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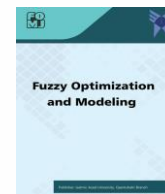
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A Fuzzy VOSviewer Modelling of EMI Research: A Multifaceted Perspective

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A B S T R A C T

English plays an increasingly important role in non-English-speaking countries, and bilingual elites with English-Chinese always make a country's economy prosperous. Thus, to efficiently promote and implement the "English as a Medium Instruction" (EMI) program in higher education to raise university students' English proficiency is inevitable. This study collects a total amount of 594 EMI important papers of articles, periodicals, books, etc., of the last 20 years from the Scopus database and sequentially conducts a bibliometric literature analysis of these papers with the VOSviewer software tool to gain the study conclusions. In network visualization analysis, especially when using tools like VOSviewer, fuzzy sets are essential for capturing the multifaceted nature of node relationships, enabling a more precise and informative representation of network structures and connections. According to the analysis results, the EMI study mainly started in 2014, and EMI papers have increased since. Four EMI majors have been focused. They are the aspects of higher education, the issues of trans-language, the perspectives of teachers and students, and the viewpoints of human social behavior. This research simultaneously arranges and provides valuable information on the journals, authors, units, institutes, and countries that have published EMI articles the most.

1. Introduction

Nowadays, English Medium Instruction (EMI) is a global phenomenon in English education. English Medium Instruction, referring to the practice of using English as the medium of instruction for academic subjects in non-English speaking countries or regions, is also known as CLIL (Content & Language Integrated Learning) or CBT (Content Based Teaching). English is the most essential communication language in this 21st globalization century of a knowledge economy. To improve students' English proficiency in Taiwan, EMI is significant for students in the globalized workplace, as it enhances their English ability, helps them understand international business and culture, and makes them adapt quickly to the globalized environment in the societies of Taiwan [14]. Under the EMI frameworks, English teachers use English as the medium of instruction for

professional courses, such as mathematics, geography, or medicine. The most essential topics in English education are the study of EMI for its purpose, goals, strategies, methods, advantages, disadvantages, learning outcomes, current situation, and challenges [15].

Promoting the EMI program can enhance students' English level, help them better understand English culture, improve their international competitiveness, better adapt to the globalized society, and provide them with competitive language abilities to earn more employment opportunities in the community. With different motivations and goals among countries and regions, EMI programs nowadays also face other challenges and encounter difficult obstacles; it is necessary to examine the EMI policies, strategies, and methods from the very comprehensive perspectives explained below [21]:

(1) EMI affects university evaluation and internationalization.
(2) EMI affects the language ability and subject knowledge of students and teachers.
(3) EMI affects students' understanding of lecture content.
(4) EMI affects the interaction and communication between teachers and students.
(5) EMI affects the university promotion at different stages.
(6) EMI affects other factors.

With EMI's purpose and policies, teachers implement different English teaching methods to guide students to learn English efficiently. As a medium of English for students' expertise instruction, the global promotion of EMI has different ways of implementation among other countries.

The promotion effect of EMI at the university stage involves different factors, such as the students' English ability, lecturers' teaching methods, academic subject content, national cultural background, and so on. Therefore, the effectiveness of the promotion effect of EMI at the university stage needs to be evaluated according to different situations and goals. EMI program policies and teaching methods to guide students to learn English efficiently are briefly explained as follows [11]:

(1) Adopting language teaching (ALT) assistants for co-teaching.
(2) Introducing online English conversation courses into teaching.
(3) Recruiting "native English speaker" teachers to assist in teaching.
(4) Designing and rearranging direct-method English curriculums and courses.
(5) Choosing drama novels as English teaching materials.
(6) Teaching students through creative and exciting extracurricular activities, such as book clubs, reading aloud, singing and storytelling competitions, etc.

Taiwan's English policies of higher education have been implemented to improve the English capabilities and subject academic knowledge of the university students of Taiwan. EMI program plays a vital role in enforcing its strengths. EMI programs are considered to help students become more competitive in the global job market with strong English proficiency and abilities [15]. The Ministry of Education (MOE), therefore, started carrying out a bilingual education program for students in universities, referred to as the Project on Bilingual Education for Students in College (BEST), with the goals of building a bilingual teaching and learning environment in colleges and universities, strengthening the English proficiency of students' levels, as well as promoting EMI courses to enhance the overall international competitiveness of higher education in Taiwan [8]. With the BEST goals of building a bilingual teaching environment and learning scenarios in universities and strengthening the English proficiency of university-level students, EMI-promoting courses enhance the overall international competitiveness of higher education in Taiwan, The EMI program also seeks to foster positive interactions between English teaching, learning and assessment programs at universities. This entails aligning EMI programs with specific language standards, tracking students learning progress, and understanding how a learning institution's courses affect assessment performance [9]. The effectiveness of EMI involves various factors, such as the student's English proficiency, teachers' academic expertise, lecturers' teaching methods, specific subject contents, national cultural background, etc. The studies of EMI are profound and complicated. Some researchers have found EMI programs may improve students' English listening and reading skills but have less influence on their English speaking and writing skills. Several studies point out that EMI programs may reduce students' understanding of the professional subject content, especially when the teacher's

instructions on academic English are unclear or inappropriate. The effectiveness of EMI programs at the university level needs to be evaluated according to different situations and goals, and teachers should learn how to teach non-native English students in an up-to-date way [28, 29].

