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ARTIFICIAL INTELLIGENCE IN LANGUAGE EDUCATION: A BIBLIOMETRIC ANALYSIS

Annotation. Artificial Intelligence (AI) occupies a transforming role in education, including language teaching and learning. Using bibliometric analysis, this study aims to overview the most recent research related to the use of AI in language education. Specifically, it reviews the existing body of research, productivity in this field in terms of authors and countries, co-authorship, most cited references and most popular journals that publish on this topic. Furthermore, the study also analyses the most common keywords and extracts relevant terms that reveal trending topics. For the period between 2018 and 2022, 2,609 documents were retrieved from the Web of Science database. The results showed that each year a consistent number of publications on the application of AI in language education appears. Scholars from China and the USA have been revealed to be most productive. *Computer Assisted Language Learning* contains the highest number of publications. Within the research on the use of AI in language education, the most targeted language-learning aspects were acquisition, motivation, performance, vocabulary, instruction, feedback, and impact. The analysis of the most common keywords related to AI-based solutions showed that mobile-assisted language learning, virtual reality, augmented reality, elements of gamification, games, social robots, machine translation, intelligent tutoring systems, chatbots, machine learning, neural networks, automatic speech recognition, big data, and deep learning were most popular.

Keywords: artificial intelligence; bibliometric analysis; language education; language teaching/learning.

Introduction

Today, artificial intelligence (AI) affects numerous areas of life; however, the effects and impact of AI may be perceived to be controversial. On the one hand, AI is believed to play a prominent role in the fourth industrial revolution (Lawler & Rushby, 2013) and to have the potential to be a game-changer and completely alter the traditional job market (Horakova et al., 2017). Furthermore, Tulasi (2013) highlights the potential of AI to revolutionise education. Cope et al. (2021) conclude with an audacious statement that

"things are profoundly wrong with traditional pedagogy (…) Artificial intelligence promises a new way forward for (…) education" (p. 1242). On the other hand, there are more critical voices that see some problematic areas of using AI in an educational context; some of them, according to Zhai et al. (2021), include teachers' attitudes towards AI (Horizon Report, 2018), techniques of AI not being adequate in the field of education (Loeckx, 2016) and ethical issues (Kessler, 2018; Aoun, 2017). In addition, Zhai et al. (2021) try to temper the enthusiasm for AI by cautiously reminding of the fact that television and computers at a certain point in history were also envisioned to bring about dramatic changes in education, but ultimately only served to provide a broader access to information and did not actually transform the fundamental traditions of educational practices.

Sceptical attitudes, however, do not seem to dominate the discourse regarding AI. As a result, the growth of AI stimulates questions and raises concerns about possible changes in the teaching profession. Specifically, there is the fear that the spread of AI may result in teachers being made redundant, or at least cause substantial changes in the traditional organizational forms (Fenwick, 2018). Furthermore, the use of AI intimidates some teachers. Currently, some educators, including language educators, are reluctant to use AI because of misconceptions about its potential for enhancing learning experience (Kuddus, 2022). For the main part, the lack of an overall proper understanding of the scope and constituent parts of AI appears to be at the root of this reluctance (Hinojo-Lucena et al., 2019); however, Horizon Report (2018) indicates that teachers' opposition to AI may also be related to their "inadequate, inappropriate, irrelevant, or outdated professional development" (Zhai et al., 2021, p. 13). Moreover, even though learning about AI is now being introduced into the school curriculum (Zhai et al., 2021), it is still unclear to educators how to capitalize on the power of AI on a broader scale, and how to use it meaningfully in education (Zawacki-Richter et al., 2019). A paradox emerges: while a considerable part of the world's population uses social media and AI-related technologies as part of their daily routine (e.g., in 2017, according to Kemp (2017), there were more than three billion social media users across the globe, which corresponds to roughly 40% of the entire world's population; moreover, this number was expected to continue growing),

the existing multitude of resources such as tools, websites and applications can have an overwhelming effect when trying to select optimal options for educational purposes. On the other hand, there are also those who are overly enthusiastic about the use of AI in the process of learning and teaching, and this results in more focus on AI technologies rather than learning itself (Kessler, 2018; Horizon Report, 2018; Zhai et al., 2021). Therefore, there is a clear need for a more sustained and systematic approach towards integrating the latest knowledge of AI in teachers' pre-service and continuous professional development programmes.

As far as language education is concerned, the use of AI in this field is promising, but it is still in a rather early phase of development (Huang et al., 2021; Liang et al., 2021). Kessler (2018) notes that language educators are not always familiar with recent developments in the use of AI in language classrooms, and this can lead to missing opportunities to incorporate the use of technologies and in this way deprive learners of valuable moments that could facilitate effective learning, e.g., experiencing authentic learning activities situated in authentic contexts (Egbert et al., 2007), increasing student motivation (Dörnyei & Ushioda, 2001), and enabling learners to develop their sense of autonomy and engagement in the learning process (Reinders & Hubbard, 2013).

Recently, however, researchers have been attempting to classify the ways in which AI solutions are integrated in language education (see, for example, Pokrivčáková, 2019; Zawacki-Richter et al., 2019; Huang et al., 2021). Kessler (2018) discusses several types of application of AI that are especially relevant in language education in more detail. First, the use of corpora offers a way to engage learners in more meaningful and effective language learning. While the use of corpora in research is not a recent trend as such, using corpora for pedagogical needs has not been extensively used. However, advantages of relying on corpora when teaching vocabulary, extensive reading, pragmatics in speaking, and collocational competence have been highlighted (Kessler, 2018). Crucially, since corpora involve large volumes of authentic language use, introducing the use of corpora into language classrooms implies opportunities to offer, according to Kessler (2018), "authentic activities that take place in authentic contexts and thus

authentically represent the kind of language that learners will encounter in the real world" (p. 213). Second, AI enables tracking students' activities. For example, tracking aspects such as students' behaviour, performance and usage of materials through, e.g., keystroke logging and/or eye-tracking software, allows to observe, among others, how students interact with materials, learning environments, and how they make decisions. As a result, this data can provide insights into how aspects such as language accuracy and fluency and the learning experience overall can be enhanced through individualised feedback "at the points in the learning process where they are most salient to the learner" (Kessler, 2018, p. 214).

