

Lexical Cohesion Patterns of Natural Science Academic Text and Implications for Lexical Teaching: Textual Analysis of IELTS Reading Passages

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Abstract—With IELTS’s worldwide recognition as an accountable indicator of English proficiency level, scholars have investigated IELTS extensively to provide insights for ESL teaching. Despite the manifold investigation into the validity, typographical features, washback on candidates and practical knowledge of the reading test, little research is done to manifest its lexical cohesion patterns and pedagogical implications. To fill in the research gap, the researcher selected 20 natural science passages from IELTS reading passages and conducted textual analysis under Halliday and Hasan’s English cohesion framework. Pedagogical implications are revealed by combining research findings with a lexical-based teaching approach, lexical syllabus design and knowledge structure development in the subject matter. Research findings indicate that the lexical cohesion patterns of natural science passages share similar organisational structures with subject matter knowledge. Reiteration patterns establish a panoramic view and taxonomic framework of subject matter, whereas collocation patterns focus on detailed explanations, examples and contextual extension that can contribute to the accrument of real-world knowledge. Based on these findings, the study suggests that the teacher can integrate lexical cohesion syllabus into the traditional pre-reading, while-reading and post-reading teaching stages. Though limited in scope and validity, these findings can provide a framework of combined research between text analysis and teaching approaches. More empirical experiments can be followed up to undergird the efficacy of the suggested lexical syllabus and provide more detailed pedagogical insights.

Index Terms—IELTS reading, natural science, lexical cohesion, lexical-based teaching, lexical syllabus

I. INTRODUCTION

The International English Language Testing System (IELTS) is one of the most authoritative and acknowledged tests for English language learners worldwide. IELTS tests are divided into two general systems: the academic test for study purposes and the general test for immigration or work. Both types include four sections overall: listening, reading, writing and speaking.

Extensive investigation has been done regarding the validity and reliability of the test as well as the efficacy of the preparation strategy for all the different sections. In terms of the IELTS Reading test, past research generally focuses on the validity of the reading test (Buell, 1992; Kovalenko, 2018), corpus analysis of vocabulary (Chen & Liu, 2020), washback on candidates (Khoshshima et al., 2018), processing strategies (Bax, 2013), content and practical knowledge of the test (Al-Bulushi et al., 2018; Karbalaei & Rahmzade, 2015), and typographical features of the text (Lonsdale, 2016; Liao, 2020). Despite rising interest in IELTS reading passages and vocabulary, few studies concentrate on their lexical cohesion patterns and pedagogical implications.

Apart from the lack of in-depth analysis of cohesive characteristics of the text, insights for stockholders of the IELTS test are also studied in an unbalanced way. Most research findings focus on implications for students as they are most frequently studied as participants of empirical experiments. By contrast, pedagogical implications of the test for TESOL (Teaching English to Speakers of Other Languages) teachers are less revealed.

Therefore, to better understand lexical cohesion patterns of the IELTS Reading test and its implications for TESOL teachers, this study aims to explore the intersection of textual analysis and language teaching by combining cohesion analysis and a lexical-based teaching approach. Addressed to TESOL teachers, this research will also contribute to the design of lexical syllabi of IELTS reading by suggesting an outline of lexical teaching procedures in teaching IELTS Reading comprehension.

A. Research Purpose and Significance

This research conducts a textual analysis of selected IELTS Reading passages and will further summarise the lexical cohesion pattern of the test. Based on the cohesive framework, the textual analysis will be done regarding the subject-specific lexical cohesion pattern of IELTS Reading text. Lexical revelations of the text will be further combined into discussing implications for designing lexical syllabi and a lexical-based teaching approach. By attempting to connect

the findings of textual analysis with subcategories of applied linguistics (lexical teaching approach), the researcher hopes to narrow the gap between text linguistics and applied linguistics. Moreover, research findings will be pragmatic and applicable for TESOL teachers, as suggested lexical syllabi and teaching approach will be readily accessible.

B. Research Questions

In general, this research aims to answer the following research questions:

- 1) What are the subject-specific lexical cohesion patterns of the selected texts?
- 2) What lexical syllabi can be devised based on the findings?
- 2) How can the lexical syllabi contribute to the lexical teaching approach?

