Computer-Mediated Immediate and Delayed L1 and L2 Glosses and Vocabulary Learning and Reading Comprehension of an ESP Text

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Abstract

This paper reports on research on how four different computerized gloss types impacted target vocabulary learning and reading comprehension of an ESP text. A total of 100 electrical engineering students were asked to read four differently glossed ESP texts. As for the treatment, the first experimental group read the computerized glossed version of the ESP passages with the target words glossed in L1 (Persian) presented immediately by clicking on the target words. The second group read the same glossed version of the passages, with the target words immediately glossed in L2 (English). The third group was exposed to the target words glossed in L1 presented within a time interval of fifteen seconds by clicking on the words. The fourth group read the same passages with the target words delay-glossed in L2, and the control group read the computerized passages with no glossing. MANOVA results indicated that reading comprehension and target vocabulary learning were enhanced due to the effects of both immediate and delayed computerized glosses in L1 and L2. Also, delayed glossing had a moderating effect on reading comprehension performance. The results showed that the L1 gloss type was more effective than the L2 gloss type on target vocabulary learning and reading comprehension performance of the participants.

Keywords: computerized glossing, L1 and L2 glossing, ESP text, reading comprehension, vocabulary learning

Introduction

Over the years, technology has been used in a variety of educational contexts including teaching and learning foreign languages. Nowadays, mobile phones and computer-based devices have become normalized in our daily lives. These devices come with powerful and friendly multimedia designs, which makes them invaluable to us as sophisticated tools for our daily educational needs.

Since 1960, computer-assisted language learning (CALL) has been used in education for a variety of purposes. Diverse CALL software has been used as

comprehensive alternatives to classic and traditional books and booklets, and other materials. As Gunduz (2005) claims, CALL is traditionally described as a means of presenting, reinforcing, and testing particular language items.

In their integrative review of CALL research in Iran, Fathali and Emadi (2021) commented that contrary to many publications and the overall increasing trend of CALL, fluctuations in the number of publications resemble an unsteady trend of CALL in Iran. Extensive focus on quantitative methods and adult language learners at universities and language institutes, the repetitive study of some specific topics, lack of theoretical basis for the studies, and lack of studies on teachers and languages other than English are found as central concerns in Iran-based CALL (p. 33).

This indicates that CALL research in the Iranian EFL context still needs to be enriched through diverse studies focused on genuine needs. Recently, several computer-based vocabulary enhancement techniques have begun to come to the fore, one of which is concerned with electronic glossing in reading texts (Khezrlou et al., 2017). Glossing refers to providing L1/L2 equivalents of unknown words to facilitate learners' comprehension of texts and improve their vocabulary learning. According to Nation (2013), "a gloss is a brief definition or synonym, either in L1 or L2, which is provided with the text" (p. 238).

Electronic glossing has been distinguished from traditional paper-based glossing. According to Beach et al. (2011), the online multimedia environment provides a special way of reading a text by including hyperlinks to offer multimedia vocabulary information called electronic glosses, in terms of texts, pictures, sounds, videos, etc.

None of the previous studies compared the effect of different types of computerized glosses in an ESP context either in L1 or L2; these studies mainly focused on the learning of English for general purposes (EGP), dealing with diverse EFL learning contexts. Another aspect of novelty in this study has to do with its focus on the time element in presenting the intended gloss types, which became feasible thanks to the computer-mediated glossing procedure. That is, it takes immediate and delayed glosses into account (one may call it the difference between immediate and delayed pop-up glosses), the role of which still requires further investigation.

Given the facilitative role of the computer in providing different gloss types to help enhance the reader's vocabulary knowledge and reading comprehension ability, this study was an attempt to examine the efficacy of immediate and delayed L1 and L2 computer-mediated glosses in promoting target vocabulary learning and reading comprehension of an ESP text in an EFL context, with the time element being a novel aspect of the study.