The rapid growth of EMI has brought many challenges, such as insufficient English proficiency of students, teachers' unfamiliarity with teaching in academic English, etc. However, EMI courses are becoming increasingly popular in Taiwan, and many universities offer them as part of their curriculum. Global research on EMI is also underway. The research fields of EMI include studies that specifically explore the practice of EMI worldwide [9]. In addition, some studies examine the effects and impacts of EMI programs on student learning achievements. However, there are some challenges in implementing EMI courses in Taiwan. One of the challenges is that many Taiwanese students lack English proficiency, which may make it difficult to understand the course content on specific subjects. Another challenge is that some teachers may not be familiar with teaching English in academic fields, which may lead to communication problems between teachers and students. Other obstacles to EMI include these factors explained as follows [1,14].

(1) Language barrier: Students may not understand the teacher's instruction due to the language barrier.
(2) Cultural difference: Students may not understand the teacher's instruction due to cultural differences.
(3) Teacher training: Teachers may need more training to use English for instruction better.
(4) Learning assessment: Schools may not quickly assess students' learning outcomes through their English abilities and specific course comprehensiveness.
(5) Student attitude: Students may feel uncomfortable or uneasy about using English as a medium of instruction to study specific knowledge.
(6) Recruiting teachers: Departments may hardly hire teachers with excellent English teaching abilities and required expertise in the subject courses.

Despite these challenges and difficulties, EMI courses are becoming increasingly popular in Taiwan, and many universities now offer them as part of their curriculum. For a study of future direction, EMI programs involve various aspects such as disciplines, regions, languages, teaching and learning, etc. It is a broad topic, and research articles always include conceptual and policy analysis and review of EMI, systematic synthesis and review of EMI program implementation methods and effects, and Case studies and discussions of specific situations and issues on EMI programs [8]. For schools to plan and carry out EMI programs, several points of view should be noted for promoting EMI, such as ensuring that teachers have sufficient English proficiency and professional knowledge to use English for instruction, providing adequate training and support to assist teachers better use English for student instruction, training students with sufficient English abilities as well as cultural knowledge to understand the teacher's instruction content on specific issues and topic, and so on [8].

EMI is a broad topic that involves various aspects such as disciplines, regions, languages, teaching, and learning. Research articles continuously focus on conceptual and policy analysis and commentary on EMI, systematic synthesis and review of EMI implementation methods and effects, case studies and discussions of specific situations and issues of EMI, and so on. [9]. In sum, EMI programs have received attention from colleges and universities in English teaching.

The contributions of this paper are explained below: (1) To conclude the research, provide future trends, and offer suggestions for EMI study, especially for those non-English-speaking countries and economic units, the researcher conducts a bibliometric analysis method for the research papers concerning with the topic of EMI study which have been gathered and collected by the Scopus database, (2) to find the solutions of the 3 questions presented on the below sections. This study looks forward to answering the following questions to make the EMI research bring more practical positive influential effects.

- Question 1: In the past ten years, in the EMI topic research, which countries and organizations have advantages regarding the number and quality of papers published?
- Question 2: What are the related studies on the EMI research topic?
- Question 3: What are EMI research's potential areas and future directions?

2. Materials and Methods

2.1 VOSviewer

VOSviewer is a free JAVA-based software developed by van Eck and Waltman from the Centre for Scientific and Technological Research at the University of Leiden, the Netherlands, in 2009, which is mainly oriented to the analysis of literature, adapted to the analysis of one-mode wireless networks, and focuses on the visualization of scientific knowledge. The main features of VOSviewer include support for multiple types of data formats, data cleansing functions, general vocabulary filtering, etc. It also provides advanced features such as support for web publishing, support for the use of command lines, and support for memory expansion, The main features of VOSviewer include support for multiple types of data formats, interpretation of multiple types of views, data cleansing, and filtering of general terms, etc. VOSviewer also provides advanced features such as support for web publishing, support for using command lines, and support for memory expansion. VOSviewer can help users construct relationships and visualize and analyze "network data" to map scientific knowledge and show knowledge domains' structure, evolution, and cooperation.

Zhihu [36] includes an article on VOSviewer entitled "Co-occurrence Network Analysis and Visualization," which introduces VOSviewer in scientific knowledge mapping and provides detailed tutorials and case studies. The article mentions that VOSviewer can be used to analyze literature databases, general-purpose web data, and text data and supports multiple types of visual interpretation and advanced functionality. Van Eck & Waltman [30] introduced a design philosophy, features, and use cases of VOSviewer. The research mentioned that VOSviewer was initially developed to help researchers perform scientific literature metrics analysis and then gradually extended to other fields.

