

Exposure to L2 online text on lexical and reading growth

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Abstract

With the fast-paced development of technology in today's society, there has been emerging a shift from paper-based reading to digital online reading. While the benefits of exposure to print have been well-established in previous studies, how online reading may impact individuals' literacy development is largely underexplored. The current study investigated if the amount of English reading experience on the Internet could predict EFL students' lexical knowledge and reading comprehension ability. Participants were ninety-seven Vietnamese undergraduate students who were administered a website checklist and a vocabulary size test. Their reading comprehension scores were also collected as measures of their reading abilities. Descriptive statistics, hierarchical linear regression and structural equation modelling were utilized for data analysis. The results indicated that exposure to L2 online text was a significant predictor of the participants' vocabulary size as well as their reading comprehension growth during a course of two years. Pedagogical implications are discussed.

Keywords: *Reading Comprehension, Online Reading, Vocabulary Knowledge, Print Exposure*

Language(s) Learned in This Study: *English*

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Introduction

The positive relationship between print exposure and individuals' reading abilities has been well-established in previous studies. Print exposure or out-of-school reading experience as it is commonly referred to was consistently found to be associated with learners' literacy development, including but not limited to vocabulary, reading comprehension, background knowledge, spelling and writing skill (e.g., S. Y. Chen & Fang, 2016; Cunningham & Stanovich, 1991, 1997; Martin-Chang & Gould, 2008; Moore & Gordon, 2015; Stanovich, West, & Harrison, 1995; Zhang et al., 2018). Moreover, lexical knowledge has been reliably associated with reading development (Suggate, Schaughency, McAnally, & Reese, 2018). The relationships among print exposure, vocabulary, and reading skills have been found to be reciprocal with each being both a consequence and an independent contributor to the others (Mol & Bus, 2011).

Reading practice nowadays has moved from paper-based to screen-related activities (Liaw, 2017) and it is more common to see young learners read on electronic devices than read print books in their free time. Compared to print reading, online digital reading possesses its own characteristics (e.g., Coiro & Dobler, 2007; Leu et al., 2005; Mangen, Walgermo, & Brønneick, 2013), thus developing among readers new reading behaviors. Indeed, Loan (2012) found that online readers tended to read more extensively, inconsequentially, and superficially. In addition, text-presentation format, that is, print and digital format, has also been found to impact an individual's text comprehension level. For example, online hypertext (i.e., text with active links to other web pages) is believed to increase readers' cognitive load and potentially impede their comprehension efficacy (DeStefano & LeFevre, 2007). This raises concern of whether reading online digital text and print text will benefit learners' literacy development in a similar manner.

While the advantages of exposure to print have been well-documented, whether exposure to online text can yield comparable literacy benefits is relatively unknown. Furthermore, the differential influence of reading text-presentation format on readers' comprehension has been commonly investigated on a short-term basis in previous studies (e.g., Mangen et al., 2013; Porion, Aparicio, Megalakaki, Robert, & Baccino, 2016). This longitudinal study was carried out, in response, to address the association between exposure to online text and readers' literacy development. Specifically, it aimed to investigate if exposure to online text could predict English as a foreign language (EFL) learners' lexical knowledge and reading comprehension growth over a duration of two years.

Literature Review

In this section, following previous studies (S. Y. Chen & Fang, 2016; Cipielewski & Stanovich, 1992; Cunningham & Stanovich, 1991; Zhang et al., 2018), the authors first provide empirical findings on the relationship between print exposure and reading abilities. Next, the nature of online digital reading is discussed, taking into consideration its new textual features and reading skills. Finally, the differential impact of print and digital reading on readers' comprehension is elaborated upon before common methodologies to assess print exposure are presented.

Print Exposure, Vocabulary and Reading Comprehension Achievements

Research in recent decades has supported print exposure as a crucial environmental factor for literacy development (e.g., Cunningham & Stanovich, 1991, 1997; Echols, West, Stanovich, & Zehr, 1996; Siddiqui, West, & Stanovich, 1998). Although previous researchers have various ways of defining print exposure, the term commonly refers to the amount of out-of-school reading that learners engage in. In other words, print exposure also reflects free voluntary reading which has long been promoted as a powerful way to enhance linguistic abilities and language learning motivation (Krashen, 2004; Lee, 2007).

The relationships among exposure to print, reading comprehension and lexical knowledge has been well documented in previous studies. R. C. Anderson, Wilson, and Fielding (1988) found that the amount of free reading significantly predicted fifth-graders' reading achievements, including their vocabulary, reading comprehension and reading rate. Likewise, results in Stanovich and Cunningham's (1992) study indicated that the amount of non-school reading experience significantly accounted for the participants' vocabulary, spelling, verbal fluency, and cultural background knowledge.

In the same vein, in their longitudinal study, Cunningham and Stanovich (1997) revealed that print exposure could significantly predict children's reading growth from third to fifth and third to tenth grade, that is, seven years later. Mol and Bus (2011) examined 99 print-exposure studies in their meta-analysis and concluded that there was a moderate to strong relationship between print exposure and individuals' reading-related abilities and overall academic achievement. Another noteworthy conclusion was that the engagement in pleasure reading activities proved to be beneficial to both more able and poorer readers.

Regarding the significance of lexical knowledge, vocabulary has been found to play a crucial role in facilitating reading comprehension. Share and Leikin (2004) indicated that vocabulary knowledge was a significant predictor of participants' reading comprehension skills after controlling for age, gender, nonverbal IQ, and socioeconomic status ($N = 454$). Similarly, Muter, Hulme, Snowling, and Stevenson (2004) reported on a moderate correlation between children's vocabulary and their reading comprehension two years later. In another longitudinal study spanning 15 years, Suggate et al. (2018) found that vocabulary knowledge measured when participants were 19 months old significantly predicted their reading comprehension 10 years later.

In short, numerous studies have reported on the interrelations among print exposure, vocabulary, and reading comprehension ability. Print exposure is commonly considered both as a consequence and an independent contributor to a person's reading abilities (Mol & Bus, 2011). The quest for the impact of exposure to print on literacy development is, however, primarily based on short-term research (e.g.,

Acheson, Wells, & MacDonald, 2008; S. Y. Chen & Fang, 2016; Grant, Wilson, & Gottardo, 2007; Martin-Chang & Gould, 2008). How free reading experience can influence one's development of cognitive abilities can be more reliably substantiated with longitudinal data (Cipielewski & Stanovich, 1992). This study adopts a longitudinal design to investigate the effect of text exposure on readers' vocabulary and reading achievements in a new literacy context, that is, online reading environment.

