE ( PUBYEAR,2022) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) )

TITLE-ABS-KEY ( grammar ) AND EXACTSRCTITLE ( computers AND education ) OR EXACTSRCTITLE ( british AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE ( journal AND of AND computer AND assisted AND learning ) OR EXACTSRCTITLE ( journal AND of AND educational AND computing AND research ) OR EXACTSRCTITLE ( journal AND of AND educational AND technology AND society ) OR EXACTSRCTITLE ( educational AND technology AND research AND development ) OR EXACTSRCTITLE ( interactive AND learning AND environments ) OR EXACTSRCTITLE ( international AND journal AND of AND educational AND technology AND in AND higher AND education ) OR EXACTSRCTITLE ( australasian AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE (Education and Information Technologies) OR EXACTSRCTITLE (International Journal of Educational Technology in Higher Education) OR EXACTSRCTITLE (Journal of Computers in Education) OR EXACTSRCTITLE (Turkish Online Journal of Educational Technology) OR EXACTSRCTITLE (International Journal of Computer-Supported Collaborative Learning) OR EXACTSRCTITLE (Behaviour and Information Technology) OR EXACTSRCTITLE (Technology, Pedagogy and Education) OR EXACTSRCTITLE (Computers and Education: Artificial Intelligence) AND ( LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) OR LIMIT-TO ( DOCTYPE,"re" ) ) AND ( EXCLUDE ( PUBYEAR,2022) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) )

TITLE-ABS-KEY ( vocabulary ) AND EXACTSRCTITLE ( computers AND education ) OR EXACTSRCTITLE ( british AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE ( journal AND of AND computer AND assisted AND learning ) OR EXACTSRCTITLE ( journal AND of AND educational AND computing AND research ) OR EXACTSRCTITLE ( journal AND of AND educational AND technology AND society ) OR EXACTSRCTITLE ( educational AND technology AND research AND development ) OR EXACTSRCTITLE ( interactive AND learning AND environments ) OR EXACTSRCTITLE ( international AND journal AND of AND educational AND technology AND in AND higher AND education ) OR EXACTSRCTITLE ( australasian AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE (Education and Information Technologies) OR EXACTSRCTITLE (International Journal of Educational Technology in Higher Education) OR EXACTSRCTITLE (Journal of Computers in Education) OR EXACTSRCTITLE (Turkish Online Journal of Educational Technology) OR EXACTSRCTITLE (International Journal of Computer-Supported Collaborative Learning) OR EXACTSRCTITLE (Behaviour and Information Technology) OR EXACTSRCTITLE (Technology, Pedagogy and Education) OR EXACTSRCTITLE (Computers and Education: Artificial Intelligence) AND ( LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) OR LIMIT-TO ( DOCTYPE,"re" ) ) AND ( EXCLUDE ( PUBYEAR,2022) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) )

TITLE-ABS-KEY ( pronunciation ) AND EXACTSRCTITLE ( computers AND education ) OR EXACTSRCTITLE ( british AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE ( journal AND of AND computer AND assisted AND learning ) OR EXACTSRCTITLE ( journal AND of AND educational AND computing AND research ) OR EXACTSRCTITLE ( journal AND of AND educational AND technology AND society ) OR EXACTSRCTITLE ( educational AND technology AND research AND development ) OR EXACTSRCTITLE ( interactive AND learning AND environments ) OR EXACTSRCTITLE ( international AND journal AND of AND educational AND technology AND in AND higher AND education ) OR EXACTSRCTITLE ( australasian AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE (Education and Information Technologies) OR EXACTSRCTITLE (International Journal of Educational Technology in Higher Education) OR EXACTSRCTITLE (Journal of Computers in Education) OR EXACTSRCTITLE (Turkish Online Journal of Educational Technology) OR EXACTSRCTITLE (International Journal of Computer-Supported Collaborative Learning) OR EXACTSRCTITLE (Behaviour and Information Technology) OR EXACTSRCTITLE (Technology, Pedagogy and Education) OR EXACTSRCTITLE (Computers and Education: Artificial Intelligence) AND ( LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) OR LIMIT-TO ( DOCTYPE,"re" ) ) AND ( EXCLUDE ( PUBYEAR,2022) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) )

