

Research Progress and Trends of Pigai.org Automated Writing Evaluation System in English Writing: A Systematic Bibliometric Analysis (2011-2023)

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Abstract

This study presents a systematic literature review on the application of the Pigai.org automated writing evaluation system in English writing in China. It aims to explore the research progress and trends in English writing during the period (2011-2023). Journal papers in this study were extracted from the two main databases: CNKI and EBSCOhost, dating from January 1, 2011, to June 22, 2023. The PRISMA 2020 guidelines and the bibliometric analysis technique design were adopted to conduct an in-depth analysis of the journal articles on the Pigai.org automatic writing evaluation system. Additionally, a comparative study on Performance Analysis, Science Mapping and Network Analysis on the number of published articles, authors, institutions, *h*-index(*h*) papers, and keywords were identified. Besides that, the thematic analysis of the keywords revealed the research focuses of Pigai.org in English writing education. Thus, the findings culminated the research progress and trends in China and the world by discussing the implications of the results and indicated promising directions for future research.

Keywords: Pigai.org, systematic literature analysis, English writing, literature review

1. Introduction

1.1 Research Problems

The automated Writing Evaluation (AWE) system is a process of automatically scoring and evaluating learners' written work through computer programs in educational settings (Shermis & Burstein, 2013). It originated in the 1960s in the United States with the evolution of Page Essay Grade (Page, 2003). With the development of natural language processing technologies, linguistics and computer science principles can be combined to create computer applications. For instance, E-Rater, a commercial AWE system developed by the Educational Testing Service, is used to score the writing section of the Graduate Management Admissions Test. It combines artificial intelligence specifically tailored to analyse students' responses and can be used for scoring and providing feedback by identifying features related to students' writing proficiency (Sari & Han, 2021).

In China, AWE systems have been developed specially designed for Chinese English as Foreign Language learners, and Pigai.org is one of them. It was developed by the National Language Intelligence Center of China, launched in 2010 and introduced to the market in 2011 as a commercial online assessment platform (Bai & Hu, 2017). It is a kind of online writing service system that offers teachers and students online writing correction services, like plagiarism detection and remedial feedback, and it also offers a ranking that includes overall comments and score information. (Zhang, 2020). As Pigai.org AWE system can produce an overall essay score by estimating the quantitative differences between the essay and the texts in its corpus in four areas: vocabulary, sentence structure, organization and structure, and subject relevance (Wang & Bai, 2021), it is therefore, students can submit and resubmit their drafts following the comments. The amount of time and effort students put into their writing by the number of revisions they made could be measured with Pigai.org and checked by teachers. Teachers could then offer directions based on their students' performance both online and off.

Presently, as the Pigai.org AWE system is widely used in China and the world (Geng & Razali, 2020), and with its continuous improvement and expansion into the teaching and research field, it is necessary to conduct a systematic bibliometric analysis research between 2011 and 2023 to address the research progress and trends for further study. The following research questions are the focus of this study:

- 1) What are the changes and trends of the study on Pigai.org?
- 2) What are the research hotspots for the Pigai.org study?
- 3) What are the research stages of the study on Pigai.org?

1.2 Research Importance

With the adaption of the PRISMA 2020 guideline (Page et al., 2021) and the Bibliometric Analysis Technique Design (Donthu et al., 2021), this study employed the literature visualisation tools (NVivo 12 and Excel charts) to visually analyse the literature on Pigai.org in English writing in both China and the world and to summarise the research findings and limitations. The research will shed light for scholars or educators for their further research and teaching practice.

1.3 Relevant Scholarship

In terms of the research on Pigai.org in English Writing, researchers have mainly focused on the introduction, application and suggestions for effective collaboration use (Zhu, 2019; Luo & Liang, 2022 & Zhang, 2022) or on its application in English writing to construct a multiple feedback writing mechanism (Liu, 2022; Yao, 2021; Wang & Bai, 2021), or case studies in one particular university, including a combined teaching module, an assessment and evaluation method, or a tentative study on its validity (Tan, 2019; Yan, 2019; Guo, 2020 & Yang et al., 2022). The researchers are mainly from educational backgrounds, but their research focuses vary from each other. Based on a thorough analysis of the research from China National Knowledge Infrastructure (CNKI) and EBSCOhost, there is a necessity to conduct a comparative systematic bibliometric analysis on the application of Pigai.org AWES in English writing both in China and the world. For instance, to examine relevant studies on using Pigai.org to teach English writing and to summarise prior experience to lay the groundwork for future research.

2. Methods

In this study, the bibliometric analysis technique design advocated by Donthu et al. (2021) was adopted. It forms a comparative study based on the main techniques like Performance Analysis and Science Mapping, enriched by Network analysis. Bibliometric studies can provide quantitative summaries of a given research field or topic from both Performance and Network perspectives. Performance analysis involves measuring productivity through counting, rankings, and citations, while network analysis reveals intellectual connections using techniques such as co-authorship and co-citation analysis (Romanelli et al., 2021). To conduct a systematic bibliometric literature review on the application of Pigai.org in English writing, the CNKI and EBSCOhost databases were used to ensure a thorough analysis of the research progress and trends in education in China and the rest of the globe. The citation and co-citation analyses were based on these two distinct databases to conduct this comparative study and to find the difference in the research progress and trends in China and the world.