The New Literacy Environment with Online Digital Text

In the 21st century, people tend to engage in online reading on a daily basis, either for work or for pleasure. Compared to print reading, online reading is featured with technology-enhanced textual features, posing further reading challenges (Coiro & Dobler, 2007). For example, previous educational researchers have examined the effect of hypertext on readers' cognitive load and text comprehension. Hypertext can be conceptualized as "documents containing links that allow readers to move from one chunk of text to another" (DeStefano & LeFevre, 2007, p.1617). In their review of 38 empirical studies, DeStefano and LeFevre (2007) supported the argument that hypertext could impact readers' text comprehension and navigation ability by increasing the mental load. Regarding the linearity of reading, online readers can actively self-construct their own reading text by clicking on embedded links (Coiro & Dobler, 2007).

The process of online reading involves complex cognitive tasks. Leu, Kinzer, Coiro, and Cammack (2004) conceptualized Internet reading as a new literacy encompassing five processing tasks, namely identifying important questions, locating necessary information, critically evaluating the information, synthesizing and communicating the information. First, the act of online reading is often initiated with a question necessitating clarifying information. The next step for online readers is to locate the answer for the problem which further requires at least four searching-related skills, that is, utilizing search engines, reading the search results, scanning the websites and locating the location of the essential information (Henry, 2006; Leu et al., 2007). Information evaluation is another essential skill as online information originates from diverse sources with differential levels of credibility. The fourth task deals with information-combining skills which can be a challenging task as readers need to exercise their cognitive ability to form a coherent story from different pieces of information read (Leu et al., 2007). Finally, online reading can be extended to relevant output activities, such as communicating results of the reading with other people.

In sum, existing differences between print and online reading may raise the question of whether exposure to online texts can yield similar cognitive advantages for online readers, particularly in the long term.

The Differential Effect of Print and Digital Reading on Comprehension

Previous educational researchers have suggested a differential effect of print and digital text on readers' comprehension level. For instance, Mangen et al. (2013) reported that after controlling for word reading ability and vocabulary, print-based reading group did significantly better in the reading comprehension test than their counterparts in the digital-based reading group. A recent study by Pfost, Dörfler, and Artelt (2013) investigated the effect of multiple reading sources, including print-based materials and online reading activities, on secondary school students' literacy development. The participants were administered a battery of reading-related tests and reading-habit questionnaires. The results showed that traditional book reading was found to be beneficial to the students' literacy skills, whereas online reading activities had a negative impact on both their reading comprehension and lexical competence.

Spear-Swerling, Brucker, and Alfano (2010) further found that only print fiction-related reading habits were correlated with reading comprehension achievement, and other online reading habits were either not related or were negatively related to the participants' reading abilities, including reading fluency, vocabulary, and comprehension. However, there are also empirical studies that demonstrated a null result for the reading medium effect. For example, Porion et al. (2016) found no statistical difference between the print and digital reading on readers' text comprehension in regard to surface, semantic, and inference understanding.

It should be noted that previous studies examining the effect of digital-text reading on learners' reading accomplishment have been conducted mostly in a short-term manner (e.g., Mangen et al., 2013; Porion et

al., 2016) and employed self-report questionnaires to probe reading experience (e.g., Pfost et al., 2013; Spear-Swerling et al., 2010). Concern for the accuracy of data produced from self-report questionnaire has been raised due to its vulnerability to either participants' inaccurate judgement or socially desirable answers (E. L. Anderson, Steen, & Stavropoulos, 2017; Krashen, 2004; Stanovich & West, 1989).

In a nutshell, support for the differential impact of print and digital text on readers' reading abilities has been mixed and would merit further studies with more objective instruments to assess participants' reading experience.

Assessing Individuals' Exposure to Print

Measuring an individual's exposure to print is the first vital step to examine its effect on literacy skill development. However, assessing print exposure has proved to be a challenging task. Self-report measures, such as questionnaire and diaries, are commonly used as instruments to measure participants' reading experience (e.g., R. C. Anderson et al., 1988). These measures are, nonetheless, susceptible to receiving socially desirable responses (Acheson et al., 2008; Cunningham & Stanovich, 1991; Stanovich & West, 1989). This is because when asked about reading activity, a socially-valued behavior, people tend to overestimate their reading amount (Rain & Mar, 2014).

To circumvent the aforementioned challenge, Stanovich and West (1989) introduced the employment of Author Recognition Test (ART), a checklist containing both real and fake names of book authors. Participants were asked to check only the authors they knew. Scoring for the ART was calculated simply by subtracting the total number of incorrect choices from that of the correct choices. Since its first development, recognition tests have been widely adopted as an additional or alternative method to estimate participants' print exposure. It is, nevertheless, important to note that rather than measuring an exact amount of reading experience (in hours or minutes) as self-report measures (e.g., R. C. Anderson et al., 1988; S. Y. Chen & Fang, 2016), a recognition test only serves as an indicator of participants' relative difference in print exposure (see Stanovich & West, 1989). Ciplewski and Stanovich (1992) elaborated on the advantages of recognition tests in comparison to traditional self-report measures: (1) short administration time; (2) low cognitive demand; and (3) more objectivity.

Recognition tests have consistently proved to be a potent predictor of an individual's reading abilities in previous studies (e.g., Grant et al., 2007; Sénéchal, LeFevre, Hudson, & Lawson, 1996; Stanovich et al., 1995; Zhang et al., 2018). McBride-Chang, Manis, Seidenberg, and Custodio (1993) contended that recognition tests could be considered as "the purest and best measure of print exposure to date" (p. 237). Likewise, Stainthorp (1997), after examining the validity and reliability of a UK version of the ART, also supported the utilization of recognition test as "an excellent addition" to traditional self-report instruments (p. 150).

Strongly upheld by the reviewed empirical studies, the present research, therefore, chose to adopt this very method and further utilized a newly-developed Website Recognition Test (WRT) to address these participants' online reading experience (Cong-Lem, 2019), given that Vietnamese students commonly practice L2 reading with online digital text rather than with print books.