TITLE-ABS-KEY ( spelling ) AND EXACTSRCTITLE ( computers AND education ) OR EXACTSRCTITLE ( british AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE ( journal AND of AND computer AND assisted AND learning ) OR EXACTSRCTITLE ( journal AND of AND educational AND computing AND research ) OR EXACTSRCTITLE ( journal AND of AND educational AND technology AND society ) OR EXACTSRCTITLE ( educational AND technology AND research AND development ) OR EXACTSRCTITLE ( interactive AND learning AND environments ) OR EXACTSRCTITLE ( international AND journal AND of AND educational AND technology AND in AND higher AND education ) OR EXACTSRCTITLE ( australasian AND journal AND of AND educational AND technology ) OR EXACTSRCTITLE (Education and Information Technologies) OR EXACTSRCTITLE (International Journal of Educational Technology in Higher Education) OR EXACTSRCTITLE (Journal of Computers in Education) OR EXACTSRCTITLE (Turkish Online Journal of Educational Technology) OR EXACTSRCTITLE (International Journal of Computer-Supported Collaborative Learning) OR EXACTSRCTITLE (Behaviour and Information Technology) OR EXACTSRCTITLE (Technology, Pedagogy and Education) OR EXACTSRCTITLE (Computers and Education: Artificial Intelligence) AND ( LIMIT-TO ( SRCTYPE,"j" ) ) AND ( LIMIT-TO ( DOCTYPE,"ar" ) OR LIMIT-TO ( DOCTYPE,"re" ) ) AND ( EXCLUDE ( PUBYEAR,2022) ) AND ( LIMIT-TO ( LANGUAGE,"English" ) )

**Supplementary Material B2: Applied Linguistics and Social Sciences (8,977). Adopted from Chen et al. (2021)**

( "spoc" OR "Internet" OR "twitter" OR "Google Docs" OR "WhatsApp" OR "Skype" OR "wearable device" OR "hyperlink\*" OR "smartphone\*" OR "game" OR "automatic speech recognition" OR "speech-to-text recognition" OR "clicker" OR "smart watch" OR "smartwatch" OR "e-portfolio" OR "social network" OR "online communit\*" OR "e-book" OR "intelligent tutoring system" OR "multimedia" OR "video" OR "ipod" OR "digital" OR "web 2.0" OR "augmented reality" OR "wechat" OR "facebook" OR "flipped classroom" OR "moodle" OR "MOOCS" OR "blackboard" OR "google doc, google classroom, google drive" OR "skype" OR "e-learning" OR "self-instruction program" OR "programmed learning" OR "blended learning" OR "web based" OR "web-based" OR "machine learning" OR "online" OR "educational software" OR "virtual reality" OR "blog" OR "chat" OR "computer" OR "technology" OR "electronic discussion groups" OR "interactive whiteboard" OR "iPad" OR "Laptop" OR "messaging" OR "microblog" OR "micro-blog" OR "microblogging" OR "mobile" OR "padlet" OR "social media" OR "tablet" OR "wiki" OR "ubiquitous" ) AND ( "literacy learning" OR "language learning" OR "second language" ) AND ( LIMIT-TO ( SRCTYPE , "j" ) ) AND ( LIMIT-TO ( DOCTYPE , "ar" ) ) AND ( LIMIT-TO ( SUBJAREA , "SOCI" ) OR LIMIT-TO ( SUBJAREA , "ARTS" ) ) AND ( EXCLUDE ( PUBYEAR , 2022 )