Another aspect of AI are translation tools and their utilisation in language education. It is salient to note that language teachers tend to perceive it as a threat and believe that students use them in order to avoid the work that they should be doing themselves (Kessler, 2018). Similarly, Liubinienė et al.'s (2022) recent study shows that students indeed perceive the generally negative attitudes their language teachers hold towards machine translation (MT) tools and, as a result, this ambiguity (i.e., on the one hand, students know how to use MT tools and rely on them in foreign language classrooms; on the other hand, they are aware of their teachers' critical attitude towards such tools) prevents them from fully exploring the potential of MT applications. However, incorporating MT tools in the language learning process can be beneficial to learners: for instance, it can raise students' awareness of the strengths and weaknesses of translation tools and highlight ways in which these tools can be used in an effective way (Kessler, 2018).

The examples of AI integration within language education mentioned above reflect numerous benefits of the use of AI in education in general, e.g., AI contributes, among other things, to larger learners' autonomy (Pokrivčáková, 2019; Kuddus, 2022); educators' better control of managing and adjusting the learning process (Chu et al., 2022); making learning more flexible and personalized (Zawacki-Richter et al., 2019). Ironically, however, using AI-related technologies in foreign language classrooms tends to be ignored as many language educators are not aware of the recent literature regarding the trends in computer-assisted language learning and/or are not encouraged to use these tools in their own teaching practice (Kessler, 2018).

In order to help bridge this gap, the section below provides a review of findings from recent literature focusing on the use of AI in language education.

Literature Review

Researchers (e.g., Donthu et al., 2021; Liang et al., 2021; Zawacki-Richter et al., 2019) highlight that review studies are valuable reference points for a comprehensive understanding of what the current state of a particular research topic or field is, especially for novice researchers. Therefore, for the purposes of this study, we searched for the latest reviews with a focus on the broad coverage of the use of AI in language education (for a concise overview of these studies, see Table 1). The literature review includes a summary of the most salient findings from these studies; however, their comparison is problematic due to different research scopes, aims, search strategies, databases searched and periods covered.

Table 1

Review Studies on the Use of AI in Language Education

No	Authors	Title	Period	Review type	Number of papers
1.	Liang et al. (2021)	Roles and research foci of artificial intelligence in language education: an integrated bibliographic analysis and systematic review approach	1990–2020	Bibliometric analysis and systematic	5,594 initially/71 in the final review
2.	Huang et al. (2021)	Trends, Research Issues and Applications of Artificial Intelligence in Language Education	2000–2019	Systematic and bibliometric analysis	516
3.	Du (2021)	Systematic Review of Artificial Intelligence in Language Learning	2010–2019	Systematic and bibliometric analysis	1,014
4.	Chen et al. (2021)	Artificial intelligence-assisted personalized language learning: systematic review and co-citation analysis	2002–2021	Systematic and co-citation analysis	5,829 initially/17 in the final review
5.	Woo and Choi (2021)	Systematic Review for AI-based Language Learning Tools	2017–2020	Systematic	454 initially/53 in the final review

For example, Liang et al. (2021) conducted a review of studies focusing on the use of AI in language education from the Web of Science database. More specifically, the aim of this study was to overview dimensions such as research sample groups, research methods, language skills, technology used, the role that AI plays in language education as well as learning outcomes related to the integration of AI. The review showed that the research into AI was very limited during the period between 1990 and 2000; however, the following two decades (2000–2020) saw an exponential growth of publications on the topic. For the period between 1990 and 2020, Taiwan (23 articles) and the USA (20 articles) were the most productive countries in terms of the number of publications focusing on the integration of AI in language learning. In addition, for the period between 2004 and 2020 (the first empirical study related to the impact of AI on learning outcomes was published in 2004), studies addressing the use of AI in the field of higher education were most frequent (26 articles), followed by 12 articles in secondary education, nine in elementary education, seven in cross-level education, two in pre-school education and one in an unspecified field.

In terms of language acquisition, Liang et al. (2021) found that AI was most frequently applied in the development of reading and writing skills as well as vocabulary learning/teaching. Regarding affective aspects, the integration of AI was mostly researched in relation to learners' motivation, self-efficacy, acceptance of technology and engagement generated by it. Out of 183 keywords analysed, "Intelligent Tutoring Systems", "Interactive Learning Environments", "Natural Language Processing", "Evaluation of CAL Systems" and "Learning/Teaching Strategies" were the most common ones. The authors also distinguished three main types of applications characterising the main role of AI in language education: "Intelligent Tutoring Systems" (intelligent tutors guiding language learners), "Evaluation and Assessment" (intelligent assessors and advisors helping to spot and correct mistakes), and "Adaptive Systems and Personalization" (intelligent providers of personalized learning material and directions for learning based on learners' input). According to the findings of this study, Natural Language Processing, Intelligent Tutoring System, Data Mining, Statistical Learning, Natural Language Processing, and Machine Learning were the most commonly applied AI-based solutions in language

education. From the entire period analysed, the last decade (2010-2020) was characterised by five areas, i.e., Interactive Learning Environments, Intelligent Tutoring Systems, Teaching and Learning Strategies, Evaluation of Computer Assisted Learning Systems, and Natural Language Processing. In addition, "Machine Learning", "Learning Analytics", and "Computational Linguistics" were three new keywords that appeared during this period.

Huang et al. (2021) also analysed how AI was integrated in language education. Similarly to Liang et al.'s (2021) study findings, even though Huang et al.'s (2021) review was based on a more substantial number of papers, the authors found that the number of publications focusing on AI-guided language education increased during the period between 2000 and 2019 and the USA was the most productive country in terms of research output in this area. In addition to Liang et al.'s (2021) findings, Huang et al. (2021) demonstrated that AI was commonly used not only for assisting in the development of writing, reading and vocabulary learning/teaching, but also for speaking, listening and grammar learning, i.e., the main areas in the traditional discussion on language teaching/learning. Among ten main topics illustrating the application of AI in language education, Huang et al. (2021) listed the use of intelligent tutoring systems for reading and writing, automated writing evaluation and error detection, personalized systems for language learning, communication mediated by computer, natural language and vocabulary learning, web-based systems and resources for language learning, intelligent tutoring and assessment system for speech training and pronunciation. While utilizing automated writing evaluation, intelligent tutoring systems and personalized learning solutions, educators mostly used automated speech recognition, natural language processing and learner profiling (Huang et al., 2021).

