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Trend Analysis of Fluency-Related Research Articles: Using Data Mining

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ABSTRACT

This research seeks to identify recent research trends in analysing fluency in English language studies since 2010. The importance of studying corpora that compile registered research in linguistics is growing; thus, it is time to consider the significance of data mining analysis on the corpora. Considering this emerging research topic, this analysis intends to generate and compare word clouds and word metric charts from speaking and writing abstract corpora in linguistics research centred on the keyword 'Fluency'. This comparison is minimally addressed in extant research; hence, this investigation aims to fill this gap. The corpus contains 50 speaking and 15 writing abstracts from linguistics journals. To create the word cloud, AntConc4.1.4 software was used to analyse the corpora, while TF-IDF and matrix analysis were conducted using R. As a result, in spoken English, 'fluency' studies were largely related to 'teaching' and tended to be dominated by studies focusing on 'fluency' alone. In contrast, writing studies were mostly related to learner proficiency and assessment, and many studies analysed the relationship between linguistic abilities by expanding the scope of 'fluency' to include 'accuracy' and 'complexity'. This study will benefit researchers in deciding on topics as it provides research directions and trends in analysing fluency in the two interconnected but differently expressed fields (i.e., speaking and writing).

Keywords: Word cloud; Text mining; Fluency; Speaking; Writing

1. Introduction

Fluency is considered an important indicator for progressing in language learning, and it has become a condition for ensuring successful communication (Chambers, 1997). Fluency is defined as the ability to use language quickly and confidently without hesitation or too many unnatural pauses. A lack of fluency can cause communication barriers (Bailey, 2003) in learning English as a foreign language, a recent consideration by both teachers and students (Ho, 2018). In other words, fluency is an expectation for anyone wishing to be competent in a language they have spent time and effort acquiring. According to Shahini and Shahamirian (2017), fluency is a major characteristic of communicative competence. Grabe and Stoller (2019) claim that most native English students can read fluently with good comprehension but may have difficulty with grammar exercises based on their reading. In contrast, when tested, many EFL students have little fluency but considerable grammatical knowledge. Thus, EFL students do not need more grammatical knowledge but instead improved fluency. Therefore, EFL learners'fluency must be the focus in EFL teaching contexts (Albino, 2017).

EFL fluency definitions have been heavily influenced by those applied in research on speaking skills (Ho, 2018). However, in wider discussion, fluency normally encapsulates the ease of access to and production of existing language knowledge (e.g., Nation, 2014, p. 11), usually ensconced in a qualitative-temporal requirement. Fluency in wider linguistics has been measured and understood based on temporality and continuousness; coherence/logic and semantical density; degree and scope of sociolinguistic appropriacy/efficacy; and, broadly, creativity/imagination (Fillmore, 1979; Pallotti, 2020). Thus, this supports the argument that the scope of fluency research should include writing as well as speaking.

Meanwhile, a research abstract provides readers with precise and concise knowledge of the content of a lengthy research work, offering a factual summary which is an elaboration of the title and condensation of the report (Graetz 1982, p. 23). Therefore, it is necessary to analyse the abstract to understand the study content (Hanafiah & Yusuf, 2016; Bhatti et al., 2019).

This study conducted text mining on the abstracts of recently published related articles to examine English language research trends in analysing 'fluency' since 2010. Text mining is an analysis method that utilises large amounts of text data to identify trends on a specific topic. This unsupervised learning method provides researchers with a holistic view of research in a field. This study's results will be valuable for future research as they show the research trends of studies on 'fluency' scientifically using text mining. Recently, analytical research using text mining has been actively conducted in various research fields, such as engineering, medicine, and social sciences, and is often found in English language studies (Klein & Boscolo, 2016; Won & Kim, 2021). Therefore, this study is important because it organises big data from recent studies on fluency, analysing the interrelatedness of major keywords using text mining to find implications for future trends in fluency-related linguistics research fields. Also, less or no importance is applied to comparing fluency in EFL speaking and writing in linguistics abstracts. Hence, to fill this gap, the present research will illustrate a contrastive analysis of research abstracts dealing with EFL learners' speaking and writing.

2. Literature review

2.1 Speaking fluency

Fluency in speaking skills is important in language learning development because it indicates a speaker's communication ability (Suzuki et al., 2021). Within Segalowitz's (2016) framework, utterance fluency refers to observable temporal features, such as pauses and hesitations, that reflect the operation of L2 speech production mechanisms (i.e., cognitive fluency). Utterance fluency is generally divided into a triad of subcomponents—speed, breakdown, and repair fluency (Tavakoli & Skehan, 2005). Speed fluency is concerned with the density of information or the speed of delivery, and it is typically measured by the articulation rate (i.e., the mean number of syllables produced per minute, excluding pauses). Breakdown fluency refers to pausing behaviours, including silent or filled pauses. This dimension can be calculated by observing the number and length of pauses or the time in which a speaker produces language over the total time (phonation time ratio) (Pallotti, 2020). If pauses are counted, a decision must be made about how long a silence must be considered a pause (typical values are around 0.25–0.3 seconds, De Jong & Bosker (2013)). Another indicator can be the number of words produced between pauses, referred to as 'words per burst', 'mean length

of run', or 'mean length of utterance'. The position of a pause is also important. For example, it has been noted that native speakers and advanced learners tend to pause between syntactic constituents, mainly to meet conceptual planning needs, while lower-level learners also pause within these constituents, likely to search for words (De Jong, 2016; Tavakoli, 2011). Repair fluency concerns the number of repair phenomena (e.g., self-repetitions, reformulations, hesitations, false starts). It indicates the uncertainty experienced by speakers and how they may consciously monitor their production (Pallotti, 2021).

Speaking fluency is often used to measure a student's success in learning a foreign language. For instance, Lee (2014) investigated how temporal variables of speech relate to the perceived fluency of Korean speakers. To this end, she carried out a short passage-reading task and a task related to spontaneous speech, namely a picture-cued storytelling task, for 46 Korean undergraduate speakers. She discovered that the 'mean length of runs' (i.e., the number of phonemes spoken between two silent pauses) appeared to be less related to perceived fluency than other temporal variables related to pauses, such as the 'length of pauses'. The results indicate that the temporal variables of speech could well relate to the perceived fluency of Korean speakers. Tavakoli et al. (2016) used data from 35 second language learners and examined interruptions and overlaps in dialogues and compared them with monologic speech. Results show that dialogue performance is generally more fluent in speed, pause length, and repairs, but there is no difference in pause number and location.