The Current Study

The present research, to the authors' knowledge, is the first to investigate the effect of exposure to L2 online text on language learners' vocabulary size and reading comprehension growth in an EFL contexts. This study also introduces a new checklist-with-foils recognition test to assess learners' online-text exposure. Moreover, given that very few studies have employed a longitudinal design to inspect the effect of digital reading on literacy development, this study hopes to provide more valid and reliable empirical results. Specifically, the current study aims to address the following research questions:

- (1) Can exposure to online English text predict Vietnamese EFL learners' L2 vocabulary size?
- (2) Can exposure to online English text predict Vietnamese EFL learners' reading growth over the course of two years?

Methodology

Participants

Participants were 97 senior English majors (87 females) at the Department of Foreign Languages at a university in Vietnam, approximately 21 years old. Based on the first researcher's experience as a Vietnamese university lecturer and on informal interviews with the students, all of the participants had experience in reading English text on the Internet, for school, work, or pleasure reading purposes. This makes them an appropriate population for the study. All of the students in the department were distributed the study measures except for those who were absent at the time of our data collection, which allows the collected data to be more representative of the concerned student population.

Data Collection Instruments

Website Recognition Test

The procedure of designing the checklist Website Recognition Test (WRT) in this study was similar to that in prior research studies (e.g., S. Y. Chen & Fang, 2016; Ciplewski & Stanovich, 1992; Cong-Lem, 2019; Stanovich & West, 1989; Zhang et al., 2018). A preliminary survey was firstly conducted with 78 third-year English-major students at the same university to gather a list of popular English websites Vietnamese EFL students read. Additionally, the researchers also used Google to search for additional popular English websites read by EFL learners. Keywords inputted into the search engine involved, but not limited to, “most popular websites for English learners” and “best websites for learning English.”

The extensive effort resulted in 32 most-read website addresses featuring different text genres and reading sources, such as newspaper, English learning, and recreational reading sites. Seventeen fake website addresses were then created to serve as foils in the WRT. Next, these real and fake website addresses were randomly interspersed to generate a 49-item recognition test (see [Appendix](#)). The instruction for participants was: “Below is a list of English websites. Please check only the websites that you READ. If you know the name of the website, but you DO NOT READ it, please do not check it.” Scoring for the WRT was calculated similarly to previous studies, that is, taking the number of real websites chosen and subtracting the number of fake websites checked (e.g., Martin-Chang & Gould, 2008; Moore & Gordon, 2015; Rain & Mar, 2014; Stanovich & Cunningham, 1992; Zhang et al., 2018). Cronbach alpha value for the WRT was 0.76, suggesting a sufficient level of internal-consistency reliability of the instrument.

Vocabulary Size Test

The vocabulary test used in this study, consisting of 40 questions, was a shorter version of the Vocabulary Size Test (VST) developed by Beglar and Nation (2007). It is a bilingual English-Vietnamese version by Nguyen Thi Cam Le and Truong Hong Hue Minh (Nguyen & Nation, 2011). The VST is diagnostic in nature and only measures decontextualized vocabulary knowledge of EFL learners (Nation, 2006). Its reliability was rigorously examined by Beglar (2010) with a Rasch-based measurement model. The Rasch item reliability for items in the VST was higher than 0.96 and disattenuated Pearson's correlation for person measures was 0.91. The reliability of its bilingual version was also confirmed Nguyen and Nation's (2011) study.

Reading Comprehension Achievements

Regarding participants' reading growth, their reading comprehension (RC) scores for four consecutive semesters were procured from the university database. The scores were from their final examination tests for four reading courses, namely Reading Comprehension 1 (RC1), Reading Comprehension 2 (RC2), Reading Comprehension 3 (RC3) and Reading Comprehension 4 (RC4). The participants took their RC1 test in their first undergraduate year, RC2 and RC3 in the second year and RC4 in their third year.

The Reading Comprehension 1 (RC1), composed of three parts, was the most fundamental test of the four. The three parts included: 1) locating the topic sentence of a paragraph; 2) writing a topic sentence for the

paragraph; and 3) multiple choice with items on word definitions and grammar. The Mean score of RC1 for all of the participants was 2.86 ($SD = 0.75$).

Reading Comprehension 2 (RC2) also had three sections: 1) a set of multiple choice items on basic language skills as usual; 2) selecting sentences to complete a reading text with five missing sentences; and 3) a set of reading-writing tasks in which test takers answer open-ended questions with short phrases from the reading text, fill the blanks using the given words and phrases, rewrite two sentences and write up a short summary (80-100 words) of the reading text. The Mean score of RC2 was 2.71 ($SD = 0.77$).

Reading Comprehension 3 (RC3) included four major sections. The first section was the usual multiple-choice items. Section 2 required filling in the blanks using no more than three words from the text and rewriting a short paragraph. In section 3, students had to choose the most appropriate heading out of seven options for each of four paragraphs. Section 4 then asked students to decide if the given sentences were true about the reading passage and finally write up a summary in 80-100 words. The Mean score for RC3 was 3.20 ($SD = 0.66$).

Reading Comprehension 4 (RC4) was the highest level of the four reading tests, and required students to: 1) matching appropriate headings with the corresponding paragraphs; 2) the usual multiple-choice items on reading skills from general to inferring skills; 3) completing each paragraph with no more than three words from a given text; 4) paraphrasing sentences using own words; and finally 5) writing up a summary of a 100-120 word passage. The Mean score for RC4 was 2.89 ($SD = 0.69$).

The difficulty level of the four reading tests progresses from RC1 to RC4. The time allowed for each reading comprehension measures was 90 minutes. The reading tests were designed by at least three English lecturers of the Faculty of Foreign Languages at the university, who commonly hold postgraduate degrees in TESOL or Applied Linguistics from Australian universities. The four reading measures, having been developed and revised throughout many years, were employed as the official reading tests for English-major students at the university. A total of 380 reading scores were retrieved, a shortage of eight values (97 students \times 4 final-exam reading scores = 388). Eight missing scores, accounting for 2% of the total scores collected, were imputed by averaging the three procured scores (M. Chen, Xia, & Liu, 2010; Lazar, Gatto, Ferro, Bruley, & Burger, 2016).