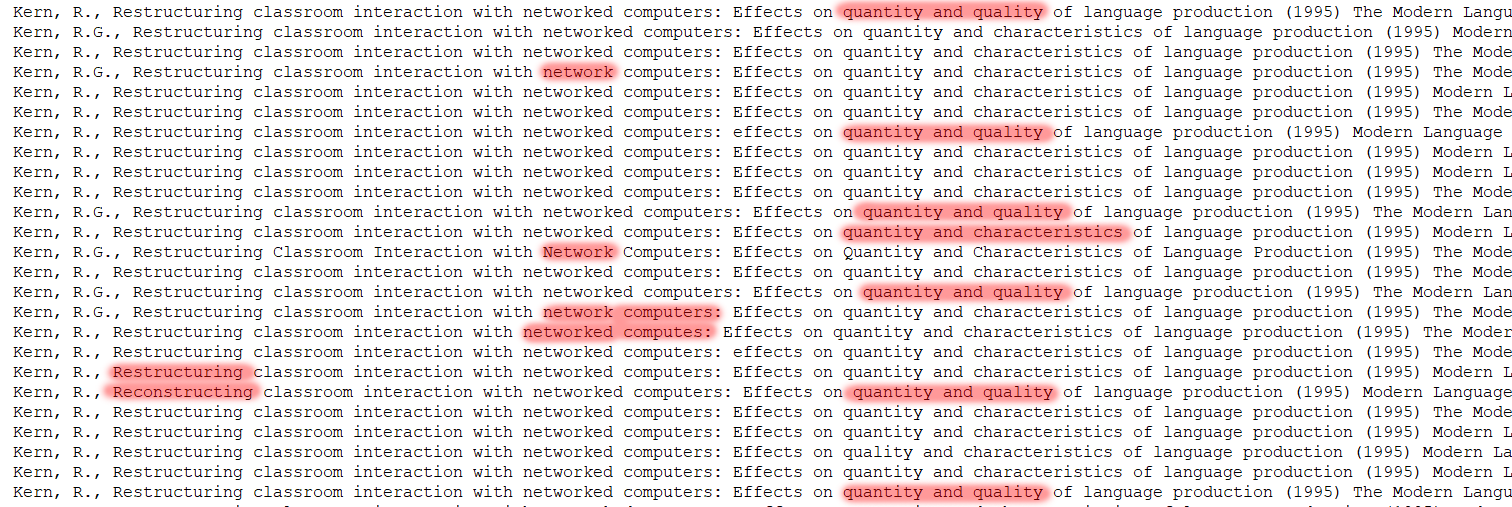
**Supplementary Material C1: Inconsistencies in authors’ names**



**Supplementary Material C2: Inconsistencies in sources of publications**



**Supplementary Material C3: A sample of inconsistencies in study titles**

**Supplementary Material C4: Inconsistencies in authors’ keywords**



**Supplementary Material D: Data analysis procedure**

In our analysis, we employed CiteSpace software 6.1 R3 Advanced (Chen, 2006) to perform a DCA over references. Additionally, we used VOSviewer (Van Eck & Waltman, 2010) to examine authors’ keyword co-occurrences, as well as the co-citation and production of publication sources. To calculate the H-index for sources of publication, we made use of Microsoft Excel. Our analysis relied on several structural and temporal metrics to identify co-citations, including Modularity effect (Q-index), silhouette scores, and betweenness centrality as structural examples, with citation bursts and sigma representing temporal metrics (Chen, 2017). Modularity Q score gauges the interrelationship within a network, ascertaining whether its elements are tightly or loosely grouped (Newman, 2006). Silhouette score quantifies the uniformity and similarity within a cluster (Rousseeuw, 1987), with higher scores indicating greater homogeneity. The term “burst” signals abrupt and significant spikes in citation frequency, reflecting intensified scholarly focus on a specific topic or document (Chen, 2011; Aryadoust, 2020). (Betweenness) Centrality ascertains node positions within a network, with nodes of higher centrality typically located between correlated clusters (Brandes, 2001). Sigma score denotes the scientific originality of a citation (Chen et al., 2012).

In our analysis, we utilized CiteSpace to identify and visualize research clusters within the field of CALL. Specifically, CiteSpace created clusters based on the frequency of words found within the titles, abstracts, and authors’ keywords of the research articles. The software also provided a timeline visualization of these research clusters, allowing us to track their emergence and evolution. To further examine the trends over time, we implemented a time slicing technique with a one-year interval per slice. Drawing on Solmi et al. (2022), we chose to investigate hotspot research within the most recent five-year period (2017-2021). When naming the clusters, we opted to use titles (T) labeling, as this approach best represented the cluster labels. Additionally, we employed the User-Defined Cluster Labels feature within CiteSpace to manually overwrite certain labels where the generated labels were found to be insufficiently indicative (Aryadoust & Ang, 2021). For instance, clusters #7 and #8 within the 1987-2021 timeframe were originally labeled as *Teaching German* and *assisted-language* by CiteSpace. Upon a detailed review of the contents within these clusters, we manually renamed them to *Foreign Language* and *CALL* to more accurately reflect their thematic focus.