2.2 Writing fluency

Writing is a complex skill that tests the ability to use a language and express ideas (Norrish, 1983), requiring coherency and effectiveness. Fluency in writing is important for EFL (English as a Foreign Language) students because it helps them to communicate their ideas more effectively and efficiently. Despite this importance, which, with respect to writing, centres on the potential of research to reveal the difficulties learners undergo in textual production, fluency remains disappointingly under-examined (Latif, 2014, p. 196). Until recently, fluency research focused more on speaking than writing. Furthermore, fluency research in L2 writing is rooted in the 1970s, when researchers adapted established

approaches (especially Skehan, 2003) to speaking fluency (Barrot & Gabinete, 2021). Recently, however, researchers have developed indices to objectively measure writing fluency.

Generally, writing fluency refers to the capacity to produce written words and other structural units (e.g., T-units and clauses) in a given time (Van Waes & Leijten, 2015). Several scholars posited that longer production (i.e., fluency) might be a manifestation of a more advanced proficiency level (Marijuan & Vallejos, 2023). In terms of measuring writing fluency, Wolfe-Quintero et al. (1998) proposed that T-unit length, error-free T-unit length, and clause length be used. In contrast, Marijuan and Vallejos (2023) argued that as speed measures (words per minute) have rarely been used in measuring written fluency, there is a lack of correlation with how oral fluency is measured (e.g., pauses and repairs). On the other hand, Baba and Nitta (2014) examined whether two university students learning English as a foreign language experience discontinuous changes (phase transitions) in their writing fluency through repeated timed writing tasks. Phase transitions were evaluated based on sudden jumps, anomalous variance, divergence, and qualitative changes in the attractor.

However, recent research compares L2 learners' fluency in speaking and writing. Kim et al. (2016) investigated the relationship between L2 proficiency and the production of 130 L2 Korean learners. They explored how aspects of CAF (i.e., complexity, accuracy, fluency) in L2 production are related to learners' proficiency development and interactions in speaking and writing. They calculated the number of syllables per minute as the unit of analysis for fluency, measuring the amount of spoken output versus written output produced by the learners within the same 10-minute period. The results showed strong correlations (a) between proficiency and fluency and (b) among fluency across speaking and writing, indicating that fluency improves in speaking and writing alongside the development of L2 proficiency.

2.3 Research on the use of text mining in English studies

Trend research is a study that analyses the research results of various literature in a specific field or topic, categorising the results by time periods or topics to examine trends, identify and discuss peculiarities, and comprehen-

sively examine research achievements within a field (Won & Kim, 2021). In recent years, the use of AI technology has been in full swing, and language-related AI services, such as machine translation and chatbots, have emerged. Thus, information technology is being utilised to study trends in various academic fields, and the influence of such technology is gradually increasing in English studies. Among them, text mining is an analysis technique that discovers knowledge, such as useful information, hidden patterns, and relationships from large-scale text sets that are representative of unstructured data. It is also a general term for related technologies that formalise various document types to generate meaningful knowledge based on natural language processing technology.

Recently, research using text mining has been actively conducted across various academic subjects, and related studies have been published in the field of English. Lee (2022) collected 542 papers on corpus-based research in English education and examined research trends using text mining. The keywords used were 'English'and 'corpus'. The results showed that the study data were mainly from textbooks used in high schools, middle schools, elementary schools, and universities and that comparative analyses of vocabulary were primarily conducted, especially analyses of the frequency of parts of speech.

In the field of English education, studies utilising text mining are relatively common. Park (2021) used data mining to analyse 1,495 articles on English writing registered on KCI between 2001 and 2020 and found that the number of studies on English writing has increased over the past 20 years. She concluded that there are about 25 major themes in English writing. The trends include increased research on learner factors, such as the 'effects of L2 proficiency on writing skills'and 'learners'attitudes and perceptions towards L2 writing'. Kwon (2020) analysed ESP research trends using network analysis. The data analysed were from 400 articles, including dissertations and journals, and the object of analysis was article titles. The analysis period covered 1990 to 2019. The author reported that the topic of 'teaching methods that reflect learners'needs' was the most researched throughout this period. Using network analysis, Shin and Kim (2020) examined research trends in English language education in Korea. The study focused on 814 articles published in a single Korean journal. The period of analysis was from 2000 to 2019. The study conducted frequency and

network analysis on the articles and reported that 'reading instruction'and 'communicative competence' were the most frequently studied topics. Won and Kim (2021) analysed trends in English language education research by examining articles published in twelve Korean English language education journals between 2000 and 2019. The study conducted topic modelling on English abstracts and classified 34 research topics related to English education as a result of the analysis. According to the results, 'CALL', 'language', 'teaching methods', and 'grammar' were the downward trending topics, while 'vocabulary', 'learner factors', 'motivation', 'assessment factors', and 'qualitative research' were the upward trending topics. The researchers analysed the gradual decline in language-centred research through 'language' and 'grammar' and a move from contextual and static research topics, such as 'learner factors' and data-driven and dynamic research topics.

Beyond English language teaching, there are also occasional examples of this technique being utilised in English literature and phonetics. Ju (2021) used text mining and network analysis to analyse trends in the study of W. B. Yeats. She selected the titles of 854 articles from KCI in 2021 using 'Yeats' as the keyword and conducted a network analysis of the publication status of Yeats-related research by year and journal and the centrality of connections between the main keywords. As a result of this analysis, the most frequent keywords were 'Heaney', 'Byzantium', 'History', 'tradition', and 'modern'. The author also found that the TF-IDF and frequency rankings of the words were the same. Park (2022), who analysed the phonology of English, studied the titles of 184 articles published in Korean journals and 205 Korean theses using the keyword 'English phonology'. Due to this analysis, the research on English phonology in Korea mainly focused on phonological aspects, with studies on phonological phenomena, phonological change, phonological awareness, and a comparative analysis of phonology between English and Korean languages. Studies on English learners' reading and listening, lexically oriented studies, phonological transfer, and loanwords were also found.

In these studies, the texts used to analyse the research trends were mainly the title, abstract, and text. Overall, titles and abstracts were most often used, and if only a paper's title was used, the network analysis of the main keywords related to the research topic had the advantage of being simpler and

the results clearer. However, this is unsuitable for tasks such as convergence research analysis using various keywords to identify detailed research trends. In contrast, abstracts have the advantage of specifically presenting the main research topics and subtopics for the trend analysis of convergence research and research topics based on more details. In addition, as the above studies are limited to domestic English studies-related articles, it is difficult to know the research trends of overseas studies. Furthermore, it is challenging to find a study that compares and analyses the research trends in English speaking and writing using 'EFL' and 'fluency' as keywords, which are the topics of this study. Therefore, this study aims to distinguish itself from previous studies using text mining by collecting a large number of studies related to EFL learners' fluency from English language academic articles published in overseas journals and analysing the abstracts of these articles divided into speaking and writing. This study aims to investigate trends in English language research papers dealing with 'fluency' in the last thirteen years, from 2010 to 2023, and to obtain implications for future research.

