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Hard or Soft Science? Conceptualizing Educational Technology through a Lexical Bundle Analytical Approach

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Abstract

An ongoing discussion on the disciplinary nature of educational technology has been taking place for years. Some view this discipline from the perspective of instructional design and implementation, whereas others conceptualize it from the perspective of media, tool, and system. This study examined educational technology from the perspective of language use by empirically investigating a special sequence of words, referred to as lexical bundles, in educational technology research articles. It aims to capture the distinctive nature of educational technology as soft technology and examine possible associations of educational technology with relevant disciplines. Employing a text analysis tool of AntConc 3.4.3, the researcher compiled a corpus encompassing 323 research articles from six journals with approximately 2.1 million words to identify lexical bundles. All identified bundles were analyzed and further compared with past relevant studies based on the number of different bundles, the content of bundles, and the grammatical structure of bundles. It was found that educational technology as an inter-discipline resembles much more soft science fields in terms of the content and structural categories of bundles. This study not only contributes to a better conceptual understanding of the nature of educational technology but offers a pedagogically beneficial bundle list for informing academic writing instruction in this field.

Keywords: Disciplinary nature of educational technology, Lexical bundle, Soft technology

1. Introduction

The term “educational technology” emerged and began officially as a discipline in the 1950s (Ellington, Percival, & Race, 1993). Ever since its historical emergence, many efforts have

been devoted to defining and conceptualizing what educational technology is (e.g., Latchem, 2014; Reiser, 2012). A continual discussion from different angles has been initiated to capture the nature of educational technology, such as the technology perspective (Lakhana, 2014), the practitioners perspective (Corbeil & Corbeil, 2013), the systems perspective (Luppicini, 2005), the epistemological perspective (Czerniewicz, 2010), the critical perspective (Selwyn, 2007, 2010), and the socio-cultural perspective (Oliver, 2011). Notwithstanding this extensive discussion, it appears that much literature was not empirically informed and little research was undertaken from the perspective of language use. Recognizing these facts, the current study aims to conceptualize educational technology by analyzing the use of lexical bundles in journal articles. By carrying out a systematic linguistic analysis, we anticipate that the disciplinary nature of educational technology could be clarified and key concepts in this discipline could be provided. In the sections that follow, a brief review of lexical bundles is offered, followed by an introduction of lexical bundles in academic texts and subsequently a depiction of what educational technology is.

1.1 Definition and Characteristics of Lexical Bundles

Appearing first in the *Longman Grammar of Spoken and Written English* (Biber, Johansson, Leech, Conrad, & Finegan, 1999), lexical bundles refer to a progressive succession of individual words occurring with a comparatively high frequency in spoken and written language (Biber & Barbieri, 2007). For instance, *thank you very much* is a recurrent spoken-form bundle in daily conversation to express one's utmost gratitude to the addressed person, while *as can be seen* is a common written-form bundle in academic prose to make readers aware of the research results shown in tables or figures. There are a number of parallel terms for denoting similar notions of lexical bundles in pertinent literature, such as *clusters* (Hyland, 2008a, b), *n-grams* (Stubbs, 2007), *lexical phrases* (Li & Schmitt, 2009), *prefabricated patterns* (Granger, 1998), *formulaic sequences* (Simpson-Vlach & Ellis, 2010), *sentence stems* (Pawley & Syder, 1983), *extended collocations* (Cortes, 2004), and *multi-word expressions* (Rayson, 2008).

Lexical bundles do not occur randomly but can be identified empirically by using computer software. To be recognized as lexical bundles, they must meet two key criteria: (a) frequency: the number of bundles occurring in a text; (b) range: the distribution of bundles in a number of text. The frequency can be set differently, varying from 10 to 50 times per million words (Biber, Conrad, & Cortes, 2004; Breeze, 2013; Grabowski, 2015; Hyland, 2008a; Simpson-Vlach & Ellis, 2010). The most extensively adopted frequency is 20 times per million words (e.g., Biber et al., 1999; Cortes, 2004; Jalali, Rasekh, & Rizi, 2008; Liu, 2012; Wei & Lei, 2011). The range, on the other hand, is applied to establish representativeness, thereby avoiding idiosyncrasies associated with particular texts. Existing bundle studies determined range using either a particular number across all texts (e.g., Biber & Barbieri, 2007; Chen & Baker, 2010; Liu, 2012) or a percentage (e.g., Jalali, et al., 2008; Hyland, 2008b). Demirel and Hesamoddin, (2013), for example, set the criterion that bundles had to occur at least across four different texts in their corpus, while Jalali et al. (2008) used bundles that distribute in at least ten percent of the texts. Different selection criteria are also related to varying corpora sizes compiled and research purposes to be accomplished, which may imply

that setting the bundle frequency along with range is somewhat arbitrary (Csomay, 2013; Hyland, 2008b).