In our study focusing on the hotspot areas of CALL research and the trending issues over time, we have carefully selected a range of tools and methods that best suit our analytical needs. For analyzing word-co-occurrences to illustrate the most prevalent topics in CALL research, we used VOSviewer. Our decision to utilize VOSviewer was informed by its efficacy in visualizing data nodes for keywords, which we found to be more effective than CiteSpace for our specific requirements. Additionally, a significant factor influencing our choice to use VOSviewer instead of CiteSpace was the handling of various file formats. Specifically, VOSviewer’s ability to work with CSV (Comma-Separated Values) files offers a considerable advantage in data refinement. CSV files, being text-based, have a structure that allows for easier identification and rectification of errors in keywords especially synonymous words. To further refine our substantial dataset, we opted to filter authors’ keywords using a CSV file. This method allowed us to precisely limit the filter to the authors’ keywords column, thereby enhancing the accuracy of our dataset refinement process. Additionally, we utilized an Excel sheet for manually identifying the number of articles per source of publication.

Given that our investigation is centered on identifying the hotspot areas of CALL research[[1]](#endnote-2) and understanding the evolving trends, we have strategically limited our analysis to focus on key areas including cluster analysis (timeline view), citation bursts, keyword analyses and co-occurrences, and the productivity and co-citation frequency of authors and journals.

**Supplementary Material E1: Clusters’ major citing articles and top 3 cited references in the 1987–2021 time frame**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cluster ID | Citing article | The major citing article | Coverage | 1st Most co-cited reference | Frequency | 2nd Most co-cited reference | Frequency | 3rd Most co-cited reference | Frequency |
| #0 | 299 | Vurdien (2017) | 22 | Nation (2001) | 161 | Golonka et al. (2014) | 77 | Thornton and Houser (2005) | 67 |
| #1 | 161 | Fischer (2007) | 20 | Levy (1997) | 89 | Krashen (1985) | 79 | Oxford (1990) | 73 |
| #2 | 252 | Yilmaz and Granena (2010) | 21 | Vygotsky and Cole (1978) | 338 | Ellis (2003) | 99 | Long (1996) | 79 |
| #3 | 146 | Shin (2006) | 18 | Kern (1995) | 127 | Warschauer (1996) | 93 | Chun (1994) | 81 |
| #4 | 125 | Tai (2015) | 9 | Lave and Wenger (1991) | 72 | Byram (1997) | 65 | Levy and Stockwell (2006) | 58 |
| #5 | 66 | Smart (2014) | 12 | Schmidt (1990) | 125 | Johns (1991) | 26 | Hyunsook (2008) | 25 |
| #6 | 21 | Eskenazi (2013) | 9 | Krashen (1982) | 56 | Braun and Clarke (2006) | 5 | Kenning and Kenning (1990) | 4 |
| #7 | 7 | Möllering (2001) | 10 | Biber (1988) | 9 | Swales (1990) | 6 | Halliday and Hasan (1976) | 5 |
| #8 | 4 | Chapelle (1990) | 5 | Carter and McCarthy (1988) | 4 | Allwright (1988) | 3 | Aitchison (1987) | 3 |
| #10 | 3 | Chen and Hsu (2008) | 6 | Heift and Nicholson (2001) | 6 | Lin and Hsieh (2001) | 3 | Cui and Bull (2005) | 3 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cluster ID | Citing article | The major citing article | Coverage | 1st Most co-cited reference | Frequency | 2nd Most co-cited reference | Frequency | 3rd Most co-cited reference | Frequency |
| #0 | 38 | Lee (2019b) | 16 | Burston (2015) | 22 | Burston (2014) | 20 | Shadiev et al. (2017) | 15 |
| #1 | 37 | H. J. H. Chen et al. (2021) | 5 | Golonka et al. (2014) | 16 | Miles et al. (2014) | 10 | Sundqvist (2019) | 9 |
| #2 | 25 | Fathi and Rahimi (2022) | 9 | Hung (2015) | 29 | Bergmann and Sams (2012) | 24 | Chen-Hsieh et al. (2017) | 20 |
| #3 | 18 | Chen (2018) | 7 | Lin and Lan (2015) | 15 | Jauregi et al. (2011) | 10 | Balaman and Sert (2017) | 6 |
| #4 | 27 | Rahimi and Fathi (2021) | 7 | Elola and Oskoz (2017) | 12 | Storch (2013) | 11 | Plonsky and Oswald (2014) | 10 |
| #5 | 23 | Bahari and Salimi (2021) | 7 | Stockwell (2010) | 11 | Blake (2016) | 10 | Wang and Smith (2013) | 9 |
| #6 | 19 | Lee (2019a) | 17 | Sundqvist and Wikström (2015) | 11 | Lai and Mingyue (2011) | 11 | Reinders and Wattana (2015) | 9 |
| #7 | 22 | Vurdien (2017) | 9 | Wang and Vasquez (2012) | 15 | Kessler et al. (2012) | 14 | Kern (2014) | 13 |
| #8 | 16 | Brudermann et al. (2021) | 5 | Stevenson and Phakiti (2014) | 11 | Ziegler (2016) | 9 | Wilson and Czik (2016) | 9 |
| #9 | 30 | Lee (2017) | 8 | Golonka et al. (2014) | 63 | Lee (2016) | 16 | Vurdien (2013) | 6 |
| #10 | 8 | Ballance (2017) | 7 | Boulton and Cobb (2017) | 20 | Boulton (2010) | 6 | Reppen (2010) | 5 |
| #11 | 11 | Hsu (2018) | 4 | Winke et al. (2013) | 9 | Schenker (2012) | 9 | Benson (2015) | 8 |
| #12 | 8 | Tsai et al. (2017) | 5 | Smith et al. (2013) | 8 | Berns et al. (2013) | 6 | Liu and Chu (2010) | 5 |

