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Four-Word Frames: Enhancing the English Reading Comprehension and Rule Induction Skills of Public Health Students in a Thai University

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ABSTRACT

This study explores the effectiveness of four-word frame training in enhancing the reading comprehension and contextual word-guessing skills of Thai public health students studying English as a Foreign Language. A mixed-methods approach was employed with 22 fourth-year undergraduate students, combining quantitative pre- and post-test assessments with qualitative surveys and interviews. A specialized corpus of public health research articles was created and analyzed using the AntConc corpus analysis software, which identified 50 frequent four-word frames. These frames were categorized into six main patterns, forming the basis for training sessions. Students were taught to identify and apply these frames to academic texts to improve their ability to infer word meaning from context. The findings showed a substantial improvement in reading comprehension, with average test scores increasing significantly after the training. However, individual performance varied, with some less engaged students showing only minimal improvement, indicating that the approach may not be universally effective. Nonetheless, most participants found the training beneficial, particularly for analyzing word patterns using the AntConc software. These results suggest that four-word frame training is a valuable tool for improving reading comprehension in specialized fields like public health, but personalized approaches may be necessary to support diverse learner needs. Further research should investigate the long-term retention of these skills and their application across different academic disciplines.

Key words: Contextual Word Guessing, EFL Learners, Four-word frames, Lexical Frame Training; Public Health, Reading Comprehension

INTRODUCTION

Public health students in Thailand who study English as a Foreign Language (EFL) often face significant challenges in understanding complex academic texts. Although English is not the primary language of instruction in most Thai universities, except in international programs, students frequently encounter English in handouts, reading materials, and research articles. These challenges primarily involve the difficulty of navigating complex sentence structures, unfamiliar technical terms, and specialized vocabulary. This frequent exposure creates a particular challenge in reading because students are expected to comprehend and engage with texts in English, even though they may not be required to excel in speaking, listening, or writing.

In academic settings, these linguistic challenges are further intensified by the need to master public health-specific content. A strong grasp of technical terms and specialized vocabulary is essential for understanding course materials. For non-native English speakers, such terms can be difficult to grasp, potentially hindering comprehension and participation. Additionally, complex sentence structures and cultural references in academic English further complicate learning, leading to frustration, reduced motivation, and a negatively impact on overall academic performance (Amano et al., 2023). In general academic settings, EFL learners also struggle with reading comprehension due to limited exposure to academic English and a lack of effective strategies to deal with unfamiliar terms (Li & Schmitt, 2009).

Furthermore, as globalization continues to influence higher education, proficiency in English becomes increasingly critical for students to access international research, collaborate with global peers, and stay updated with advancements in their field (Carlsson et al., 2021). This is particularly true in public health, where students must understand and apply knowledge from various research sources, most of which are published in English. Therefore, the ability to effectively read and comprehend academic texts is not just

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a skill but a necessity for students aiming to excel in their studies and future careers.

While much research has explored the challenges EFL learners face in general academic settings (Biber et al., 2004; Li & Schmitt, 2009), a significant gap remains in the study of public health-specific lexical frames. Public health as a field requires students to navigate both general English language and highly specialized terminology. Lexical frames, defined as recurring sequences of words that create predictable patterns, can help students overcome these challenges. However, few studies focus on the unique needs of public health students through lexical frame instruction. The present study addresses this gap by investigating the effectiveness of four-word frames in improving reading comprehension and rule induction in public health texts.

In Kasetsart University, where this study was conducted, public health students face these dual challenges. They must not only complete English language courses but also engage with English extensively in their field, particularly when reading specialized texts and writing their undergraduate theses. The burden of mastering both general English and specialized public health terminology can be overwhelming, affecting their ability to fully engage with coursework and research. Without appropriate support, these students may struggle to meet academic demands, which can impact their academic performance and future readiness for professional careers.

Despite the evident need, there is a paucity of targeted language support that addresses the specific challenges faced by non-native English-speaking public health students. Current English language courses in many universities often focus primarily on general language skills rather than the specialized vocabulary and complex sentence structures found in academic texts. This gap in support emphasizes the importance of developing effective strategies to help students overcome these obstacles and succeed academically.

To address these challenges, it is crucial to implement teaching methods that enhance language skills, particularly in the context of technical terms and specialized vocabulary. The present study introduced a novel approach through the use of four-word frame workshops, specifically designed to help students understand words in context. Four-word frames, which are recurring sequences of words that create predictable patterns, have been shown to aid in language comprehension by providing learners with contextual clues that help them decode meaning. The workshops in this study focused on public health texts and aimed to equip students at Kasetsart University with strategies to better comprehend and engage with the vocabulary in their field. These strategies comprised recognizing patterns, guessing meanings from context, and repeatedly identifying key terms to enhance understanding. By applying these strategies, students were expected to improve their academic performance and gain confidence in using English.

This research sought to identify the structure and meaning of the 50 most common four-word frames in public health research, to evaluate the effectiveness of training in these frames in improving students' ability to guess words in context, and to explore students' attitudes toward the training. By focusing on these objectives, the study aimed to fill a gap in the existing literature on EFL education in specialized fields and to provide valuable insights into how targeted language support can enhance the academic success of non-native English-speaking public health students. Therefore, this research aimed to answer the three following research questions:

1. What are the 50 most frequent four-word frames in the academic research in the field of public health?
2. How can training in analyzing four-word frames improve learners' ability to guess words in context?
3. What are the students' attitudes toward the four-word frame training?