Procedures

Prior to the data collection, the researchers contacted the lecturers in charge of the participants' classes, asking for permission to distribute the research instruments. Participants were administered the study instruments, that is, the WRT and VST, in traditional paper-and-pen format, and had 45 minutes to complete them. They were informed of the study purposes and that their reading scores would be collected. This approach is line with standard research procedures at the institution. The students were presented with small gifts, such as pens and candies, for spending time completing the research measures. Their reading comprehension scores, that is, RC1, RC2, RC3, and RC4, were then retrieved from the school data. The students took their RC1 in their first year of the undergraduate program, RC2 and RC3 in the second year, and RC3 in the third year. At the time they were administered the study instruments, they were in their fourth year.

Data Analysis

SPSS (Statistical Package for the Social Sciences) version 20 and AMOS version 22.0 were utilized for statistical analyses. Descriptive statistics of the study variables, that is, WRT, VST, and RC were first examined before the Pearson correlations were performed. To address the research questions in this study, simple linear regression, hierarchical linear regression and structural equation modelling were conducted.

Following previous studies in examining reading growth, hierarchical regression was employed to examine the effect of WRT on participants' reading abilities. Hierarchical regression is a statistical analysis that allows researchers to enter the independent variables (i.e., the predictors) into blocks in which the predictor of main interest is entered last. The effect of previous independent variables on the criterion variable will

be statistically partialled out. Such employment of hierarchical regression to investigate the effect of non-school reading experience as a predictor of participants' reading growth has been adopted in previous studies (e.g., R. C. Anderson et al., 1988; Cipielewski & Stanovich, 1992).

Finally, to further establish the structural relations among the study variables, Structural Equation Modeling (SEM) was carried out. In the field of social science, SEM is a widely adopted statistical technique to test the causal relationships among factors at both observed and latent-construct levels (Ullman & Bentler, 2013). Model fit indices are first examined to ensure that the model possesses adequate goodness of fit before the relations in the model are assessed. Previous researchers have suggested several cut-off values for the model fit indices: a p-value of χ^2 (chi-square) > .05; chi-square to degree of freedom (χ^2/df) < 5; Comparative Fit Indices (CFI) > .90; and Root Mean Square Error of Approximation (RMSEA) < .06 (Hu & Bentler, 1999; Kelloway, 1998).

Relevant data assumptions were checked before the statistical analyses were performed. To elaborate, as for the linear regressions, correlations among WRT, VST and reading abilities were all larger than 0.3. Data normality was checked with Normal P-P Plot function in SPSS. Furthermore, skewness and kurtosis values of all of the study variables fell between +3 and -3, indicating an acceptable level of data normality for inferential statistics (George & Mallery, 2001; Kline, 1998). The linearity of the data was also inspected with the scatterplot function and potential outliers examined.

Results

Descriptive Statistics of the Study Variables

Table 1. Summary of Descriptive Statistics of the Study Variables

Variables	Mean	SD	Range	Skewness		Kurtosis	
				Statistics	Std. Error	Statistics	Std. Error
WRT	3.62	3.42	0 – 15.0	.87	.25	1.25	.49
Vocabulary	18.60	6.61	4.0 – 34.0	.30	.25	-.31	.49
RC1	2.86	.75	.70 – 4.30	-.34	.25	-.15	.49
RC2	2.71	.77	1.0 – 4.50	.24	.25	-.54	.49
RC3	3.19	.66	1.0 – 4.60	-.28	.25	.30	.49
RC4	2.89	.69	1.40 – 4.70	.00	.25	-.54	.49

Notes. WRT = Website Recognition Test; RC1 = Reading Comprehension 1; RC2 = Reading Comprehension 2; RC3 = Reading Comprehension 3; RC4 = Reading Comprehension 4.

Table 1 shows the summary of descriptive statistics for all of the study variables. The reading scores used in the study analyses are the converted scores, ranging from 0 to 5, whereas the raw score range is from 0 to 10. The low mean score for the WRT can be attributed to several reasons. First, the current study investigated L2 rather than L1 reading and in an online environment rather than in print, as in previous studies. Free L2 reading tends to be practiced by more highly motivated students. Moreover, compared to book reading, Internet reading experience varies more considerably. These factors might have contributed to the low mean of the WRT. Finally, the higher rate of making guesses among the participants compared to prior studies may further increase the SD of participants' WRT scores. However, the WRT is a diagnostic test and designed to capture the individual differences rather than the absolute amount of L2 online reading.

Correlations Among Exposure to L2 Online Text, Vocabulary and Reading Comprehension Achievements

Table 2 presents the interrelations among WRT, VST and RC measures. All of the variables were

moderately related to one another ($p < .01$). A noteworthy pattern was that the connection between WRT and students' reading comprehension performance became weaker as the difficulty level of the reading test increased from RC1 to RC4. A similar pattern can also be noticed for the association between vocabulary and participants' reading achievements. This suggests a weakened effect of the WRT and VST on participants' RC abilities. Indeed, prior research has found a stronger effect of free reading activities in developing learners' linguistic competencies at the early stage of literacy development. For example, in Elley and Mangubhai's study (1983), EFL beginning learners, that is, 380 fourth- and fifth-graders, were provided with a great number of high-interest English books and progressed in reading twice the normal rate compared to the control group students.

Table 2. *Correlations Between WRT and Measures of Reading-related Abilities*

Variables	(1)	(2)	(3)	(4)	(5)
(1) WRT	-				
(2) Vocabulary	.524**	-			
(3) RC1	.415**	.556**	-		
(4) RC2	.406**	.468**	.475**	-	
(5) RC3	.365**	.469**	.417**	.584**	-
(6) RC4	.361**	.477**	.472**	.569**	.581**

Notes. WRT = Website Recognition Test; RC1 = Reading Comprehension 1; RC2 = Reading Comprehension 2; RC3 = Reading Comprehension 3; RC4 = Reading Comprehension 4.

**All correlations in the table are significant at .01 level (two-tailed).

Research Question 1: Can Exposure to L2 Online Text Predict Vietnamese EFL Learners' Vocabulary Size?

To address the first research question, simple linear regression was first run to examine whether exposure to L2 online text could account for the participants' lexical size. The results reported in [Table 3](#) indicate that WRT significantly explains 27.4% of the students' vocabulary test achievement ($p < 0.01$). If WRT accurately represented out-of-school reading exposure online, this result could be easily interpreted by the confirmed relationship between reading exposure and vocabulary acquisition, as previously discussed. By the same token, students' vocabulary knowledge could also be built by school reading. Therefore, hierarchical regression was conducted to control for the effect of reading comprehension measured by the highest level of reading comprehension test (RC4) to see if WRT could still explain additional variance in participants' vocabulary knowledge.