With a high frequency of occurrences, lexical bundles are characterized by structurally incomplete units, semantically transparent representations, and non-fixed forms (Biber & Barbieri, 2007; Biber et al., 1999; Cortes, 2004). First, most bundle structures appear in a rather fragmented way and tend to bridge over two separate syntactic units, usually with an incomplete structural unit incorporated into a complete one (Biber et al., 1999). Biber et al. (1999), in their large-scale investigation of everyday discourse, found that 95% of the lexical bundles in academic prose and 85% in conversation are structurally incomplete. Instances addressing this phenomenon include *the fact that the*, *in the context of*, and *the nature of the*. The second feature of bundles is semantic transparency, a characteristic that one can decode the bundle meaning by simply analyzing component elements. For example, the meaning of the bundle of *purpose of the study* can be derived if one understands the meaning of the four component words. This is quite distinct from idioms which are semantically opaque and the meanings of which are difficult to derive from the literal meanings of the components (Wei & Lei, 2011). The idiomatic meaning of *beat around the bush* is neither associated with *beat* nor with *bush*. Third, the bundle form is determined by the sequence of words identified. For instance, the four-word bundle of *purpose of the study* belongs to the grammatical category of noun phrase + *of*, while the six-word bundle of *for the purpose of the study* is the category of prepositional phrase + *of*. The non-fixed length of bundle units refers to the fact that researchers may choose to identify varying lengths of bundles for different research purposes. Four-word bundles are the most often explored form since, on the one hand, they are far more common than five-word and six-word bundles and, on the other hand, they offer a much clearer structure than three-word bundles (Csomay, 2013; Biber et al., 1999; Hyland, 2008a). The current study also targets four-word bundles as the research focus.

1.2 Lexical Bundles in Academic Texts

Lexical bundles constituting critical building blocks of language prevail in academic texts. Erman and Warren (2000), for example, explored the average proportion of recurrent word combinations in their compiled academic texts and found that the recurrent word combinations account for 58.6% of the spoken texts and 52.3% of the written texts. The high frequency of these recurrent word expressions suggests that the use of lexical bundles in academic texts involves not only the linguistic repertoires of scholars but the underlying structure of disciplinary knowledge. Hyland (2008b) noted that lexical bundles can serve as a tool to help assert the identity of disciplinary community and demonstrate the ways in which disciplinary members communicate with each other. Disciplinary variations could be empirically found by various ways in which lexical bundles are exploited, including the total number of bundles, the structural forms of bundles, and the rhetorical functions of bundles (Alipour, & Zarea, 2013; Kashiha & Heng, 2014a, b; Jalali, 2014). Cortes (2004), for instance, conducted a comparative study to examine lexical bundles in biology and history, finding that the total number of bundles in biology (109 bundles) is more than twice of the number in history (54 bundles). The study also revealed that history relies mainly on a limited number of structural categories of noun phrase bundles and prepositional phrase bundles, compared to

biology (Cortes, 2004). Hyland (2008b), comparing four disciplines of applied linguistics, business studies, electrical engineering, and biology, demonstrated that electrical engineering uses a considerably higher number of different bundles (213 bundles) than that in the other three disciplines. Hyland also found that the structure of passive bundles occurs in a high frequency in hard science (i.e., electrical engineering, and biology), but has a low prevalence in soft science (i.e., applied linguistics and business studies). Jalali et al. (2008) inspected the use of lexical bundles in applied linguistics in terms of the total number and structural categories, finding that this discipline has a similar total number of bundles and employs a much lower percentage of passive bundles, both results consistent with Hyland (2008b). These findings suggest that lexical bundles as part of the academic discourse are not expressed in a "monolithic entity" (Gotti, 2009, p. 10) but reveals the underlying nature of specific disciplines, a single discipline or even a group of disciplines sharing similar features. The distinctive disciplinary nature and culture reflect inherent epistemological beliefs, intellectual values, and cognitive knowledge in various micro and macro disciplinary communities (Becher & Trowler, 2001).

A series of efforts have been spent in investigating lexical bundles to uncover disciplinary characteristics. The disciplines examined cover a wide range of long-established disciplines, including applied linguistics (Hyland, 2008b; Jalali et al., 2008), law (Breeze, 2013), history (Cortes, 2004), business studies (Hyland, 2008b), physics (Alipour, & Zarea, 2013), computer engineering (Alipour & Zarea, 2013), electrical engineering (Chen & Xiao, 2015; Hyland, 2008b), biology (Cortes, 2004; Hyland, 2008b), pharmacy (Grabowski, 2015), and medicine (Jalali, Moini, & Arani, 2015). These disciplines fall into either hard science (e.g., electrical engineering, physics, biology, and medicine) or soft science (e.g., applied linguistics, politics, and business studies), which is a rigid dichotomy. Nevertheless, educational technology, eclectic in nature (Ajelabi, 2006; Davies & Schwen, 1971), subsumes concepts from both education and technology, bearing in itself relatedness to both hard science and soft science. Given that educational technology has inherent hybrid nature, it would be a worthwhile endeavor to explore its disciplinary culture by means of an empirical study on the use of lexical bundles and from the perspective of applied linguistics. In other words, what types of lexical bundles are frequently employed in educational technology? Can the bundles in educational technology characterize or reflect the disciplinary nature of this specific research field?

1.3 Disciplinary Nature of Educational Technology

The disciplinary nature of educational technology derives its underpinnings primarily from education and technology (Mangal & Mangal, 2009). Education as one disciplinary area in soft science is "functional and utilitarian, concerned with enhancement of professional practice and results in protocols/procedures (Becher & Trowler, 2001, p. 36);" it aims to help one grow, upgrade, expand, and transform in the aspects of knowledge, thoughts, skills, and attitudes so as to become a good problem solver (Spector, Johnson, & Young, 2014). Technology, on the other hand, affiliated to hard science, is "purposive and pragmatic, concerned with mastery of physical environment and results in products/techniques" (Becher, & Trowler, 2001, p. 36). It involves the application of tangible devices or systematic

knowledge to accomplish a practical purpose, thereby bringing benefits to society (Spector et al., 2014). Educational technology, incorporating the two, is the study using technological resources or technological knowledge for the purpose of learning in the educational context (Loveland, 2012).