2.1 Data Source

The CNKI database has developed into the world's most comprehensive and updated full-text database of Chinese academic journals. It also boasts the best digital library technology in the world. (Nan et al., 2022). It allows for the sharing and dissemination of China's vast knowledge and information resources in addition to promoting Chinese education and scientific research to raise institutions to a high international level (Sun & Asmawi, 2022). The 266 journal articles from 2011 to 2023 in this study were selected from the CNKI database based on the search by title “句酷批改(Pigai.org)”, which well-illustrated the academic level and research progress and trends in China.

The EBSCOhost database in this study included the search from the three most related primary databases on education: Academic Search Complete, Education Research Complete and the Education Resource Information Center databases (EBSCOhost, 2023). The 31 journal articles from 2011 to 2023 in this study were selected on the search by the subject keywords “Pigai”, “Pigai.org” and “Pigai.org AWE”. Irrelevant or less relevant journal articles were excluded by reading the article's title, keywords, and main contents.

Systematic reviews require rigorous evidence identification because the selection of relevant studies for the sample determines the review's outcome, validity, and explanatory power (Gusenbauer & Haddaway, 2020), and knowing the databases' absolute subject coverage enables the selection of the most comprehensive databases for searches, particularly relevant in lookup or exploratory searches (Gusenbauer, 2022). As the CSSCI is the most advanced and cutting-edge research in social sciences in China, the related journal articles from the CNKI were used as the data source for Chinese-language literature, while the Social Science Citation Index (SSCI) contains thousands of the most important social science journals for the foreign-language literature in the world, so the related educational journal articles from the EBSCOhost indicate the central research for this study. Both CSSCI and SSCI respectively cover the most representative and authoritative journal papers in the field of Chinese and international education. Therefore, 15 CSSCI journal articles from the CNKI database and 12 SSCI from the EBSCOhost database were selected to enrich the bibliometric analysis.

As the objective of this study is to explore the research progress and trends of Pigai.org AWE System in English Writing, the citation and co-citation analyses were based on the separate database to conduct the comparative study and to find the difference in the research progress and trends in China and the world. From this perspective, there is no merged database analysis for this research.

2.2 Data Collection

Journal articles for this study were extracted from CNKI and EBSCOhost databases on June 22, 2023. The stages involved in gathering and processing data are as follows: to begin with, the researcher conducted a literature search using the subject keyword “句酷批改”(“Pigai.org”) by title, setting the search period covered by the publication from January 1, 2011 (as it was introduced to the market) to June 22, 2023. Journal articles were the main emphasis except for magazines, dissertations, and conference papers, and the search results yielded 266 journal articles in CNKI. The same goes with the EBSCOhost search with the subject keyword “Pigai” or “Pigai.org AWE” by title. There were 31 journal articles. It also excludes the less pertinent or irrelevant literature that doesn't fit the criteria for the research by reading the title, keywords, and body of the article. Second, the researcher classified the 266 journal articles from CNKI based on the

h-index(h). The top 40 *h-index(h)* papers including 15 CSSCI journal articles and another 12 SSCI articles out of 31 journal articles from the EBSCOhost database were selected. Then, the file formats were converted and renamed separately and exported. Lastly, the researcher renamed the file "download 2011-2023 (CNKI)" and "download 2011-2023 (EBSCO)" for further data processing.

2.3 Research Design

Bibliometric analysis has gained popularity as a quantitative research methodology to evaluate scholarly productivity and identify trends within specific research areas. However, there are currently no established reporting guidelines for bibliometric studies (Koo & Lin, 2023). The present study aimed to explore the research progress and trends in English writing during the period (2011-2023) with the adoption of the PRISMA 2020 guidelines (Page et al., 2021) and the bibliometric analysis technique design (Donthu et al., 2021). It forms a comparative study using Performance Analysis and Science Mapping, enriched by Network Analysis.

According to Donthu et al. (2021), there are two main categories of the techniques for bibliometric analysis manifest: Performance Analysis and Science Mapping. The former accounts for research constituents' contributions, while the latter deals with the relationships between research constituents. Moreover, it could be enriched by Network analysis.