To reveal the popular topics related to the integration of AI in language education, Du (2021) conducted a review of publications from the Web of Science database for the period from 2010 to 2019. According to the findings of this study, before 2012, the annual output of publications was below 90, but gradually peaked at 150 publications in 2016. The research volume experienced a slight decline both in 2017 (121 publications) and in 2018 (104 publications); the findings from 2019 (58 publications) were indicated as

not informative enough because some publications might have been included in the database later. Not surprisingly, this review showed that English was the main language where AI solutions were integrated, especially in teaching English as a second language. Only a very small number of papers covered learning or teaching of native languages, minority languages and sign language as well as other foreign languages. Importantly, Du's (2021) study indicates the dominant AI technologies and scenarios that were applied in language learning. It showed that neural networks and training machines to read, write, speak, listen and assess were the most frequent AI applications. Other common technologies included intelligent language tutoring, data mining, user modelling, and automated scoring. Among the most frequent scenarios, Du (2021) distinguished "the transformation of personalized and adapted mobile learning and data-driven learning, the construction of authentic and motivated virtual worlds, and the reinforcement of intelligence aided reading and writing" (p. 27).

By restricting their review scope to the use of AI for personalized language learning, Chen et al. (2021) synthesized publications from the Social Science Citation Index and Science Citation Index databases. Although small in scale, this review showed that Taiwan was the most productive country in terms of the number of publications; its institutions dominated in the application of AI in the forms of natural language processing, intelligent tutoring systems and artificial neural networks for the facilitation of personalized diagnosis, personalised learning paths and material recommendation in language learning. The findings of Chen et al.'s (2021) study also confirmed that learner profiling mining as well as adaptation of learning resources were most common among mobile- and web-based personal language learning solutions. The finding that higher education students were the most frequent research participants corroborates Liang et al.'s (2021) conclusion that the use of AI most commonly attracts attention from researchers of this level of education.

To increase language educators' awareness of AI-based language learning tools and their benefits, Woo and Choi (2021) synthesized papers from Scopus, ERIC and Web of Science databases. Their findings showed that the most common AI-based solutions were natural language processing and

machine learning for the provision of feedback, identification of errors and assessment of language abilities. The highest number of publications (k = 14) illustrated the use of AI tools for the development of speaking and listening skills. Such tools included intelligent personal assistants for improving listening comprehension, increasing willingness to communicate and improving overall spoken production, using robots for group conversations and neural network-based dialogue systems. The second group of publications (k = 11) focused on the use of AI tools for teaching pronunciation; the tools included deep learning algorithms and other types of solutions for pronunciation training, diagnosis and evaluation. The third largest group of 11 papers described the use of AI-based solutions for the development of writing. Among them, machine translation, AI-based writing software, referencing tools and blended courses with automated feedback on writing were utilized. Based on these findings, the authors concluded that while natural language processing was more frequent for grammar and vocabulary learning as well as the development of writing and reading skills, neural networks were more common for the development of listening and speaking, including pronunciation. Similarly to Chen et al.'s (2021) and Liang et al.'s (2021) reviews, Woo and Choi's (2021) study showed that the introduction of AI-based tools was most frequent at the tertiary level, i.e., 32 articles out of 53 focused on this level of education.

Considering the different types and scopes of the reviews on the use of AI in language education discussed above, it can be established that, to the best of our knowledge, no large-scale review (bibliometric analysis) on the use of AI in language education for the period covering the last five years (2018–2022) has been conducted. Therefore, the current study aims to overview the latest research related to the use of AI in language education. As research on the application of AI in language education is still too limited (Du, 2021; Huang et al., 2021; Zawacki-Richter et al., 2019), we hope that this review will not only bridge the research gap, but will also increase language educators' awareness of this phenomenon. It also stems from our personal interest as we conduct research on both AI and language teaching/learning. Given the increasing interest in the use of AI in education in general (Chen et al., 2022; Liang et al., 2021) as well as on its use in language education (Huang et al., 2021; Woo & Choi, 2021), we believe that the present study is

a timely one. Furthermore, it serves as the initial phase for our subsequent research in this field as we plan to refine it to the context of higher education, which is the leader in the introduction of AI-based solutions (Chen et al., 2021; Liang et al., 2021; Woo & Choi, 2021).

Specifically, in the current study, we address the following research questions:

RQ1. What are the global trends of AI in language education research in terms of publication output?

RQ2. Which authors and countries have actively researched the use of AI in language education?

RQ3. What are the most important journals that contribute to the body of knowledge in the field of AI in language education research?

RQ4. What are the most cited references in the field of AI in language education research?

RQ5. What are the most popular research topics and trends regarding the integration of AI in language education?

Methods

In order to answer the questions above and "gain a one-stop overview" (Donthu et al., 2021, p. 285) of the research related to the use of AI in language education, we applied bibliometric analysis (Donthu et al., 2021). Bibliometric data was extracted from the Web of Science (WOS) database which indexes high-quality journals, books and conference proceedings. Table 2 details the search string applied. The choice to exclude the term "programming" was based on the initial finding that some articles appear within the context of teaching and learning of programming languages.

Table 2

Search String of the Current Study

Area/Topic	Search term
Artificial intelligence	"artificial intelligence" OR "AI" OR "machine intelligence" OR "intelligent support" OR "virtual reality" OR "chat bot" OR "intelligent *" OR "expert system" OR "neural network"

Area/Topic	Search term
	OR "natural language processing" OR "chatbot" OR "intelligent system" OR "speech to text" OR "text to speech" OR "Google *" OR "AI-based *" OR "AI-powered" OR "AI AND writing assistant" OR "AI AND automated tutor" OR "personal tutor" OR "grammar accuracy checkers" OR "speech recognition" OR "machine translation" OR "chat robot" OR "learning apps" OR "CALL" OR "computer assisted language learning" OR "flashcards" OR "avatar" OR "language bots" OR "personalized textbook" OR "corpus" OR "thesaurus" OR "virtual learning environment" OR "interactive language learning system" OR "big data" OR "language learning app" OR "robot" OR "AI language tutor" OR "AI assistant"
AND	
Language education	"language teaching" OR "language education" OR "language learning"
NOT	"programming"
PERIOD	2018–2022

The search was conducted on April 26, 2022. It was refined according to the publication date that ranged from the 1st of January 2018 until the 26th of April 2022. The obtained dataset included information (titles, abstracts, authors, keywords and cited references) from all types of documents (articles, proceeding papers, early access documents, review articles, book chapters, etc.). After removing duplicates and erroneous entries, the final dataset included a total of 2,609 documents.

More specifically, we applied various techniques from two main categories manifesting in bibliometric analysis: (1) performance analysis and (2) science mapping. While "performance analysis accounts for the contributions of research constituents, science mapping focuses on the relationships between research constituents" (Donthu et al., 2021, p. 287). As bibliometric analysis usually utilizes network visualization software, we applied entirely graphical user interface-based software VOSviewer (Van Eck & Waltman, 2010). It helped us to generate tables, networks and maps representing the results obtained by the techniques such as co-citation analysis, bibliographic coupling, co-authorship analysis and co-occurrence of keywords (Donthu et al., 2021).