LITERATURE REVIEW

Understanding the challenges faced by non-native English speakers in academic settings is a significant area of research. Numerous studies have highlighted the difficulties that EFL learners encounter, particularly in reading comprehension, due to complex sentence structures, specialized vocabulary, and cultural references embedded in academic English (Amano et al., 2023; Carlsson et al., 2021). In the field of public health, these challenges become even more pronounced as students must navigate technical terms and specialized content, which are often published in English. This increases the need for targeted strategies to support learners' comprehension of these texts.

EFL learners, especially in academic contexts, often struggle with multiple language barriers. One of the main challenges they face is the use of complex syntactic structures, which are common in academic writing (Biber et al., 2004). Additionally, EFL learners often experience difficulty with specialized vocabulary, as academic English frequently introduces terms that do not have direct translations or clear equivalents in the learners' first language (Li & Schmitt, 2009). Furthermore, cultural references within academic texts can complicate comprehension, as students may lack the background knowledge needed to fully grasp certain idiomatic expressions or concepts.

One promising strategy involves the use of lexical frames, which are recurring sequences of words that frequently appear together and create predictable patterns. In this study, we focus specifically on four-word frames, a type of lexical frame made up of four words that regularly occur together in public heaths texts. These frames offer contextual clues, helping learners predict the types of words that commonly follow in a sentence. Lexical bundles, on the other hand, are sequences of words that also frequently appear together, but they vary in length and do not always exhibit the same structural predictability as lexical frames. Focusing on four-word frames allows students to identify and work with more consistent patterns, which can be especially useful in navigating the dense terminology of public health texts.According to Biber and Barbieri (2007), both lexical bundles and frames help learners anticipate the words that typically follow in a sentence, facilitating context-based guessing of unfamiliar words. Their research, which examined university-level spoken and written registers, demonstrates that recognizing these

patterns can significantly enhance students' ability to process and understand academic texts more efficiently. However, while much research has been conducted on lexical frames in general academic contexts, their application in specialized fields like public health remains underexplored. Public health texts are often dense with field-specific terminology, creating unique obstacles for EFL learners. Addressing these challenges through targeted lexical frame instruction could significantly improve the comprehension of these students.

Several studies have emphasized the effectiveness of teaching four-word frames in improving learners' ability to understand complex texts. For example, Barbieri (2007) explored how corpus-based findings can be integrated into teaching and found that introducing students to recurring word combinations enhances their contextual understanding of words. This method not only aids comprehension but also helps learners produce more natural English in both written and spoken forms. Block (2020) similarly found that using sentence frames, a structured language pattern, improved EFL students' vocabulary retention in science contexts by providing clear linguistic scaffolds. The focus on four-word frames in this study aligns with these findings, as these frames offer structured patterns that help learners better engage with the technical vocabulary found in public health research. Despite these benefits, limited research exists on how such techniques can be adapted to specialized fields like public health. Esfandiari and Barbary (2023) highlight that recurrent word combinations vary significantly across disciplines, stressing the importance of tailoring instruction to the specific lexical needs of students in fields such as public health.

In specialized fields, such as public health, the role of lexical frames becomes even more critical. Luzón (2000) examined collocational frameworks in medical research papers and found that understanding these patterns is essential for non-native English speakers to navigate genre-specific language. Similar to medical research, public health texts are characterized by complex phrases, which, if recognized through lexical frame training, can greatly improve comprehension and retention of specialized content. Ang and Tan (2019) also emphasized the importance of understanding both continuous and discontinuous lexical frames in academic writing, arguing that these frames provide students with the ability to predict language patterns more effectively, which is crucial in highly specialized fields like public health. However, research specifically addressing how public health students can best be supported through the use of lexical frames is scarce. This gap in the literature highlights the need for studies like the current one, which focuses on improving public health students' comprehension of their field's specialized language through four-word frames.

Additionally, understanding lexical frames has been linked to better academic performance in specialized fields. Granger (2004) found that familiarity with commonly occurring lexical bundles allows students to read and comprehend complex texts more effectively. This is particularly important in public health, where the ability to understand research articles is crucial for both academic success and future professional practice. However, while general studies on lexical frames offer valuable insights, they often overlook the distinct challenges faced by public health students, who must master both precise terminology and field-specific collocations. Our study aimed to address this gap by focusing on four-word lexical frames specific to public health texts.

Gray and Biber (2013) also emphasized the importance of lexical frames in academic prose and conversation, noting that specific word combinations significantly aid in processing and understanding complex information. This is especially relevant in fields like public health, where the ability to predict forthcoming text patterns is critical for understanding dense and technical material. Nuttall (2021) further supported this view, demonstrating that the use of lexical frames in specialized contexts, such as grant proposal abstracts, can make complex information more accessible. These insights directly informed the current study, which applied similar principles to public health research articles and aimed to improve EFL learners' comprehension.