As shown in [Table 3](#), it was evident that the WRT significantly explained 14.2% additional variance of the EFL learners' vocabulary scores ($p < 0.01$) after controlling for reading comprehension ability (i.e., RC4). This finding shows that regardless of reading abilities, participants' exposure to L2 online text was still a significant predictor of their vocabulary size. This result is in line with findings of previous research (e.g., S. Y. Chen & Fang, 2016; Zhang et al, 2018), further implying that out-of-school online reading gives learners an advantage similar to out-of-school print reading.

Table 3. *Simple Linear Regression and Hierarchical Linear Regression Predicting Vocabulary Scores*

Step	Variables	R ²	ΔR ²	B	β	F
1.	WRT	.274	.266	1.01	.52	35.877**
1.	Reading Comprehension 4	.228	.220	3.18	.33	28.050**
2.	WRT	.370	.356	.78	.40	27.585**

Note. ** correlation is significant level, $p < 0.01$ level.

Research Question 2: Can Exposure to Online English Texts Predict Vietnamese EFL Learners' Reading Growth Over the Course of Two Years?

Since the relations presented in Table 2 are zero-order correlations, the direction could be interpreted in either way, that is, online text exposure leads to improvement in the reading abilities or the reverse. This ambiguity can be addressed by employing hierarchical regression analyses in a longitudinal study, that is, predicting reading growth (Cipielewski & Stanovich, 1992; Stanovich & Cunningham, 1992). Hierarchical regression allows researchers to decide the order of independent variable (IV) to put in the regression model. The effect of IVs entered before the last one will be statistically controlled for. The last IV will be utilized as the main predictor of the dependent variable (DV). In the current research, to predict reading growth, RC1 scores were entered first in the regression model, followed by WRT in the second IV block. RC2, RC3, and RC4 were in turn loaded as DVs for three separate analyses reflecting reading growth from RC1 to RC2, RC1 to RC3, and RC1 to RC4. Since WRT might have already contributed to RC1, when controlling for RC1 effect, some of the variance rightly belonging to WRT would be partialled out. Thus, such statistical design is considered to be biased against WRT (see also Cipielewski & Stanovich, 1992). However, by doing so, it is hoped that the effect of WRT on later reading accomplishments can be demonstrated more persuasively. The statistical procedure presented above has been adopted in previous studies predicting reading growth procedures (e.g., Cipielewski & Stanovich, 1992; Cunningham & Stanovich, 1991, 1997; Stanovich & Cunningham, 1992) and is also utilized in this study to examine the longitudinal effect of L2 online text exposure.

Table 4. Hierarchical Regressions Predicting Reading Comprehension Growth

Step	Variable	R ²	ΔR ²	B	β	F
Reading Comprehension 2						
1.	RC1	.226	.218	.38	.37	27.717**
2.	WRT	.279	.263	.06	.25	18.147*
Reading Comprehension 3						
1.	RC1	.174	.165	.09	.32	20.023**
2.	WRT	.218	.202	.02	.23	13.140*
Reading Comprehension 4						
1.	RC1	.223	.214	.36	.39	27.199**
2.	WRT	.256	.240	.04	.20	16.132*

Note. Reading Comprehension 2, 3, 4 are dependent variables. RC1 = Reading Comprehension 1; WRT = Website Recognition Test.

* $p < 0.05$, ** $p < 0.01$

Table 4 displays results of three sets of hierarchical regression analyses, in which WRT demonstrated its predictive power by consistently predicting the EFL students' reading growth throughout the course of two years. Specifically, WRT was found to significantly explain an additional 5.3 percent, 4.4 percent, and 3.3 percent of variance in students' reading scores over RC1-RC2, RC1-RC3, and RC1-RC4 respectively, and this was found to be significant at the $p < 0.05$ level, after controlling for RC1.

The results showing that exposure to L2 online text is a significant predictor of reading growth are resonant with prior studies about the effect of print exposure on reading growth (e.g., R. C. Anderson et al., 1988; Cipielewski & Stanovich, 1992; Cunningham & Stanovich, 1997).

Structural Relationships Among Exposure to L2 Online Text, Vocabulary Size and Reading Comprehension

Structural equation modelling was applied to further confirm the structural relationships among the

variables of interest. Figure 1 shows the SEM model with standardized regression coefficients. The goodness-of-fit indices suggest that this is an effective SEM model: $\chi^2 = 8.160$, $df = 8$, $p = .418$; $\chi^2/df = 1.020$; CFI (Comparative Fit Index) = .99; TIL (Tucker-Lewis Index) = .99 and RMSEA (Root Mean Square Error of Approximation) = .00, which satisfies the recommended values for an effective SEM model (Bagozzi & Yi, 1988; Hu & Bentler, 1999; Kelloway, 1998). As shown in Figure 1, WRT is a significant predictor both of participants' vocabulary knowledge ($\beta = .52$, $p < .001$) and reading comprehension ($\beta = .25$, $p < .05$) with its effect being stronger on the former. Vocabulary knowledge also significantly predicts the learners' reading comprehension ability ($\beta = .54$, $p < .001$).

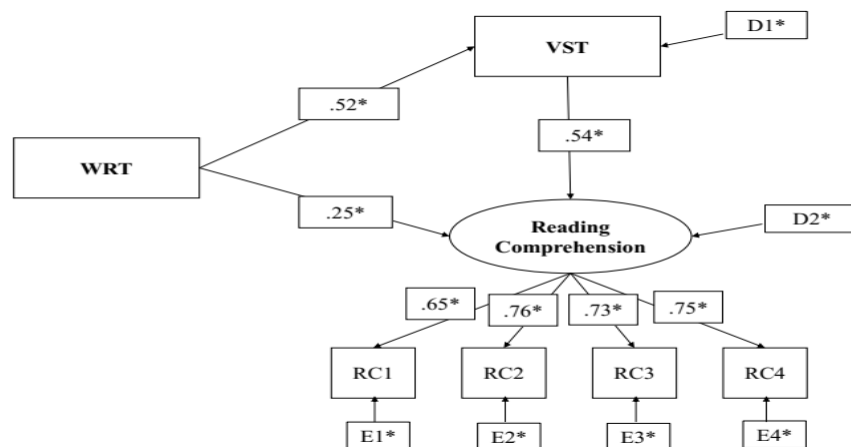


Figure 1. The structural equation model for the effect of exposure to L2 online text on vocabulary knowledge and reading abilities

Discussion

The developed Website Recognition Test is the first checklist-with-foils recognition test to estimate an individual's exposure to online text. It appears to be a reliable and valid instrument with a series of statistical procedures showing its significant association with vocabulary and reading measures as well as its predictive power on the participants' reading growth over two years. This is of critical value in that it provides an additional measure to self-report questionnaires, which prior researchers have raised concerns about related to reliability in measuring reading experience (Krashen, 2004; Stanovich & West, 1989).