Educational technology in its first emergence was regarded as identical to media with a launch of audiovisual education movement (Newby, Stepich, Lehman, & Russell, 2006); audiovisual materials, such as films, pictures, and stereopticon slides were considered synonymous with educational technology. Later, with the advent of the electronic and mass communication revolution, educational technology was linked with the use of tape-recorders, radio, television, and computer-assisted resources (Mangal & Mangal, 2009). The conception of educational technology changed in the period of 1960s to 1980s. It is no longer considered as merely audiovisual aids and hardware materials but instead understood as a process in which instructors design, implement, and evaluate (Association for Educational Communications and Technology, 1977). Such a conception departs from a traditional view seeing educational technology as a physical means to a systematic process underscoring instructional design procedure. A recent definition, proposed by the Association for Educational Communications and Technology (AECT) in 2008, suggests that "educational technology is the study and ethical practice of facilitating learning and improving performance by creating, using, and managing appropriate technological processes and resources" (Januszewski & Molenda, 2008, p. 1). This definition concludes previous conceptions, highlights both aspects of systematic processes and technological resources, and indicates the main purpose of educational technology—improving the efficiency of the teaching and learning process (Reiser, 2012).

The role that technology plays in educational technology can be viewed as a means to the instructional end. A distinction is made between hard technology and soft technology. Hard technology is primarily concerned with physical products that engineers or scientists attempt to develop, such as computer equipment, communication devices, and technology tools (Luppicini, 2005). Soft technology, the technology in educational technology, refers to the intellectual process in which individuals apply organized knowledge to accomplish educational goals (Januszewski & Molenda, 2008). It is value-laden and emphasizes the meaning of who uses technology and the manner in which technology is used (McGinn, 1978). It highlights intellectual, environmental, social, and cultural factors in its realization (Lakhana, 2014; Luppicini, 2005). These include practices of setting learning objectives, implementing instructional design, selecting media and resources, managing systems, and evaluating learning outcomes.

In summary, the conception of educational technology constantly changes and evolves as time goes by (Ellington et al., 1993; Lakhana, 2014; Luppicini, 2008; Reiser, 2012). The historical development of the conception of educational technology shifts its focus from the early emphasis on simply using media, materials as well as tools but playing down the role of humans to the recent emphasis on adopting a systematic perspective and giving equal weight to both human and non-human resources. The contemporary conception highlights a macro-level and comprehensive explanation of educational technology. Since past studies

seldom examined the notion of educational technology from the perspective of language use, an exploration of lexical bundles might enlighten the conceptual aspects of educational technology. The current study thus attempts to take a lexical bundle analytical approach to empirically investigating whether we can obtain a similar conclusion as the contemporary conception of educational technology suggests.

1.4 Purpose of the Study and Research Questions

Based on the discussions in the above sections, this study aims to investigate the extent to which the use of lexical bundles can reveal the nature of educational technology as an inter-discipline. In particular, it focuses on identifying the most frequently used four-word lexical bundles, finding out the most prevalent structural categories of bundles in educational technology, as well as comparing and contrasting the similarities and differences between educational technology and previously researched disciplines in the use of lexical bundles. By making cross-disciplinary comparisons in lexical bundles, we hope not only to provide insights into the possible association of educational technology with hard or soft science but also to clearly clarify the disciplinary nature of educational technology. Three research questions are formulated in the current study, as follows:

1). What are the most frequent four-word lexical bundles in educational technology research articles?

2). What are the structural features of the four-word lexical bundles in educational technology research articles?

3). To what extent can the use of bundles reveal the nature of educational technology?

1.5 Importance of the Study

The importance of this study is twofold. First, the disciplinary nature of educational technology is properly clarified through a systematic analysis of lexical bundles. Findings of this study can offer empirical evidence on the basis of which the conceptual aspect and the disciplinary orientation of educational technology are well elucidated. Second, what has been disclosed in this empirical study provides a beneficial list of the lexical bundles in the discipline of educational technology. An empirically derived study, as Simpson-Vlach & Ellis (2010) noted, could be pedagogically valuable so as to benefit academic writing instruction and to inform curriculum design.

2. Method

2.1 The Corpus

The corpus compiled in the study consists of 323 research articles (RAs), amounting to 2,163,545 word forms, from six representative journals of educational technology published in 2013: *Computers & Education*, *British Journal of Educational Technology*, *Educational Technology & Society*, *Journal of Computer-Assisted Learning*, *Australasian Journal of Educational Technology*, and *Educational Technology Research and Development*. These six journals were chosen partly because they are internationally leading journals in educational

technology and partly because they publish RAs on a wide variety of issues in the discipline, such as mobile and ubiquitous learning, computer-supported collaborative learning, personalized technology-enhanced learning, digital game-based learning, e-assessment, big data in education, artificial intelligence in education, development of online learning and management system, and so on. All RAs were derived from the websites of the journals. The non-textual parts in each RA (e.g., tables, figures, references, charts, notes, appendixes, and page numbers) were removed to ensure that all of the compiled data can be processed by the computer program. Table 1 shows the complete information of the corpus, including the number of texts and number of words.