Literature Review

Glossing in Reading ESP Texts

According to Hutchinson and Waters (1987), "ESP is an approach to language teaching in which all decisions as to content and method are based on the learner's reason for learning" (p. 19). This implies that ESP is strongly linked with learner needs. As such, some of its main features include: discipline-based methodology and activities, designed

for adult learners, and planned for intermediate and advanced learners ((Dudley-Evans & St. John, 1998)

Although for ESP learners to extract information accurately and quickly is more significant than language details (Johns & Davies, 1983), they need to develop their vocabulary scope for this purpose. The interplay between vocabulary and reading comprehension is so concrete and forceful that it has been referred to as 'reciprocal causation' (Bats & Reitsma, 1998; Stanovich**,** 2017)**,** signifying that developing reading comprehension ability entails increasing vocabulary knowledge and reading diverse texts is an efficient route to developing vocabulary knowledge. It is worth mentioning that this interactive relationship holds for understanding ESP texts as well. One well-established method to increase this vocabulary knowledge and, hence, to help improve understanding of ESP texts is glossing.

Theoretically speaking, glossing is grounded in Schmidt's (1995) noticing hypothesis proposing that input needs to be brought to the conscious attention of learners so that it can be further processed by them. By definition, glosses are short definitions or translations of unfamiliar words that can facilitate vocabulary acquisition and reading comprehension by providing the meaning of unfamiliar words (Nation, 2013). Glossing has been viewed from several different perspectives. According to Wenden (1991), glossing is considered a language learning strategy. Blohm (1987) viewed glossing as a metacognitive strategy, a fix-up strategy. As stated by Duffy (2009), the fix-up strategy can help L2 readers to comprehend the message of the text when they stick with certain words or certain sentences (as cited in Suhermanto, 2019). The fix-up strategy includes rereading, reading ahead, identifying unknown words, making and changing predictions, and connecting things in the text to personal experiences and memories (Moreillon, 2007). Moreover, Ha (2016) introduced glossing as a bottom-up lexical help, facilitating L2 vocabulary learning and reading comprehension.

Glossing became an established notion in second language learning due to several reasons: the reading comprehension performance of L2 learners is enhanced by reading glossed versions of passages (Nation, 1983, 1990); glossing aids L2 learners' vocabulary learning development (Watanabe, 1997); students exhibit positive attitudes toward glossing (Jacobs et al, 1994).

A review of previous research reveals that glosses are more effective in acquiring new vocabularies in L2 language in comparison to traditional paper-based dictionaries (Hulstijn et al., 1996; Knight, 1994; Luppescu & Day, 1993).

Concerning the effectiveness of glossing in reading comprehension, the results were mixed; several studies showed no improvement of L2 reading comprehension (Johnson, 1982; Pak, 1986), while others like Davis (1989) and Jacobs (1991) found that L2 learners who read the glossed version of a reading passage comprehended it remarkably better than those exposed to the non-glossed version of the same passage.

Different formats and modes of glosses

Various studies have explored the impact of different gloss formats such as (a) glosses presented at the end of the text, (b) in the margin, (c) at the bottom of the screen, and (d) in a pop-up window (AbuSeileek, 2008, 2011; Cheng & Good, 2009; Morrison, 2004; Yao, 2006; Yeung, 1999; Yeunget al., 1998). Some results showed that marginal glosses were the most effective in improving the reading comprehension of L2 learners.

According to Yeung (1999), in-text gloss formats improve reading comprehension for less-experienced learners; on the other hand, marginal glosses were more effective for more-experienced learners.

Morrison (2004) and Yao (2006) found that the pop-up format was the most effective format which enables L2 learners to adjust glosses based on their individual needs by addressing the issue of learner's control.