3. Method

3.1 Data collection

I collected recent research data to identify trends in 'fluency' in English speaking and writing. To achieve this, I searched for the keywords 'fluency', 'speaking', 'writing', and 'EFL' among articles registered on Google Scholar since 2010. After checking the collected data, many articles were identified that did not meet the purpose of this study and were thus removed by carefully checking the bibliographic information, journal name, article title, keywords, and abstract. As a result, 50 papers in the speaking domain and 15 papers in the writing domain were included in this study's dataset, and keywords from the abstracts of these papers were normalised to a format that is easy to analyse and compare between the two domains (**Table 1**). The lower number of articles utilising EFL learners' writing is likely because it has been expected that fluency relates less to writing (Pérez-Vidal & Garau, 2009). As a result, the overemphasis on oral fluency (the dimension thought to determine L2 proficiency (Freed, 1995)) has, to some extent, received even less attention. However, as this study uses the normalisation process

of extracting the ratio of keywords to the total number of words, there is no problem with the comparative analysis of the two domains.

3.2 Analysis process

In this study, AntConc 4.1.4 was used as a pre-processing program to analyse research trends on the topic of fluency. AntConc4.1.4 lemmatised the data, refined the results, and produced a matrix. This program is a big data processing solution for English language studies. It can extract results based on the relevance and accuracy of the data. That is, it can check the frequency of words in unstructured data to determine their importance and create a word cloud (Muchnik-Rozanov & Tsybulsky, 2022).

The R programming language was used to generate the Term-Document Matrix (TDM), compute TF-IDF and connection centrality, as well as generate and visualize graphs. Initially, a corpus was created, and pre-processing tasks were performed, such as converting all text to lowercase and removing punctuation, non-words, and whitespace. Subsequently, a TDM was created from the pre-processed corpus. This matrix has rows for words and columns for documents, where each element represents the frequency with which a word appears in a document. The TF-IDF values of the words were then computed based on the TDM. TF-IDF, which stands for Term Frequency-Inverse Document Frequency, indicates a word's importance. Following this, the co-occurrence matrix between words was calculated and used to determine the connection centrality of each word. Centrality measures how central a node is in the network. Finally, a graph was generated based on the co-occurrence matrix, subgraphs from the heavily weighted edges were created, and these were visualized.

Data pre-processing

As the papers' abstracts under study are in an unstructured form and their meaning is unclear, a data structuring process, such as text mining, is necessary (Shin & Kim, 2020). In this study, lemmatisation was performed using AntConc 4.1.4 before the text mining (**Figure 1**). This was done so that words with different forms but the same base form counted as a total. For example, words such as 'abandons', 'abandoning', 'abandoned', etc. were extracted and counted as a single word of the prototype 'abandon'

Table 1. Examples of fluency papers.

Speaking	Writing
Wang, Z. (2014). Developing accuracy and fluency in spoken English of Chinese EFL learners. *English Language Teaching, 7*(2), 110-118.	Dormer, R. (2016). Fluency in L2 writing: A literature review. *Kwansei Gakuin University Humanities Review*, *21*, 275-284.
Albino, G. (2017). Improving speaking fluency in a task-based language teaching approach: The case of EFL learners at PUNIV-Cazenga. *Sage Open, 7*(2), 2158244017691077.	Khonamri, F., Ahmadi, F., Pavlikova, M., & Petrikovicova, L. (2020). The effect of awareness raising and explicit collocation instruction on writing fluency of EFL Learners. *European* Journal of Contemporary Education,*9*(4), 786-806.
Alrayah, H. (2018). The effectiveness of cooperative learning activities in enhancing EFL learners' fluency. *English Language Teaching, 11*(4), 21-31.	Biria, R., & Jafari, S. (2013). The impact of collaborative writing on the writing fluency of Iranian EFL learners. *Journal of Language Teaching & Research, 4*(1).
Derakhshan, A., Khalili, A. N., & Beheshti, F. (2016). Developing EFL learner's speaking ability, accuracy and fluency. *English Language and Literature Studies, 6*(2), 177-186.	Hwang, J. A. (2010). A case study of the influence of freewriting on writing fluency and confidence of EFL college-level students. *Second Language Studies, 28*(2), 97-134.
Namaziandost, E., Homayouni, M., & Rahmani, P. (2020). The impact of cooperative learning approach on the development of EFL learners' speaking fluency. *Cogent Arts & Humanities, 7*(1), 1780811.	Herder, S., & King, R. (2012). Extensive writing: Another fluency approach for EFL learners. *Extensive Reading World Congress Proceedings, 1*, 128-130.
Doe, T. (2021). Fluency development in an EFL setting: A one-semester study. *Language Teaching Research,* 13621688211058520.	Dickinson, P. (2014). The effect of topic-selection control on EFL writing fluency. *Journal of Niigata University of International and Information Studies, 17*, 15-25.
Onoda, S. (2014). An exploration of effective teaching approaches for enhancing the oral fluency of EFL students. *Exploring EFL Fluency in Asia*, 120-142.	Barrot, J., & Gabinete, M. K. (2021). Complexity, accuracy, and fluency in the argumentative writing of ESL and EFL learners. *International review of applied linguistics in language teaching, 59*(2), 209-232.
Bahrani, T. (2011). Speaking fluency: Technology in EFL context or social interaction in ESL context? *Studies in Literature and Language, 2*(2), 162-168.	Alghizzi, T. M. (2017). *Complexity, accuracy, and fluency (CAF) development in L2 writing: The effects of proficiency level, learning environment,text type, and time among Saudi EFL learners* [Doctoral dissertation, University College Cork].
Houn, T., & Em, S. (2022). Common factors affecting grade-12 students' speaking fluency: A survey of Cambodian high school students. *Jurnal As-Salam, 6*(1), 11-24.	
Tavakoli, P., Nakatsuhara, F., & Hunter, A. M. (2020). Aspects of fluency across assessed levels of speaking proficiency. *The Modern Language Journal, 104*(1), 169-191.	