**Supplementary Material E2: Clusters’ major citing articles and top 3 cited references in the 2017–2021 time frame**

**Supplementary Material F: Top Co-cited journals with at least 600 citations of a source**

|  |  |  |
| --- | --- | --- |
| Source | Co-Citation Frequency | Total Link Strength |
| Language Learning & Technology | 5400 | 83125 |
| Computer Assisted Language Learning | 5389 | 81607 |
| Computers & Education | 3971 | 45049 |
| CALICO Journal | 3457 | 53125 |
| The Modern Language Journal | 3433 | 58292 |
| System | 3187 | 52088 |
| ReCALL | 3175 | 49896 |
| Tesol Quarterly | 2092 | 32208 |
| Language Learning | 2031 | 39664 |
| Applied Linguistics | 1778 | 31240 |
| Studies in Second Language Acquisition | 1636 | 33862 |
| Foreign Language Annals | 1473 | 24014 |
| Journal of Second Language Writing | 1421 | 22444 |
| British Journal of Educational Technology | 1336 | 19664 |
| Journal of Educational Psychology | 1199 | 11688 |
| Computers in Human Behavior | 1167 | 15636 |
| Journal of Computer Assisted Learning | 1020 | 14295 |
| ELT Journal | 955 | 13424 |
| Educational Technology & Society | 947 | 13604 |
| Language Teaching Research | 850 | 16958 |
| Language Teaching | 738 | 12603 |
| Educational Technology Research and Development | 612 | 8506 |