Although substantial research has focused on the general benefits of teaching lexical bundles and frames, there is a distinct lack of targeted studies addressing their specific impact on non-native English-speaking students in specialized fields such as public health. Most existing studies, like those by Biber et al. (2004) and Hunston and Francis (2000), have focused on general academic writing, while others, such as Li and Schmitt (2009), address the broader use of lexical frames in language learning. Due to their general scope, these approaches often overlook the unique challenges that public health students face, where precise terminology and field-specific collocations are essential for comprehension. As such, Gray and Biber (2013) argue that a one-size-fits-all approach may not be sufficient for students in specialized fields, suggesting instead the need for discipline-specific lexical frame instruction to maximize learning outcomes.

This study sought to fill this gap by focusing specifically on the use of four-word lexical frames in public health texts and by evaluating their effectiveness in improving reading comprehension and contextual guessing skills in Thai EFL learners. By doing so, it aimed to provide new insights into how targeted language support can enhance the academic success of non-native English-speaking students in specialized fields. The focus on public health-specific lexical frames offers a novel contribution to the existing literature, highlighting the potential for lexical frames to be adapted across different academic disciplines to improve both comprehension and academic success.

METHODOLOGY

Research Design and Instrument

This study employed a mixed-methods research design, combining quantitative and qualitative approaches to comprehensively explore the impact of four-word lexical frame training on the English reading comprehension and rule induction abilities of Thai public health students. The research instruments included pre-test and post-test assessments, alongside semi-structured interviews, aimed at gathering insights into

the experiences and perceptions of the students regarding the training.

The semi-structured interviews were designed to provide detailed insights into the challenges public health students faced when engaging with academic texts in English. Specifically, the interviews explored how students used four-word frames to improve their understanding of complex texts. The interview questions focused on the effectiveness of the training, the challenges in understanding complex vocabulary, and the ways the four-word frame strategy could enhance their ability to read and comprehend public health materials in English.

Participants

The participants of this study were 22 fourth-year undergraduate students from the Faculty of Public Health at a Thai public university. These students were enrolled in an independent study course during the second semester of the 2024 academic year. The participants were divided equally between two majors: 11 students from Environmental Health and 11 from Occupational Health and Safety. The sample comprised 21 female participants and one male participant. The selection of participants was based on their enrollment in the independent study course, which required them to engage with English-language research materials. This provided an ideal context for examining challenges to their comprehension of English academic reading.

Creating a corpus

To address the research questions, a specialized corpus of public health research article papers was compiled. The corpus consisted of 127 research articles selected from the Elsevier SCOPUS database, all of which met the following criteria:

1) The articles were in the field of public health.
2) The articles were indexed internationally by Scopus.
3) The articles were published between 2020 and 2024.

These criteria ensured that the corpus was both current and relevant to the field of public health. The corpus totaled 1,300,821 words and was built using AntConc (version 4.3.0) a text analysis tool that allowed for the identification and analysis of lexical patterns within the corpus (Anthony, 2022).

Instruments

Pre-test and post-test

The pre- and post-tests were designed to measure the participants' ability to guess words in context, which addresses Research Question 2: How can training in analyzing four-word frames improve learners' ability to guess words in context? Each test consisted of 60 multiple-choice questions, developed based on six patterns identified from the top 50 four-word lexical frames in the public health corpus. These patterns included prepositional-based frames, noun-phrase frames, verb-phrase frames, and other structural types commonly found in public health texts. The test items were directly aligned with these patterns in order to assess the participants' ability to apply the four-word frames in understanding and completing sentences.

Alignment with Research Question 2.

The 60 multiple-choice questions were specifically designed to evaluate students' ability to guess the correct words that fit the context provided by the lexical frames. These questions covered the six patterns identified from the corpus analysis, testing the students' understanding and application of these patterns. Forexamples students were given a sentence with a four-word frame and a blank slot to fill in, such as "The majority of _____voted the new policy into effect," where they had to select the most appropriate word (i.e., people) based on their knowledge of the frame's structure and meaning.

The test items were divided as follows:

- Multiple-choice questions to evaluate frame usage. These questions assessed students' ability to recognize and complete four-word lexical frames within a given context.
- Sentence completion tasks. These involved filling in the blanks within four-word frames.
- Error identification tasks. These tested the participants' ability to identify incorrect usage of four-word frames.

Example Test Items and Their Purposes.

To provide a clearer understanding of how the tests were structured, below are some representative test items along with their purposes:

1. Multiple-Choice Question on Frame Usage:
   - *Question*: "On the impact of" is commonly used to:
     - A. Discuss the effects or influences of a specific factor
     - B. Introduce statistical data about the frequency of events
     - C. Provide specific quantitative data or statistics
     - D. Situate research within a specific time period
   - Answer: A. Discuss the effects or influences of a specific factor
   - Purpose: This question assessed students' understanding of the typical function of the lexical frame "on the impact of" within a sentence, which is to discuss effects or influences.

2. Sentence Completion Task:
   - *Question*: The study was conducted ___ the implementation of health reform to explore the contextual factors influencing healthcare practices during this period.
     - A. on the impact of
     - B. in the context of
     - C. on the number of
     - D. during the COVID-19 pandemic
   - Answer: B. in the context of
   - Purpose: This item tests the students' ability to use context clues to select the appropriate four-word frame that completes the sentence meaningfully, reinforcing their contextual guessing skills.