C. Organization of the Research

The investigation is conducted through textual analysis of 20 IELTS Reading passages (natural science subjects), categorised into three groups based on their subdivisions. The lexical cohesion pattern is then summarised based on two levels: the reiteration pattern and the collocation pattern. Based on the research findings, pedagogical implications of IELTS Reading will be further discussed to shed light on vocabulary-centred IELTS Reading teaching.

II. LITERATURE REVIEW

A. Research in IELTS Reading

With the increasing worldwide popularity of IELTS, multidimensional research has been done regarding both its washback on participants and the test per se. In terms of washback on participants, research generally focuses on the cognitive processing's influence on participants' performance during the test (Bax, 2013), test-taking strategy's effect on learners (Khoshima et al., 2018), and coaching and repeated test-taking's impact on candidates' performance and long-term achievement (Hu & Trenkic, 2019). Study about the test itself revolves around the efficacy and validity of the test (Kovalenko, 2018), typographic features and difficulty of the text (Liao, 2020; Lonsdale, 2016), task characteristic of the text (Liao, 2020), the implied content knowledge and practical knowledge (Karbalaee & Rahmazad, 2015; Al-Bulushi et al., 2018). In addition, paralleled research has also been conducted by putting IELTS reading in line with TOEFL reading about their similarities and differences (Baghaei et al., 2020; Buell, 1992; Li, 2018).

Despite broad interest in IELTS, few studies have been conducted on the vocabulary of IELTS reading. Though Chen and Liu (2020) have explored the role of vocabulary breadth and depth in candidates' performance in the test, the emphasis is on the correlation rather than the lexical pattern itself. Follow-up suggestions are also given regarding the importance and efficacy of teaching vocabulary in IELTS reading, but the appropriate vocabulary teaching approach is only vaguely mentioned. Aimed to reveal a more pragmatic and specific lexical-based teaching approach, this research will use selected IELTS reading passages as the primary source of teaching materials and combine findings of lexical cohesion pattern with a lexical-based teaching approach.

B. Textual Analysis

As defined by Beaugrande and Dressler (1981), text performs communicative functions by meeting specific selection criteria to fulfil the needs of a particular discourse community. Based on pre-set criteria, different textual dimensions are assessed regarding the efficacy of particular strategies by conducting textual analysis.

Since the middle of the 20th century, text analysis has been developing and evolving into various forms in applied linguistics. The focus of text analysis can be classified into two groups: linguistic ones that focus on syntactic, semantic and pragmatic features, and contextual ones that encompass sociological interaction. By analysing parts of the text, applied linguists also explore discourse management and logical flow that contribute to cohesion patterns of the text.

C. Cohesion Study

Cohesion refers to the interrelation of lexicon, syntax and context that contribute to the communicative meaning of the text. Multiple methods such as discourse analysis and corpus analysis have been proposed to reveal the general principles both at the macrolevel and microlevel. Macrolevel analysis generally focuses on logical flow or idea development with the passage (Hinkel, 2002). By contrast, micro-level analysis deals with lexicon or syntax that makes the text coherent (de Beaugrande & Dressler, 1981; Halliday & Hasan, 1976).

Halliday and Hasan's approach is distinctive by combining register study with cohesion analysis among these different approaches. From his perspective, the text's coherence can be revealed through studying register, the context-dependent use of lexicon that imbues the text with specific genre features, and cohesion, the semantic relations between these words. By putting cohesion study under a set register, genre-specific coherence features of the text can be revealed. This study will analyse text under Halliday's cohesion framework, focusing on natural science passages as the selected type.

D. Research in Lexical Cohesion

1. The English Cohesion Framework

Halliday and Hasan (1976) defined cohesion as the dynamic interaction between different linguistic components that

contribute to the texture or coherence of the text. Based on this principle, some common patterns are identified in their research, including reference, substitution, ellipsis, conjunction and lexical cohesion. In contrast with the more noticeable and rule-based structural cohesion, lexical cohesion does not conform to clear rules. The cohesive effect can only be achieved by relating with the context. Many classes of words relations are suggested as reference frameworks, including synonyms, hyponyms and general words. Despite these findings, research continues to support the view that the reader often feels cohesive pattern; and is hard to be programmed (Bamberg, 1983; Halliday & Hasan, 1976; Klebanove & Shamir, 2006). This makes the lexical cohesion pattern of the text challenging to be analysed through computer-based software.