Multimedia glosses are computerized versions of glosses that could be presented in different modalities, such as text, pictures, videos, and animations. Researchers have revealed that multimedia glosses especially those that are accompanied by visual modes are more effective for improving reading comprehension and vocabulary learning (Al-Seghayer, 2001; Chun & Plass, 1996; Plass et al., 1998; Yoshii & Flaitz, 2002). Also, some researchers have pinpointed advantages for multimedia glosses over paper-based conventional glosses. First, these glosses can contribute to reading enjoyment as information can be reached at a mouse click without interrupting the reader's attention (AbuSeileek, 2011). Second, they accommodate multiple input formats such as pictures, sound, videos, etc, by which to discover the meaning of unknown vocabulary (Beach et al., 2011). Third, flexible connection methods via hyperlinks yield as much information as possible (Chen & Yen, 2013). Fourth, such glosses can appear freely on any portion of the screen, which is unlike conventional glosses that can be approached only linearly (Khezrlou et al., 2017). Finally, they contribute to reader independence and a more interactive reading context (Beach et al., 2011; Ahmad, 2019).

Glossing and L2 reading and vocabulary learning

Several studies yielded mixed results regarding the impact of L1 or L2 glosses on reading comprehension and vocabulary learning (Jacobs et al., 1994; Chen, 2002; Ko, 2005, 2012). A few studies showed a more positive impact of one type of gloss than the other (Chen, 2002; Jacobs et al., 1994; Miyasako, 2002; Yoshii, 2006; Ko, 2012).

Miyasako (2002) found that L2 glossing was more efficient for high-level Japanese junior high school students than low-level students and the reverse held for L1 glossing.

Ko (2012) explored the impact of L1 and L2 glosses on L2 vocabulary learning of 90 Korean university students. The results revealed a significant difference between non-glossed and glossed conditions. The results also indicated the efficacy of L2 glosses for high-intermediate levels. However, there was no significant difference between L1 and L2 glosses for low-intermediate to intermediate levels.

Sadeghi et al (2016) discovered that out of text-picture, text-audio, and text-picture-audio gloss types, the last type led to better results in learning L2 vocabulary and enhancing reading comprehension in the target language.

In a meta-analysis study, Yanagisawa et al (2020) reported that glossed reading resulted in better learning of words than non-glossed reading. Multiple-choice glosses were the most effective, and in-text glosses and glossaries were the least effective gloss types. L1 glosses led to greater learning than L2 glosses; however, no interaction was found between language (L1, L2) and proficiency (beginner, intermediate, advanced), and no significant difference among modes of glossing (textual, pictorial, auditory) was observed. Cakmak and Erctin (2018) studied the effects of multimedia glosses on text recall and incidental vocabulary learning in a mobile-assisted L2 listening task. Their

results showed that glossing helped facilitate the recognition and production of vocabulary, whereas gloss type played no role in this regard. On the other hand, glosses had no effect on text recall. Fakher Ajabshir (2022) investigated the effects of L1 and L2 glosses along with their formats on the incidental vocabulary learning of Iranian EFL learners. Her findings showed that the impact of L1 glosses was more than the L2 ones in such a way that L1-margin and L1-bottom were ranked in superiority before L2-margin and L2-bottom glosses although the delayed posttest results indicated no superiority for the language of the glosses.