Wang & Zhang [32] conducted a metric analysis of the Journal of Educational Psychology literature from 2016-2020 using Vosviewer. This study's findings indicated that the journal's research themes focused on learning, teaching, assessment, and development. In addition, the paper also analyzed the distribution of authors, organizations, and countries of the journal. Wang & Zhang [33] conducted a metric analysis of the Journal of Educational Technology and Society literature from 2018-2022 using Vosviewer. The results showed that the research themes of the journal focused on online learning, mobile learning, gamified learning, and virtual environments. In addition, the paper analyzed the distribution of authors, organizations, and countries in the journal.

2.2. Fuzzy Exploration: VOSviewer and Fuzzy Set Analysis

From the above literature, it can be seen that VOSviewer can be used to analyze literature for both single and multiple journals, and it can provide detailed statistical and graphical descriptions of the distribution of the studies in terms of topics, time, authors, organizations, and publication countries. The mathematical framework known as Fuzzy Set theory, introduced by Zadeh [35], addresses ambiguity and vagueness in data and reasoning processes. Fuzzy sets provide a versatile and robust framework for addressing uncertainty and imprecision across many disciplines, such as data processing and decision-making. In contrast to conventional binary sets, fuzzy sets let items possess partial membership inside a set, as denoted by membership values ranging from 0 to 1. The definition of the fuzzy set is defined as follows:

Definition 1. (*Fuzzy Set* [35]): Assume X is a universe of discourses and $x \in X$. A fuzzy set F on X is defined as follows:

$$F = \{x, \mu_F(x); x \in X\}.$$

where $\mu_F(x): X \to [0,1]$ is a function called a membership function of F and $\mu_F(x)$ is a grade of membership or membership degree of $x \in X$ in F.

Definition 2. (*Membership Function* [6]): A mathematical function that defines the degree of membership of an element in a fuzzy set. It maps elements from the universe of discourse to membership values between 0 and 1.

Definition 3. (*Defuzzification* [35]): The process of converting crisp inputs into fuzzy values. It involves determining the degree to which each input belongs to the linguistic terms defined in the system.

Definition 4. (*Fuzzy Regression* [35]): A regression analysis technique that incorporates fuzzy logic to model relationships between variables when the data is imprecise or uncertain.

Definition 5. (*Fuzzy Inference System* [7, 35]): A system that uses fuzzy logic to represent and process knowledge. It consists of a rule base, a fuzzification interface, an inference engine, and a defuzzification interface.

The application of VOSviewer in literature analysis, coupled with the utilization of Fuzzy Set theory to address uncertainty and imprecision, establishes a crucial connection between data-driven insights and effective decision-making in management processes. To manage suppliers and select the best supplier in construction companies under uncertainty, Nafei et al. [16] proposed a decision-making framework based on neutrosophic sets. Nezhadkian et al. [17] proposed a new product development model for businesses using grounded theory and the Fuzzy method. Pourrafiei et al. [19] suggested using credibility fuzzy value at risk in portfolio models to address ambiguity and lack of historical data. They aim to solve the portfolio problem by incorporating third and fourth credibility moments in multi-objective higher-order moment models, introducing new objective functions based on different entropies. Nafei et al. [18] first developed a new Hamming distance between single-valued neutrosophic numbers and then presented an extension of the TOPSIS method for multi-attribute group decision-making (MAGDM) based on single-valued neutrosophic sets. Ruano et al. [20] proposed an integrated approach using the Delphi technique and Fuzzy DEMATEL based on fuzzy set theory to identify and analyze sustainable ecotourism indicators in Belize.

The capacity to depict partial membership is significant in circumstances characterized by unclear or imprecise data. Fuzzy logic and fuzzy sets have been extensively used in several domains, including control systems, artificial intelligence, and pattern recognition. Bayesian networks provide a means to effectively represent and analyze uncertain information, making them crucial in addressing real-world challenges characterized by intrinsic ambiguity. Fuzzy sets and membership functions are essential in enhancing the comprehension of intricate network structures within network visualization analysis and tools such as VOSviewer. In visualizing and analyzing networks, it is essential to acknowledge that the interactions between nodes may only sometimes adhere to a purely binary nature, where nodes are either linked or not connected. The membership function facilitates the measurement of the intensity or extent of correlation between nodes, capturing subtle variations in network connections. The complex depiction of information is vital in academic disciplines such as bibliometrics, where the significance and level of cooperation across authors, keywords, or publications might vary. VOSviewer can enhance the quality of network visualizations by integrating fuzzy sets and membership functions, therefore facilitating researchers in identifying hidden patterns and structures within their data, leading to more comprehensive and perceptive analyses. Because of this, VOSviewer will be used as the literature measurement tool for this research, and the keyword "EMI" (English as a Medium Instruction), which has not received much attention in the field of education, will be the research topic.