3. Error Identification in Four-Word Frames:
    - *Question*: Identify the error in the following sentence: "The researchers conducted a study in the effect of air pollution on health."
        - A. study
        - B. in
        - C. effect
        - D. of
    - Answer: B. in (Correct answer, as "on" should replace "in")
    - Purpose: This question was designed to evaluate students' ability to identify incorrect usage of a four-word frame and correct it, which is crucial for understanding proper lexical structure and usage.
4. Word Guessing Based on Context:
    - *Question*: The results were analyzed ___ the new guidelines.
        - A. for the purpose of
        - B. in the context of
        - C. on the basis of
        - D. during the study of
    - Answer: B. in the context of
    - Purpose: This question helped assess the students' ability to guess the correct phrase based on contextual understanding, an essential skill for reading comprehension.

The pre-test was administered before the training session to establish a baseline for the participants' initial understanding, while the post-test was conducted after the training to measure any improvements in the comprehension and usage of the four-word frames.

Survey

To assess the students' attitudes toward the four-word frame training, a structured survey was administered after the post-test. This survey specifically addressed Research Question 3: What are the students' attitudes toward the four-word frame training? The survey included both Likert-scale questions and open-ended responses to capture the students' reflections on the training experience. The Likert scale ranged from 1 to 5 (strongly disagree to strongly agree), while the open-ended questions allowed participants to provide more detailed feedback regarding the challenges and benefits they encountered during the training.

Interview

In addition to the survey, semi-structured interviews were conducted with five selected participants to obtain deeper qualitative insights into their experiences with the four-word frame training. The selection criteria were based on their improvement between the pre-test and post-test scores: one student showed little-to-no improvement, two showed moderate improvement, and two demonstrated significant improvement. Each interview lasted approximately 15 minutes and focused on exploring the challenges faced during the training, the application of lexical frames, and the participants' overall confidence in using the learned skills in academic and professional settings. The interviews provided valuable perspectives on student motivation and engagement, helping to explain the varying degrees of improvement observed in the pre- and post-test scores.

Research Procedure

This study received IRB approval with the IRB number KUREC-CSC67/009. The research procedure followed several key steps to ensure that the study's objectives were met:

1. Corpus Creation: The first step involved creating a corpus of 127 public health research articles that met the specific criteria. The articles were analyzed using the AntConc software to identify the 50 most frequent four-word lexical frames.
2. Lexical Frame Selection: The identified four-word frames were reviewed, and any that were not meaningful were discarded. The remaining 50 frames were then categorized into six distinct patterns based on their structure and function within public health research texts.
3. Development of Training Materials: Based on the selected four-word frames, training materials were developed to help participants study word concordances and induce rules from the identified patterns. These materials included handouts with six-line concordance examples for each pattern, which participants used during the pre-test, training sessions, and post-test.
4. Training Sessions: Two training sessions were conducted to teach participants how to identify and apply the selected four-word frames. These sessions focused on improving contextual guessing and rule induction strategies, with an emphasis on enhancing students' comprehension of English-language public health research texts.
5. Testing and Data Collection:
    - A pre-test was administered before the training sessions to establish a baseline of the participants' initial abilities.
    - After the training, a post-test was conducted to measure any improvements in understanding and applying the four-word frames.
    - Following the post-test, a structured survey was distributed to gather feedback on the students' attitudes toward the training and their perceptions of the usefulness of the four-word frames.
    - Additionally, semi-structured interviews were conducted with five participants to explore their experiences in greater depth.

DATA ANALYSIS

The data from the pre-test and post-test were analyzed using descriptive statistics, including percentages, means, and standard deviations. This analysis was used to capture overall trends and improvements in the participants' ability to comprehend and use four-word lexical frames after the

training. For the survey, the survey results were analyzed to identify general trends in the participants' attitudes toward the training, focusing on how effective they perceived the training to be in enhancing their understanding of public health vocabulary and their text analysis skills. The interview data were analyzed thematically, with a focus on patterns of engagement, motivation, and the challenges faced by the students during the training. This qualitative analysis helped contextualize the quantitative results, providing deeper insights into the factors that influenced students' performance and their perceptions of the training.

RESULTS

Identification and Categorization of Four-Word Frames

Using a specialized corpus of public health research articles, the 50 most frequent four-word frames were generated using the AntConc software. These frames were analyzed for their frequency and relevance to public health literature. Frames that did not contribute significantly to the understanding of public health texts, such as those with generic meanings or non-technical language, were discarded, leaving a refined list of 50 useful frames.

These 50 frames were further categorized based on their grammatical structure and function within the text. The analysis identified seven distinct patterns; however, one of these patterns (Pattern 3: Noun Phrase) was excluded from further analysis due to its limited utility in helping students understand the core concepts of public health. This exclusion was based on the observation that many noun phrases, such as "received in revised form," were formulaic and not contextually rich enough to improve reading comprehension in specialized texts.

The patterns and their corresponding frequencies are summarized in Table 1.

The analysis of the 50 most frequent four-word frames in public health research, summarized in Table 2, revealed seven key patterns, though as noted above only six patterns were retained for further analysis. These patterns represent distinct linguistic structures that are both frequent and functionally important in academic discourse. Each of the retained patterns was considered significant in helping students predict words and meanings, and these patterns later formed the basis for the multiple-choice test items.

Prepositional-Based Frames (16 frames; 34.8%): Prepositional-based frames are the most common in public health literature. These frames, such as "in the context of" and "on the basis of," are essential for establishing relationships between entities or conditions within academic writing. The frequent appearance of prepositional frames in public health discourse emphasizes their importance in conveying meaning, particularly for setting up conditions or comparisons.