(**Figure 1**). The program performs lemmatisation by converting various forms of a word to their base form using a lemmatisation setting in the 'Tool Preferences' menu. Words unrelated to the keywords of 'fluency', 'EFL', 'speaking', and 'writing' or that were not content words were excluded. That is, after lemmatisation, the words were extracted in order of frequency of use. The following unimportant functional words were excluded: 'a', 'an', 'and', 'as', 'at', 'be', 'between', 'by', 'for', 'from', 'ministerial', 'in', 'it', 'not', 'of', 'on', 'that', 'the', 'there', 'their', 'this', 'to', 'which', 'with', etc.

Frequency analysis

The first step in text mining is to find the main words by counting the frequency of keywords. After lemmatisation using AntConc 4.1.4, the simple frequency of basic format words and the ratio to the total number of words were obtained. This analysis aims to provide the most fundamental information from text mining, showing the descriptive statistics of the overall research-related keywords.
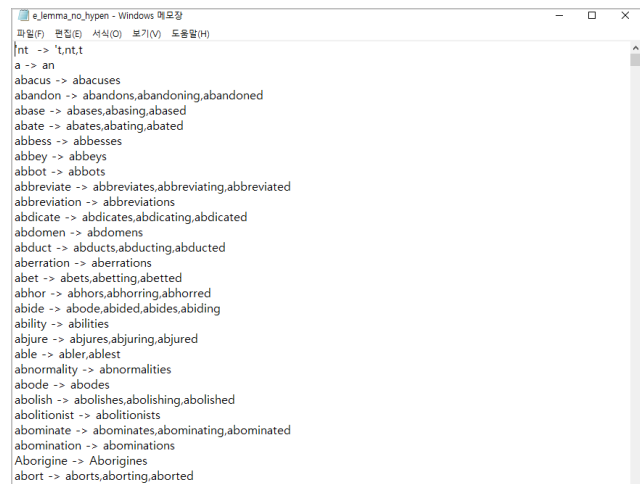

Figure 1. e_lemma_np_hypen.txt from AntConc4.1.4 for lemmatisation.

TF-IDF analysis

TF-IDF is utilised to consider the importance of each word. TF-IDF consists of two metrics. First, TF (term frequency) is a statistical measure of a word's importance within a certain range in terms of frequency. Second, document frequency (DF) is a statistical measure of how often

a particular word is used within a document, and the higher the frequency of a particular word, the more common it is. In addition, IDF (inverse document frequency) is the inverse of DF, specifically by taking the inverse between documents so that IDF decreases as DF increases. In other words, TD-IDF is a metric that reduces the weight of commonly occurring words in the analysed text or document by finding the relative frequency of words rather than their absolute frequency. For general words, it is a relative frequency that compensates for their frequent occurrence in multiple documents, which makes up for the weaknesses of a single frequency.

Connection centrality analysis

The next step in text mining is to analyse connection centrality as an indicator of the connectivity of keywords. There are various data analysis indicators in text network analysis, but I used 'frequency' and 'degree centrality' in this study. Frequency is a calculation of the number of co-occurrences of a node. The more frequently a word is used, the more likely it is to be a major keyword appearing in multiple papers or a topic researchers thought was important at a certain time. Centrality shows the degree to which a node is located at the centre of a network, while connection centrality refers to the degree to which it is directly connected to other words, measured by the total number of connected neighbours. Therefore, words with high connection centrality are more likely to be a research focus. Nodes with a high value have a large number of connected targets, and removing them makes it difficult to organise the research content (Oh, 2020).

Matrix analysis

The last step of the analysis is to find connections between keywords based on their correlation indicators. The matrix analysis provides information on the correlation analysis of keywords based on the matrix data created by the co-occurrence frequency between the refined words. High co-occurrence means that if nodes appear simultaneously within a certain range, there is a high degree of semantic correlation between those nodes. The basic form of social network data for mathematical analysis is a table-like matrix, and the co-occurrence frequency matrix is calculated to provide network visualisation information through the co-occurrence frequency and proximity relationship of the data to be analysed. In this study, a graph was generated based on the co-occurrence matrix, and subgraphs were created from edges with high weight and then visualised.

4. Results

4.1 Frequency analysis

This study aims to present research trends and analyse the correlation between keywords in English speaking and writing studies examining 'fluency'. First, the frequency of words related to the research topic is shown in **Table 2**. It indicates that the total word count of the abstracts from speaking studies before the lemmatisation process was 10,302 (M: 206), and after the process, it was 6,216 (M: 124.32). For writing studies, the former was 3,587 (M: 239), and the latter was 2,271 (M: 151.4).

Although 'fluency', 'speak', 'write', and 'EFL' have high frequencies in both domains, it is unnecessary to include them to identify research trends because they are search terms themselves; thus, they will not be interpreted. In addition, words unrelated to keywords, especially function words, were excluded from the targets. Therefore, according to the word frequency analysis, the top-ranked words were 'group', 'learner', 'study', 'language', 'task', 'reading', 'test', 'accuracy', and 'oral' in the speaking domain. In the writing domain, the top words were 'learner', 'group', 'complexity', 'study', 'accuracy', 'task', 'student', and 'result'.

Figure 2 below is a graphical representation of the frequency distribution for the top frequency words in **Table 1**.
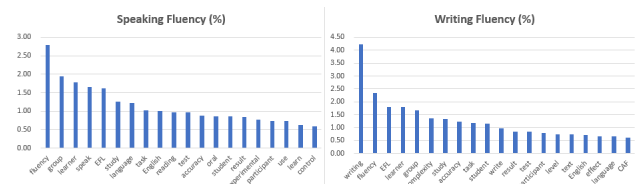

Figure 2. Frequency distribution of top 20 words.

Table 2. Frequency of keywords.