In the visualisations of bibliometric data, links show connections or relationships between items. Each link has its strength, which is represented by a positive numerical value. The higher this value, the stronger the link. The strength of the link indicates the number of cited references two publications have in common (in the case of bibliographic coupling links), the number of publications two researchers have co-authored (in the case of co-authorship links), or the number of publications in which two keywords occur together (in the case of co-occurrence links). The occurrences attribute indicates the number of documents in which a keyword occurs.

The VOSviewer software creates networks and maps by using colourful groups of circles (or nodes), known as clusters, which mark either keywords or authors. The size of the author marking node depends on the number of his/her published documents. Similarly, the size of the keywords marking nodes is determined by their co-occurrence in the published documents and link strength. Additionally, the nodes in the clusters are connected by lines. The stronger the link between two items, the thicker the line that connects them. The colour of the circle or node is determined by the cluster to which it belongs.

The density visualization maps indicate the size and impact of different areas; two types of density are distinguished, i.e., item and cluster (Van Eck & Waltman, 2020). Using blue and yellow as the colour scheme, the density maps illustrate the density at specific points. The clusters and nodes are shown within the colour scheme with a range of blue chosen to represent zero and yellow to indicate an increase in the value from zero (Van Eck & Waltman, 2020).

Results and Discussion

In answer to RQ 1, we analysed yearly publication output. In answer to RQ 2, we analysed publication output across countries, collaboration of authors and authors' productivity. In answer to RQ3, we investigated journals publishing on the topic of AI in language education. In answer to RQ4, we analysed top cited references. In answer to RQ5, we looked into the keywords and textual data in the dataset of the present study.

Yearly Publication Output

As shown in Table 3, the total number of articles on the use of AI in language education published from 2018 to 2022 was 2,609. Most of the publications appeared in 2021 (23.99%) and 2019 (23.84%), followed by 2018 (23.30%) and 2020 (23.23%). 2022 (until the 26th of April) has also seen a considerable number of publications. The number of publications is rather consistent across the years. However, these numbers also point to the fact that there was no significant increase of interest among researchers in this topic during the period covered.

Table 3

Publications Each Year

Publication year	Record Count	%
2022	147	5.62
2021	626	23.99
2020	606	23.23
2019	622	23.84
2018	608	23.30

Publication Output Across Countries

As shown in Table 4, China and USA were most productive in terms of academic papers on the topic of AI in language education during the period between 2018 and 2022 and produced 478 articles (18.32%) and 476 articles (18.24%) respectively, followed by Taiwan with 174 articles (6.67%). Importantly, the top ten countries published 1,977 out of 2,609 articles (75.76%), which means that only around 24.24% of research was published in other countries.

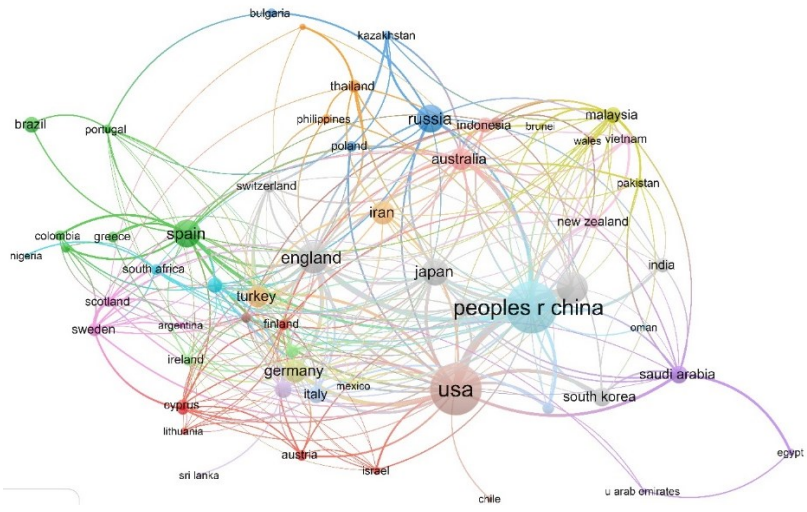
Table 4

Top 10 Countries Representing the Highest Number of Documents

Countries	Record Count	%	Citations	Total link strength
Peoples R China	478	18.32	1673	833
USA	476	18.24	2515	838
Taiwan	174	6.67	928	521
England	171	6.55	854	332
Spain	136	5.21	392	219
Russia	134	5.14	71	20
Japan	132	5.06	338	175
Iran	95	3.64	399	297
Germany	94	3.60	373	134
Australia	87	3.33	264	218

Figure 1

Co-Authorship of Countries Based on the Number of Documents



China and USA have published the highest number of articles (in total, 36.56 %) in the field, have been cited most and have also collaborated with each other. As showed in Figure 1, the USA and China have collaborated with researchers from other countries the most, i.e., with 31 and 34 countries,

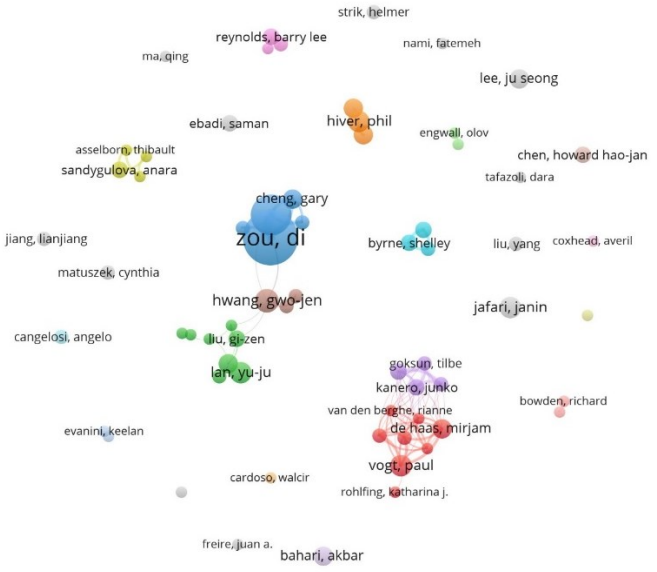
respectively; Saudi Arabia, Spain, Japan and Turkey are among top collaborating countries. Crucially, if countries do not collaborate with other countries, they are removed from the network by default. The lines connecting the nodes on the map specify the co-authorship among countries, and the length between the nodes shows the strength between them and the volume of publications produced as a result of the co-authorship among countries.