2. Reader-based Lexical Cohesion Analysis

To supplement the inadequacy of digital analysis of cohesion pattern, Morris and Hirst (2005) conducted a reader-based experiment to group the related words manually, which saw an overall 65% agreement. This research provided a theoretical foundation of reader-based lexical analysis. Following this postulation, Klebanove and Shamir (2006) conducted experimental research that allows participants to group related words and identify the lexical cohesion pattern using their shared knowledge. This research was also validated in the follow-up experiment, thus substantiating the validity and feasibility of such a research method. This research conducted a reader-based analysis of lexical cohesion patterns concerning the studies above. Considering the high requirement of consistency and continuity of the research design, the research object is limited to one participant to ensure more detail-oriented and consistent findings.

3. Lexical-based Teaching

a. The Importance of Teaching Vocabulary in Language Teaching Classroom

Vocabulary has been proven to be a significant predictor of reading ability. Research continues to support the central role of vocabulary in reading comprehension (Aarnoutse & van Leeuwe, 1998; Gottardo et al., 2017; Oslund et al., 2017; Quinn et al., 2015). In addition, vocabulary teaching has also been proven to be effective in developing students' schemata, in which process prior knowledge is also involved in forming new knowledge (Adams & Bruce, 1980). Despite its importance, vocabulary alone does not guarantee expertise in reading comprehension. As suggested by many researchers, the interaction between vocabulary and schemata must occur to improve the overall comprehension level, which involves the expansion of both schemata and vocabulary (Meneses et al., 2018; Wong, 2016). Therefore, content-based vocabulary teaching must be adopted to teach subject-specific knowledge. IELTS academic reading passages, being noticeably discipline-centred, involve terminologies and content knowledge. In this regard, when teaching IELTS reading text, TESOL teachers can improve students' overall reading comprehension ability by introducing subject-specific vocabulary. Hence, by selecting natural science passages as samples, this research hopes to pave the way for subject-specific lexicon teaching.

b. Text-Based Lexical Syllabi

Sinclair and Renouf (1988) defined that syllabi provide instruction for monitoring the whole teaching process. The linguistic syllabuses are generally categorised into the following three types: grammatical ones for being form-centred, lexical ones for being vocabulary-based, and notional ones for emphasising pragmatic meanings (Ellis & Shintani, 2014). All the syllabuses are in accordance with what White (1988) defined to be a Type A syllabus, which involves the pre-class selection of teaching items and specification of learning content according to distinct learning objectives. Syllabuses provide both teachers and learners with more distinct in-class procedures, thus contributing to higher efficacy in both teaching and learning.

With the development of computer-based corpora analysis, lexical syllabuses are also gaining booming interest in the language teaching classroom and are widely searched by investigators. Though being highly praised for its revolutionary status in language teaching, problems with corpora-based lexical teaching are also emerging. The Cobuilder Course (Willis & Willis, 1988), whose syllabuses were devised based on corpora findings, was not widely accepted among teachers (Taylor, 1991). In a study on teachers' experiences with corpora learning and teaching, Breyer (2009) found that pre-training in using corpora has imposed challenges for novice teachers for being technologically demanding and time-consuming.

In research focusing on the limitations of corpora-based language teaching, Kalthenbock and Mehlmauer-Larcher (2005) pointed that corpus data are lacking in context and display fragmentary language use. The characteristics of corpora-based teaching also make it limited in use. By giving access to various types of texts, corpora-based lexical teaching is not suitable for genre-specific language teaching, among which IELTS reading is an example. As this research only focuses on teaching IELTS reading texts, a corpora-based approach is not adopted to incorporate multiple genres.

Lewis (1993, 1997) has suggested a more text-based lexical approach, which, as he argues, can provide the primary source for language learning. Ellis and Shintani (2014) further pointed out that words should be selected not in terms of frequency but on constructions by using the text as the primary content. When rewriting on the development of lexical syllabuses, they argue that lexical syllabi may not be ideal for language learning due to a lack of selection criteria. This research, however, attempts to use the lexical cohesion framework proposed by Halliday and Hasan (1976) as the selection criteria, thus contributing to the investigation of accountability of contextualised, subject-specific lexical

syllabi.

c. Integration of Conceptual Knowledge and Language Teaching in Science Classroom for ESL Learners

Integration of ESL instruction into science classrooms has been advocated at the state level among many non-English-speaking countries. In Malaysia, the government has reintroduced English as the medium of science education to prepare students for learning scientific concepts in English (Mohd et al., 2010). Research in South Africa's science curriculum has also focused on integrating English aptitude and conceptual development to promote equal access to science (Msimanga et al., 2017). The Chinese Ministry of Education, with its longstanding emphasis on scientific and technological advancement in the international arena, has also been encouraging bilingual education in science majors (Tong & Shi, 2012).