Table 1. Corpus composition

Journal	No. of texts	No. of words
Computers & Education	59	462,880
British Journal of Educational Technology	70	404,415
Educational Technology & Society	54	292,549
Journal of Computer-Assisted Learning	36	241,333
Australasian Journal of Educational Technology	60	391,593
Educational Technology Research and Development	44	370,775
Total	323	2,163,545

2.2 The Computer Program and the Structural Analysis of Bundles

After the compilation of the corpus, the next step was to employ an appropriate computer program to identify lexical bundles. The computer program employed in the current study was AntConc 3.4.3. (Anthony, 2014), a free and open-source text analysis tool by which users can extract lexical bundles by setting specific criteria of frequency and desired bundle size. The present research aims to clarify the nature of educational technology and define its disciplinary orientation by comparing the research findings with those in past studies. Two important disciplinary studies by Hyland (2008b), which was based on a 3.5-million-word corpus, and Jalali et al. (2008), which was based on a 1.2-million-word corpus were targeted for a comparison since they investigated the use of lexical bundles in a number of hard and soft science fields, including applied linguistics, business studies, electrical engineering, and biology. Comparing educational technology with those hard and soft science fields may help us better understand whether and how educational technology, in terms of its underlying nature and the disciplinary orientation, is more geared towards hard science or soft science. To draw a parallel comparison, four-word bundles were targeted and the cut-off frequency must occur at least 20 times per million words together with in at least ten percent of all texts. Such criteria were consistent with those set in Hyland (2008b) and Jalali et al. (2008).

After all of the lexical bundles were identified, the structural analysis ensued. The identified bundles, following Biber et al.'s (1999) taxonomy with twelve structural categories (see Table 2), were analyzed by two doctoral students who specialize in the field of educational technology and are familiar with the method of corpus analysis. The intercoder agreement reached 94.4%.

Table 2. Structural categories of lexical bundles

Structural categories	Examples
Noun phrase + *of*	*the results of the, the use of the, the effectiveness of the*
Other noun phrases	*the students in the, the extent to which, a positive effect on,*
Prepositional phrase + *of*	*in the context of, on the basis of, at the end of*
Other prepositional phrases	*on the other hand, in line with the, in a way that*
Passive + prepositional phrase fragment	*are shown in table, is based on the, used in this study*
Anticipatory *it* + verb/adjective	*it is possible to, it is important to, it is necessary to*
Be + noun/adjectival phrase	*are more likely to, be due to the, is based on the*
(Verb phrase +) *that* clause fragment	*that there was a, that there is a, the results showed that*
(Verb/adjective +) *to*-clause fragment	*can be used to, are more likely to, to be able to*
Adverbial clause fragment	*as shown in figure, as shown in table*
Pronoun/noun phrase + *be*	*this study is to, this study was to*
Others	*as well as the, and the use of*

3. Results

3.1 The Most Frequent Four-word Lexical Bundles in Educational Technology RAs

Setting the criteria of 20 times per million words as the cut-off frequency along with ten percent of distribution throughout the texts, the present study yielded 125 different bundles, with a total frequency of 10,196 occurrences of these 125 bundles. 86 % of the bundles occur over 50 times, and 18% over 100 times. The bundle of *on the other hand* is the most frequently used, with a frequency as high as 314 occurrences, while the bundle of *the analysis of the* is the least frequently used, with a relatively low frequency of 44 occurrences. A complete list of the bundles is presented in the appendix 1. Table 3 shows the top 20 lexical bundles.

Table 3. The top 20 lexical bundles in educational technology RAs

Rank	Lexical bundles	Frequency	Range*
1	*on the other hand*	314	154
2	*the results of the*	236	123
3	*at the end of*	222	103
4	*the end of the*	213	111
5	*the use of the*	209	98
6	*as well as the*	205	130
7	*in the context of*	190	114
8	*the students in the*	168	66
9	*at the same time*	165	110
10	*in the form of*	154	99
11	*as shown in table*	151	75
12	*in terms of the*	143	89
13	*as a result of*	131	77
14	*the results of this*	129	82
15	*on the basis of*	128	61
16	*it is important to*	127	89
17	*can be used to*	124	83
18	*in this study the*	116	80
19	*the extent to which*	110	62
20	*the beginning of the*	109	61

*Range refers to the number of texts where a lexical bundle occurs.

3.2 Structural Analysis of Four-word Lexical Bundles in Educational Technology RAs

Table 4 shows the results of the structural analysis of bundles. As can be seen, the structural category of noun phrase + *of* has the highest percentage (25.64%), followed in a descending order by prepositional phrase + *of* (22.09%), other prepositional phrases (20.93%), and other noun phrases (6.76%). The four categories together account for three-fourths of all occurrences. The remaining one-fourth is made up of the other eight structural categories, each of which constitutes a very small percentage of less than 5%.