The Noun of Based Frames (9 frames; 24.5%): This pattern includes frames like "the majority of" and "the impact of." These frames are commonly used to quantify or specify relationships in public health research, making them vital for understanding data, results, and key findings.

Table 1. Top 50 four-word lexical frames

No.	4-word frame	Rank	Frequency	Range
1	the + of the	1	918	126
2	in the + of	9	426	112
3	and the + of	49	287	107
4	of the + of	50	273	101
5	to the + of	52	264	98
6	public + in practice	54	243	73
7	public health + practice	54	243	73
8	for the + of	58	218	87
9	on the + of	58	218	92
10	and + of the	63	186	85
11	of the + and	66	177	87
12	the + of health	67	162	56
13	the + of a	68	154	68
14	the + of this	69	152	82
15	of + in the	70	147	76
16	during the + pandemic	71	142	43
17	with the + of	71	142	77
18	at the + of	75	140	72
19	royal society + public	76	139	110
20	royal + for public	77	138	110
21	the + society for	77	138	110
22	the royal + for	77	138	110
23	in the + and	81	133	71
24	during + covid pandemic	82	132	41
25	the + in the	85	128	68
26	and + in the	86	126	74
27	a + of the	91	124	67
28	on + of the	94	123	93
29	it is + to	96	122	62
30	of the + in	102	118	57
31	received + revised form	115	116	116
32	society + public health	115	116	113
33	received in + form	115	116	116
34	society for + health	118	115	113
35	that the + of	118	115	64
36	is + open access	123	111	94
37	this + an open	123	111	94
38	is an + access	123	111	94
39	this is + open	123	111	94
40	an + access article	127	110	94
41	access + under the	131	109	93
42	open + article under	131	109	94
43	access article + the	131	109	93
44	on behalf + the	131	109	90
45	open access + under	131	109	94
46	behalf + the royal	140	104	89

(Contd...)

Table 1. *(Continued)*

No.	4-word frame	Rank	Frequency	Range
47	the + of covid	154	99	37
48	this study + to	154	99	70
49	by the + of	159	97	63
50	used to + the	160	96	56

Conjunction + Noun of Based Frames (3 frames; 7.3%): These frames, such as "and the risk of," are essential in joining ideas or factors in research discussions. This pattern is particularly relevant when dealing with multiple variables in public health studies.

Verb Phrase Based Frames (5 frames; 6.7%): Verb phrase-based frames, like "received + revised form," are crucial for describing standard procedures in research papers, especially within methodology sections.

Subject-Verb Based Frames (4 frames; 5.4%): These frames, such as "it is + to," frequently appear in academic writing to make claims or conclusions. They are critical for recognizing conclusions or recommendations in public health research.

That Clause (1 frame; 1.4%): The that-clause structure, such as "that the + of," introduces explanations or specific aspects of findings. Although less frequent, it plays a significant role in linking evidence to claims within public health research.

The six retained patterns formed the basis for the 60 multiple-choice questions used in both the pre-test and post-test. These questions were designed to assess students' understanding of the patterns' roles in public health literature. Familiarity with these patterns allowed students to better predict meanings and relationships between words, which is critical for enhancing reading comprehension in specialized fields.

The insights from Table 2 also informed the development of targeted training sessions. In these sessions, students were exposed to examples from each pattern using a six-line concordance, which helped them understand how these frames function in real public health texts.

Impact of Four-Word Frame Training on Contextual Word Guessing

The results of the pre-test and post-test assessments demonstrated that the four-word frame training led to clear improvements in participants' ability to guess words in context. As shown in Table 3, the majority of students experienced an increase in their scores following the training. On average, students' scores improved substantially, with the mean pre-test score rising from 18.1 to 32.1, resulting in an average score increase of +14.0 points. This substantial increase highlights the overall effectiveness of the training in enhancing students' comprehension and application of four-word frames. Specifically, all 22 participants improved, with score increases ranging from +1 to +42 points.

Focusing on the increase in scores reveals how much progress each participant made, allowing for a quick comparison of individual performance. For instance, P22 showed the greatest improvement with an increase of +42 points, and P21 improved by +36 points. These results suggest that students who began with lower pre-test scores gained the most from the training, as it provided them with tools to better recognize and apply four-word frames in context.

On the other hand, students such as P13 (+13 points) and P14 (+14 points), who started with relatively higher pre-test scores, also showed notable improvements, although their gains were more moderate compared to those who started with lower initial scores. This suggests that even for students with more advanced English skills, the training was effective in reinforcing and refining their understanding of four-word frames, leading to meaningful, if somewhat smaller, progress.

In contrast, the experience of P1, who showed an increase of only +1 point, indicates that the training may not have been equally effective for all participants. This suggests that individual learning differences or external factors may have influenced the outcomes for certain students. It may also point to the need for more tailored support or varied instructional approaches to accommodate different learning styles.

Moving beyond the overall scores, an item-level analysis provides further insights into how students performed on individual test items. As can be seen from the pre-test and post-test scores for specific items, certain four-word frames were more challenging than others, while some showed greater improvement as students became familiar with them through training.