Authors' Collaboration

The analysis of the 2,609 documents revealed that 5,369 authors contributed to the field. As recommended by Van Eck and Waltman (2010), the minimum number of articles showing authors' collaboration with each other was set to five. As a result, 65 authors met this criterion. The largest set of connected items consists of 16 items (blue cluster, see Figure 2), which shows the highest research output of this group. Zou Di was the most productive author in this cluster.

Figure 2

Collaboration Among the 65 Authors



Authors' Productivity

The top ten highly productive authors who published on the topic of the use of AI in language education during the period from 2018 and 2022 are shown in Table 5. According to the volume of publications, Zou Di (23 articles and 255 citations) dominates the list of top authors. Importantly, Oudgenoeg-Paz Ora and Verhagen Josje have the highest average number of citations per paper among these most productive authors.

Table 5

Top 10 Most Productive Authors During the Period Between 2018 and 2022

No.	Author	Total publications	Total citations	The average number of citations per paper	Total link strength
1	Zou Di	23	255	11.09	223
2	Vogt Paul	9	77	8.56	181
3	Xie Haoran	17	186	10.94	169
4	Oudgenoeg-Paz Ora	5	118	23.60	168
5	Verhagen Josje	5	118	23.60	168
6	De Haas Mirjam	8	63	7.88	157
7	Van den Berghe Rianne	5	117	23.40	149
8	De Wit Jan	6	64	10.67	148
9	Krahmer Emiel	6	69	11.50	148
10	Goksun Tilbe	6	93	15.50	135

Top Journals

As far as the numbers of publications and citations are concerned, the top ten productive journals publishing on the use of AI in language education are listed in Table 6. To provide more valuable information, next to the data provided by VOSviewer, we additionally calculated the average

number of citations per paper and searched for other important journal-related information, such as IF, H-index, category quartile and journal category.

As can be seen in Table 6, publications on the use AI in language education are published in high-ranking prestigious journals. For example, *Computer Assisted Language Learning* stands out during the period between 2018 and 2022, with 354 publications on this topic. This journal has a H-index of 48 and its impact factor is 4.832. It is important to note that *Foreign Language Annals* has the highest average number of citations per paper (12.83). *Educational Technology & Society* has the highest H-index (88) and impact factor (4.14), followed by *Sustainability* (H-index of 85 and impact factor of 3.251).

Table 6

Top 10 Journals with Most Publications on the Use of AI in Language Education During the Period Between 2018 and 2022

No.	Journal	Total publications	Total citations	The average number of citations per paper	Total link strength	IF (5-year impact factor)	H-index	Quartile	Journal Category
1	Computer Assisted Language Learning	354	2576	7.28	466	4.832	48	Q1	Education & Educational Research Language & Linguistics Linguistics
2	Language Learning & Technology	53	288	5.43	143	4.313	73	Q1	Language & Linguistics Education Computer Science Applications
3	Interactive Learning Environ-ments	27	181	6.70	117	3.868	44	Q1	Education & Educational Research
4	RECALL	29	163	0.18	82	3.326	52	Q1	Education & Educational Research Language & Linguistics Linguistics
5	Foreign Language Annals	18	231	12.83	66	1.912	49	Q1	Education & Educational Research Linguistics

No.	Journal	Total publications	Total citations	The average number of citations per paper	Total link strength	IF (5-year impact factor)	H-index	Quartile	Journal Category
6	International Journal of Computer-Assisted Language Learning and Teaching	97	144	1.48	57	0.69	8	Q1 Q2 Q3 Q3	Linguistics and Language Education Computer Science Applications Computer Vision and Pattern Recognition
7	Sustainabi-lity	10	94	9.40	56	3.473	85	Q2 Q2 Q3 Q4	Environmental Sciences Environmental Studies Green & Sustainable Science & Technology Green & Sustainable Science & Technology
8	System	34	200	5.88	52	3.59	77	Q1 Q1	Education & Educational Research Linguistics
9	Educational Technology & Society	12	71	5.92	48	4.14	88	Q1	Education Sociology and Political Science General Engineering
10	Language Teaching	24	120	5	38	4.496	58	Q1 Q1	Education & Educational Research Language & Linguistics Linguistics

Top Cited References

Table 7 provides the list of the top ten most cited references during the period between 2018 and 2022. The most cited article "Technologies for foreign language learning: A review of technology types and their effectiveness" was published in *Computer Assisted Language Learning* and has been cited 99 times during this period, while it has been cited in WOS 331 times. *Computer Assisted Language Learning* publishes articles focusing

on technology-mediated language learning processes. Three articles listed in the list of top ten most cited references were published in this journal. In addition, three most cited articles were published in *RECALL,* i.e., the journal of the European Association for Computer Assisted Language Learning. Its articles focus on the use of technology for the learning and teaching of languages and cultures.

Table 7

Top 10 Most Cited References in the Publications Related to AI in Language Education

Rank	Title	Author	Year	Source	Citations	Citations (In WOS)	Total link strength
1	Technologies for foreign language learning: a review of technology types and their effectiveness	Golonka, Ewa M.	2014	*Computer Assisted Language Learning*	99	331	265
2	Research trends in mobile assisted language learning from 2000 to 2012	Duman, Guler	2015	*RECALL*	33	90	149
3	Review of research on mobile language learning in authentic environments	Shadiev, Rustam	2017	*Computer Assisted Language Learning*	40	82	139
4	MALL: the pedagogical challenges	Burston, Jack	2014	*Computer Assisted Language Learning*	35	94	138
5	Twenty years of MALL project implementation: A meta-analysis of learning outcomes	Burston, Jack	2015	*RECALL*	38	130	135

Rank	Title	Author	Year	Source	Citations	Citations (In WOS)	Total link strength
6	An overview of mobile assisted language learning: From content delivery to supported collaboration and interaction	Kukulska-Hulme, Agnes	2008	*RECALL*	31	-	121
7	The Ecology and Semiotics of Language Learning	Van Lier, Leo	2004	*Springer Dordrecht*	26	26	103
8	Social Robots for Language Learning: A Review	Van den Berghe, Rianne	2019	*Review of Educational Research*	31	75	100
9	Social Robots for Early Language Learning: Current Evidence and Future Directions	Kanero, Junko	2018	*Child Development Perspectives*	25	48	97
10	Will mobile learning change language learning?	Kukulska-Hulme, Agnes	2009	*RECALL*	29	251	97

Popular Research Topics

Figure 3 illustrates co-occurrence networks of all keywords (7,927) in the use of AI in language learning research. This map was plotted using the following criteria-type of analysis: co-occurrence; unit of analysis: all keywords and full counting method. The minimum number of occurrences was set to ten for a keyword. Consequently, 258 keywords were extracted.