	Speaking (total token: 6216, M: 124.32)				Writing (total token: 2271, M: 151.4)			
Rank	**Keyword**	**Derivative (Freq.)**	**Freq.**	**Ratio**	**Keyword**	**Derivative (Freq.)**	**Freq.**	**Ratio**
1	fluency	fluency 174	174	2.80	writing	writing 92 writings 4	96	4.23
2	group	group 68 groups 53	121	1.95	fluency	fluency 53	53	2.33
3	learner	learner 6 learners 105	111	1.79	EFL	EFL 41	41	1.81
4	speak	speak 3 speaking 95 spoken 5	103	1.66	learner	learner 2 learners 39	41	1.81
5	EFL	EFL 100	100	1.61	group	group 23 groups 15	38	1.67
6	study	studied 2 studies 4 study 69 studying 3	78	1.25	complexity	complexity 31	31	1.37
7	language	language 75 languages 1	76	1.22	study	studies 5 study 23 studying 2	30	1.32
8	task	task 44 tasks 20	64	1.03	accuracy	accuracy 28	28	1.23
9	English	English 62	62	1.00	task	task 18 tasks 9	27	1.19
10	reading	reading 60	60	0.97	student	students 26	26	1.14
11	test	test 53 testing 3 tests 4	60	0.97	write	write 2 written 19 wrote 1	22	0.97
12	accuracy	accuracy 55	55	0.88	result	resulted 1 results 18	19	0.84
13	oral	oral 53	53	0.85	test	test 13 tests 6	19	0.84
14	student	student 2 students 51	53	0.85	participant	participants 18	18	0.79
15	result	result 4 resulted 1 results 47	52	0.84	level	level 10 levels 7	17	0.75
16	experimental	experimental 48	48	0.77	text	text 8 texts 9	17	0.75
17	participant	participants 46	46	0.74	English	English 16	16	0.70
18	use	use 16 used 14 using 16	46	0.74	effect	effect 13 effects 2	15	0.66
19	learn	learn 3 learning 36	39	0.63	language	language 15	15	0.66
20	control	control 35 controlled 1	36	0.58	CAF	CAF 14	14	0.62
21	both	both 35	35	0.56	construct	construct 1 constructs 13	14	0.62
22	teacher	teacher 6 teachers 27	33	0.53	context	context 5 contexts 9	14	0.62
23	performance	performance 25 performances 4	29	0.47	learn	learning 14	14	0.62
24	effect	effect 12 effects 15	27	0.43	performance	performance 13 performances 1	14	0.62

Table 2. *Cont.*

	Speaking (total token: 6216, M: 124.32)				Writing (total token: 2271, M: 151.4)			
Rank	Keyword	Derivative (Freq.)	Freq.	Ratio	Keyword	Derivative (Freq.)	Freq.	Ratio
25	indicate	indicate 2 indicated 20 indicates 2 indicating 3	27	0.43	proficiency	proficiency 14	14	0.62
26	repetition	repetition 22 repetitions 4	26	0.42	term	term 7 terms 7	14	0.62
27	research	research 25 researched 1	26	0.42	finding	findings 13	13	0.57
28	analysis	analyses 6 analysis 19	25	0.40	high	high 11 higher 1 highest 1	13	0.57
29	pre	pre 25	25	0.40	topic	topic 12 topics 1	13	0.57
30	teaching	teaching 25	25	0.40	control	control 12	12	0.53

Figure 3 below is a schematic representation of the distribution of keywords analysed by fluency in English studies, i.e., a word cloud plotting the relative frequency of keywords. A word cloud is a visualisation of the top keywords in a more comprehensible form using a specific number of words. The larger the keyword font size, the higher the ranking. Therefore, **Figures 3** and **4** illustrate the keyword frequencies shown in **Table 1** as a percentage of the total data, which can help to understand research topic trends. Except for the main search terms and function words used in this study, in speaking, 'group', 'learner', 'study', 'language', 'task', 'reading', 'test', 'accuracy', 'oral', etc. have a high relative frequency. In writing, the order is 'learner', 'group', 'complexity', 'study', 'accuracy', 'task', 'student', and 'result'.

Figure 3. Word cloud (Left: speaking, Right: writing).

4.2 TF-IDF analysis

TF represents a word frequency value indicating how often a particular word occurs within a document. DF represents the number of documents in which a particular word appears. In general, if a word has a high frequency in multiple documents, it is interpreted to mean it is a frequently used word. IDF is the inverse of DF. In particular, IDF decreases as DF increases by taking the inverse among documents. Therefore, TF-IDF = TF × 1/DF. Thus, it is a method that finds the frequency of all words in documents within a certain range, takes the inverse, and multiplies them to determine the importance of words (Park, 2022).

According to the TF-IDF analysis in **Table 3**, when search terms such as 'speak', 'write', and 'fluency' and function words are excluded, the scores of 'group', 'learner', 'language', 'read', 'study', 'task', 'accuracy', 'student', 'oral', and 'result' are high in speaking research. However, writing research scored high in 'learn', 'group', 'complexity', 'study', 'accuracy', 'student', 'task', 'character', and 'participant'. Based on this, it can be inferred that 'accuracy' is a common factor in both these research streams. This shows that there is substantial research on the relationship between 'fluency' and 'accuracy'. Another noteworthy point is that the word 'complexity' ranks high in writing research, indicating that 'fluency' in writing is related to linguistic 'complexity'

skills. The order of keywords by TF-IDF is based on relative importance, slightly different from the ranking in **Table 1**, which simply considers frequency.

Table 3. TF-IDF results.

	Speaking		Writing	
Rank	Keyword	TF-IDF	Keyword	TF-IDF
1	fluency	545.9	write	327.3
2	group	488.2	learn	200
3	learner	418.8	fluency	195
4	speak	388.8	group	176.6
5	EFL	367.3	EFL	160.1
6	language	337.9	complexity	132.7
7	read	333.2	study	125.4
8	study	314.6	accuracy	123.9
9	task	300	student	120.9
10	English	295.1	task	114.7
11	accuracy	257.3	character	94.73
12	student	253.5	participant	94.21
13	oral	250.4	result	91.15
14	result	244.1	text	88.97
15	use	233.1	English	83.74
16	participant	231.5	language	83
17	experimental	228	context	82.76
18	learn	197.2	effect	81.39
19	control	184.1	level	77.46
20	teacher	183.2	performance	76.85
21	performance	165.4	term	76.85
22	indicate	154	plan	74.8
23	analysis	146.9	topic	72.76
24	comprehension	146.6	control	67.78
25	research	145.4	use	67.78
26	approach	144	pair	67.78
27	activity	142.5	time	66.7
28	online	135.2	freewriting	66.7
29	test	133.5	high	65.03
30	data	133.5	CAF	63.52

4.3 Connection centrality analysis

In Text Network Analysis, the 'connection centrality' metric is a value that indicates the degree to which a node is at the centre of a network, displaying the degree to which a word is directly connected to other words, measured by the total number of connected neighbours. Therefore, a word with a high connection centrality is more likely to be at the centre of a study topic using 'fluency' in a corpus of speech and writing in English, and a node with a high value has many connected objects, making it difficult to organise a study using this topic by removing it.

The connection centrality of fluency research in speech and writing is quantified based on the direct connection between the analysis of the keyword 'fluency' and the main

keywords. Words with high connections can be considered to have a strong influence on the relationship with the target keyword.