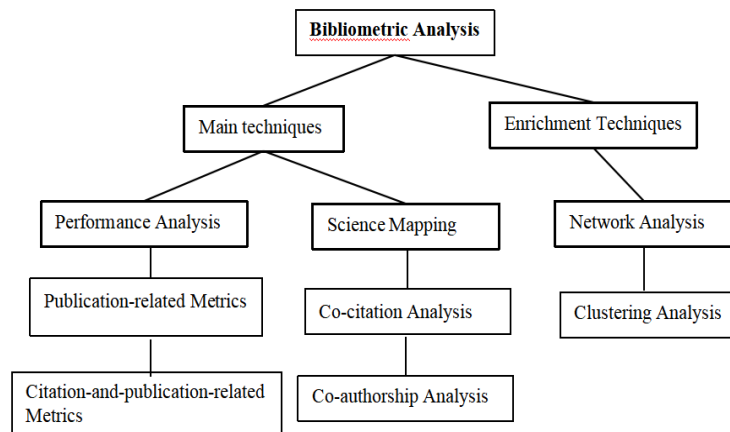


Figure 1. The research design of a bibliometric analysis

As is shown in Figure 1, Performance Analysis examines the contributions of research constituents to a given field (Donthu et al., 2021). Two metrics, publication-related and citation-and-publication-related Performance Analysis, were adopted to explore the number of publications and citations per year or research constituent. It includes a proxy for productivity for publication, citation of impact and influence, as well as citation per publication and *h-index(h)*, to measure the performance of research constituents. Science Mapping examines the relationships between research constituents (Donthu et al., 2021). In this study, the co-citation analysis and co-authorship analysis were also conducted, together with the Clustering analysis of Network Analysis to enrich the bibliometric assessment. Therefore, this study provides a comprehensive analysis to explore the research progress and trends of the Pigai.org AWE system in English Writing (2011---2023).

In addition, relevant information about Pigai.org in English writing in China and around the world was concisely conveyed using an Excel spreadsheet, software (NVivo12) analysis tool, curve charts, and other visualisation tools. An in-depth analysis was based on the quantity, authors and institutions, citation frequency, and keyword co-occurrence on the journal articles from the CNKI and EBSCOhost databases. Moreover, this study divided the period from 2011 to 2023 into 13 time slices using a one-year time slice.

3. Results

The results were drawn from bibliometric analysis, including Performance Analysis, Science Mapping, and Network analysis.

3.1 Performance Analysis

There are several measures for performance analysis, and the most prominent one is the number of publications and citations per year or research constituent. The publication is a proxy for productivity, while the citation is a measure of impact and influence. There are other measures, such as citation per publication and *h-index(h)*, that combine citations and publications to measure the performance of research constituents (Donthu et al., 2021).

3.1.1 Publication-related Metrics

The sample size for this analysis is 266 pieces of journal articles with the search of "Pigai.org (句酷批改)" in the CNKI database and 31 journal articles from the EBSCOhost database. Figure 2 and Figure 3 show the distribution of journal articles from the databases by year.

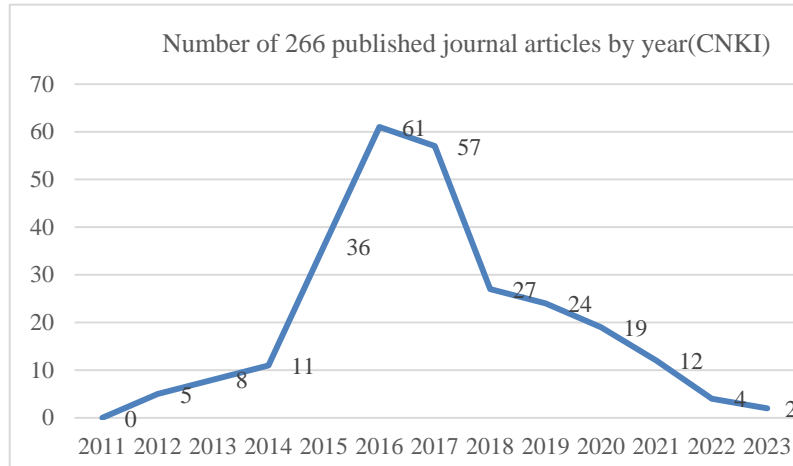


Figure 2. The number of 266 published journal articles from CNKI by year

As is shown in Figure 2, there were no published journal articles on Pigai.org in China in 2011, but stable growth was witnessed in the next four years. After that, the journal articles number grew sharply from 11 in 2014 to 61 in 2016, and this trend lasted one year in 2017, with 57 before it dropped to 27 in 2018, hitting bottom in 2022 and 2023 with 4 and 2, respectively.

To make a comparative study, all 31 journal articles from the EBSCOhost database on Pigai.org were selected to complement as indicated in Figure 3.

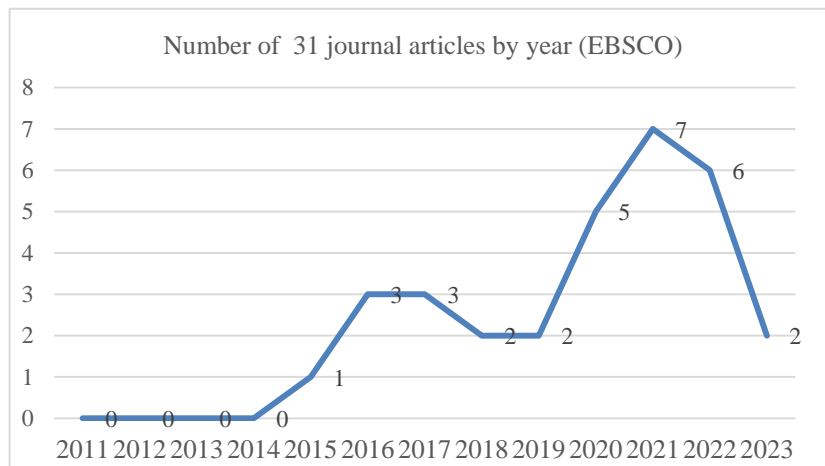


Figure 3. The number of 31 journal articles from the EBSCOhost database by year

Figure 3 shows that the study of Pigai.org in English writing started in 2015. The journal article number remained stable at about 2 or 3 in the next three years. After that, rapid growth jumped from 2 in 2019 to 7 in 2021. In 2022, there were still 6 related articles, but this figure went down to 2 in 2023. The journal articles were clustered in the three consecutive years from 2020 to 2022.