Accordingly, extensive research has been done regarding the intersection between language teaching pedagogy and subject matter knowledge. For example, Case (2002) explored the role of content in assisting students' learning, which came to positive conclusions. Huang (2004) also researched the efficacy of functional analysis and knowledge structure analysis in teaching science, which was proven effective. Chiu (2009) examined the validity of semantic-based contextualised teaching strategies and pointed out that semantic restructuring can be achieved through demonstrating contexts and comparing word pairs. When doing case-based studies, Pando and Aguirre-Muñoz (2020) found that disciplinary literacy and conceptual understanding are the most suitable scaffolding strategies for meeting the needs of students. Slater and Mohan (2010) also provided a register perspective in teaching science. Despite the wide range of genre or register analysis of science materials, most centre around experimental study rather than textual analysis procedures. Therefore, this study shall use textual analysis to provide a pedagogical framework for lexical cohesion analysis and the design of lexical syllabus.

III. RESEARCH DESIGN AND METHODS

A. Materials: IELTS Authentic Examination Papers 9-15, 20 Passages

To categorise IELTS Reading passages into more systematic groups, classes and divisions of each passage are identified based on Dewey Subject Index Classification (1876). Overall, 20 passages fall under natural science class. Subdivisions are determined based on the framework, with six subcategories and one interdisciplinary passage.

Common features these passages share are 1) apparent central topics; 2) evolving central arguments or display of contradictory ones; 3) incorporation of subject-specific terminologies.

IELTS 9			
Test 1			
Passage Number	Title	Class	Division
1	William Henry Perkin -The man who invented synthetic dyes	Natural Science	Chemistry
2	Is There Anybody out There? -The Search for Extra-terrestrial Intelligence	Natural Science	Astronomy
3	The History of the Tortoise	Natural Science	Zoology
Test 2			
2	Venus in Transit	Natural Science	Astronomy
Test 3			
3	Information Theory – The Big Idea	Natural Science	Physics
IELTS 10			
Test 3			
2	Autumn Leaves	Natural Science	Biology
Test 4			
1	The Megafires of California	Natural Science	Geography
IELTS 11			
Test 1			
1	Crop-Growing Skyscrapers	Natural Science	Geography
3	Reducing the Effects of Climate Change	Natural Science	Geography
Test 3			
2	Great Migrations	Natural Science	Biology
3	Preface to 'How the other half thinks: Adventures in mathematical reasoning'	Natural Science	Mathematics
IELTS 12			
Test 7			
1	Flying tortoises	Natural Science	Zoology
2	The Intersection of Health Sciences and Geography	Useful Arts & Natural Science	Medicine and Geography
Test 8			
2	Bring Back the Big Cats	Natural Science	Zoology
IELTS 13			
Test 2			
2	Oxytocin	Natural Science	Chemistry
Test 4			
2	Saving the Soil	Natural Science	Geography
IELTS 14			
Test 4			
2	Why zoos are good	Natural Science	Zoology
3	Assessing the Threat of Marine Debris	Natural Science	Biology
IELTS 15			
Test 2			
2	Should we try to bring extinct species back to life?	Natural Science	Biology
Test 4			
1	The Return of the Huarango	Natural Science	Geography

B. Analytical Framework: Lexical Cohesion Framework

Overall, Halliday and Hasan have categorised the cohesion pattern of the text into the following five categories: reference, substitution, ellipsis, conjunction and lexical. On the lexical level, lexical cohesion is subdivided into five specific groups: same item, synonym or near synonym (including hyponym), superordinate, general item and collocation (p. 239). The first four types of lexical cohesion are summarised as reiteration cohesion, and can be differentiated by referential relation. Same item equals the same referent; synonyms or near-synonyms are often inclusive in lexical relation; superordinate is exclusive in general; general words are mainly unrelated to the referent. By contrast, collocation is a more inclusive and complicated cohesion concept, the study of which can only be conducted through text analysis.