Figure 3

Network Map of Keyword Co-Occurrence in AI and Language Learning Research Based on Article-Weights

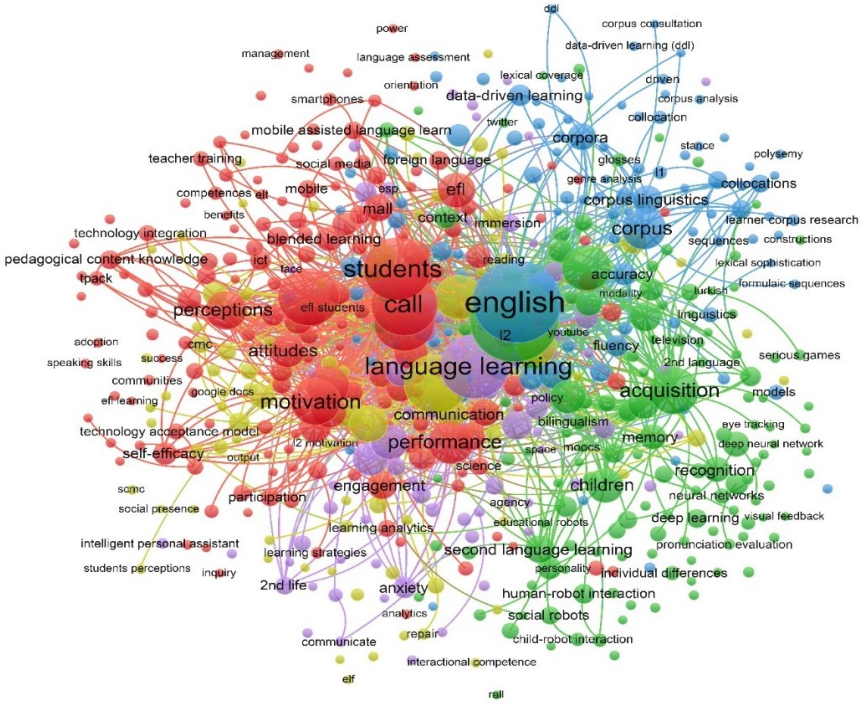


Table 8 shows the frequency and link strength of the top 20 keywords out of 258 keywords that reached the minimum total link strength of 25. "English" is the most popular keyword in the field with the highest number of occurrences (291) and a total link strength of 1795, followed by "language", "students" and "learners". The dominance of the keyword "English" indicates that the most considerable amount of research related to the use of AI in language education concerns the teaching and learning of English.

Table 8

Top 20 Keywords

Rank	Keyword	Occurrences	Total link strength
1	English	291	1795
2	Language	286	1481

Rank	Keyword	Occurrences	Total link strength
3	Students	180	1217
4	Learners	162	1050
5	Technology	153	906
6	CALL	172	853
7	Education	149	778
8	Acquisition	104	655
9	Language learning	186	640
10	Motivation	107	623
11	Performance	89	507
12	Acquisition	104	497
13	Vocabulary	101	436
14	Perceptions	74	431
15	Classroom	77	407
16	Instruction	69	384
17	Computer-assisted language learning	98	378
18	Feedback	70	324
19	2nd-language	57	313
20	Impact	55	280

As seen in Table 8, the keywords indicating AI-based solutions did not appear among top 20 keywords; therefore, we extracted them additionally. The list reflects the AI applications that were researched the most in language education. The dominant AI-based solutions were mobile-assisted language learning (also mobile learning, mobile assisted learning, mobile-assisted learning, phones, smartphones), virtual reality, augmented reality, elements of gamification, games, social robots (also social robot, human-robot interaction, child-robot interaction), machine translation, intelligent tutoring systems, chatbot, machine learning, neural networks, automatic speech recognition (also speech recognition), big data and deep learning.

Table 9

Top Keywords Related to AI-Based Solutions

Rank	Keyword	Occurrences	Total link strength
1.	MALL	40	211
2.	Virtual reality	64	206
3.	Mobile learning	37	157
4.	Augmented reality	29	135
5.	Mobile assisted language learning	19	111
6.	Game	17	109
7.	Mobile-assisted language learning	21	92
8.	Gamification	21	86
9.	Social robots	19	73
10.	Machine translation	24	65
11.	Phones	10	62
12.	Games	14	58
13.	Virtual reality	13	58
14.	Intelligent tutoring systems	17	56
15.	Smartphones	11	55
16.	Chatbot	12	53
17.	Human-robot interaction	22	51
18.	Machine learning	20	45
19.	Child-robot interaction	12	42
20.	Neural networks	14	40
21.	WhatsApp	11	39
22.	Automatic speech recognition	14	37
23.	Speech recognition	26	36
24.	Social robot	11	29

Rank	Keyword	Occurrences	Total link strength
25.	Big data	14	27
26.	Deep learning	21	25

Additionally, the network map of keyword co-occurrence in AI and language learning research based on article-weight is showed through the density map in Figure 4. The density map uses the values expressed by blue and yellow to demonstrate density at specific points, where yellow represents the highest number.

Figure 4

Network Map of Keyword Co-Occurrence in AI and Language Learning Research Based on Article-Weights