**Supplementary Material G1: Top 10 references with the highest (betweenness) centrality and sigma scores 1980–2021 time frame**

|  |  |  |
| --- | --- | --- |
|  | Reference | Cluster ID |
| Centrality | | |
| 0.30 | Vygotsky and Cole (1978) | 2 |
| 0.10 | Levy (1997) | 1 |
| 0.09 | Krashen (1982) | 6 |
| 0.08 | Schmidt (1990) | 5 |
| 0.08 | Nation (2001) | 0 |
| 0.07 | Kern (1995) | 3 |
| 0.05 | Oxford (1990) | 1 |
| 0.04 | Warschauer (1996) | 3 |
| 0.04 | Ellis (2003) | 2 |
| 0.04 | Chun (1994) | 3 |
| Sigma | | |
| 3.45 | Levy (1997) | 1 |
| 2.09 | Kern (1995) | 3 |
| 1.75 | Chun (1994) | 3 |
| 1.65 | Warschauer (1997) | 3 |
| 1.65 | Golonka et al. (2014) | 0 |
| 1.45 | Krashen (1982) | 6 |
| 1.28 | Oxford (1990) | 1 |
| 1.26 | Krashen (1985) | 1 |
| 1.23 | Warschauer (1996) | 3 |
| 1.23 | Levy and Stockwell (2006) | 4 |

**Supplementary Material G2: Top 10 references with the highest (betweenness) centrality and sigma scores 2017–2021 time frame**

|  |  |  |
| --- | --- | --- |
|  | Reference | Cluster ID |
| Centrality | | |
| 0.14 | Reinders and Wattana (2014) | 6 |
| 0.14 | Storch (2013) | 4 |
| 0.14 | Lee (2016) | 9 |
| 0.13 | Godwin-Jones (2019) | 1 |
| 0.12 | Hung (2015) | 2 |
| 0.11 | Burston (2014) | 0 |
| 0.11 | Boulton and Cobb (2017) | 10 |
| 0.10 | Li (2018) | 4 |
| 0.09 | Burston (2015) | 0 |
| 0.09 | Jauregi et al. (2011) | 3 |
| Sigma | | |
| 1.51 | Reinders and Wattana (2014) | 6 |
| 1.35 | Jauregi et al. (2011) | 3 |
| 1.32 | Stockwell (2010) | 5 |
| -1.17 | Lin et al. (2016) | 5 |
| 1.11 | Sundqvist and Wikström (2015) | 6 |
| 1.11 | Lee (2011) | 9 |
| 1.11 | Lai and Mingyue (2011) | 6 |
| 1.10 | Amiryousefi (2016) | 2 |
| 1.09 | Benson (2015) | 11 |
| 1.09 | Aydin and Yildiz (2014) | 7 |

**Supplementary Material H: Characteristics of clusters**

In this study, we identified 23 major clusters across two distinct timespans. Given the extensive nature of these clusters, a comprehensive analysis of each is not feasible. Instead, we focus on major clusters, particularly those sharing thematic similarities. By examining the highly cited references and impactful citing articles, we construct a thematic map to elucidate the primary foci within the CALL field.

1. Writing issue

This subject matter aligns closely with broader research in applied linguistics and particularly emphasizes the role of technology in augmenting various forms of feedback (Crosthwaite et al., 2022). In the first timespan from 1987 to 2021, two significant clusters emerged: Cluster #0, which focused on corrective feedback, and Cluster #2, which centered on Web-based Collaborative Writing. In the more recent timespan from 2017 to 2021, five clusters were identified: Cluster #2 on writing complexity and accuracy, Cluster #4 on the use of Google Docs, Cluster #8 on automated writing evaluation, and Cluster #9 on writing motivation. This suggests a diversification and deepening of research focus in technology-enhanced writing within CALL.

In the context of the entire research period, two clusters emerged that are pertinent to the field of L2 writing: written corrective feedback and web-based collaborative writing. Cluster #0, labelled as corrective feedback, was identified as a trending issue in the CALL field, featuring 245 cited articles and 299 citing articles. According to Zakaria and Aryadoust (2023), a research cluster exhibits strong thematic patterns between citing and cited articles. The most highly cited reference within this cluster is Nation’s (2001) book on learning vocabulary in another language, suggesting that the cluster’s focus is on vocabulary acquisition to enhance L2 writing. The most highly citing article is by Vurdien (2017), which concentrates on the use of MALL in vocabulary acquisition within L2 writing corrective feedback contexts.