Table 4. Structural analysis of lexical bundles in educational technology

Structural categories	No. of bundles	Overall frequency	Percentage
Noun phrase + *of*	31	2614	25.64%
Prepositional phrase + *of*	25	2252	22.09%
Other prepositional phrases	26	2134	20.93%
Other noun phrases	8	689	6.76%
(Verb/adjective +) *to*-clause fragment	7	505	4.95%
(Verb phrase +) *that* clause fragment	8	465	4.56%
Passive + prepositional phrase fragment	5	445	4.36%
Others	4	358	3.51%
Anticipatory *it* + verb/adjective	5	342	3.39%
Pronoun/noun phrase + *be*	3	187	1.83%
Adverbial clause fragment	2	139	1.36%
Be+ noun/adjectival phrase	1	66	0.65%
Total	125	10196	100%

Noun phrase + *of*, as the most frequent structural category, is formed usually by a head noun as the center of bundle, preceded by such modifiers as articles and determiners and followed by an incomplete embedded of-phrase (e.g., *of the*, *of a*). The most prominent prevailing pattern is "*the* + head noun + *of* + *the*." Instances using this pattern include *the results of the*, *the end of the*, *the use of the*, *the effect of the*, *the design of the*, and so forth. In these instances, the head noun is enclosed by *the* in the beginning and *of the* in the end. The head nouns within these bundles are mostly abstract nouns, but not necessarily discipline-specific topic words. They perform a wide range of functions, such as description of research procedures (e.g., *the use of the*, *the design of the*, *the development of the*, *the implementation of the*), quantifications (e.g., *the majority of the*, *the rest of the*), and label of the location (e.g., *the end of the*, *the beginning of the*).

Apart from noun phrases, prepositional phrases are another important element in bundles, considering that the second and the third structural categories constitute 43% of all bundles. A number of prepositional phrases have been found, such as *in*-phrases, *on*-phrases, *at*-phrases, *of*-phrases, *for*-phrases, *through*-phrases, and *within*-phrases. Of these phrases, *in*-phrases occur most extensively. *In the form of, in the field of, in terms of the, in addition to the, in the present study,* and *in a way that* are some examples of incorporating *in*-phrases into bundles.

3.3 Comparison between the Present Study and Previous Studies

To reveal possible bundle similarities and differences between disciplines, a cross-discipline

comparison was made. The findings of this study were compared and contrasted with two past studies: Hyland (2008b), a multi-disciplinary study on lexical bundles in four disciplines – electrical engineering, business studies, applied linguistics, and biology, and Jalali et al. (2008), a study on lexical bundles in applied linguistics. Table 5 lists the results of the two studies as well as the present study.

Table 5. Cross-discipline comparison of lexical bundles

Discipline	Electrical Engineering (Hyland)	Business Studies (Hyland)	Biology (Hyland)	Applied Linguistics (Hyland)	Applied Linguistics (Jalali)	Educational Technology (this study)
No. of different bundles	213	144	131	141	125	125
Structural categories						
Noun phrase + *of*	22.3%(2)	28.5%(1)	23.7%(2)	22.9%(2)	22.89%(2)	25.64%(1)
Prepositional phrase + *of*	7.9%	16.0%(3)	9.2%	19.9%(3)	29.69%(1)	22.09%(2)
Other prepositional phrases	11.6%(3)	19.7%(2)	13.7%(3)	24.4%(1)	19.26%(3)	20.93%(3)
Other noun phrases	10.8%(4)	12.4%(4)	9.4%(4)	9.6%(4)	10.49%(4)	6.76%(4)
(Verb/adjective +) *to*-clause fragment	-	-	-	-	-	4.95%
(Verb phrase +) that clause fragment	-	-	-	-	-	4.56%
Passive + prepositional phrase fragment	29.8%(1)	9.0%	31.3%(1)	6.9%	2.34%	4.36%
Others	9.2%	9.9%	6.4%	10.7%	8.22%	3.51%
Anticipatory *it* +	8.4%	4.5%	6.3%	5.6%	5.46%	3.39%

verb/adjective						
Pronoun/noun phrase + *be*	-	-	-	-	-	1.83%
Adverbial clause fragment	-	-	-	-	-	1.36%
Be + noun/adjectival phrase	-	-	-	-	1.65%	0.65%

The comparison revealed several interesting results. First, concerning the number of different bundles, electrical engineering has a by-far larger number (213) than the other disciplines, including business studies (144), applied linguistics (141 and 125, respectively), biology (131), and educational technology (125), while these other disciplines do not differ greatly from each other. Educational technology, as shown in this study, holds a much smaller number of different bundles than electrical engineering.

Second, the cross-discipline structural comparison, as shown in Table 5, showed that the prevailing structural categories of lexical bundles in educational technology are similar to those in business studies and applied linguistics. Four bundle structures, namely, noun phrase + *of*, prepositional phrase + *of*, prepositional phrase + *of*, and other prepositional phrases, recur in the RAs in these three disciplines, though in different rankings. The four categories together account for over three-fourths of the total frequency in each of the three disciplines. In comparison, the top four bundle categories in biology and electrical engineering are: passive + prepositional phrase fragment, noun phrase + *of*, other prepositional phrases, and other noun phrases. The greatest difference is the category of passive + prepositional phrase fragment, which is not often used in the three previously mentioned disciplines (i.e., 4.36% in educational technology, 6.9% and 2.34% in applied linguistics, and 9.0% in business studies) but frequently employed in biology (31.3%) and electrical engineering (29.8%). This finding may distinguish educational technology from such hard science disciplines as electrical engineering and biology.