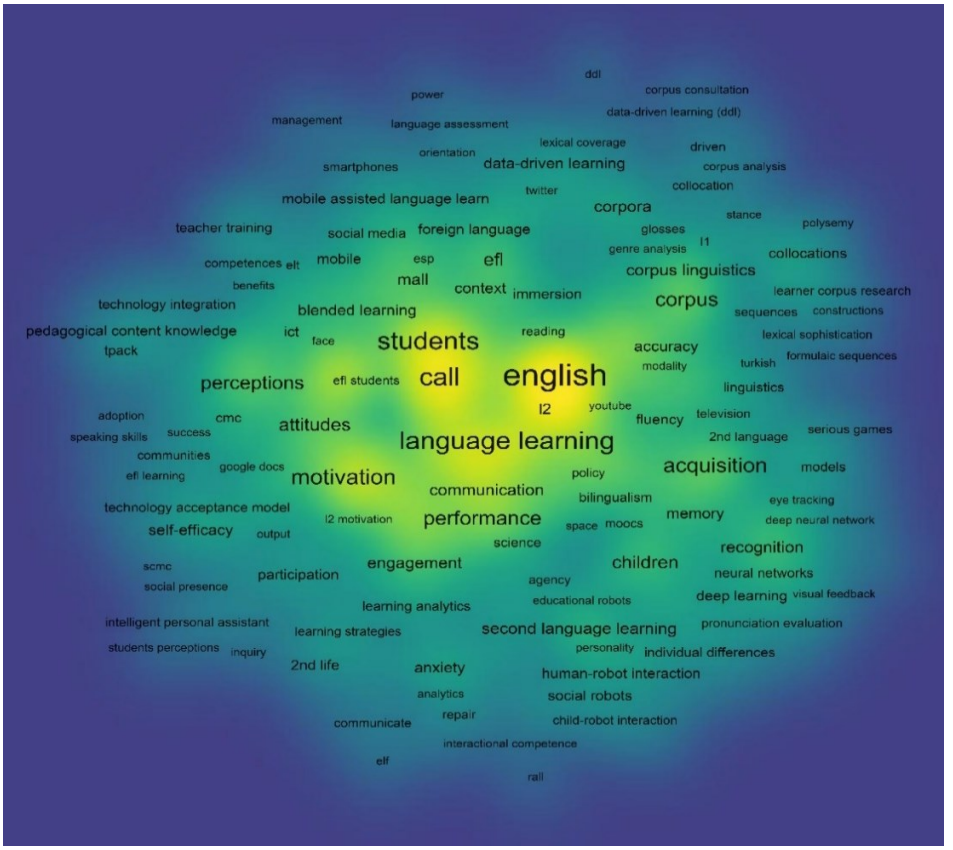


Figure 5 below shows the main seven clusters made of 258 clustered keywords that reached the minimum threshold occurrence and are closely related to the topic. Some keywords are close together or even linked in a cluster while others are further apart and form small separate clusters. The closer the keywords are to each other, the stronger the relationship they have in the research on the use of AI in language education.

Figure 5

Cluster Density Visualization Map (Red – Cluster 1, Green – 2, Blue – 3, Yellow – 4, Purple Blue – 5, Black – 6, Orange – 7)

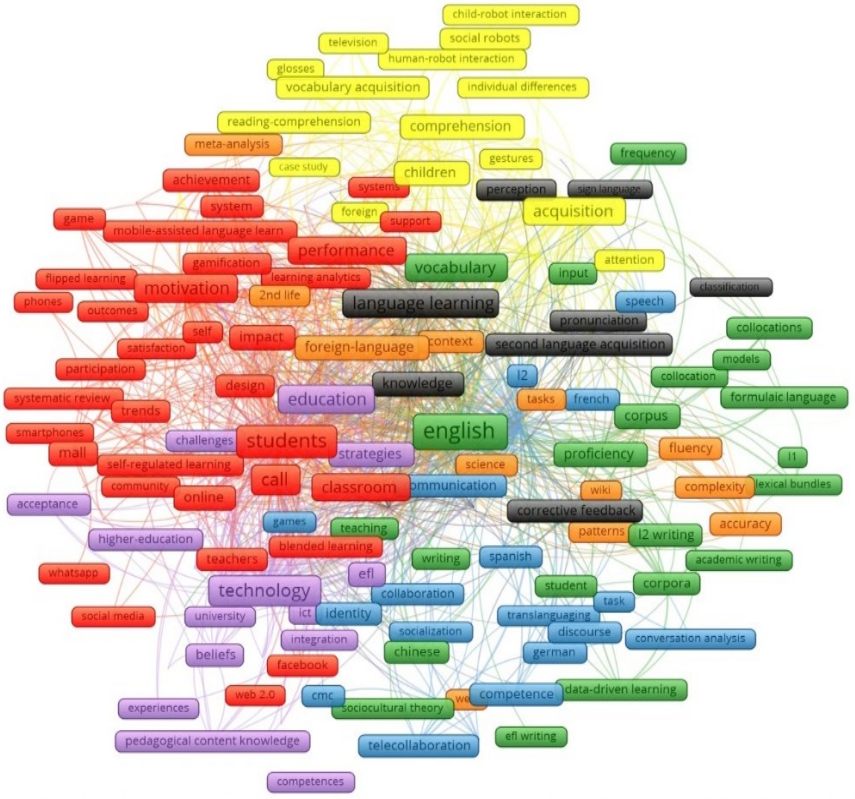
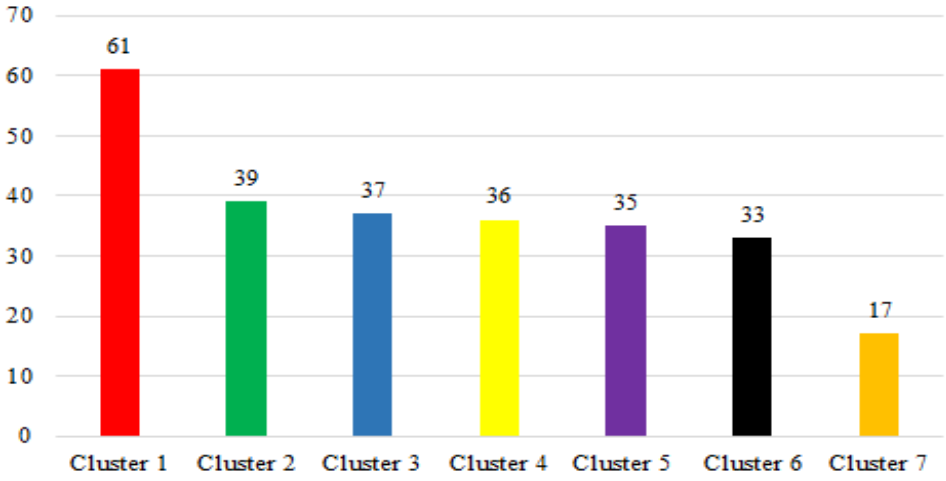


Figure 6 shows the number of keywords in each cluster.

Figure 6

Clustered Keywords (n=258)



The analysis of the keywords in all seven clusters showed that Cluster 6 includes the most substantial number of keywords associated with AI. Therefore, we selected all the items from this cluster (see Table 10) for a more in-depth analysis. The first three items ("language learning", "perception" and "computer assisted language learning") are the same as in Table 8 and belong to the main 20 cited keywords. Their total link strength is the highest and varies from 527 to 378. The next group of keywords such as "feedback", "knowledge", "model", "second language acquisition", "corrective feedback", "foreign language learning" have a lower total link strength (ranging from 324 to 140). The keywords such as "computer-assisted language learning (CALL)", "artificial intelligence", "recognition", "educational technology", "quality", "efficacy", "pronunciation", "machine translation" have a total link strength ranging from 135 to 65. The last group of keywords such as "intelligent tutoring systems", "chatbot", "learner corpus", "machine learning", "neural networks", "automatic speech recognition", "speech recognition", "big data", "deep learning" have the lowest link strength varying from 62 to 19, which shows that they are the most recent ones in the research on the use of AI in language education.