As defined by Hasan and Halliday, the function of lexical collocation is to organise the text with instantial meaning and endow the text with topic consistency and developmental predictability (p. 288). This research will focus on the study of both the reiteration cohesion pattern and collocation cohesion pattern of IELTS Reading texts in a subject-based approach. Only the most frequently occurred subcategory will be identified and further discussed in the reiteration cohesion pattern. As to the collocation cohesion pattern, research will be conducted based on the instantial meaning of the lexicon to reveal how the lexicon organises the development and consistency of the texts.

IV. RESULTS AND DISCUSSION

Overall, 20 passages are analysed in terms of the lexical cohesion pattern. According to the division, all the passages

fall under the class natural science and are subdivided into six groups. Subgroups include chemistry, astronomy, zoology, geography, biology, and interdisciplinary. Due to the limit in length and space, only one sample of the lexical analysis framework is provided in the appendix section.

A. Major Findings

Findings and implications for lexical teaching are categorised into two groups: the reiteration pattern and the collocation pattern. More details are provided in the subcategories regarding the lexical cohesion pattern by combining findings of text analysis and subject matter knowledge development.

1. Reiteration Pattern: Same Word; Synonym/Near Synonym; Superordinate; General Word

Same word refers to the word repeated most frequently in the passage. Based on the findings, repeated words are often listed in the title to hint the central debate and establish the central topic. However, in some cases, these words may be hyponyms or superordinate or inflectional words of the central topic. Therefore, while teaching students reading, the title can be used to help students predict the central topic of each passage and help them build a connection with their schemata or world knowledge. By designing pre-reading activities such as free semantic mapping or semantic feature analysis, the teacher can help students utilise their previous knowledge, thus enhancing the connection with new knowledge.

Synonyms/near synonyms, superordinate and general words altogether provide a macrolevel framework of the subject the central topics fall under. Classification of the content knowledge is also established taxonomic or relations between the conceptual terms. The subject or content-specific knowledge are organised based on the taxonomic framework, which provides 1) frontier research findings and implications (generally positive as they regard to progress or advancement in the field); 2) existing or deep-rooted problems within the field, and efficacy of current approaches to these problems; 3) framework of understanding the universe or nature, as those natural science passages are mostly about status quo on earth or the space.

In this sense, by providing synonyms, superordinate or general words during the pre-reading section, students will be acquainted with the taxonomic framework of subject matter knowledge related to the passage, which can help them maintain equilibrium. Discussion activities can be organised to engage students' interest in advancement in research, long-established problems or general understanding of the subject, which should be complemented by a brief introduction of the core issues in the passage.

2. Collocation Pattern: Verbs, Nouns; Adjectives

Overall, the collocation patterns provide detailed knowledge or specific examples of the passage's central topic or core issues. Verbs and adjectives offer background information about the content, function, effect, or primary features of the topic. By putting the central word in line with a verb or adjective, collocations, organisation patterns or main argument of each paragraph can be revealed, which can at the same time contribute to students' vocabulary repertoire. Nouns, by contrast, expand and supplement the subject content by providing relevant components, related elements or debatable issues. All the verbs, nouns and adjectives in the selected passages are highly topic-contingent but may overlap when divided into subject-based groups.

The collocation patterns are thus more suitable for supporting while-reading activities by asking students to identify word groups, subcomponents of each paragraph's central topic, or main arguments. The teacher can also assign tasks such as identifying related examples of the major topic, characteristics of the subject, developmental stages of events or phenomenon involved etc. After that, the teacher can provide a graphic representation of the key terms or phenomena to enhance students' cognitive development in assimilating new content knowledge. The semantic relations between each key concept can also be deduced, emphasising the lexicon.

The design of tasks should vary according to the specific features of each passage's topic. While the issue pertains to natural phenomena and prevalent or deep-rooted problems, the tasks should be events-based or projects-driven, presented chronologically. In this way, students may better understand the involvement of the key issue from a macrolevel. In comparison, when the topic focuses on one specific item, species or chemical, the tasks can be arranged as to their interrelation with other elements in the universe or the world (for example, their functions and effects). Semantic relations can be emphasised under specific context settings, enhancing students' subject matter knowledge.