For the connection centrality analysis, the centrality index of the keyword 'fluency' was analyzed based on the frequency matrix generated by R (**Table 4**). According to this analysis, in speaking research, the following connections have high centrality: 'learner', 'language', 'study', 'student', 'group', 'use', 'result', 'oral', 'accuracy', 'task', 'teacher', 'participant', 'learn', 'read', and 'activity'. In writing research, the connections with high centrality are 'learn', 'study', 'student', 'complexity', 'accuracy', 'group', 'task', 'result', 'text', 'level', 'context', 'CAF', and 'proficiency'. Therefore, the trends in research on analysing 'fluency' in English speaking and writing can be categorised into similarities and differences between the two domains. First, the commonality in studying learners' fluency in speaking and writing is that 'fluency' is related to 'accuracy'. Second, the difference between the two domains is that 'fluency' studies based on speaking have high centrality scores for the words 'teacher' and 'read'. In other words, it can be assumed that 'fluency' in speaking relates to teachers' ability and utilising the 'task' of 'reading'. In contrast, in writing, the words 'level' and 'proficiency' have a high connection centrality, so the majority of 'fluency' studies in writing are related to learners' proficiency and evaluation.

4.4 Matrix analysis

Matrix analysis provides association information between keywords based on matrix data from co-occurrence frequencies among refined words. Co-occurrence means that when nodes co-occur in a certain range within the entire text (a row), it can be assumed that there is a semantically correlated relationship between all nodes within this range. The basic form of social network data for mathematical analysis is a matrix in the form of a table. The co-occurrence frequency matrix is calculated to provide network visualisation information through the co-occurrence frequency, proximity relationships, etc., of the data to be analysed.

In this study, using the matrix provided by the R program, a correlation analysis was conducted between the main keywords related to the studies that examined 'fluency' in English speaking and writing. It aimed to identify research trends in the abstracts of these studies based on the

co-occurrence frequency of each word.

Table 4. Connection centrality analysis results.

	Speaking		Writing	
Rank	**Keyword**	**Centrality**	**Keyword**	**Centrality**
1	fluency	0.5579	write	0.6872
2	learner	0.4222	learn	0.4659
3	speak	0.3845	fluency	0.4459
4	EFL	0.3575	EFL	0.416
5	language	0.3426	study	0.3794
6	study	0.3276	student	0.3361
7	student	0.285	complexity	0.3195
8	English	0.2836	accuracy	0.2928
9	group	0.2694	English	0.2795
10	use	0.258	group	0.2745
11	result	0.2488	task	0.2679
12	oral	0.2452	result	0.2629
13	accuracy	0.2409	text	0.2479
14	task	0.2338	level	0.213
15	teacher	0.2125	language	0.2047
16	participant	0.2075	use	0.1997
17	learn	0.2054	context	0.1963
18	read	0.1869	CAF	0.1897
19	activity	0.1812	construct	0.1847
20	indicate	0.1628	participant	0.1814
21	teach	0.162	term	0.1814
22	performance	0.1613	proficiency	0.1747
23	class	0.1613	pair	0.1714
24	experimental	0.1507	effect	0.1631
25	research	0.1493	high	0.1631
26	suggest	0.1478	improve	0.1597
27	approach	0.1464	control	0.1581
28	analysis	0.1414	base	0.1581
29	improve	0.1407	influence	0.1581
30	production	0.1343	freewriting	0.1547

According to the matrix analysis, the highly correlated terms are 'EFL', 'performance', 'oral', 'investigate', 'indicator', 'objective', and 'paper' in speaking research, and 'EFL', 'language', 'accuracy', 'complexity', 'CAF', and 'foreign' in writing research (**Figure 4**). Based on these results, it can be inferred that fluency studies in English speaking corpora tend to focus on a single analysis of fluency skills, while in writing corpora, learners' fluency skills are expanded to include accuracy and complexity (CAF triad: complexity, accuracy, fluency) skills to analyse their proficiency.

5. Discussion and conclusions

This study aimed to analyse the research trends of fluency-related articles using big data analysis conducted through text mining. The keywords used to search for articles were 'fluency', 'speaking', 'writing', and 'EFL', and the abstracts of 65 articles (50 speaking and 15 writing articles) related to 'fluency' in English studies were examined. Focusing on abstracts rather than titles provided a detailed presentation of main research topics and subtopics, essential for a comprehensive trend analysis of convergence research. By categorising the abstracts into speaking and writing, this study offered novel insights into the field and demonstrated the benefits of examining EFL learners' fluency through a more detailed lens. The analysis results of the text mining conducted in this study are as follows.
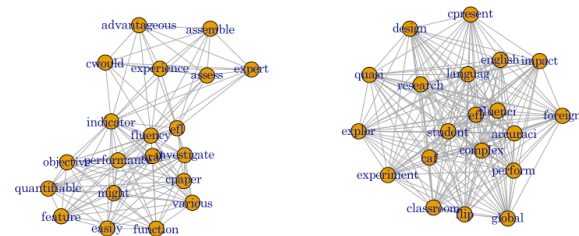

Figure 4. Matrix analysis (Left: speaking, Right: writing).

First, the frequency of keywords was analyzed, revealing that the top-ranked words related to research trends in the speaking domain were 'group', 'learner', 'study', 'language', 'task', 'reading', 'test', 'accuracy', and 'oral'. In writing, the top-ranked words were 'learner', 'group', 'complexity', 'study', 'accuracy', 'task', 'student', 'result', etc.

Second, according to the TF-IDF analysis, the scores of 'group', 'learner', 'language', 'read', 'study', 'task', 'accuracy', 'student', 'oral', and 'result' were high in speaking. In writing, the scores for 'learn', 'group', 'complexity', 'study', 'accuracy', 'student', 'task', 'character', and 'participant' were high. Based on this, it can be concluded that 'accuracy' is a common top-ranked term in both speaking and writing research. This shows the trend in English language studies that the scope of 'fluency' research is expanding to include 'accuracy' as well. Another noteworthy point is that the word 'complexity' is highly ranked in writing, which shows that many studies analyse 'fluency' in writing by expanding the scope to include not only 'accuracy' but also 'complexity' skills.

It means that the popularity of CAF has increased as a framework that instructs L2 research. In literature, the CAF triad has been used as a dependent variable to investigate factors such as the effects of instruction, individual differences, and the effects of learning context or task design (Housen et al., 2012). CAF has also appeared in language

testing research as an indicator of language performance in oral and written language assessments. This indicates that many researchers have employed complexity (syntactic and lexical), accuracy, and fluency both together as a triad and separately.