Table 10

Most Common Keywords in Cluster 6

Rank	Keyword	Occurrences	Total link strength
1	Language learning	186	527
2	Perception	74	431
3	Computer assisted language learning	98	378
4	Feedback	70	324
5	Knowledge	51	269
6	Model	57	229
7	Second language acquisition	46	189
8	Corrective feedback	36	160
9	Foreign language learning	44	140
10	Computer-assisted language learning	38	135
11	Artificial intelligence	35	123
12	Recognition	36	101
13	Educational technology	20	95
14	Quality	16	88
15	Efficacy	14	81
16	Pronunciation	18	74
17	Machine translation	24	65
18	Foreign language teaching	28	62
19	Intelligent tutoring systems	17	55
20	Information	16	55
21	Chatbot	12	53
22	Learner corpus	17	47
23	Machine learning	20	45
24	Natural language processing	34	43

Rank	Keyword	Occurrences	Total link strength
25	Neural networks	14	40
26	Automatic speech recognition	14	37
27	Speech recognition	26	36
28	Sign language	12	29
29	Big data	14	27
30	Translation	14	26
31	Deep learning	21	25
32	Classification	15	22
33	Error analysis	10	19

For a more careful analysis of the data, we additionally used the function of the Create Map wizard provided by VOSviewer (for more details, see Van Eck & Waltman, 2020). We chose to analyse textual data (titles and abstracts, excluding keywords) to construct a network of co-occurrence links among terms that are identified by the software using natural language processing algorithms. While general terms might provide very little information, the usefulness of a network tends to increase when these terms are excluded. To exclude general terms, VOSviewer calculates a relevance score for each term. Terms with a high relevance score tend to represent specific topics covered in textual data, while terms with a low relevance score tend to be of a general nature and are generally not representative of any specific topic (Van Eck & Waltman, 2020). By excluding terms with a low relevance score, general terms are filtered out and the focus shifts to more specific and more informative terms.

In Table 11, the list of the most relevant terms was created using binary counting, where the occurrences attribute indicates the number of documents in which a term occurred at least once. The minimum number of occurrences was set to 12 for a term. Out of 43,240 terms, 964 met that threshold. For each of them, a relevance score was calculated. "Social robots" (6.19), "CNN" (abbreviation for "convolutional neural network") (4.65), "convolutional neural network" (4.14), "social robot" (3.86), "structural

equation modelling" (3.50), "supplemental data" (3.30) and "deep neural network" (3.29) were the most relevant terms extracted from textual data.

Table 11

Top 10 Relevant Terms Extracted from Textual Data

Rank	Term	Occurrences	Relevance
1	Social robots	14	6.19
2	CNN	13	4.65
3	Convolutional neural network	18	4.14
4	Social robot	34	3.86
5	Structural equation modelling	12	3.50
6	Supplemental data	16	3.30
7	Deep neural network	18	3.29
8	Young child	14	3.23
9	TPACK	15	3.15
10	Pre-service teacher	13	2.98

For a comprehensive review of how social robots (designed to interact and communicate with people) are used in language education, researchers or language educators may refer to Van den Berghe's (2019) publication. The same article also appears in the list of the most cited references in the publications focusing on the use of AI in language education during the period researched. The types of neural networks such as deep neural networks, conventional neural networks and recurrent neural networks are used to implement speech evaluation and writing assessment (Du, 2021). The term "TPACK" stands for **t**echnology, **p**edagogy, **a**nd **c**ontent **k**nowledge.

Conclusion

The current study is the first large-scale review of the use of AI in language education for the period between 2018 and 2022. The bibliometric

analysis enabled us to draw conclusions about the latest amount of research, the most productive authors and countries in this field, authors' collaboration, the titles of the journals that publish on this topic the most, the most cited articles as well as to analyse the most common and relevant terms. Significantly, the analysis showed that there is a consistent number of publications with a focus on the application of AI in language education each year (2018–2021). We cannot draw conclusions about the rate of publications in 2022 because the review covered only roughly one third of this year.

In terms of the number of publications on the use of AI in language education, China and the USA were revealed to be the most productive countries, which was also shown by previous reviews on the same issue, albeit covering different periods. Zou Di, Vogt Paul and Xie Haoran were the most productive and mostly cited authors in this field during the period researched. Assigned the highest quartile (Q1) and representing the most prolific high-quality journals, *Computer Assisted Language Learning, Language Learning & Technology,* and *Interactive Learning Environments* are the journals that published the highest number of publications on the use of AI in language education during the period analysed.

Both the analysis of the most common keywords and extraction of terms from textual data enabled a better understanding of the more specific thematic aspects addressing the research related to the use of AI in language education. Not surprisingly, the analysis of the most common keywords confirms that English is the most common language in the scientific discussion on the application of AI in language education. Among the most common aspects related to language education, we found frequent keywords such as "acquisition", "motivation", "performance", "vocabulary", "instruction", "feedback" and "impact"; most relevant terms were "online task", "mispronunciation", "flipped teaching", "willingness to communicate" and "task design", which shows that the use of AI-based solutions to be most common when targeting these areas. In addition, as far as AI-based solutions are concerned, the analysis of the most common keywords revealed that mobile-assisted language learning, virtual reality, augmented reality, gamification elements, games, social robots, machine translation, intelligent tutoring systems, chatbots, machine learning, neural networks, automatic speech

recognition, big data and deep learning were the most popular AI-based solutions.

Although we consider this review to be comprehensive as it covers a substantial number of all types of the latest documents on the use of AI in language education (e.g., including proceeding papers or early access documents), it is not without limitations. First, as all types of reviews, it is unique. Second, it included documents only from one database. Third, the search string used might not ensure full completeness and thus absence of bias, especially considering that the landscape of AI-based solutions in language education is constantly evolving. For a more thorough understanding of how AI is used in language education, we suggest combining additional research methods and thus reducing the volume of data for analysis.

Availability of Data and Materials

The datasets analysed during the current study are available from the corresponding author upon request.

Declaration of Conflicting Interests

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DIRBTINIO INTELEKTO TAIKYMAS MOKANT(IS) KALBŲ: BIBLIOMETRINĖ ANALIZĖ

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Pagrindinės sąvokos: dirbtinis intelektas; bibliometrinė analizė; kalbų švietimas; kalbų mokymas(is).