To look further into the similarities of educational technology with other disciplines, the content of the identified bundles in each discipline was compared with each other and analyzed. Since Hyland's (2008b) study offers only the top 50 bundles, not a complete list, the top 50 bundles from each of the other studies were drawn for comparison. The result of the cross-discipline analysis revealed that 50% of the top 50 bundles in educational technology are overlapping with those in applied linguistics (Jalali et al., 2008), 40% are overlapping with those in business studies and applied linguistics (Hyland, 2008b), and 34% with biology, but only 20% with electrical engineering. Table 6 presents a list of the top 50 bundles in educational technology, applied linguistics, and electrical engineering.

Table 6. Cross-discipline comparison of the top 50 lexical bundles

Educational technology	Applied Linguistics(Jalali)	Applied Linguistics(Hyland)	Electrical engineering(Hyland)
on the other hand*	**on the other hand****	**on the other hand****	**on the other hand****
the results of the	**in the case of**	**at the same time**	as shown in figure
at the end of	**at the same time**	**in terms of the**	**in the case of**
the end of the	**the extent to which**	**on the basis of**	is shown in figure
the use of the	**the end of the**	**in relation to the**	it can be seen
as well as the	**in the context of**	**in the case of**	as shown in fig
in the context of	**the use of the**	**in the present study**	is shown in fig
the students in the	**at the end of**	**the end of the**	can be seen that
at the same time	**as well as the**	the nature of the	**can be used to**
in the form of	**in terms of the**	**in the form of**	the performance of the
as shown in table	**on the basis of**	**as well as the**	as a function of
in terms of the	**it is important to**	**at the end of**	is based on the
as a result of	**as a result of**	the fact that the	**with respect to the**
the results of this	the ways in which	**in the context of**	is given by equation
on the basis of	**to be able to**	is one of the	the effect of the
it is important to	**in the present study**	in the process of	the magnitude of the
can be used to	on the part of	**the results of the**	**at the same time**
in this study the	**in the form of**	in terms of their	in this case the
the extent to which	on the one hand	to the fact that	it is found that
the beginning of the	a wide range of	in the sense that	the size of the
results of this study	as a second language	the relationship between the	be seen that the
at the beginning of	**at the beginning of**	of the hong kong	the accuracy of the
in the case of	**the results of the**	**at the beginning of**	**as well as the**
that the use of	the fact that the	the role of the	the same as the
the quality of the	the nature of the	of the present study	is one of the
to the use of	in the process of	**as a result of**	a function of the
on the use of	**in the field of**	**one of the most**	as a result the
to be able to	can be seen in	can be seen as	**the results of the**
in addition to the	**the beginning of the**	**it is important to**	**in the form of**
of this study is	at the time of	it should be noted	is assumed to be
of this study was	English as a second	on the one hand	of the power system
used in this study	as can be seen	can be found in	it is necessary to
a positive effect on	the part of the	the ways in which	it is possible to
the purpose of this	**in addition to the**	in other words the	the length of the

students were asked to	in the target language	**the other hand the**	are shown in fig
with respect to the	the way in which	the starting point of	can be obtained by
with regard to the	**in the use of**	be seen as a	**in terms of the**
the degree to which	in terms of their	in the eyes of	are shown in figure
the use of technology	in the course of	**the beginning of the**	is due to the
the effectiveness of the	**the students in the**	should be noted that	the structure of the
the design of the	**in relation to the**	that there is a	is defined as the
the content of the	**one of the most**	at the level of	it was found that
this study was to	with respect to the	for the purpose of	**the other hand the**
in the current study	a small number of	in hong kong and	the presence of the
in the present study	the role of the	are more likely to	with the use of
one of the most	to the fact that	the meaning of the	is the same as
in the use of	of the present study	on the part of	it can be observed
the other hand the	as a foreign language	the purpose of the	it is because the
in relation to the	native speakers of English	a wide range of	than that of the
in the field of	the percent of the	**the use of the**	will be discussed in

*1. Bundles underlined in educational technology are those shared with applied linguistics, electrical engineering or both fields.

**2. Bundles in bold in applied linguistics or electrical engineering are those shared with educational technology.

As can be observed from Table 6, the overlapping bundles that educational technology and applied linguistics share with each other contain less discipline-specific words but mostly serve the general purpose of academic writing or even general writing. This is illustrated by the bundles of *on the other hand, the other hand the, at the same time, on the basis of, as a result of, in terms of the, as well as the, in addition to the, in relation to the, the extent to which, the beginning of the, the end of the, at the end of, in the context of, in the case of, it is important to*, and so on. Applied linguists use these general-purpose bundles to perform a variety of functions essential to the organization of arguments, such as displaying the connection or the transition of text, directing readers to the organization of text, explaining causative relations between elements, noting a particular context or a referent, and weaving the thread of authorial argument. Extensively using these bundles in applied linguistics, as Hyland (2008b) argues, reflects "the more discursive and evaluative patterns of argument in the soft knowledge fields, where persuasion is more explicitly interpretative" (p.16).

The general-purpose bundles in electrical engineering, comparatively, are less frequently used; rather, most bundles in electrical engineering were found to refer to figures (e.g., *as shown in figure, is shown in figure, as shown in fig, is shown in fig, are shown in figure, are shown in fig*) and demonstrate a series of research/experiment-related aspects, such as model construction, material employment, procedure depiction or specification of physical

environment (e.g., *the size of the, the performance of the, the magnitude of the, the accuracy of the, the structure of the, a function of the, the length of the*). Moreover, many bundles in electrical engineering are present in passive voice (e.g., *is shown in figure, are shown in fig, is assumed to be, is given by equation, is defined as the, can be obtained by*). These findings place a particular emphasis of authorial absence and human invisibility in scientific writing in electrical engineering, as opposed to educational technology.