Third, the centrality analysis showed that the words 'learner', 'language', 'study', 'student', 'group', 'use', 'result', 'oral', 'accuracy', 'task', 'teacher', 'participant', 'learn', 'read', 'activity', etc. have a high centrality in speaking research. In writing research, it was 'learn', 'study', 'student', 'complexity', 'accuracy', 'group', 'task', 'result', 'text', 'level', 'context', 'CAF', and 'proficiency'. Therefore, data mining of the abstracts of papers that studied 'fluency' in English speaking and writing revealed similarities and differences between the two domains. The commonality between the two domains is that many studies on learners' 'fluency' are related to 'accuracy' skills. This result is consistent with the TF-IDF analysis. Skehan (2009) asserted that complexity, accuracy, and fluency (CAF) have proved to be useful measures of second language performance. In recent decades, researchers viewed CAF as sufficiently distinct and important; thus, each must be measured as part of task-based research studies (Bui & Skehan, 2018). This conceptualisation of performance has become increasingly important in recent years, as in Housen et al. (2012) and Ellis et al. (2019). This study found that 'fluency' and 'accuracy' are related among CAFs, a trend many studies are analysing. The difference between the two domains is that 'fluency' studies in speaking research have high centrality scores for the words 'teacher' and 'read'. In other words, it can be assumed that the 'fluency' ability in speaking is related to teachers'abilities and to utilising reading tasks. However, in writing research, the words 'level' and 'proficiency' have high centrality scores, indicating that most fluency studies in writing relate to learners' proficiency.

Fourth, the metrics analysis showed that the highly correlated terms were 'EFL', 'performance', 'oral', 'investigate', 'indicator', 'objective', and 'paper' in speaking research, and 'EFL', 'language', 'accuracy', 'complexity', 'CAF', and 'foreign' in writing research. Based on these results, it can be inferred that 'fluency' studies in English speaking corpora tend to examine only 'fluency' skills, whereas when studying learners' 'fluency' skills in writing corpora, this extends to 'accuracy' and 'complexity' skills, i.e., they analyse learners

with three skills (the CAF triad).

Text mining was used in this study to identify the research trends of fluency-related papers in English speaking and writing using big data analysis techniques. The analysis results showed that the evaluation of fluency skills for English language learners has expanded to include 'accuracy' and 'complexity' skills. These findings are expected to help researchers identify the scope of applications of article abstract corpus in English language research and to guide researchers in the right direction. As for the research topics using the corpus in the field of English studies, the results of TF-IDF analysis, connection centrality analysis, and keyword network analysis showed that there are common research trends but different topics in fluency research in speaking and writing. In other words, in speaking and writing, 'fluency' is commonly studied in relation to 'accuracy'. On the other hand, in speaking, keywords related to 'teach' and 'read' are highly centralised, so it can be assumed that the improvement of 'fluency' in speaking is related to teaching methods such as 'reading'. In addition, compared to writing studies, speaking studies tend to be dominated by those that focus only on fluency. However, writing studies mainly relate to learners' proficiency and assessment, and studies assess learners by expanding the scope of 'fluency' skills to 'accuracy' and 'complexity' skills. The upward trends in 'vocabulary' and 'assessment factors' identified by Won and Kim (2021) show similarities with the present findings from writing studies. In their research, evaluating learners' 'proficiency' and 'vocabulary' are among the upward trending topics in language education research. The emphasis on 'vocabulary' is connected to the concept of complexity, as linguistic complexity encompasses both syntactic and lexical complexity (Housen et al., 2012). Therefore, this study partially aligns with the analysis conducted by Won and Kim (2021), since emphasizing the importance of assessment and lexical complexity in understanding learners' writing proficiency.

Therefore, when researching 'fluency' in English speaking and writing, future researchers can follow the mainstream research in each area if they select topics and scopes based on the trends and directions of these research topics revealed through this study's big data analysis.

However, until recently, fluency research has focused more on speaking than writing, so although it has been nor-

malised, the limited number of fluency-related studies in the writing domain are not as specific and generalisable to research trends as those in the speaking domain. Therefore, in future research, it would be useful to conduct data mining on a wide range of data, including not only English papers but also Korean papers, to identify and refine research trends.

Conflict of Interest

The author declares no conflict of interest.

Data Availability Statement

I have collected recent research data to identify trends in 'fluency' in English speaking and writing. To achieve this, I searched for the keywords 'fluency', 'speaking', 'writing', and 'EFL' among articles registered on Google Scholar since 2010. As a result, 50 papers in the speaking domain and 15 papers in the writing domain were included in this study's dataset. This data is publicly available and can be easily accessed by anyone online.

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References

Albino, G., 2017. Improving speaking fluency in a task-based language teaching approach: The case of EFL learners at PUNIV-Cazenga. Sage Open. 7(2). DOI: https://doi.org/10.1177/2158244017691077

Baba, K., Nitta, R., 2014. Phase transitions in development of writing fluency from a complex dynamic systems perspective. Language Learning. 64(1), 1–35. Available online: http://www.ebsco.co.kr/linksource/kookmin_ls.bmp (accessed on 12 May 2024).

Bailey, K.M., 2003. Speaking. Practical English Language Teaching. New York: McGraw-Hill. pp. 47–66.

Barrot, J., Gabinete, M.K., 2021. Complexity, accuracy, and fluency in the argumentative writing of ESL and EFL learners. International Review of Applied Linguistics in Language Teaching. 59(2), 209–232. DOI: https://doi.org/10.1515/iral-2017-0012

Bhatti, I.A., Mustafa, S., Azher, M., 2019. Genre analysis of research article abstract in linguistics and literature: A cross disciplinary study. International Journal of English Linguistics. 9(4), 42–50. DOI: https://doi.org/10.5539/ijel.v9n4p42

Bui, G., Skehan, P., 2018. Complexity, accuracy, and fluency. In The TESOL Encyclopedia of English Language Teaching, 1st ed. Hoboken: John Wiley & Sons, Inc. pp. 1–7. DOI: https://doi.org/10.1002/9781118784235.eelt0046

Chambers, F., 1997. What do we mean by fluency? System. 25(4), 535–544. DOI: https://doi.org/10.1016/S0346-251X(97)00046-8

De Jong, N.H., Bosker, H.R., 2013. Choosing a threshold for silent pauses to measure second language fluency. In The 6th workshop on disfluency in spontaneous speech (diss) (pp. 17–20). Available online: https://pure.mpg.de/pubman/faces/ViewItemOverviewPage.jsp?itemId=item_1900232 (accessed on 12 May 2024).

Ellis, R., Skehan, P., Li, S., et al., 2019. Task-based language teaching: Theory and practice. Cambridge: Cambridge University Press.

Fillmore, C.J., 1979. On fluency. In: Filmore, C.J., Kempler, D., Wang, W., (Eds.), Individual differences in language ability and language behavior. San Diego, CA: Academic Press. pp. 85–101.