An item-level analysis of the pre-test and post-test results categorized the items into four groups based on the level of improvement observed: substantial improvement, moderate improvement, minimal improvement, and no change. These categories were determined by the difference in scores between the pre-test and post-test:

- Substantial Improvement: An increase of 10 or more points.
- Moderate Improvement: An increase of between 5 and 9 points.
- Minimal Improvement: An increase of between 1 and 4 points.
- No Change: No difference in scores between the pre-test and post-test.

This categorization, as shown in Table 4, helps illustrate which four-word frames posed greater challenges and which frames students were able to master more effectively through the training.

As shown in Table 4, most items fell into the moderate improvement and minimal improvement categories. This suggests that while the training was largely effective, the degree of improvement varied depending on the complexity and familiarity of the four-word frames. Only two items showed no change, indicating that students were already proficient in some lexical structures prior to the training. Below are examples from each category.

Detailed Analysis of Selected Items from Each Category

1. Substantial Improvement (improvement of 10 or more points)

Table 2. Categorization and frequency of the top 50 four-word frames

Pattern	Number of Frames	Frequency	Percentage of Total (%)	Example of Four-Word Frames (Frequency)	Fillers
Prepositional-Based Frames	16	2,859	34.8%	in the + of (426)	context, case
The Noun of Based Frames	9	2,013	24.5%	The + of the (918)	impact, results
Noun Phrase (Discarded)	12	1,644	20.0%	public + in practice (243)	health
Conjunction+Noun of Based Frames	3	599	7.3%	and the + of (287)	number, risk
Verb Phrase Based Frames	5	550	6.7%	received + revised form (116)	in
Subject-Verb Based Frames	4	443	5.4%	it is + to (122)	important, necessary
That Clause	1	115	1.4%	that the + of (118)	majority, prevalence
Total	50	8,223	100.0%		

Table 3. Pre-test and post-test scores with mean scores

Participant	Pre-Test Score	Post-Test Score	Increase/ Decrease
P1	18	19	1
P2	16	18	2
P3	27	29	2
P4	30	33	3
P5	14	18	4
P6	17	21	4
P7	20	25	5
P8	23	29	6
P9	12	19	7
P10	23	31	8
P11	14	23	9
P12	16	26	10
P13	18	31	13
P14	19	33	14
P15	13	30	17
P16	15	34	19
P17	12	34	22
P18	17	39	22
P19	13	41	28
P20	25	58	33
P21	22	58	36
P22	14	56	42
Mean	18.1	32.1	14.0

- Item 39:
  "The impact ___ the new policy was not immediately clear."
- Pre-Test Score: 0
- Post-Test Score: 15
- Improvement: +15

This item required the preposition "of" to complete the frame "the impact of." Before the training, none of the students answered it correctly, but after the training, 15 students were able to use the structure accurately. This frame, commonly used in academic writing to discuss consequences, was unfamiliar to students before the training. The improvement highlights how the training helped them gain confidence and competence in applying this key structure.

Table 4. Categorization of items by improvement in scores

Category	Number of Items
Substantial Improvement	6
Moderate Improvement	25
Minimal Improvement	27
No Change	2

- Item 33:
  "The results were presented ___ the basis of several studies."
- Pre-Test Score: 7
- Post-Test Score: 20
- Improvement: +13

This item requires "on" to complete the frame "on the basis of." Like Item 39, this prepositional frame is commonly encountered in academic texts, particularly when discussing foundational reasoning or justifications for research. The +13 point improvement indicates that students became more familiar with this structure after the training. The frequent use of such frames in academic writing likely made it easier for students to recall and apply them during the post-test.

2. Moderate Improvement (improvement between 5 and 9 points)
   - Item 12:
     "The findings are discussed ___ the context of previous research."
   - Pre-Test Score: 6
   - Post-Test Score: 15
   - Improvement: +9

This item required the preposition "in" to complete the frame "in the context of." A +9 point improvement was observed, with correct responses increasing from 6 in the pre-test to 15 in the post-test. This frame is commonly used in academic writing to introduce comparative or contextual explanations, linking new findings to existing research. The

improvement shows that the training helped reinforce students' ability to use this frame more confidently, although some students had partial familiarity with it before the training.

3. Minimal Improvement (improvement between 1 and 4 points)
   - Item 29:
     "The conference will focus ___ the impact of the pandemic on global health."
   - Pre-Test Score: 10
   - Post-Test Score: 11
   - Improvement: +1

This item required the preposition "on" to complete the frame "on the impact of." The minimal improvement of +1 suggests that students were already familiar with this frame before the training. Since this is a widely used structure in both academic and everyday language, the training likely reinforced their existing knowledge rather than introducing new concepts.

4. No Change (no improvement)
   - Item 44:
     "The government based ___ recommendations on several studies."
   - Pre-Test Score: 9
   - Post-Test Score: 9
   - Improvement: (–)

This item required "its" to complete the frame "based its recommendations on." There was no improvement observed, with pre-test and post-test scores both standing at 9. Unlike prepositional frames, this item focused on the use of a possessive adjective, which serves a different linguistic function by signaling ownership or association. Since the frame required students to choose "its," it may have already been a familiar structure due to its frequent use in academic texts, making additional improvement unnecessary. Furthermore, the presence of multiple-choice distractors, such as other possessive adjectives (e.g., "their," "his"), may have contributed to students' pre-existing familiarity with this grammatical pattern.