Stringent analyses were carried out to examine the effect of WRT on participants' lexical knowledge. The fact that WRT significantly accounted for individual differences in vocabulary size after controlling for reading comprehension ability suggested its independent role in facilitating vocabulary learning. To put it in another way, regardless of the students' reading comprehension ability, engagement in L2 online reading appears to benefit lexical knowledge of the language learners in the study. In the same vein, when controlling for earlier reading comprehension ability, WRT was still a significant predictor of the participants' reading growth two years later. Given the fact that RC4 was the highest-level reading test at the participants' university, the power of exposure to L2 online texts should not be underestimated.

The results of the SEM provide further evidence for the structural relationships between exposure to L2 online texts and participants' linguistic competencies. Specifically, L2 online pleasure reading was found to be a significant predictor of the learners' lexical knowledge and reading comprehension ability, though WRT effect is stronger on the former. This result corresponded well with Arndt and Woore's (2018) study using pseudo-words to replace target words in videos and blog posts and found that the participants could indeed acquire different linguistic aspects of the target words, such as orthographic and grammatical features, through watching and reading materials online. To summarize, the relationship between online L2 text exposure and reading abilities should be considered a reciprocal one in which print exposure is both a

consequence and an independent contributor to the readers' literacy development (see Mol & Bus, 2011).

Another interesting finding is the weakened effect of exposure to L2 online text on learners' reading growth. Specifically, the correlation between WRT and participants' reading accomplishments and the percentage of variance in later reading comprehension accounted for by WRT were diminished over time. This certainly suggests a decreasing impact of L2 online reading as learners become more proficient in L2 language. A similar pattern can be observed in regard to the weakened effect of the VST on participants' reading abilities. Indeed, at later stages of proficiency development, EFL learners may need to develop the depth of their lexicon, that is, expressive vocabulary, in addition to the lexical breadth as measured in this study. For instance, Ouellette (2006) found that only expressive vocabulary, but not the receptive vocabulary, could account for unique variance in participants' reading comprehension ability after controlling for their age, nonverbal IQ, decoding and visual word recognition abilities.

The current study provided valuable empirical findings that digital reading appears to produce a similar positive effect on readers' literacy development that print reading does. Indeed, previous researchers have found that readers can familiarize themselves with electronic reading over time. Participants in the study by Leu et al. (2005), that is, 89 seventh graders, were assigned to read their science course materials in two conditions: (1) in print and (2) in digital format. Learners in the digital reading group experienced some difficulties in acquiring new knowledge at first, yet they later became competent in digital reading and could read equally well compared to the print-reading counterpart group. This suggests that the disturbance of this new reading format may not last and that online reading could render a long-term advantage.

Despite numerous studies in L1 print exposure, the impact of exposure to L2 text is relatively unknown. It has been argued that L1 and L2 reading processes differ due to three major aspects: (1) linguistic and processing differences, (2) individual and experiential differences and (3) socio-cultural and institutional differences (Grabe & Stoller, 2013). For example, with regard to the linguistic aspect, unlike L1 reading where students already possess basic language knowledge, L2 students "begin to read simple sentences and passages almost at the same time that they learn the language orally" (ibid, p.37). In this study, exposure to L2 text was, however, found to produce similar literacy advantages compared to that in L1 text exposure.

These empirical findings bear significant pedagogical implications, particularly in the Vietnamese context where print materials are not readily available. In EFL contexts where L2 print books and other print materials are expensive or for other reasons are not readily available for pleasure reading purposes, L2 online reading seems to be an adequate alternative. Moreover, in a contemporary educational setting where learners tend to read electronic texts more than print-based materials, language educators and policymakers should design lessons and curriculums that reflect the learners' reading interests, habits, and experience.

In sum, the power of L2 online reading should not be underestimated, as it contributes significantly to learners' L2 reading growth. However, it is essential to acknowledge that "the proliferation of authentic texts on the Web is far from enough to guarantee that language learners can profitably delve into texts they have located to help them in their language acquisition" (Godwin-Jones, 2007, p.8). Pedagogically, language educators should design extra learning tasks that encourage L2 online reading and help enhance students' critical and evaluation skills, which are crucial for successful online reading (Godwin-Jones, 2007). High interest reading materials, either in print or in electronic format, should be made available to learners to increase their exposure to reading input.

Conclusions and Limitations

The study was conducted to examine the long-term effect of exposure to L2 online texts on Vietnamese EFL learners' lexical size and reading growth. A checklist-with-foils recognition test was developed, utilizing website addresses as its items. The checklist Website Recognition Test (WRT) served as a proxy of individuals' exposure to L2 online text and was found to be significantly associated with the participants' vocabulary size and reading comprehension abilities. Further hierarchical regression analyses confirmed exposure to L2 text online as an independent contributor to the participants' literacy development.

Pedagogical implications thus suggested the use of online reading materials for language teaching, learning, and pleasure reading.

Regarding the study limitations, confounding factors, such as decoding skills and memory, which might also influence vocabulary performance and reading development, should be controlled for in future studies. Secondly, the format variation in the reading tests (i.e., RC1, RC2, RC3, RC4), though limited, might increase the variance in the measurement of participants' reading comprehension, thus potentially making over- or underestimating the effect of exposure to L2 online texts in this research. Future research could overcome this limitation by adopting standardized reading measures with the same format.

Finally, the SEM model in this study is still rather a simple one, which may be one of the reasons why it could obtain excellent model-fit indices. More factors can be added to the model in future research to address the relationship between L2 online text exposure and literacy achievements more comprehensively. Since text genre may have an effect on readers' literacy development (Spear-Swerling et al., 2010), a potential follow-up study could be conducted to investigate the impact of text genres on readers' literacy development in the online reading environment.