2.3. PDCA

PDCA was first proposed by Walter A. Shewhart [22], and the purpose of this study is to explore the application and practice of PDCA for higher education and to provide some successful study cases to provide recommendations for further study, an American quality management expert, and adopted by Deming, a quality management guru, who publicized and popularized PDCA, so it is also known as Deming's circle. PDCA is a scientific program that follows the Plan-Do-Check-Action sequence of quality control and goes around and around.

PDCA is widely used in various sectors, not least in education, where Langford [13] mentioned that PDCA was first proposed by Shewhart [22]. Langford's study mentions that the PDCA cycle promotes learning and improvement. According to the author, the PDCA cycle is a scientific quality control method that can help teachers and students improve teaching and learning effectiveness. The study concluded that the PDCA cycle

can help educators and learners develop a continuous improvement mindset, improving the quality of education and learning outcomes.

The application of PDCA to non-educational fields has also been favored by Yankson [34] in his study of SCT (Smart Connected Toys), which can be adopted and used during the design of SCT to minimize privacy leakage. The researcher found that PDCA is considered a helpful tool that can help SCT developers program, execute, check, evaluate, and assess to achieve the expected privacy goals and outcomes. Meanwhile, according to the different types and functions of SCTs, the PDCA framework is an abstract model that can be customized and extended to match the different privacy needs.

This research is based on the theoretical foundation of PDCA and summarizes the experience and results of practical application in various fields. This research develops the literature measurement tool used in this research and the PDCA management cycle- and formulates the five significant steps of this research process, which are summarized and illustrated in Figure 1. The researcher adopts and implements the PDCA management cycle development of the research document analysis approach to analyze and develop the 5 steps of the bibliometric literature study. (1) Defining research topic, time, period, and scope. (2) Choosing research method. (3) Collecting relevant topic data and references. (4) Implement and analyze data with VOSviewer. (5) Research conclusions and future suggestions.
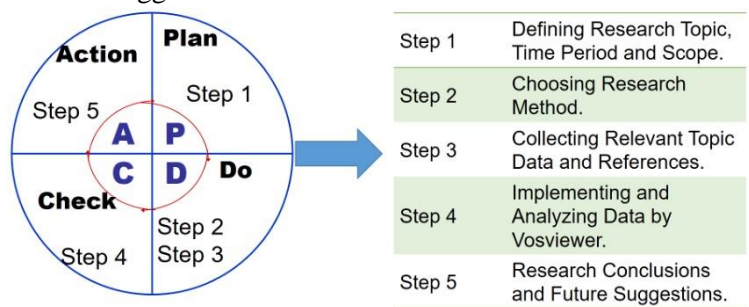

Figure 1. The bibliometric flow chart of this research.

3. Results and Discussion

This study was conducted on August 4, 2023, using the data captured from the Scopus database as the basis for the literature metrics analysis, and the keywords "EMI, English as a media of instruction" were used to search for relevant literature that had been included in the Scopus database from 2003 to 2023. The keyword "EMI, English as a media of instruction," was used to search for relevant literature in the Scopus database from 2003 to 2023. The four criteria of the journals collected in the Scopus database include (1) They have published at least 50 articles per year. (2) The journal article needs at least one peer-reviewed reference before publication. (3) Authors from at least five different countries write the journal article. (4) Authors write the journal article from at least three different countries and have at least one peer-reviewed reference. Among the document types of the search results, only two significant types of journal articles, articles, and reviews, were listed in this study as the most valuable published documents. Journal paper. In addition, only EMI-related journals published in English were selected as the publication language. Finally, 594 articles were selected, and their (1) Citation Information, (2) Bibliographical Information, (3) Abstract and keywords, (4) Funding Details, and (5) Other Information were exported to CSV. The relevant literature information was exported to CSV files and analyzed for this study using VOSviewer version 1.6.18.

3.1 Research Categories

In recent years, EMI has attracted the attention of researchers, and this study has been based on practical data for the past 20 years (2003~August 2023)—status of papers in the Scopus database. Since 2003, some researchers have begun to pay attention to the keyword EMI, but from 2004 to 2006, researchers have published articles in the past three years. Since 2016, researchers have officially favored EMI and have begun to publish internationally with double-digit publications every year. In particular, more than 100 journal papers were

published in 2021. We can see from the results of international publications by year EMI as a keyword in Figure 1 below, 2003 to 2015. The number of publications from 2016 to the present has begun to grow positively, and there should be more people/teams investing in EMI research in the future.

3.1.1   Journal Distribution

According to the analysis results, the journal with the keyword "EMI" published the most articles is "The Journal of Multilingual and Multicultural Development" with 11% of the articles published. The second and third most published journals were "International Journal of Bilingual Education and Bilingualism" and "System," respectively. These two journals published 27 and 23 journal articles with EMI as the theme/keyword, respectively. The top 20 journals with EMI as a theme/keyword are shown in Table **1**, which will be helpful for future research on the topic of EMI. We used the fuzzy concept to better understand the journals' contribution to EMI. Thus, the journal with the highest percentage has the highest degree of membership, and other journals get membership degrees in proportion to their contribution.