B. Suggested Lexical Syllabus

Based on the research findings and implications for teaching, a lexical syllabus is designed for TESOL teachers while teaching natural science passages. This may also guide EAP (English for Academic Purposes) teachers about the teaching approach of natural science passages. In general, the syllabus is designed based on three teaching stages, during which the main tasks or activities vary.

1. Pre-reading:

During this process, predictive and introductory activities can be adopted to mobilise students and help them build a connection with their prior knowledge. For example, the teacher can use semantic maps, which focus on the hierarchy of words within the same content group. The teacher may provide the repeated same term as the main topic to get

started. After that, the teacher asks students to think of related word pairs or ideas. Students' suggestions can be supplemented to the semantic map and categorised into groups or clusters. In the end, synonyms, near synonyms and superordinate within the passage can be compared with students' answers to complete the semantic map. In this way, students' prior knowledge can also be connected with new knowledge to contribute to schemata; the general subject-based taxonomic framework will also be developed.

2. While-reading:

Overall, the while-reading part can be divided into the following three phases: 1) the opening phase, in which the lexical cohesion pattern and organisation of the passage are revealed; 2) the concept enhancement phase, in which shades of differences or mismatches are explained and elucidated; 3) application of new knowledge, in which students try to apply the acquired knowledge through completing the questions in the test.

a. The Opening Phase:

After students finish reading the passage, the teacher can ask students the following key questions:

1) How does the passage deal with the central topic/key issue (How are the key terms or ideas classified and organised)?

2) What specific examples are given (identify the content-based collocation)?

3) How do those terms or word pairs form conceptual hierarchies (identify the construction of semantic relations)?

For question 2, when using the collocation pattern of the central topic to help students analyse the structure and organisation of the passage, the teacher can vary the emphasis based on different characteristics of the topic. For passages that involve chemicals, evolution or environmental protection, verbs can also be emphasised to establish a panoramic view of a constituent of the subject. Nouns and adjectives can be categorised according to more specific sub-topics for more descriptive passages regarding advancement in spatial exploration or theoretical development.

When students carry on the discussion, the teacher should maintain students' interest at three levels: 1) the subject matter content of the central topic; 2) the classification structure built through exact word repetition, alternation of synonym, near synonym, superordinate and general nouns; 3) the main arguments, specific examples or semantic relations established by collocation patterns or word pairs, and the shades of difference between them.

b. Concept Enhancement:

At this phase, the teacher needs to compare interchangeable word pairs and explain their shades of differences, including semantic use to the students. Meanwhile, the teacher can ask the students to define critical terminologies or rephrase central arguments. After this process, the mismatch made by students needs to be corrected by the teacher. In this way, the teacher combines linguistic knowledge with scaffolding strategies, which can help students enhance the previous knowledge structure they have developed.

c. Application of New Knowledge:

In this process, students must finish the questions and task items provided in the test. The questions mainly involve interchangeable synonyms, passage structures and content knowledge, which are all included in the syllabus. By checking the accuracy of students' answers, the teacher can complement the in-class tasks with feedback regarding students' lexical learning efficacy. Suggestions can be given about content learning through classification strategies or semantic relations construction.

d. Post-reading:

As suggested, the proposed lexical syllabus is highly content-based and subject-dependent. Therefore, to enhance the efficacy of vocabulary teaching, the teacher can assign the testing items in authentic tests and supplement with extended content-based reading materials in the same disciplinary arena. As summarised, the reading passages generally share up-to-date research findings, approaches to noticeable problems or framework of the subject-based way of interpreting the world. In this sense, follow-up reading materials can also be selected based on the general directions to help students develop and enhance disciplinary knowledge. Formative assessment in terms of the knowledge structure or semantic meanings can be devised to test students' progress in both subject matter knowledge and linguistic competence.

V. CONCLUSIONS AND SUGGESTIONS

Being manually collected, the data are not validated through quantitative statistical analysis or inter-annotator agreement. Therefore, the identified cohesion patterns are highly subjective and researcher-based, which may lead to negligence of certain cohesive words and debatable selection criteria. To make up for this defect, an inter-annotator experiment can be done to identify the typical cohesion pattern. In addition, computer-based statistical analysis can also be done as to the agreement rate, which may provide more insights into the most recognised regarding the typical pattern. Computer-based cohesion analysis can also be done to provide a comparison group, in which case the overlapping pattern and supplementary parts can also be revealed. In this way, reader-based and computer-based cohesion patterns can be further used separately to compare the applied teaching settings as well as their respective merits and demerits.