In addition, to conduct a comparative study on the research progress and trends in detail, the Top 40 *h*-index(*h*) journal articles from CNKI were chosen to complement the research by year, as the rest of the journal articles contributed less to the leading research for the research progress and trends. It is indicated in Figure 4.

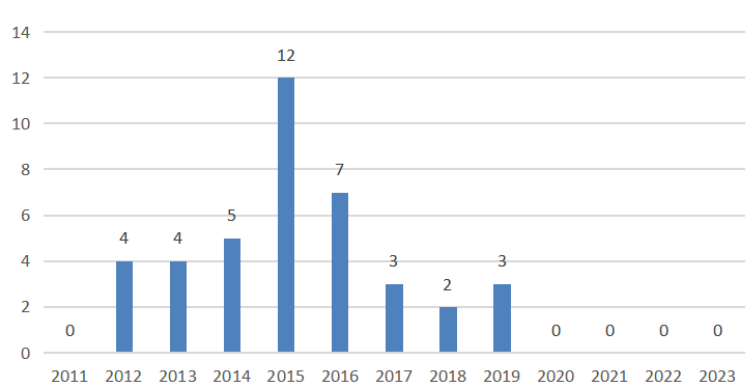


Figure 4. Number of Top 40 highly cited journal articles by year (CNKI)

As is shown in Figure 4, the number of journal articles on Pigai.org from CNKI increased dramatically from 2012 to 2015, rising from 4 to a peak of 12. After that, there was a downward trend from 12 in 2015 to 3 in 2019. It should be noted that, both in 2011 and the years after 2019, almost no highly cited journal articles were published. In other words, few English writing advances were made after 2016. In 2015, the total number of published journals from the CNKI database was 36, but 12 out of the Top 40 highly cited journal articles were published. The highly cited journal articles were clustered in 2015 and 2016.

3.1.2 Citation-and Publication-related Metrics

The categories of the published journal articles exhibit a wide range of distribution characteristics, which is consistent with the field of the application of Pigai.org AWES in English writing. The more frequently the journal articles are cited, the greater the influence of the research is. We could identify the scholars who had a major impact on the area by looking at the citation rate of journal papers, and we could also find out whose academic achievements were more highly regarded by their peers.

As the quality of journal articles published in general journals varied, the articles published in core journals played a vital role in the research progress and trends study analysis. A criterion to make a comparative study shall be set first by screening findings of the source categories. Then, 15 CSSCI publications out of the 266 journal articles from the CNKI database and 12 SSCI publications out of 31 from the EBSCO database were selected. As illustrated in the following Table 1 and Table 2.

Table 1. 15 CSSCI journal articles from CNKI from 2011 to 2023

Ranking	Title	Year	h-index(h)	Journal
1	A study on the reliability and validity of English composition scored by Pigai	2013	261	Modern Educational Technology
2	Research on the application of online AWES (Pigai) in college English writing teaching	2012	245	Modern Educational Technology
3	Intelligent tutor system for English Writing teaching in China: Achievements and challenges-taking Pigai as an example	2013	161	e-education Research
4	Research on autonomous writing revision based on online automatic feedback	2015	106	Journal of PLA University of Foreign Languages
5	The influence of online essay self-revision on college students' English writing results	2015	103	TEFLE
6	English based on "output-oriented pedagogy" Analysis of the change path of writing ability	2018	96	Journal of The Chinese Society of Education
7	A case study on the feedback effect of automatic essay review system	2015	85	TEFLE
8	Research on the second writing process based on automatic evaluation system	2016	69	Foreign Language World
9	Learning analysis and foreign language teaching in the big data era	2016	57	TEFLE
10	The influence of online English writing platform on college students' writing syntactic ability	2015	39	TEFLE

11	Construction of Formative assessment model for online college English writing	2015	30	Modern Educational Technology
12	A Study on the Blending Teaching Model of College English Writing Based on “pigai.org” Software	2016	20	Education Modernization
13	To construct the application framework of information technology in college English courses	2014	20	Modern Educational Technology
14	Research on multiple interactive teaching model of English basic course under the "Internet+"	2019	16	Journal of The Chinese Society of Education
15	The Design and New Development of Intelligent Tutoring System based on PST Theory -- Taking Pigai.org as an example	2017	15	Modern Educational Technology

As listed in Table 1, there were 5 articles published by Modern Educational Technology, which had the first and second highest *h*-index (*h*) with 261 in 2013 and 245 in 2012. Another leading journal, TEFLE, contributed 4 journal articles, mainly in 2015 and 2016. The other 6 *h*-index(*h*) CSSCI journal papers were from six different journals. The latest one was published in 2019 in the Journal of the Chinese Society of Education on multiple interactive teaching models with 16 *h*-index(*h*). The number of *h*-index(*h*) journals led the research on Pigai.org in China. Modern Educational Technology and TEFLE were ahead of other journals on the research in English writing. All the *h*-index(*h*) journal articles were clustered in 2015 and 2016.