Table 1. Top 20 most productive journals.

Item No.	Source	Occurrences	%	Membership Degree
1	Journal of Multilingual and Multicultural Development	36	11%	1
2	International Journal of Bilingual Education and Bilingualism	27	8%	0.72
3	System	23	7%	0.63
4	Journal of English for Academic Purposes	19	6%	0.54
5	RELC journal	14	4%	0.36
6	Current Issues in Language Planning	13	4%	0.36
7	Language Teaching Research	11	3%	0.27
7	Linguistics and Education	11	3%	0.27
9	Journal of ASIA TEFL	10	3%	0.27
10	Language and Education	10	3%	0.27
11	Sustainability (Switzerland)	10	3%	0.27
12	TESOL Quarterly	10	3%	0.27
13	Asian Englishes	9	3%	0.27
14	Frontiers in Psychology	9	3%	0.27
15	Higher Education	9	3%	0.27
16	English for Specific Purposes	8	2%	0.18
17	SAGE Open	8	2%	0.18
18	Teaching in Higher Education	8	2%	0.18
19	European Journal of Language Policy	7	2%	0.18
20	Applied Linguistics Review	6	2%	0.18
21	ELT Journal	6	2%	0.18
22	Issues in Educational Research	6	2%	0.18
23	Language Learning in Higher Education	6	2%	0.18
24	Language, Culture and Curriculum	6	2%	0.18
25	Revista Alicantina de Estudios Ingleses	6	2%	0.18
26	World Englishes	6	2%	0.18

3.1.2   Country and Institution Distribution

From the Scopus database and analyzed by VOS viewer, there are 33 countries/regions where EMI keywords/themes are published in journal articles (as shown in Table **2**). The country with the highest number of EMI-related publications is the United Kingdom, with a 13% share of these publications. However, this

finding may turn the imagination of foreign language teacher's upside down, as EMI is used in non-native English-speaking countries/regions, and it turns out that the United Kingdom dominates EMI-related research; the strengths and weaknesses of the national economies that publish EMI-related papers are shown in Figure 2. This puts pressure on China, Spain, Hong Kong, and Taiwan, which are in the second to fifth places. Through the findings of this study, it is hoped that more foreign language educators in Asia will be called upon to formalize EMI in the same way as English-speaking countries.

Table 2. Top 10 publication countries/economy (n=33).

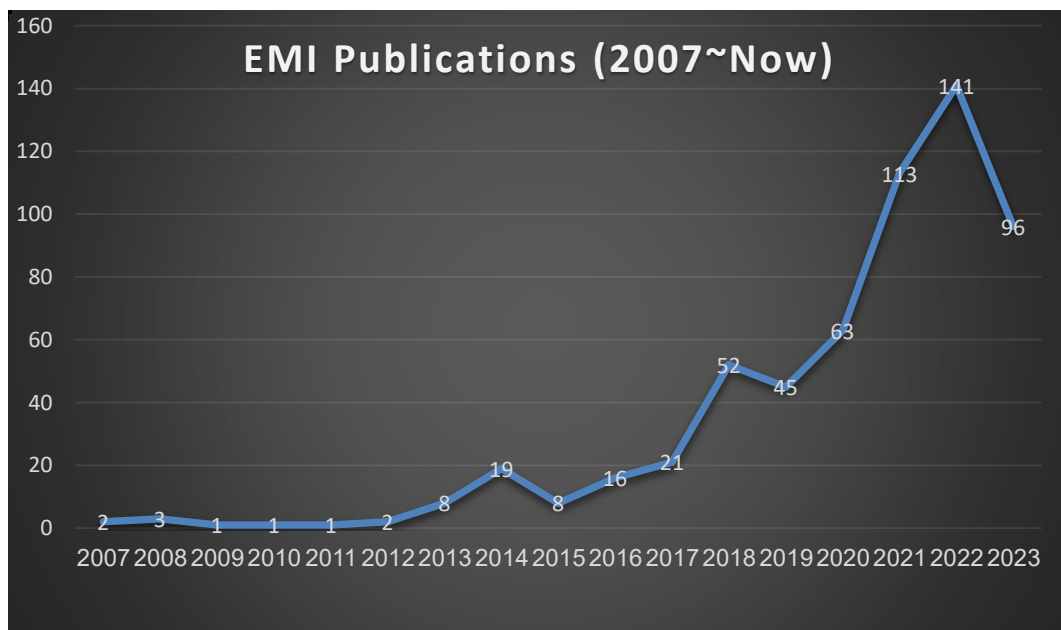| Item No.	Country/ Economy	Documents	%
1	United Kingdom	88	13%
2	China	74	11%
3	Spain	73	10%
4	Hong Kong	67	10%
5	Taiwan	36	5%
6	South Korea	35	5%
7	Australia	30	4%
8	Japan	29	4%
9	Turkey	27	4%
10	Saudi Arabia	24	3%
10	United States	24	3%

Figure 2. The bibliographic coupling network visualization of countries.