The suggested lexical syllabus also needs to be further specified. Being a general framework, the proposed syllabus is not specific enough about the applied student groups and classroom settings. More empirical experiments need to be conducted with regard to the syllabus's efficacy on different student groups by considering variants such as age, prior knowledge, motivation, language aptitude and learning styles, etc. The classroom settings also need to be taken into account. Needs analysis and learner goals may greatly influence the difficulty level of selected cohesive words in syllabus design, in which case the varied selection standards should also be proposed.

Based on the lexical cohesion patterns of natural science passages, the research findings have established an analytical framework and referable patterns for future lexical cohesion analysis in other subjects. In this sense, suggestions for future research can be categorised into three dimensions. The first one is the extended scope of analysis materials from natural science academic articles. By doing so, discourse analysis can provide insights into teaching natural science students' EAP courses. Another direction for future research is the connection between lexical cohesion pattern analysis and pedagogical revelations for writing. The genre approach can be adopted to combine lexical cohesion patterns with writing techniques. Finally, more subject-specific research can be done with regard to the contextualised lexical cohesion pattern. Analysis of social science, humanities and art passages can be done separately or comparatively to establish a more universal framework for lexical cohesion analysis.

APPENDIX. FRAMEWORK FOR ANALYSIS OF LEXICAL COHESION PATTERN

Lexical Cohesion Pattern of IELTS Reading Texts – Zoology

Five passages analysed: *The History of the Tortoise* (Passage 6); *Flying Tortoises* (Passage 7); *Bring Back the Big Cats* (Passage 8); *Why Zoos are Good* (Passage 9); *Should we try to bring extinct species back to life?* (Passage 10)

A. Reiteration Pattern

1. Same Word

Passage Code	Same Word	Frequency
Passage 6	turtle	12
Passage 7	tortoise	16
Passage 8	lynx	9
Passage 9	zoo	17
Passage 10	species	12

In passage 6, 7, 9 and 10, the most often used word also appears in the title, with passage 8 being the exception, in which case the synonym is mentioned most frequently.

2. Synonym, Superordinate and General Word

	Synonym/Near Synonym	Superordinate	General Word
Turtle	tortoise	mammal, fossil animals, amphibious species, land creature, sea creature	animal
Tortoise	/	species, subspecies	/
Lynx	a large spotted cat/ the tassel-eared cat	specialist predator, the big cats, wildlife	animal
Zoo	wildlife park	/	/
Species	the passenger pigeon, the thylacine, mammoth	species	animals

Not every section can be identified in these passages. Passage 6 and 7, though sharing similar topics, do not overlap in synonyms. When the topic centres on one single species, synonyms or hyponyms may not appear. As to the other three passages, hyponyms or synonyms are provided with more specific contents or characteristics of the substituted part. Superordinate and general nouns overlap in zoology passages with words such as animals and species. However, these words appear at different levels in these passages. In passage 6, 7 and 8, the superordinate also indicates the animals' place in the food chain.

3. Collocation Pattern

	Verb	Noun	Adjective
Turtle	develop, breathe, lay, descend from	migration, reptile, land creatures, land animals, ancestor, ancestry	marine, modern, ancient, later, amphibious, aquatic
Tortoise	hunt, survive, breed, introduce, transport	subspecies, predator, length, prey, habitat, population, location, territory, vegetation, repatriation	ancestral, immobile, captive-bred
Lynx	reintroduce, die out,	extinction, glimpse,	totemic, environmental,

	explode, require, present, spread, re-establish	rewilding, environmentalism, restoration, ecosystem, conservation, risk, population	native
Zoo	aid, provide	animals, species, environment, conservation, population, extinction, education, living creature, research, ecosystem, captivity	safe, sophisticated
Species	survive, threaten, exist, die out, thrive, re-establish, survive, preserve	animals, existence, extinction, migration, specimen, project, technology, damage, population, prospect, genetic rescue, hazard, risk	extinct, existing, native

Basically, the verbs involve the evolution history, status quo of the species, as well as human-animal relationship. The selected passages are all about human endeavour in restoration or preservation of each species. Nouns establish the connection of animals with their living environments and the food chain. Their predators and role in the ecosystem are also frequently discussed in those passages. Adjectives provide either more specific categories or features of these central topics.

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