Table 2. 12 SSCI journal articles from EBSCOhost from 2011 to 2023

Ranking	Article Title	Year	h-index(h)	Journal
1	In the Face of Fallible AWE Feedback: How Do Students Respond?	2017	84	Educational Psychology
2	Teacher Engagement with Online Formative Assessment in EFL Writing During COVID-19 Pandemic: The Case of China.	2021	41	Asia-Pacific Education Researcher (Springer Science & Business Media B.V.)
3	Exploring the integration of automated feedback among lower-proficiency EFL learners.	2020	38	Innovation in Language Learning & Teaching
4	Understanding Changes in EFL Teachers' Feedback Practice During COVID-19: Implications for Teacher Feedback Literacy at a Time of Crisis.	2021	26	Asia-Pacific Education Researcher (Springer Science & Business Media B.V.)
5	Perspectives on Using Automated Writing Evaluation Systems to Provide Written Corrective Feedback in the ESL Classroom.	2020	25	TESL Canada Journal / Revue TESL du Canada
6	A Computer-Assistance Learning System for Emotional Wording.	2016	11	IEEE Transactions on Knowledge & Data Engineering
7	Understanding AWE Feedback and English Writing of Learners with Different Proficiency Levels in an EFL Classroom: A Sociocultural Perspective.	2022	8	Asia-Pacific Education Researcher (Springer Science & Business Media B.V.)
8	The effectiveness of automated writing evaluation in EFL/ESL writing: a three-level meta-analysis.	2022	5	Interactive Learning Environments
9	Role of assessment in second language writing research and pedagogy.	2017	4	Educational Psychology
10	Using automated corrective feedback tools in language learning: a review study.	2023	2	Interactive Learning Environments
11	“It improves our writing enthusiasm”: Exploring multimodal resources for teaching contemporary College English writing in China.	2022	0	Educatio Siglo XXI
12	Is Less Really More? The Case for Comprehensive Written Corrective Feedback.	2021	0	Canadian Journal of Applied Linguistics

As listed in Table 2, the highest *h*-index(*h*) was 84 by Educational Psychology in 2017, followed by Asia-Pacific Education Researcher with 41 in 2021, while both Education Siglo XXI and Canadian Journal of Applied Linguistics had 0 *h*-index(*h*). The research on the feedback and online formative assessment on Pigsaw.org in English writing were the mainstream in the international study. All the *h*-index(*h*) papers were almost from the three leading journals: Asia-Pacific Education Researcher (3), Educational Psychology (2) and Interactive Learning Environments (2). There are two periods of *h*-index(*h*): 3 journal articles from 2016 to 2017 and 9 from 2020 to 2023. The research direction reverted to multiple aspects of Pigsaw.org in English writing, including integration, motivation, and effectiveness.

3.2 Science Mapping

Science mapping examines the relationships between research constituents, and the analysis pertains to the intellectual interactions and structural connections among research constituents (Donthu et al., 2021). The techniques for science mapping include citation analysis, co-citation analysis, bibliographic coupling, co-word analysis, and co-authorship analysis. To explore the intellectual interactions in this study, co-citation analysis and co-authorship analysis were adopted. Together with network analysis, such techniques are instrumental in presenting the research field's bibliometric structure and intellectual structure (Baker et al., 2020).

3.2.1 Co-citation Analysis

Co-citation analysis is a Science Mapping technique that assumes publications cited together frequently are similar thematically (Hjørland, 2013). To conduct the research progress and trends, statistics on the authors and institutions of the journal articles could be adopted to track the most active researchers and the most attributive institutions for Pigsaw.org in English writing teaching and research. The authors and the institutions of the Top 40 *h*-index(*h*) journal articles from CNKI and 31 journal articles from EBSCOhost were selected for the comparative study. Figure 5 and Figure 6 are the separate author maps.



Figure 5. Top 40 *h*-index(*h*) journal articles by CNKI



Figure 6. 31 journal articles by EBSCOhost

Figure 5 and Figure 6 were the Author maps of the Top 40 *h*-index(*h*) journal articles by CNKI and 31 journal articles by EBSCOhost

from 2011 to 2023, respectively, ranging by correspondence author. Depending on how many publications the writers authored, they were given either a large or small presentation. The name becomes bigger the more journal papers it has. The visual statistical results of Figure 5 show that the researchers with two articles were from Zhang Li, one in 2013 from Donghua University and one in 2015 from Shanghai Jiaotong University. The remaining 38 were published by Individual authors, and this goes with the trend in Figure 6, while all the 31 journal papers based on the EBSCO database were all from individual authors. The author maps indicated that the research on Pigi.ai.org in English writing in China and abroad was not extended or expanded throughout the years except for Zhang Li.