The second cluster, #2, centers on Web-based Collaborative Writing and was identified in the first period (1987-2021). This cluster has gained attention due to its potential to help learners understand the organizational aspects of writing and acquire complex interactional skills (Abe, 2020). With a timespan from 1962 to 2019, the cluster comprises 204 cited references and 252 citing articles. It is theoretically anchored in the sociocultural theory proposed by Vygotsky and Cole (1978), emphasizing collaborative learning’s role in enhancing synchronous collaborative writing. The most highly citing article in this cluster is by Yilmaz and Granena (2010), which investigates the impact of different task types on students’ focus on linguistic forms in SCMC settings. This article cites 22 studies from the current cluster and is followed by Vurdien (2017), which also appears in the previous cluster for its focus on using wikis in a collaborative writing environment to enhance writing skills.

The period from 2017 to 2021 has seen a surge in scholarly interest within the CALL community, particularly focusing on the enhancement of writing skills. Four distinct clusters have been identified that explore cutting-edge technologies aimed at improving these skills. Two of these clusters are interrelated and concentrate on advancing L2 writing development. The first cluster, labeled as #2 “Writing Complexity Accuracy” by CiteSpace, features two prominent articles that explore the flipped classroom strategy. The article by Hung (2015) tops the list of cited references with the highest betweenness centrality and sigma scores, while the work by Chen Hsieh et al. (2017) ranks as the third most cited article. Bergmann and Sams' (2012) book on the flipped classroom is the second most cited work in this cluster. The article by Fathi and Rahimi (2022), which covers nine cited references, stands out as the most highly cited work in this cluster. This article investigates the impact of the flipped classroom on improving EFL writing performance in terms of complexity, accuracy, and fluency. Notably, all citing articles in this cluster were published between 2015 and 2021, indicating that this is a trending research issue that has gained traction in recent years.

In relation to Cluster #8, labelled as automated writing evaluation, the major citing article is by Brudermann et al. (2021), which delves into the effectiveness of various types of corrective feedback for refining EFL students’ writing errors. The most highly cited reference within this cluster is a systematic review by Stevenson & Phakiti (2014), followed by a conceptual article by Ziegler (2016). The latter emphasizes the benefits of corrective feedback for enhancing learners’ writing outcomes within the context of task-based language teaching. A third cluster pertinent to the writing domain is Cluster #9, labeled as writing evaluation. The top-cited reference here is an article by E. Golonka et al. (2014), which synthesizes CALL literature to identify the most effective technological devices for language learning. Other highly cited articles include Lee (2016), focusing on autonomous learning, and Vurdien (2013), which explores the use of blogging to improve L2 writing skills. Another cluster identified in the second period is Cluster #4, labeled as Google Docs. The top-cited article in this cluster is a conceptual paper by Elola & Oskoz (2017), offering frameworks to assist instructors in integrating social tools to foster L2 writing development in a digital age. Storch's (2013) book, focusing on collaborative writing, ranks as the second top-cited source, while Bahari & Salimi (2021) stands as the top citing article for this cluster.

2. MALL

In the timeline view of CALL research, two clusters related to MALL emerged as the most researched areas. MALL was identified as a hotspot, ranking second in the whole period under the label #1 cell phone (1998-2021) and first in the last five years as #0 mobile-assisted dynamic assessment (2012-2021). The first cluster, #1 cell phone, contained 219 cited references and 161 citing references. Top-cited works in this cluster include Levy’s 1997 book on CALL, Krashen's 1985 book on the input hypothesis, and Oxford’s 1990 book on language learning strategies, signifying that MALL is grounded in a robust theoretical framework. The top citing article in this cluster is Fischer (2007), which examined the effectiveness of tracking students’ usage of CALL software to gain insights into student behavior.

The second cluster, #0 mobile-assisted dynamic assessment, appearing in the most recent period, comprised 86 cited references and 97 citing references. The most cited work in this cluster is by Golonka et al. (2014), which synthesized the use of various mobile devices like tablet PCs, iPods, and smartphones in CALL studies. This work outlined potential applications such as running language learning apps, accessing media, and recording speech. The top citing article in this cluster is Hoi & Mu (2021), which emphasized the crucial role of teachers in guiding effective out-of-class mobile learning, covering 10 cited references.