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References

- Acheson, D. J., Wells, J. B., & MacDonald, M. C. (2008). New and updated tests of print exposure and reading abilities in college students. *Behavior Research Method*, *40*(1), 278–289.
- Anderson, E. L., Steen, E., & Stavropoulos, V. (2017). Internet use and Problematic Internet Use: A systematic review of longitudinal research trends in adolescence and emergent adulthood. *International Journal of Adolescence and Youth*, *22*(4), 430–454.
- Anderson, R. C., Wilson, P. T., & Fielding, L. G. (1988). Growth in reading and how children spend their time outside of school. *Reading Research Quarterly*, *23*(3), 285–303.
- Arndt, H. L., & Woore, R. (2018). Vocabulary learning from watching YouTube videos and reading blog posts. *Language Learning & Technology*, *22*(3), 124–142. Retrieved from https://scholarspace.manoa.hawaii.edu/bitstream/10125/44660/22_03_arndt_10125-44660.pdf
- Bagozzi, R. P., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science*, *16*(1), 74–94. doi:10.1007/BF02723327
- Beglar, D. (2010). A Rasch-based validation of the Vocabulary Size Test. *Language Testing*, *27*(1), 101–118. doi:10.1177/0265532209340194
- Beglar, D., & Nation, P. (2007). A vocabulary size test. *The Language Teacher*, *31*(7), 9–13.
- Chen, M., Xia, J., & Liu, R. R. (2010). *Developing a strategy for imputing missing traffic volume data*. Paper presented at the Journal of the Transportation Research Forum.
- Chen, S. Y., & Fang, S. P. (2016). Print exposure of Taiwanese fifth graders: Measurement and prediction. *The Asia-Pacific Education Researcher*, *25*(1), 69–78.
- Cipielewski, J., & Stanovich, K. E. (1992). Predicting growth in reading ability from children's exposure to print. *Journal of Experimental Child Psychology*, *54*(1), 74–89.

- Coiro, J., & Dobler, E. (2007). Exploring the online reading comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet. *Reading Research Quarterly*, 42(2), 214–257.
- Cong-Lem, N. (2019). *Predicting undergraduate students' L2 vocabulary size and reading growth from their exposure to digital text online*. (Master). National Taiwan University of Science and Technology, Taipei, TW. Retrieved from <http://ir.lib.ntust.edu.tw/handle/987654321/75782>
- Cunningham, A. E., & Stanovich, K. E. (1991). Tracking the unique effects of print exposure in children: Associations with vocabulary, general knowledge, and spelling. *Journal of Educational Psychology*, 83(2), 264–274.
- Cunningham, A. E., & Stanovich, K. E. (1997). Early reading acquisition and its relation to reading experience and ability 10 years later. *Developmental Psychology*, 33(6), 934–945.
- DeStefano, D., & LeFevre, J.-A. (2007). Cognitive load in hypertext reading: A review. *Computers in Human Behavior*, 23(3), 1616–1641.
- Echols, L. D., West, R. F., Stanovich, K. E., & Zehr, K. S. (1996). Using children's literacy activities to predict growth in verbal cognitive skills: A longitudinal investigation. *Journal of Educational Psychology*, 88(2), 296–304.
- Elley, W. B., & Mangubhai, F. (1983). The impact of reading on second language learning. *Reading Research Quarterly*, 19(1), 53–67.
- George, D., & Mallery, P. (2001). *SPSS for Windows step by step*. Needham Heights, MA: Allyn & Bacon.
- Godwin-Jones, R. (2007). E-texts, mobile browsing, and rich Internet applications. *Language Learning & Technology*, 11(3), 8–13. Retrieved from <https://www.iltjournal.org/item/2583>
- Grabe, W. P., & Stoller, F. L. (2013). *Teaching and researching: Reading*: Routledge.
- Grant, A., Wilson, A. M., & Gottardo, A. (2007). The Role of Print Exposure in Reading Skills of Postsecondary Students With and Without Reading Disabilities. *Exceptionality Education International*, 17(2), 175–194.
- Henry, L. A. (2006). SEARCHing for an answer: The critical role of new literacies while reading on the Internet. *The Reading Teacher*, 59(7), 614–627.
- Hu, L. t., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: a Multidisciplinary Journal*, 6(1), 1–55.
- Kelloway, E. K. (1998). *Using LISREL for structural equation modeling: A researcher's guide*. Thousand Oaks, CA: Sage.
- Kline, R. B. (1998). *Principles and practice of structural equation modeling*. New York, NY: Guilford.
- Krashen, S. D. (2004). *The power of reading: Insights from the research: Insights from the research: ABC-CLIO*.
- Lazar, C., Gatto, L., Ferro, M., Bruley, C., & Burger, T. (2016). Accounting for the multiple natures of missing values in label-free quantitative proteomics data sets to compare imputation strategies. *Journal of Proteome Research*, 15(4), 1116–1125.
- Lee, S. Y. (2007). Revelations from three consecutive studies on extensive reading. *RELC Journal*, 38(2), 150–170.
- Leu, D. J., Castek, J., Hartman, D., Coiro, J., Henry, L., Kulikowich, J., & Lyver, S. (2005). *Evaluating the development of scientific knowledge and new forms of reading comprehension during online*