3.2.2 Co-authorship Analysis

Co-authorship analysis examines the interactions among scholars in a research field and is a formal way of intellectual collaboration among scholars (Donthu et al., 2021). It is essential to understand how scholars interact amongst themselves, including associated author attributes such as affiliated institutions and countries. To achieve a better and more detailed visual presentation of the comparative study of the institutions, bar chart maps were used to illustrate this research, as was shown in Figure 7 and Figure 8.

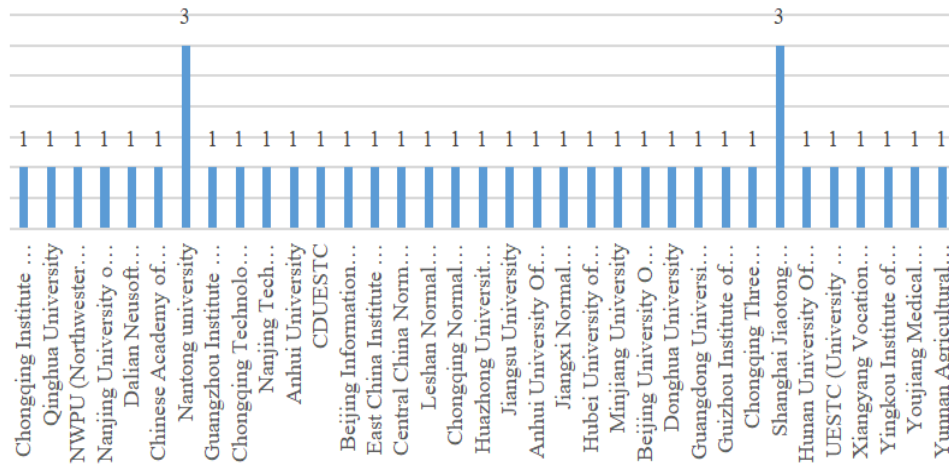


Figure 7. Institution map of Top 40 *h*-index(*h*) by CNKI from 2011 to 2023

As is shown in Figure 7, Shanghai Jiaotong University and Nan Tong University each had three journal articles, and the other 34 universities and polytechnics each contributed one, respectively. Two top 40 *h*-index(*h*) articles were from polytechnics: Chongqing Technology & Business Institute and Xiangyang Vocational and Technical College. Figure 7 shows Shanghai Jiaotong University and Nan Tong University led the research in China in terms of the quantity of *h*-index(*h*) journal articles from CNKI,

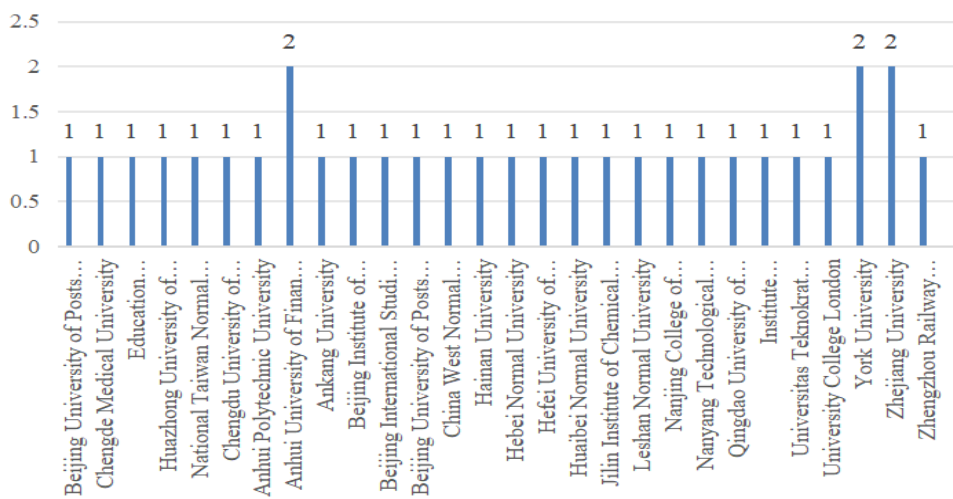


Figure 8. Institution map of 31 journal articles by EBSCOhost from 2011 to 2023

Figure 8 shows that most journal articles were from Chinese universities and colleges, among which Zhejiang University and Anhui University of Finance & Economics each had 2, and the other 19 Chinese universities and colleges contributed one individually. The

remaining 8 journal papers were all out from mainland China: York University (2); Taiwan (2); London College University (1), University Teknokrat Indonesia (1), Nanyang Technological University (1) and Hong Kong (1). The distribution characteristics of institutions were almost broadly consistent with those of the authors. That is, few institutions or countries had a clear dominance in terms of the number of papers published. Figure 8 also presents Zhejiang University, and Anhui University of Finance & Economics led the international study in China, while Canada and Taiwan led the international study outside mainland of China.

The above data showed that the research on Pigai.org in English writing had a broad scope and was aligned with the university's positioning of cultivating talents for applied foreign language. Educational establishments like comprehensive universities, colleges and polytechnics in finance and economics, foreign studies, teacher education, telecommunications and other industries were widely covered. Moreover, the research trend was not only for some specific colleges and universities with extensive experience in teaching English writing using Pigai.org but also for the fundamental state of English talent training at different school levels and institutes, allowing scholars to gain a better understanding of the status of Pigai.org AWE system in English writing.