In summary, the cross-discipline quantitative analyses of the number of different bundles and the structure of bundles unanimously show that educational technology sits at a close distance from applied linguistics but at a relatively long distance from electrical engineering. Qualitative analysis of the content of the bundles across three disciplines further suggests that educational technology adopts a similar discursive style to that by applied linguistics to frame writing. Synthesizing both quantitative and qualitative findings in the present study, it is possible to conclude that educational technology can be defined as a discipline more closely related to soft science than to hard science.

4. Discussion and Conclusion

"Academic writing is not a single undifferentiated mass, but a variety of subject-specific literacies" (Hyland, 2002, p.352). It not only conveys values and beliefs writers hold but also reflects the disciplinary nature within a particular academic community. This study, through the lens of academic literacies, investigates the features of lexical bundles in terms of frequency, content, and structural categories, with an aim to capture empirically the disciplinary nature of educational technology.

First, regarding the number of different bundles, researchers in educational technology tend to use as many lexical bundles as researchers in applied linguistics, business studies, and biology but a relatively smaller number of lexical bundles than researchers in electrical engineering. This result might imply that academics in the four disciplines of educational technology, applied linguistics, business studies, and biology use a more limited number of prefabricated linguistic patterns to develop their claims, compared with academics in electrical engineering who employ a wider variety of prefabricated patterns. Scrutinizing the content of the identified bundles demonstrates similarities and differences between educational technology and other disciplines. Educational technology has a fairly high overlap of bundle use with applied linguistics and business studies but a considerably low overlap with electrical engineering. Such a finding may suggest that academics in educational technology, applied linguistics, and business studies share a close affinity in framing arguments and constructing propositions in their disciplinary writing.

Second, the cross-discipline content analysis of the top 50 high-frequency bundles demonstrates that a large number of general-purpose bundles are shared by educational technology and applied linguistics. These shared general-purpose bundles are mostly "text-oriented bundles" (Hyland, 2008b, p. 13) (e.g., *in addition to the, in relation to the, as well as the*), ones that help organize the text, develop the structure of arguments, and make a link between discourse elements. In contrast, electrical engineering predominantly uses a myriad of "research-oriented bundles" (Chen & Xiao, 2015; Hyland, 2008b, p. 13) (e.g., *the*

magnitude of the, the accuracy of the, the structure of the, of the power system) for reporting scientific experiments and empirical research activity. This finding probably reflects a fact that educational technology, similar to soft science fields such as applied linguistics, appears to map arguments and disseminate knowledge in a discursively elaborate and interpretive manner (Hyland, 2004). In other words, a key feature shared by educational technology and applied linguistics is not simply how they report experimental activity and research results, but also how they give explanation and make plausible reasoning, suggesting that they may have different disciplinary nature and academic cultural norms from electrical engineering.

Third, concerning the structure of lexical bundles, noun phrase + *of*, prepositional phrase + *of*, other prepositional phrases, and other noun phrases are four structural categories extensively used in educational technology. Noun phrases and prepositional phrases are two essential elements constructing the building blocks of these lexical bundles. This result is in line with the findings of previous studies that whatever the disciplines, noun phrases and prepositional phrases are favorable structural units abounding in academic wiring (Breeze, 2013; Hyland, 2008b). Further exploration into the prevailing structural categories across disciplines suggests that the bundle structure of passive + prepositional phrase fragment is not frequently used in educational technology but makes a striking feature in electrical engineering and biology. Its high frequency in electrical engineering and biology might be closely related to the prevalence of passive voice in hard science. Passive voice has been notably preferred and considered a tradition in scientific papers since it helps underscore the centrality of technical content in natural science and engineering research as well as the importance of objectivity in hard science studies (Plotnick, n.d.). More specifically, by obscuring or diminishing the agent of the action, passive voice helps create an objective picture of reality and reflect the nature of non-human intervention in hard science. The frequency of passive bundles in educational technology does not constitute such a high proportion as that in electrical engineering and biology. This finding may provide another supportive evidence to position educational technology as a field not so closely related to hard science as the word ”technology” may suggest.

Differences in the use of lexical bundles between educational technology and electrical engineering may be somewhat elucidated by the notions of people and technology. Technology, from the perspective of engineers, typically refers to machines, computer devices, technical equipment, electronic tools, physical systems, and hardware aspects (Luppicini, 2005). Comparatively, educational technologists view technology as intellectual processes that systematically apply scientific knowledge to attain educational goals (Januszewski & Molenda, 2008). It is not merely material construction itself but socially constructed and intellectually shaped (Lakhana, 2014; Luppicini, 2005). Educational technologists are not devoted to making technological design but to selecting and evaluating technological processes and resources in order to enhance the effectiveness and efficiency of instruction (Hlynka & Jacobsen, 2009). Such a distinction in the conception of technology probably influences the linguistic realization of lexical bundles. Analyses of the number of different bundles, the content of bundles, and the structure of bundles all demonstrate that educational technology characterizes soft technology and exhibits a considerable interplay

between human contexts and technology use.