- learning*. Paper presented at the the North Central Regional Educational Laboratory/Learning Point Associates.
<http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.547.3811&rep=rep1&type=pdf>
- Leu, D. J., Kinzer, C. K., Coiro, J. L., & Cammack, D. W. (2004). Toward a theory of new literacies emerging from the Internet and other information and communication technologies. *Theoretical Models and Processes of Reading*, 5(1), 1570–1613.
- Leu, D. J., Zawilinski, L., Castek, J., Banerjee, M., Housand, B., Liu, Y., & O’Neil, M. (2007). What is new about the new literacies of online reading comprehension. In A. Berger, L. Rush, & J. Eakle (Eds.), *Secondary School Literacy: What Research Reveals for Classroom Practices* (pp. 37–68). Chicago, IL: NCTE/NCRL.
- Liaw, M. L. (2017). Reading strategy awareness training to empower online reading. *The English Teacher*, 38, 133–150.
- Loan, F. A. (2012). Impact of the Internet surfing on reading practices and choices. *Webology*, 9(1), 1–10.
- Mangen, A., Walgermo, B. R., & Brønnick, K. (2013). Reading linear texts on paper versus computer screen: Effects on reading comprehension. *International Journal of Educational Research*, 58, 61–68.
- Martin-Chang, S. L., & Gould, O. N. (2008). Revisiting print exposure: Exploring differential links to vocabulary, comprehension and reading rate. *Journal of Research in Reading*, 31(3), 273–284.
- McBride-Chang, C., Manis, F. R., Seidenberg, M. S., & Custodio, R. G. (1993). Print exposure as a predictor of word reading and reading comprehension in disabled and nondisabled readers. *Journal of Educational Psychology*, 85(2), 230–238.
- Mol, S. E., & Bus, A. G. (2011). To read or not to read: a meta-analysis of print exposure from infancy to early adulthood. *Psychological Bulletin*, 137(2), 267–296.
- Moore, M., & Gordon, P. C. (2015). Reading ability and print exposure: Item response theory analysis of the author recognition test. *Behavior Research Method*, 47(4), 1095–1109.
- Muter, V., Hulme, C., Snowling, M. J., & Stevenson, J. (2004). Phonemes, rimes, vocabulary, and grammatical skills as foundations of early reading development: evidence from a longitudinal study. *Developmental Psychology*, 40(5), 665–681.
- Nation, P. (2006). How large a vocabulary is needed for reading and listening? *Canadian Modern Language Review*, 63(1), 59–82.
- Nguyen, L. T. C., & Nation, P. (2011). A bilingual vocabulary size test of English for Vietnamese learners. *RELC Journal*, 42(1), 86–99.
- Ouellette, G. P. (2006). What’s meaning got to do with it: The role of vocabulary in word reading and reading comprehension. *Journal of Educational Psychology*, 98(3), 554–566.
- Pfost, M., Dörfler, T., & Artelt, C. (2013). Students’ extracurricular reading behavior and the development of vocabulary and reading comprehension. *Learning and Individual Differences*, 26, 89–102.
- Porion, A., Aparicio, X., Megalakaki, O., Robert, A., & Baccino, T. (2016). The impact of paper-based versus computerized presentation on text comprehension and memorization. *Computers in Human Behavior*, 54, 569–576.
- Rain, M., & Mar, R. A. (2014). Measuring reading behavior: Examining the predictive validity of print-exposure checklists. *Empirical Studies of the Arts*, 32(1), 93–108.
- Sénéchal, M., LeFevre, J.-A., Hudson, E., & Lawson, E. P. (1996). Knowledge of storybooks as a predictor of young children’s vocabulary. *Journal of Educational Psychology*, 88(3), 520–536.

- Share, D. L., & Leikin, M. (2004). Language impairment at school entry and later reading disability: Connections at lexical versus supralexical levels of reading. *Scientific Studies of Reading, 8*(1), 87–110.
- Siddiqui, S., West, R. F., & Stanovich, K. E. (1998). The influence of print exposure on syllogistic reasoning and knowledge of mental-state verbs. *Scientific Studies of Reading, 2*(1), 81–96.
- Spear-Swerling, L., Brucker, P. O., & Alfano, M. P. (2010). Relationships between sixth-graders' reading comprehension and two different measures of print exposure. *Reading and Writing, 23*(1), 73–96.
- Stainthorp, R. (1997). A children's author recognition test: A useful tool in reading research. *Journal of Research in Reading, 20*(2), 148–158.
- Stanovich, K. E., & Cunningham, A. E. (1992). Studying the consequences of literacy within a literate society: The cognitive correlates of print exposure. *Memory & Cognition, 20*(1), 51–68.
- Stanovich, K. E., & West, R. F. (1989). Exposure to print and orthographic processing. *Reading Research Quarterly, 40*(2), 402–433.
- Stanovich, K. E., West, R. F., & Harrison, M. R. (1995). Knowledge growth and maintenance across the life span: The role of print exposure. *Developmental Psychology, 31*(5), 811–826.
- Suggate, S., Schaughency, E., McAnally, H., & Reese, E. (2018). From infancy to adolescence: The longitudinal links between vocabulary, early literacy skills, oral narrative, and reading comprehension. *Cognitive Development, 47*, 82–95.
doi:<https://doi.org/10.1016/j.cogdev.2018.04.005>
- Ullman, J. B., & Bentler, P. M. (2013). Structural equation modeling. In I. B. Weiner (Ed.), *Handbook of psychology (2nd ed.)* (pp. 607–634): John Wiley & Sons, Inc.
- Zhang, S. Z., Georgiou, G. K., Xu, J., Liu, J. M., Li, M., & Shu, H. (2018). Different measures of print exposure predict different aspects of vocabulary. *Reading Research Quarterly, 53*(4), 443–454.

Appendix. Website Recognition Test (WRT)

32 real website addresses

http://www.humansofnewyork.com/	https://www.theguardian.com
https://en.wikipedia.org	http://www.foxnews.com/
http://www.bbc.co.uk/learningenglish	http://edition.cnn.com/
https://www.quora.com/	http://www.huffingtonpost.com/
https://www.voanews.com/	http://news.bbc.co.uk/
https://www.reddit.com/	http://learningenglish.voanews.com/
http://www.lifehack.org/	http://www.ielts-blog.com/
http://ielts-simon.com/	http://ieltsliz.com/
http://www.wikihow.com/	http://businessinsider.com
https://www.nytimes.com/	https://www.yahoo.com
http://lifehacker.com/	https://www.vocabulary.com/
http://www.ieltsbuddy.com/	http://www.nationalgeographic.com/
https://www.ielts-exam.net/	http://www.fluentu.com/
https://www.ted.com/	http://www.classicreader.com/
http://learnenglish.britishcouncil.org/	http://www.manythings.org
https://learnenglishteens.britishcouncil.org	
https://www.wsj.com	

17 fake website addresses

http://www.bestenglish.com	http://english-skills.com
http://readonlinefree.com	http://goctienganh.com
http://englishreading.com	http://essay-reading.com
http://englishme.com	http://cbcnews.com
http://hoctienganhcaptoc.com	http://englishexam.com
http://ieltsreading.com	http://www.readEnglishonline.com
http://cunghoctienganh.net	https://lifetips.com
http://toeicpractice.com	http://englishfluency.com
http://englishforyourlife.com	

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