3. SCMC

One of the most notable clusters identified in the whole period as SCMC, which focused on potential of technology to facilitate language learning through real-time digital interaction. The members of this cluster is 196, which ranges from 1959-2010, with meaning year 1999. The most cited articles was (Kern, 1995), recording 127 citations, which examined students’ language production vis synchronous written discussions. The second highly cited references was Warschauer’s (1996) article which also investigated the same issue but integrated individual student factors like proficiency, cultural background, and attitudes correlated with participation in the face to face versus SCMC. The most citing article was (Shin, 2006) which covers 18 cited articles, focusing on how ESL context could affect students; interaction in a SCMC environment.

4. Data-driven learning

The Data-Driven Learning (DDL) category in CALL research has been examined across two distinct periods, appearing as the fifth cluster in the overall timeline and as the tenth cluster in the recent period. Cluster #5, the sixth largest, comprises 71 members and is primarily concerned with guided induction in DDL. The most cited work in this cluster is by Schmidt (1990), which explores the role of consciousness in second language learning. This is followed by Johns (1991), which theorizes DDL, and Hyunsook (2008), which investigates the impact of corpus use on students’ writing improvement. The major citing article for this cluster is Smart (2014), which examines the efficacy of DDL in enhancing students’ grammatical competence. In contrast, Cluster #10, the eleventh largest cluster in the second phase, consists of 13 members and spans from 2009 to 2017. It features two key articles by Boulton (2010) and Boulton & Cobb (2017) as the most cited references, both focusing on pedagogical models of concordance use in language learning. The top citing article for this cluster is Ballance (2017), which investigates the use of different types of concordances in language learning.

5. Intercultural competence

The research area of CALL and culture, termed as “computer-assisted Languaculture learning” by Chun, has emerged as a significant trend. This is evident from its labeling as the fifth cluster, designated as #4 Intercultural Competence, which contains 107 members and spans the period from 1967 to 2017. The most highly cited work in this cluster is Lave and Wenger’s (1991) seminal book on situated learning. This is followed by Byram’s (1997) influential book on teaching and assessing intercultural competence, and Levy and Stockwell’s (2006) work emphasizing the role of culture in technology-enhanced language learning. The major citing article within this cluster is Tai (2015), which references nine other works. Notably, this cluster has seen increased activity in recent years, specifically between 2022 and 2021, with a peak in 2018 that recorded 26 cited reference works.

6. Pronunciation

The area of Computer-Assisted Pronunciation Training (CAPT) has emerged as a significant microskill research trend within the broader field of CALL. Identified as the seventh cluster by CiteSpace, this cluster comprises 47 members and spans the years from 1968 to 2006. The most highly cited works within this cluster are seminal books that have theorized the subject of pronunciation. Specifically, these include Biber’s work from 1988, Tardy and Swales’ contribution from 2014, and Halliday and Hasan’s work also from 2014. The article by Möllering in 2001 stands as the most frequently citing work within this cluster.

7. Second life

The last five years have been marked by a distinct focus on the utilization of Second Life technology in the field of CALL. This technology enables language learners to engage in immersive simulations and role-playing scenarios within a 3D virtual world, thereby offering a unique platform for practicing communication in the target language. CiteSpace identifies this as the fourth largest cluster, comprising 35 members. The most highly cited reference within this cluster is a systematic review by Lin and Lan (2015), which found that the majority of studies have focused on foreign language learners in higher education settings, particularly using open social virtual worlds like Second Life. Following this, the work by Jauregi et al. (2011) ranks as the second most cited article, exploring the use of the 3D virtual world Second Life for the development of intercultural communicative competence. Balaman and Sert’s work in 2017, emphasizing the importance of enhancing interactional competence for learners, is the third most cited article. The major citing article within this cluster is by Chen (2018), which investigates the task-based negotiation skills of EFL learners in a 3D multi-user virtual environment, specifically Second Life.

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1. We mean by labelling the term “Hotspot areas of research” to an area of CALL that is thoroughly investigated in the CALL literature that could be identified through research clusters outputted by CiteSpace. [↑](#endnote-ref-2)