In a critical review of glossing and L2 vocabulary learning, Boers (2022) concluded that many questions still remain to be answered in this research area and that this is due to the diverse research designs utilized along with insufficient transparent research reports. Some studies have also focused on the effect of different types of electronic glosses on reading comprehension and/or vocabulary acquisition of FL learners (Al-Seghayer 2001; Rouhi & Mohebbi, 2012; Khezrlou 2018; Khezrlou et al., 2017; Lee & Lee, 2014; Salem & Aust, 2007; He, 2019). He (2019), for example, found that glosses, in general, had a positive effect on incidental vocabulary acquisition in Chinese, but he found no differences between paper-based, e-dictionary, and pop-up glosses in this regard. Focusing on the effects of electronic glosses on EFL learners' noticing and retention of idioms in reading, Zuo (2020) found that these glosses were effective in learning such lexical items as idioms. Namaziandost et al. (2021) investigated the effects of three modes of CALL-based, MALL-based, and classroom-based L2 vocabulary learning by Iranian EFL learners. Their results revealed the overall effectiveness of technology-based learning in learning the target language vocabulary. Durongbhandhu and Suwanasilp (2021) concluded that multimodal glossing was more effective than textual glossing in English vocabulary acquisition for the EFL learners in Thailand. Tadayonifar et al. (2021) studied the impact of computer-assisted L1 and l2 textual and audio glosses on reading comprehension and vocabulary learning across different learning styles. They found that L1 glosses were more beneficial than L2 glosses for vocabulary learning. The study also showed that textual glosses were more effective than audio glosses for vocabulary learning. In a meta-analysis review of studies on the efficacy of multimedia annotations in vocabulary learning, Vahedi (2021) concluded that hypertext annotations had a large, positive, significant effect on learners' vocabulary development.

Purpose of the Study

Given the gap mentioned above as well as the mixed results obtained in some studies, this study sought to explore the impact of computer-mediated L1 and L2 glosses on vocabulary learning in an ESP context. Moreover, the researchers intended to find out whether the learners' vocabulary learning development and reading comprehension performance could be promoted by introducing immediate and delayed computerized L1 and L2 glosses. To this end, the following research questions were raised:

Research Questions

RQ1: What is the effect of computerized immediate L1 glossing on the participants' reading comprehension of an ESP text and their target vocabulary learning?

RQ2: What is the effect of computerized delayed L1 glossing on the participants' reading comprehension of an ESP text and their target vocabulary learning?
RQ3: What is the effect of computerized immediate L2 glossing on the participants' reading comprehension of an ESP text and their target vocabulary learning?
RQ4: What is the effect of computerized delayed L2 glossing on the participants' reading comprehension of an ESP text and their target vocabulary learning text?

Methodology

The Design of the Study

Even though there have been a few studies on the effects of computerized L1 and L2 glosses on incidental vocabulary learning and reading comprehension performance of EFL learners, the effects of computerized L1 and L2 glosses considering the time element in an ESP context have not yet been examined. Thus, the design of the study tends to be more exploratory than confirmatory in this respect. Also, due to non-random sample selection, the design can be labeled a quasi-experimental pre-test/post-test design. As for the variables, computerized glossing across two levels (immediate and delayed) and gloss type (L1 and L2) constituted the independent and moderator variables, respectively; target vocabulary learning and reading comprehension comprised the dependent variables of the study.

Participants

The participants consisted of five intact groups, including 100 undergraduate students of Electronic Engineering recruited from the University of Zanjan, Iran, during the academic year of 2019-2020. They were both male and female students and all were native speakers of Persian. They were taking their ESP course in Electrical Engineering. Their English language proficiency level was labeled as intermediate. They were between 19 and 24 years old.

Instruments

The Quick Proficiency Test (OQPT): This test was used to select the intermediate EFL learners as the participants. It is a widely used test that contains 60 multiple-choice type items focusing on vocabulary and grammar. Some items are presented in a cloze format. According to the scoring procedure, the learners who scored from 0 to 17 were beginners; the learners whose scores stood between 18 and 29 were considered as elementary learners; the learners whose scores fell within the range 30 to 39 were intermediate learners; those learners whose scores were between 40 to 47 were upper intermediate; the learners who obtained scores from 48 to 54 were considered as the advanced learners; finally, the students whose stood between 55- 60 were proficient English learners. Those subjects whose scores fall within the range of 30-39 were selected as the final intermediate participants of the study (N = 100). The Cronbach alpha for this test in the current study was calculated at 0.78.