In conclusion, the cross-disciplinary comparison of lexical bundles suggests that educational technology may be more inclined to soft science fields in terms of the number of different bundles, the content of bundles, and the syntactic structure of bundles. In other words, the use of bundles can reveal the underlying nature of educational technology as the contemporary conception suggests. This study provides empirical value to complement existing research, enlightening our understanding of the disciplinary nature and orientation of educational technology. Nevertheless, this study is exploratory in nature and more evidence related to disciplinary findings is required to consolidate the conclusion. Future research on a more comprehensive cross-disciplinary investigation is recommended to derive a more robust conclusion.

As a corpus-informed study, the present study provides very practical pedagogical value. The generated frequent lexical bundles are helpful for designing specialized courses for educational technology, particularly beneficial for novice researchers who struggle to meet the expectations of disciplinary writing conventions and endeavor to establish a proper link to the disciplinary discourse community. Pedagogical applications may include such activities as comparing the usage of lexical bundles generated by novices with that in the bundle list or conducting a concordance analysis to examine how the identified lexical bundles are contextualized. Familiarization of lexical bundles through these activities enables individuals to raise linguistic awareness of academic writing and advance to a more competent participator in the disciplinary community

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Appendix

Appendix 1. Four-word Lexical Bundles in Educational Technology RAs

Rank	Frequency	Range	Lexical Bundle
1	314	154	*on the other hand*
2	236	123	*the results of the*
3	222	103	*at the end of*
4	213	111	*the end of the*
5	209	98	*the use of the*
6	205	130	*as well as the*
7	190	114	*in the context of*
8	168	66	*the students in the*
9	165	110	*at the same time*
10	154	99	*in the form of*
11	151	75	*as shown in table*
12	143	89	*in terms of the*
13	131	77	*as a result of*
14	129	82	*the results of this*
15	128	61	*on the basis of*
16	127	89	*it is important to*
17	124	83	*can be used to*
18	116	80	*in this study the*
19	110	62	*the extent to which*
20	109	61	*the beginning of the*
21	107	67	*results of this study*
22	103	65	*at the beginning of*
23	99	53	*in the case of*
24	98	65	*that the use of*
25	98	59	*the quality of the*
26	98	60	*to the use of*
27	96	65	*on the use of*
28	94	65	*to be able to*
29	91	69	*in addition to the*

30	90	69	*of this study is*
31	90	67	*of this study was*
32	89	58	*used in this study*
33	88	32	*a positive effect on*
34	88	66	*the purpose of this*
35	87	57	*students were asked to*
36	87	49	*with respect to the*
37	85	42	*with regard to the*
38	84	39	*the degree to which*
39	84	48	*the use of technology*
40	83	59	*the effectiveness of the*
41	80	55	*the design of the*
42	79	52	*the content of the*
43	78	61	*this study was to*
44	76	37	*in the current study*
45	76	45	*in the present study*
46	75	59	*one of the most*
47	73	50	*in the use of*
48	73	56	*the other hand the*
49	72	49	*in relation to the*
50	72	37	*in the field of*
51	72	39	*it was found that*
52	72	39	*the total number of*
53	72	50	*through the use of*
54	71	45	*are more likely to*
55	71	44	*the results showed that*
56	70	43	*as shown in figure*
57	70	45	*in this paper we*
58	70	59	*to participate in the*
59	69	41	*are shown in table*
60	69	54	*purpose of this study*
61	68	42	*of the use of*

62	68	50	*the nature of the*
63	68	48	*to the fact that*
64	67	46	*in the process of*
65	66	54	*is one of the*
66	66	56	*the fact that the*
67	65	49	*in other words the*
68	65	40	*the role of the*
69	63	46	*in a way that*
70	63	49	*the purpose of the*
71	63	49	*the rest of the*
72	62	39	*for each of the*
73	62	35	*for teaching and learning*
74	61	45	*as part of the*
75	60	48	*the use of a*
76	59	33	*in teaching and learning*
77	59	52	*in this study was*
78	59	43	*in this study we*
79	59	44	*is based on the*
80	59	39	*participants were asked to*
81	58	37	*of teaching and learning*
82	58	34	*the effect of the*
83	58	40	*the majority of the*
84	57	46	*for the purpose of*
85	57	38	*in the learning process*
86	57	38	*of the present study*
87	57	33	*the implementation of the*
88	56	36	*it should be noted*
89	56	41	*the development of the*
90	55	39	*in terms of their*
91	55	39	*there is a need*
92	54	49	*a wide range of*
93	54	41	*information and communication technology*

94	54	39	*that there was a*
95	54	44	*this study is to*
96	53	39	*as well as to*
97	53	37	*on the one hand*
98	53	40	*that can be used*
99	53	42	*with the use of*
100	52	37	*a higher level of*
101	52	39	*and the use of*
102	52	36	*were randomly assigned to*
103	51	40	*for the development of*
104	51	36	*in the design of*
105	51	37	*it is necessary to*
106	50	40	*in the development of*
107	50	36	*the development of a*
108	49	37	*in line with the*
109	49	33	*should be noted that*
110	49	37	*within the context of*
111	48	42	*has the potential to*
112	48	41	*in this study were*
113	48	32	*participated in the study*
114	48	32	*the results show that*
115	47	38	*of the students in*
116	47	37	*that there is a*
117	46	42	*an important role in*
118	46	38	*it is possible to*
119	46	38	*the context of the*
120	46	32	*was found to be*
121	45	39	*in the next section*
122	45	33	*the results indicate that*
123	44	32	*a better understanding of*
124	44	36	*a result of the*
125	44	34	*the analysis of the*