3.2 Network Analysis

Building on the core techniques of bibliometric analysis, network analysis presents the add-ons to enrich the outcomes of the analysis techniques applied in bibliometric studies. In total, three enrichment pathways for network analysis are suggested in the form of network metrics, clustering, and visualisation (Donthu et al., 2021), among which the clustering adopted in the study is to create thematic or social clusters, depending upon the analysis.

Keywords are a concise summary of the main ideas of a journal paper that can indicate the research progress and trends in a particular research area (Chen et al., 2016). The thematic analysis of Pigai.org in English writing education and research from 2011 to 2023 can be recognised using the keyword summary map provided by NVivo 12 (Table 3 and Table 4).

The keywords of the Top 40 h-index(h) journal articles from CNKI and 31 from EBSCO were selected using NVivo 12, set within a minimum length of three and grouped with the same specialisation. The higher the frequency of occurrence of the keyword was, the more popular the study topic would be, such as activity (11.89%), study (11.29%), writing (7.35%) and so forth. As the co-occurrence was significant in the corpus, the similar words on the right column were all included for the keyword co-occurrence. Lastly, the top 20 keywords from the CKNI and EBSCOhost databases were chosen in this study.

Table 3. Co-occurrence Map of Hot Words on Pigai.org in English Writing from 2011 to 2023 by CKNI

Word	Length	Count	Weighted Percentage (%)	Similar Words
activity	8	92	11.89	activity, analysis, application, composition, computing, course, dynamic, engineering, essay, feedback, intelligence, manual, method, model, modeling, process, review, second, support, teaching, technology, training, utility, writing
study	5	43	11.19	computing, engineering, english, linguistics, report, review, study, technology
writing	7	61	7.35	analysis, composition, correction, essay, language, platform, report, review, score, study, style, writing
pigai	5	22	7.14	pigai
evaluation	10	17	4.25	essay, evaluating, evaluation, rating, review, score, scoring
automatic	9	12	3.90	automatic
output	6	33	3.79	output, writing
process	7	24	3.39	activity, computing, feedback, language, learning, operability, process, study, style
online	6	10	3.25	online
quality	7	22	2.99	ability, complexity, error, quality, style, system, utility, validity
org	3	9	2.92	org
teaching	8	15	2.33	course, learning, teaching, tutor
awes	4	7	2.27	awes
college	7	10	1.79	college, colleges
complexity	10	12	1.79	college, complexity
ability	7	16	1.63	ability, intelligence, language, method, system
composition	11	16	1.58	complexity, composition, framework, report, score, study
system	6	12	1.41	internet, network, platform, system, vocabulary
corpus	6	4	1.30	corpus

As Table 3 listed, the percentage of hot words had an enormous gap between each other. The highest percentage of the hot words was 'activity' (11.89%), which includes the study related to the activity, analysis, application, computer-related course, and other teaching activities. This was followed by a 'study' (11.19%), which included the study on computing, engineering, English linguistics, reports,

reviews, etc. The following three most popular keywords in consecutive were writing, Pigai.org itself and evaluation, contributing 18.74% of the total keywords

Table 4. Co-occurrence Map of Hot Words on Pigai.org in English Writing from 2011 to 2023 by EBSCOhost

Word	Length	Count	Weighted Percentage (%)	Similar Words
process	7	32	6.78	assessment, awareness, development, education, feedback, integration, language, learning, process, study, translation
writing	7	41	6.65	analysis, correction, development, instruction, language, line, platform, program, review, revision, study, text, writing
communication	13	39	6.46	analysis, application, communication, information, instruction, language, line, lower, network, program, revision, writing
study	5	16	5.02	architecture, design, english, history, review, study, technology
education	9	26	3.82	development, education, instruction, learning, pedagogy, teacher, teaching
quality	7	15	3.74	ability, accuracy, complexity, effectiveness, proficiency, quality, system
evaluation	10	11	3.27	assessment, evaluation, review, scoring
automated	9	8	3.17	automated
line	4	19	2.67	architecture, course, education, engagement, instruction, line, pedagogy, teaching
learning	8	22	2.49	education, instruction, learning, study, teaching
pigai	5	6	2.38	pigai
complexity	10	6	2.18	college, complexity, hybrid
ability	7	15	2.14	ability, design, innovation, language, literacy, pedagogy, proficiency, system
computer	8	6	1.98	computer, integration, process
system	6	11	1.84	design, internet, line, network, platform, program, system, systems
corrective	10	4	1.32	correction, corrective
awe	3	3	1.19	awe
classroom	9	3	1.19	classroom
online	6	3	1.19	online
students	8	3	1.19	student, students

Table 4 shows the highest percentage was the word ‘process’, accounting for 6.78%. The other two were ‘writing’ (6.65%) and ‘communication’ (6.46%), which indicated the research focuses were on the assessment, development, feedback, integration, analysis, and application of Pigai.org in English writing. Meanwhile, there were still others like the design, evaluation, and complexity of these studies of Pigai.org, but these were less popular compared with the first three.