Freed, B.F., 1995. Second language acquisition in a study abroad context. In Second Language Acquisition in a Study Abroad Context. Noord-Holland: John Benjamins Publishing.

Grabe, W., Stoller, F.L., 2019. Teaching and researching reading. Routledge. DOI: https://doi.org/10.4324/9781315726274

Graetz, N., 1982. Teaching EFL students to extract structural information from abstracts. In Proceedings of the International Symposium on Language for Special Purposes; August 2–4; Eindhoven, The Netherlands. pp. 1–23.

Hanafiah, R., Yusuf, M., 2016. Lexical density and grammatical intricacy in linguistic thesis abstract: A qualitative content analysis. In Proceedings of the EEIC; November 12–13; Banda Aceh, Indonesia. pp. 43–46.

Ho, P.V.P., 2018. Fluency as successful communication. In 1st National Conference on English Language Teaching Upgrade: A Focus on Fluency; December 1; HoChiMinh, Vietnam. pp. 15–24.

Housen, A., Kuiken, F., Vedder, I., 2012. Dimensions of L2 performance and proficiency. Noord-Holland: John Benjamins.

Ju, M., 2021. An analysis of research trends on W. B. Yeats using text mining and network analysis: Based on KCI. The Yeats Journal of Korea. 65, 249–274.

Kim, Y., Nam, J., Lee, S.-Y., 2016. Correlation of proficiency with complexity, accuracy, and fluency in spoken and written production: Evidence from L2 Korean. Journal of the National Council of Less Com-

monly Taught Languages. 19(Spring), 147–181.

Klein, P.D., Boscolo, P., 2016. Trends in research on writing as a learning activity. Journal of Writing Research. 7(3), 311–350. DOI: https://doi.org/-10.17239/jowr-2016.07.03.01

Kwon, E.Y., 2020. A study of research trends in ESP using Python and text mining. Foreign Languages Education. 27(2), 111–139.

Lee, Y., 2022. Exploring corpus-related research trends in English education based on big data: Using text mining. Journal of Linguistic Studies. 27(1), 191–215.

Lee, Y., 2014. Quantifying English fluency in Korean speakers' read-aloud and picture-cued storytelling speech. Linguistic Research. 31(3), 465–490. DOI: https://doi.org/10.17250/khisli.31.3.201412.003

Marijuan, S., Vallejos, C., 2023. Complexity, fluency and accuracy in study abroad research. In: Pérez-Vidal, C., Sanz, C., (Eds.). Methods in Study Abroad Research. Noord-Holland: John Benjamins. pp. 209–238.

Muchnik-Rozanov, Y., Tsybulsky, D., 2022. Linguistic analysis of science teachers'narratives using AntConc software. In Research Anthology on Applied Linguistics and Language Practices. Hershey: IGI Global. pp. 665–684. DOI: https://doi.org/-10.4018/978-1-6684-5682-8.ch031

Nation, P., 2014. How much input do you need to learn the most frequent 9,000 words? Reading in a Foreign Language. 26(2), 1–16. DOI: http://hdl.handle.net/10125/66881

Norrish, J., 1983. Language learners and their errors. London: Macmillan Education.

Oh, J.-S., 2020. A study on research trends and knowledge system in cultural contents studies using topic modeling and text network analysis based on Big Data. The Journal of Cultural Policy. 34, 35–70.

Pallotti, G., 2020. Measuring complexity, accuracy, and fluency (CAF). The Routledge Handbook of Second Language Acquisition and Language Testing. London: Routledge. pp. 201–210.

Park, E., 2021. Topic analysis in EFL writing in Korea using text mining. Korean Journal of Applied Linguistics. 37(3), 95–122.

Park, S., 2022. An analysis of domestic study trends in English phonology using text mining. Studies in Phonetics, Phonology and Morphology. 28(1), 83–110.

Segalowitz, N., 2016. Second language fluency and its underlying cognitive and social determinants. International Review of Applied Linguistics in Language Teaching. 54(2), 79–95. DOI: https://-

doi.org/10.1515/iral-2016-9991

Shahini, G., Shahamirian, F., 2017. Improving English speaking fluency: The role of six factors. Advances in Language and Literary Studies. 8(6), 100–104. DOI: http://dx.doi.org/10.7575/-aiac.alls.v.8n.6p.100

Shin, Y.S., Kim, Y.H., 2020. Research and trends in English language education from 1990 to 2019: A keyword analysis of published articles in English Language Teaching. English Language Teaching. 32(4), 205–224.

Skehan, P., 2009. Modelling second language performance: Integrating complexity, accuracy, fluency, and lexis. Applied Linguistics. 30(4), 510–532. DOI: https://doi.org/10.1093/applin/amp047

Skehan, P., 2003. Task-based instruction. Language Teaching. 36(1), 1–14. DOI: https://doi.org/10.1017/-S026144480200188X

Suzuki, S., Kormos, J., Uchihara, T., 2021. The relationship between utterance and perceived fluency: A meta-analysis of correlational studies. The Modern Language Journal. 105(2), 435–463. DOI: https://doi.org/10.1111/modl.12706

Tavakoli, P., 2016. Fluency in monologic and dialogic task performance: Challenges in defining and measuring L2 fluency. International Review of Applied Linguistics in Language Teaching. 54(2), 133–150. DOI: https://doi.org/10.1515/iral-2016-9994

Tavakoli, P., Skehan, P., 2005. Strategic planning, task structure and performance testing. In: Ellis, R., (Ed.), Language Learning & Language Teaching. Noord-Holland: John Benjamins. pp. 239–273. DOI: https://doi.org/10.1075/lllt.11.15tav

Van Waes, L., Leijten, M., 2015. Fluency in writing: A multidimensional perspective on writing fluency applied to L1 and L2. Computers and Composition. 38, 79–95. DOI: https://doi.org/10.1016/j.comp-com.2015.09.012

Vidal, C.P., Juan-Garau, M., 2009. The effect of study abroad (SA) on written performance. Eurosla Yearbook. 9(1), 269–295. DOI: https://doi.org/-10.1075/eurosla.9.13per

Wolfe-Quintero, K.E., Inagaki, S., Kim, H.Y., 1998. Second language development in writing: Measures of fluency, accuracy, & complexity. Honolulu, HI: University of Hawai'i, Second Language Teaching & Curriculum Center.

Won, Y.K., Kim, Y.W., 2021. Analysis of Research Trends in Korean English Education Journals Using Topic Modeling. The Journal of the Korea Contents Association. 21(4), 50–59.