The lack of improvement might also suggest that the focus of the training, which emphasized prepositional and noun-phrase frames, did not specifically target possessive adjective structures, as they were considered basic knowledge for students at this level. This could explain why no further gains were observed in this case. However, the steady scores indicate that students were already proficient in using this type of frame before the training began.

Students' Attitudes Toward the Lexical Framework Training

The survey results, as summarized in Table 5, provide a broad overview of the participants' perceptions of the four-word frame training. On a scale from 1 to 5 (with 5 representing "strongly agree"), students responded to several key statements about the usefulness and impact of the training. The results demonstrate generally high levels of satisfaction and perceived effectiveness, with all ratings falling above 4.0.

As seen in Table 5, students rated the training highly, particularly for its ability to help them analyze word patterns and apply text analysis skills to public health research. The highest rating of 4.64 was for the training's effectiveness in analyzing word patterns.

The survey findings indicate that students found the four-word frame training to be both practical and effective. These quantitative results are further supported by qualitative insights obtained from interviews with five selected students, offering deeper context to the survey responses.

According to the survey, students gave an average rating of 4.4 for the statement "The training helped me summarize the rules and understand the use of words in the public health corpus." This suggests that most students found the training effective in clarifying how words and rules operate in specialized public health texts. This sentiment is echoed in an interview with P8, who initially faced challenges with vocabulary retention but eventually recognized how words fit together in context. She remarked, "At first, I struggled with understanding all the new words and grammar rules. ...But after the training, I started noticing how words fit together in sentences." This highlights how the training successfully addressed gaps in word usage and grammar comprehension, particularly for students who initially found these areas difficult.

The survey result for the statement "The training helped me infer the meanings of unfamiliar words in public health research articles." was rated at 4.3, indicating that students generally found the training useful for developing contextual guessing strategies. Interview insights from P15 support this view. She explained, "*I tried to guess the meaning of words by looking at the whole sentence. The training helped me see how conjunctions and word order work.*" This demonstrates that the training not only helped students guess word meanings but also deepened their understanding of sentence structure and context.

For the statement "The training made it easier for me to read public health research articles," students gave an average rating of 4.18. While still positive, this rating was slightly lower than others, suggesting that some students might have found it challenging to immediately apply the four-word frames in more complex texts. P1, who showed little improvement, reflected this challenge in his interview. He admitted, "I didn't really pay attention during the training. I just don't think I'll ever use them." This suggests that engagement and perceived relevance play crucial roles in how effectively students apply the training to their reading practices.

The statement "The training helped me understand the structure of the vocabulary framework and better infer the meanings of words in context." received a strong rating of 4.4. This high score indicates that students appreciated the training's focus on helping them navigate the structure of public health texts. In the interview, P17 reinforced this result, noting, "The training taught me to pay attention to sentence structure, like where adjectives go before nouns. That really helped me guess the meaning of words." Her comments illustrate how the training allowed students to internalize grammatical structures, aiding in their ability to predict word usage and infer meaning.

Table 5. Survey results on attitudes toward lexical frame training

Survey Statement	Average Rating (N=22)
1. The training helped me summarize the rules and understand the use of words in the public health corpus.	4.4
2. The training helped me infer the meanings of unfamiliar words in public health research articles.	4.3
3. The training made it easier for me to read public health research articles after learning about the vocabulary framework.	4.2
4. The training helped me understand the structure of the vocabulary framework and better infer the meanings of words in context.	4.4
5. The AntConc training helped me analyze word patterns in public health research articles.	4.6
6. The AntConc training improved my ability to analyze and synthesize data from public health articles.	4.4
7. The text analysis skills I learned from the AntConc training are useful for my work related to public health.	4.3

Students awarded the highest rating (4.6) for the AntConc software's effectiveness in helping them analyze word patterns in public health research articles. This suggests that students found the software to be an essential tool for breaking down complex text structures and understanding recurring word combinations. In her interview, P19, who showed the most substantial improvement, described how the AntConc training improved her confidence in recognizing patterns in sentences. She commented, "Now I can recognize patterns in sentences and understand how the words work together. I feel much more confident, especially with public health vocabulary." This reflects the practical impact of the software, which was highly valued by the participants.

The AntConc-based training also received a high score (4.4) for its role in improving students' ability to analyze and synthesize data from public health articles. This suggests that beyond vocabulary, students found the training helpful in engaging with broader analytical tasks. Both P17 and P19 acknowledged that the software played a significant role in helping them synthesize information more effectively. P19, in particular, noted how the training helped her navigate complex research articles, increasing her overall comprehension and analytical skills.

Finally, students rated the practical utility of the text analysis skills they learned for their work in public health at 4.3. This rating confirms that students saw the training as applicable to their academic and professional needs. P15 noted in her interview, "I'm getting better at it, but I still need more practice to fully understand." This suggests that while the training was valuable, some students felt that further practice would help them fully integrate the skills they learned into their public health work.

DISCUSSION

The findings of this study confirm the overall effectiveness of four-word lexical frame training in improving the reading comprehension of Thai public health students. However, there are notable differences in individual learning outcomes, highlighting the variability in how students respond to this method. This section discusses the results in relation to existing literature, addresses the pedagogical implications, and suggests directions for future research, while acknowledging the study's limitations.