Overall, the studies from CNKI and EBSCOhost databases were related to the evaluation, students’ motivation, and corrective and automatic online study, but the percentages of each study varied for the research. The keywords co-occurrence from EBSCOhost had a high percentage in communication, with 6.45% dominating the third, while it never occurred for the Top 20 hot words from CNKI. The researchers from CNKI were more concerned with the study in the actual application of Pigai.org from the teachers’ or the researchers’ perspectives, while the EBSCOhost database focused on the ‘process’, and the studies were mainly based on the assessment, learners’ awareness, and authors’ feedback. In other words, the EBSCOhost focused more on the online tool communication between the students and researchers or teachers.

4. Discussion

This study selected journal articles from the CNKI and EBSCOhost databases on Pigai.org in English writing in China and the world from 2011 to 2023. A systematic bibliometric analysis was based on Performance Analysis, Science Mapping, and Network Analysis on the number of published articles, authors and institutions, keywords, and thematic items. The study might shed light for the researchers for future studies. The presentation of the results aims at answering the three research questions.

RQ 1: What are the changes and trends of the study on Pigai.org?

From 2011 to 2023, the number of journal articles on Pigai.org in the CNKI database increased with the continuing development of English writing. It increased rapidly and peaked in 2015, the dividing year in China. After that, the number of research decreased gradually till 2019. One trend worth mentioning is that from 2020 till now, there have been very few high-quality journal articles, which indicates the lack of sustainable development in the research on Pigai.org in English writing. From the analysis of journal articles from EBSCOhost databases, no research was found in the first four years since Pigai.org was launched in 2011. Though it experienced a slow development from 2015 to 2019, the highest achievement in research in quality and quantity was made from 2019 to 2021, and it still presented a sustainable development in the next three years till 2023.

In China, the *h*-index(*h*) journal articles were predominantly between 2012 and 2013 shown by the analysis of 15 CSSCI articles. It

experienced a fast development in the initial research on Pigai.org in English writing in earlier periods but contributed less after that. 12 *h-index(h)* SSCI journal articles out of 31 from the EBSCOhost database indicated the high quality of the research in the world, and it also presented an upward and sustainable development stage between 2022 and 2023.

RQ2: What are the research hotspots for the Pigai.org study?

According to the analysis of keywords co-occurrence, author and institutions, the research on Pigai.org in English writing in China mainly focused on its application and teaching practice. In contrast, the research from the EBSCOhost database shows that the research focuses were mainly on the process of Pigai.org, including the assessment, students' motivation, integration, communication, and feedback of the online AWES system. It also revealed innovations in teaching modes and instructional design based on the flipped classroom in China and the world. A sizable amount of research was conducted on Pigai.org English writing instruction at universities or college levels. This demonstrates the need to expand the research scope to lower-level colleges, such as vocational colleges, to cultivate applied foreign language talents.

RQ3: What are the research stages of the study on Pigai.org?

The comparative study of the research progress and trends showed two distinct development stages in China and overseas studies. In China, the development of Pigai.org in English writing from 2011 to 2023 can be divided into three stages: Initial fast Exploration Stage (2011-2015), Sustainable Development Stage (2016-2019) and Unclear Development Stage (2020-2023). The initial exploration stage developed very fast, and the journal articles were of good quality but with narrow research topics, focusing primarily on their application in English writing. In the sustainable development stage, the high-quality papers decreased. However, the research topics became more diversified, covering teaching theories, educational reforms and designs, and the research was expanded to polytechnics, too. In the present unclear development stage, as the high-quality papers were relatively small, researchers in China lacked further exploration on Pigai.org AWES in English writing.

As for the international research stages, the analysis of the overseas study from the EBSCO database presented three entirely different stages: the Initial Exploration Stage (2011-2015), the Sustainable Development and Prosperity Stage (2015-2021) and The Sustainable Development Stage (2022-2023). In the first stage, as the application of Pigai.org was introduced and widely used in China, the influence towards the world was limited, and this situation changed as more high-quality journal articles were published in 2015 and 2016. It gradually drew the world's attention between 2015 and 2021. After that, it entered a sustainable development stage. There were still several high-quality papers in 2023, and more hot words appeared afterwards.

5. Conclusion

To conclude, a systematic bibliometric analysis of Pigai.org's automated writing evaluation system in English Writing indicated clear research progress and trends in China and the world. The implication of the results shed light for the researchers to conduct further research and assist the teachers in the application of the AWE system in their teaching practice. However, this study only focused on the research progress and trends during the period from 2011 to 2023, and the limited 266 journal articles from CNKI (including the Top 40 highly cited papers and all the 15 CSSCI journal articles) and 31 from EBSCO databases (including 12 SSCI journal articles) on the keywords, citation frequency, authors and institution analysis, it might exclude the magazines, dissertations and conference papers which were also crucial research published by other scholars or from other countries, and some reference materials might be missing. Future research shall include more research materials and sources and larger samples to conduct a deeper analysis of the Pigai.org AWE system in English writing, and the research scope shall be expanded to more vocational colleges or polytechnics, especially in this Educational Industry 4.0 era.

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Authors contributions

Dr. Maslawati Mohamad was responsible for the study design. Wenyi Li was responsible for the data collection. Dunjiao Xiao drafted the manuscript and all authors revised it. All authors read and approved the final manuscript.

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