3.1.3   Author Distribution

Among the EMI-related papers, the most published expert scholars are Alhamami M. and Song Y. who have published five papers on this topic. Alhamami M. has published two papers independently from 2015 to 2021 Alhamami [1], Alhamami [2], and three papers together with Alshahrani, A. papers; Alhamami & Alshahrani (2019), Alhamami & Alshahrani (2020), Alhamami & Alshahrani (2021) [3-5]. The commonality of these five papers is that they mainly explore English as a medium of instruction (EMI) in Saudi Arabia. Three papers examine the impact of using EMI in computer science courses in Saudi universities on students' academic

achievement and analyze the perceptions and attitudes of students, teachers, and educational institutions towards EMI. The other two papers examine the application of EMI in other areas in Saudi Arabia and present challenges and solutions.

As an example, researcher Song, Y. Song, Y has published five EMI-related papers with Zhang, L. J. since 2018; Song & Zhang [23], Song & Zhang [24], Song & Zhang [25], Song & Zhang [26], Song & Zhang [27]. These five papers focus on using English as a medium of instruction (EMI) in Chinese higher education. Three papers examine EMI's development, status, and challenges in Chinese higher education and analyze the perceptions and attitudes of students, teachers, and educational institutions towards EMI. The other two papers examine the application of EMI in academic writing and teachers' professional development in Chinese higher education and propose related challenges and solutions.

Table **3** shows the list of authors who have published more than three EMI-related papers in the Scopus database. Table **4** below shows a compiled list of the top six research organizations/units (8 units in total) that have published EMI-related papers. From Table **3** and Table **4**, we can see that the authoritative researcher or authoritative organization of EMI-related papers has not yet been fully constructed, and it will take some time before it becomes clearer.

Table 3. Prominent authors by documents and citations.

Item No.	Author	Documents	Citations
1	Alhamami m.	5	9
1	Song y.	5	50
3	Siegel j.	4	18
3	Tai k.w.h.; Wei l.	4	103
4	Barnawi o.z.	3	23
5	Bradford a.	3	138
6	Chang s.-y.	3	25
7	Doiz a.; Lasagabaster d.	3	62
8	Sahan k.	3	24
9	Tai k.w.h.	3	25
10	Trent j.	3	11
11	Zhang m.; Pladevall-Ballester e.	3	18

Table 4. Top 6 publication organizations.

Item No.	Organization	Documents	Citations
1	Department of Education, University of Oxford, Oxford, United Kingdom	12	379
2	Department of Education, University of Bath, Bath, United Kingdom	10	273
3	Department of English, City University of Hong Kong, Hong Kong	6	54
4	University of Oxford, United Kingdom	6	687
5	Ulsan National Institute of Science and Technology, south Korea	5	59
6	Department of English Language Education, the Education University of Hong Kong, Hong Kong	4	25
7	Department of Foreign Language Education, Kocaeli University, Turkey	4	59
8	UCL Centre for Applied Linguistics, UCL Institute of Education, University College London, London, United Kingdom	4	122

3.1.4   Keywords Co-Occurrence Analysis

Among the 594 EMI articles, the highest keyword was "Higher Education" 117 times, and its Total Link Strength was also the highest at 230, with "Student / Students" as the keyword 30 times. Still, its Total Link Strength was 186, the second highest among all keywords. Students" as the keyword adds up to 30 times, but its Total Link Strength adds up to 186, the second highest among all keywords. The keyword "Translanguaging" is ranked second with 36 occurrences, while "Language Policy" is ranked third with 28 occurrences.

From the Top 20 research keywords of EMI publications in Table **5** and the above explanations, this study can figure out the thematic trends of EMI research: (1) the application to "Higher Education" is the most, (2) the application to cross-cultural and language communication is the second most, (3) the application to cross-cultural and language communication is the second most, and (4) the application to cross-cultural and language communication is the most. (2) the application to cross-cultural communication is the second most common, and (3) apart from Higher Education, research on students has also attracted a lot of attention. Again, to analyze the contribution of each keyword in EMI publications, we considered their membership function under the fuzzy environment. Thus, the keyword with the highest percentage has the highest degree of membership, and other keywords get membership degrees in proportion to their contribution. These functions determine the degree to which an element belongs to a particular set of journals. In this respect, by implementing the network visualization of keyword co-occurrence analysis as shown in Figure **3**, we can consider that each significant keyword is concentrated in a single color with its extension, which reflects that the current EMI-related research is divided into four major regions, namely (1) Higher Education - red block, (2) Translanguaging - blue block, (3) Student- purple block, and (4) Human - green block.

Table 5. Top 20 research keywords of EMI publications.