To begin, the results align with previous studies, particularly those examining the role of lexical bundles and frames in academic discourse. Biber and Barbieri (2007) argue that lexical bundles create predictable structures in academic texts, facilitating comprehension for non-native speakers. This was clearly observed in the present study, where participants showed a marked improvement in their ability to guess words in context after the lexical frame training. The improved use of frames like "the impact of" and "on the basis of" was especially notable, supporting Gray and Biber's (2013) suggestion that repeated exposure to common word combinations enhances students' ability to process academic texts.

Additionally, the study's results resonate with Block's (2020) findings on the efficacy of sentence frames in vocabulary learning. Block demonstrated that scaffolding through sentence frames helps learners to grasp the meanings of complex, domain-specific terms. Similarly, in this study, students were able to infer the meaning of unfamiliar public health terminology more effectively after training, particularly those from lower proficiency levels, who benefited more from structured language input. This suggests that the structured nature of four-word lexical frames may act as a cognitive aid, allowing learners to deconstruct and understand complex sentences.

Despite the overall success, the findings also reveal considerable variability in student performance. This echoes the observations made by Esfandiari and Barbary (2023), who reported that corpus-driven approaches can yield uneven results based on factors such as student motivation, prior knowledge, and engagement. In this study, students like P22 and P21 made substantial gains, while P1 showed only minimal improvement. These discrepancies can be attributed to differences in how learners engaged with the training, suggesting that some students may require more tailored instructional strategies or additional motivation.

Carlsson et al. (2021) noted similar challenges, stating that individual differences in learners' engagement and prior exposure to English heavily influence the outcomes of such interventions. P1's minimal progress in this study reflects these factors, suggesting that while lexical frame training is generally beneficial, it may not suit all learners equally, especially those who struggle with the relevance or application of the material. The need to adapt teaching methods to the specific academic needs of learners is highlighted by Biber et al. (2004), who emphasize that a one-size-fits-all approach may not be suitable for all educational contexts.

The findings also underscore the importance of providing tools that allow learners to independently explore language patterns. The AntConc software, which received high satisfaction ratings in this study, enabled students to analyze word patterns in public health texts, reinforcing Li and Schmitt's (2009) argument that hands-on tools can significantly enhance language learning outcomes. However, the study also highlights the need for flexibility in instructional approaches, as some students, like P1, showed little engagement with the material. This suggests that educators might need to incorporate more personalized or interactive elements to cater to different learning preferences, as recommended by Biber et al. (2004) and Granger (2004).

Flexibility and adaptability are crucial elements in ensuring that language training benefits a diverse group of learners. While the four-word frame training was effective for many students, those who showed lower levels of engagement, like P1, may require a more adaptable approach. Flexibility in instructional design, such as offering more interactive components or varied teaching methods, could better support different learning styles. This adaptability may include adjusting the training to accommodate students' individual needs, incorporating visual aids, collaborative tasks, or more hands-on practice with the lexical frames. By making these adjustments, educators can ensure that all learners, regardless of their learning preferences, can benefit from the training. This aligns with the call for more adaptive teaching strategies in specialized academic fields, as noted by Biber et al. (2004) and Granger (2004).

The relationship between motivation and success also became apparent in the study, with highly motivated students like P17 and P19 showing the greatest improvements. This aligns with Granger's (2004) findings that learner engagement is critical in mastering complex linguistic structures. As such, it may be beneficial to integrate more dynamic and engaging activities into lexical frame training, perhaps by incorporating collaborative tasks or real-world applications of public health terminology in order to increase motivation across the board.

While the study offers valuable insights into the benefits of lexical frame training, it also has limitations. The relatively small sample size of 22 students restricts the generalizability of the findings. Expanding future studies to include students from other academic fields or from different cultural backgrounds could provide a more comprehensive understanding of the efficacy of lexical frame training across diverse contexts. With a larger sample, statistical analysis could be conducted, enabling the research to transcend these indicative findings.

Additionally, the focus on short-term outcomes limits our understanding of long-term retention. Future longitudinal research could explore whether the benefits observed in this study persist over time, particularly in terms of how well students can retain and apply lexical frames in their professional or academic work. Esfandiari and Barbary (2023) also emphasize the importance of longitudinal studies to evaluate the sustainability of corpus-based instruction.

Finally, while the survey and interviews provided valuable insights into student perceptions, more in-depth qualitative research could offer a richer understanding of how students interact with lexical frame training. For example, follow-up interviews or focus groups could help to elucidate why some students, like P1, struggled with engagement, while others thrived. Such research could lead to the development of more targeted interventions aimed at improving learning outcomes for all students.

CONCLUSION

The findings of this study reaffirm the potential of four-word lexical frame training to enhance the reading comprehension of non-native English speakers in specialized fields such as public health. However, the results also highlight the need for more flexible and adaptive instructional approaches to cater to diverse learner profiles. Flexibility in teaching strategies – such as incorporating more interactive and personalized elements – can better support students who may struggle with traditional methods, ensuring that they, too, can benefit from lexical frame training. While lexical frames offer a powerful tool for improving academic reading comprehension, they are not a universal solution, and future research should focus on more personalized and dynamic teaching strategies to support a broader range of learners. This study contributes to the growing body of literature on corpus-based language instruction and underscores the importance of tailoring language teaching to meet the specific needs of learners in specialized academic disciplines.

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