Item No.	Keyword	Occurrences	Total Link Strength	Fuzzy Membership Degree
1	Higher Education	117	230	1
2	Translanguaging	36	57	0.24
3	Language Policy	28	40	0.17
4	Motivation	21	25	0.10
5	Internationalisation	19	43	0.18
6	Language	19	117	0.50
7	Internationalization	18	28	0.12
8	Medium of instruction	18	32	0.13
9	Multilingualism	18	53	0.23
10	China	17	70	0.30
11	Hong Kong	17	39	0.16
12	English	16	35	0.15
13	Internationalization of Higher Education	16	7	0.03
14	Learning	15	117	0.50
15	Student	15	121	0.52
16	Students	15	65	0.28
17	Japan	14	28	0.12
18	Bilingual Education	13	16	0.06
19	Challenges	13	37	0.16
20	Education	11	54	0.23
21	Language Ideology	11	22	0.09
22	Teaching	11	70	0.30

3.2 Top 5 cited references

Analyzed by VOSviewer, among these 594 articles, the most cited references are those listed in Table **6**. The research background, motivation, objectives, methodology, and results and recommendations of these five papers are as follows for readers' reference, and we hope to inspire readers to continue to contribute to EMI-related research.

1.   A systematic review of English medium instruction in higher education.

- Background of the Study: The use of English as a medium of instruction is becoming increasingly common in higher education worldwide, but evaluating its effectiveness remains controversial.

- Research Motivation: This study aims to systematically review English Medium Instruction (EMI) to evaluate its effectiveness in higher education.

- Research Aims: This study aims to answer the following questions: What is the impact of EMI on students' academic achievement, English proficiency, and attitudes? How is EMI implemented, and how do contextual factors affect its effectiveness? What are the challenges of EMI for teachers and students?

- Research Methodology: This study utilized a systematic literature review methodology in which relevant literature was collected from multiple databases, and quality assessment and data extraction were conducted.

- Result and suggestions of the study: EMI positively impacts students' academic achievement, English language proficiency, and attitudes. The way EMI is implemented and contextual factors may affect its effectiveness. Challenges may arise during EMI implementation and need to be further explored.

2.   English medium instruction

- Background of the Study: The use of English in higher education worldwide is becoming increasingly common, but there is still controversy about whether it is effective.

- Research Motivation: The purpose of this book is to explore various aspects of English Medium Instruction (EMI), including its history, theory, practice, and future development.

- Research Aims: This book aims to answer the following questions: What is EMI? What is the historical and theoretical background of EMI? What are the practices and effects of EMI? What are the future directions of EMI?

- Research Methodology: This book adopts the literature review and analysis method to explore various aspects of EMI from multiple perspectives.

- Result and suggestions of the study: EMI is a global phenomenon, and its practice and effects vary from country to country, region to region, and discipline to discipline. More research is needed to evaluate the effects and challenges of EMI. EMI needs to be better integrated with language policy and language education.

3.   English-taught programs in European higher education: The state of play in 2014.

- Background to the study: English-Taught Programmes (ETPs) in European higher education have grown rapidly over the last decade, but knowledge of their development and impact is still limited.

- Research Motivation: This study aims to update and extend a similar study conducted in 2008 to reflect the current status of ETPs in European higher education.

- Research Aims: This study aims to answer the following questions: What is the size and distribution of ETPs in European higher education? What are the characteristics and quality assurance mechanisms of ETPs? What are the motivations and objectives of ETPs? What is the impact of ETP on students, teachers, and schools?

- Research Methodology: This study used a questionnaire survey and a case study approach to collect and analyze data from higher education institutions in 28 European countries.

- Result and suggestions of the study: ETPs show a diverse and dynamic development in European higher education, with their size, distribution, characteristics, quality, motivation, objectives, and impact varying from country to country, region to region, and subject to subject. ETPs need more research and policy support to ensure they align with the goals of diversification and internationalization of higher education in

Europe.

4. English-medium teaching in European higher education.

- Research background: English-medium teaching programs (ETPs) in European higher education have grown rapidly over the past decade, but knowledge of their development and impact is still limited.

- Research Motivation: This paper aims to examine the status and trends of ETP in European higher education and its impact on students, teachers, and schools.

- Research Aims: This paper aims to answer the following questions: What is the size and distribution of ETPs in European higher education? What are the characteristics and quality assurance mechanisms of ETPs? How does ETP impact students' academic achievement, English language proficiency, and attitudes? How does ETP impact teachers' professional development and job satisfaction? What is the impact of ETP on the internationalization and diversity of schools?

- Research Methodology: This paper employed a literature review and analysis to explore various aspects of ETP from multiple perspectives.

- Result and suggestions of the study: ETPs show a diverse and dynamic development in European higher education, with their size, distribution, characteristics, quality, and impact varying from country to country, region to region, and subject to subject. ETPs need more research and policy support to ensure they meet the goals of diversification and internationalization of higher education in Europe.

5. English-medium instruction in Chinese higher education: A case study. Higher Education

- Background: In recent years, English Medium Instruction (EMI) in Chinese higher education has become increasingly popular, but its implementation and effectiveness remain controversial.

- Motivation: This study aims to investigate the implementation and effectiveness of EMI in Chinese higher education and its impact on students and teachers.

- Research Motivation: This study aims to investigate the implementation and effectiveness of EMI in Chinese higher education and its impact on students and teachers.

- Purpose of the Study: This study aims to answer the following questions: What is the scale and distribution of EMI in higher education in China? How are EMI implemented, and how do contextual factors affect its effectiveness? How does EMI impact students' academic achievement, English language proficiency, and attitudes? How does EMI affect teachers' professional development and job satisfaction?

- Research Methodology: This study adopted a case study methodology to conduct an in-depth investigation and analysis of a Chinese university.

- Findings and Recommendations: EMI in Chinese higher education has shown a diverse and dynamic development, and the way it is implemented and its effects are influenced by various factors. EMI has a positive impact on students' academic achievement, English proficiency, and attitudes, and EMI has a positive impact on teachers' professional development and job satisfaction. In the future, the development and challenges of EMI in Chinese higher education need to be further explored.
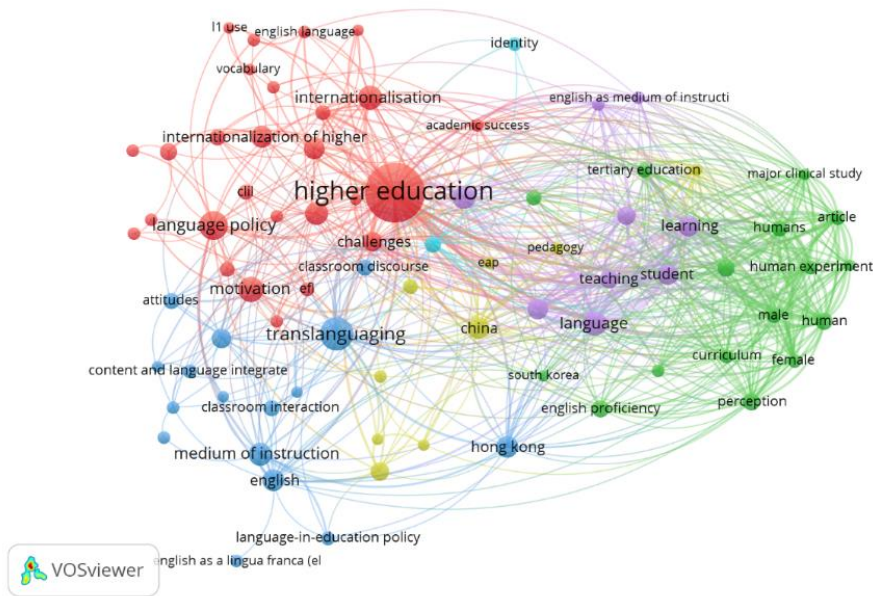
Figure 3. Network visualization of keyword co-occurrence analysis.

Table 6. Top 5 cited references list

No.	Top 5 Cited References	Citations
1	Macaro, E., Curle, S., Pun, J., An, J., & Dearden, J. (2018). A systematic review of English medium instruction in higher education. Language Teaching, 51(1), 36-76. [15]	147
2	Macaro, E. (2018). English medium instruction. Oxford University Press. [14]	78
3	Wächter, B., & Maiworm, F. (2014). English-taught programmes in European higher education: The state of play in 2014. Higher Education, 67(5), 551-567. [31]	48
4	Coleman, J. A. (2006). English-medium teaching in European higher education. Language Teaching, 39(1), 1-14. [10]	44
5	Hu, G., & Lei, J. (2014). English-medium instruction in Chinese higher education: A case study. Higher Education, 67(5), 551-567. [12]	43

4. Conclusions

This study contributes by consolidating research papers over the last two decades related to the topic of English Medium Instruction (EMI), elucidating the findings and accomplishments derived from these studies, and projecting future trends in EMI research. Beyond answering three pivotal questions, the research reveals three principal findings: (1) EMI research predominantly originates from English-speaking regions, with a growing interest in Asian countries; (2) Higher education remains the focal point of EMI research, driven by the ongoing globalization of industries; (3) EMI studies about students' English education are on the rise, indicating potential enhancements in EMI teaching quality. The research underscores the importance of English teachers utilizing the provided references for improvement and highlights the role of EMI as a fundamental tool in higher education. With "EMI" as the central keyword, this study employs the VOSviewer software tool in a fuzzy environment for bibliometric literature analysis of EMI journal papers. The analysis addresses three key questions: (1) Countries and organizations with advantages in the quantity and quality of EMI papers published; (2) Related studies on the EMI research topic; (3) Potential areas and future directions of EMI research. The findings indicate a growing global interest in EMI, with the United Kingdom leading in publications. The analysis also identifies major EMI research areas, emphasizing the significance of future studies in non-English-speaking countries, focusing on higher education, cross-cultural aspects, and human social behavior. The study concludes by acknowledging limitations, suggesting future research directions, and emphasizing the irreversibility of EMI's application in higher education.

Conflict of interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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