Vocabulary Learning Test: A Vocabulary Knowledge Scale (VKS) based on Paribakht and Wesche's (1999) model was used as pre-test and post-test. Given the levels suggested by the model, those vocabulary items unknown to or not recalled by over 80 percent of the participants were selected to be included in glosses.

Level IV = I know what this word/phrase means and I can use it in a sentence.
Level III = I know what this word/phrase means, but I'm not sure how to use it.
Level II = I've seen this word/phrase before, but I don't know what it means.
Level I = I've never seen this word/phrase before.

Reading comprehension pre-test and post-test: An ESP reading comprehension test, including 15 multiple choice and true/false items, was used to measure the comprehension of each text before and after the treatment for pre-test and post-test purposes. These tests were based on four reading passages selected from an ESP textbook by Haghani (2018).

To estimate the validity and reliability of the instruments, the reading comprehension test was given to a pilot group of 20 students with characteristics identical to those of the target sample. The Cronbach alpha for the test was calculated at 0.82. Two professors, one from the Electrical Engineering Department and another from the English Language Department at the University of Zanjan, Iran, were asked to rate the test for its content and construct validity. The professors were asked to judge the validity of the four reading comprehension tests by responding to a questionnaire. The questionnaire was a five-point Likert-type scale. The mean obtained from the ratings was 4.62 out of 5, which indicated a high degree of agreement on the validity of the test. The inter-rater reliability index turned out to be 0.78 which indicated a moderate rate of agreement between the two raters.

Materials

The ESP Reading Passages: The textbook used in the University of X for the ESP course was written by Haghani (2018) and published by the SAMT Organization, Iran. The book is composed of twenty short passages on different topics in electronics followed by comprehension questions.

Target lexical items/glosses: To choose the target lexical items, the above-mentioned VKS scale was deployed to ensure their unfamiliarity to the participants. Based on the VKS, the vocabularies that were neither familiar to nor could be recalled by more than 80% of the participants were chosen as the target lexical items.

The researcher-designed website: The researchers designed a new website to present the immediate and delayed computerized glosses in L1 and L2 to the participants (http://fatimafaghfouri.ir). Via this website, the researchers presented the four different gloss types within the four reading comprehension passages, accompanied by the reading comprehension tests and VKS-based target word tests. The startup page of the website provided a brief overview of the research and the computerized glosses to inform the participants and persuade them to take the intended test. Then, the participants were asked to declare their consent to participate in the project. On the next page, they were required to provide some demographic information about their education, mother tongue, English proficiency level, gender, and age. By clicking on the "next" option, a short description

appeared providing instructions as to how to take the test on the next page. It should be noted that the overview of the project and the required information were all provided both in Persian and English to make it easier for the participants to continue with the procedure.

Data Collection Procedure

The participants were five intact groups that were randomly divided into one control group and four experimental groups. After homogenizing the participants based on the proficiency test scores, the next step was to administer a pilot reading comprehension test to calculate the reliability and validity of the main pre/post-tests to be used later in the study. Afterward, the participants were given the reading comprehension tests and the vocabulary knowledge scale (VKS) as pre-tests to ensure their homogeneity regarding their reading comprehension and to determine which target words were unfamiliar to the participants before treatment application. Forty vocabulary items were selected randomly from among the four passages. Finally, thirty out of forty words of the VKS were selected as the target words. Then after two weeks, the four experimental groups were asked to read the computerized texts with four different types of glosses.

Four passages were randomly selected from the book mentioned earlier. Since the book was suggested by the curriculum of the Ministry of Education, the selected passages all suited the level and needs of the participants. After obtaining the results of the VKS and the reading comprehension pretest, the four passages which also contained the target words were selected to be included in the process of implementing computerized glosses.

As for the computerized glosses, the reading texts were prepared in five versions:(a) texts with immediate L1 glosses, (b) texts with immediate L2 glosses, (c) texts with delayed L1 glosses, (d) texts with delayed L2 glosses, and (e) texts with no glosses. Then, these texts were presented to each respective experimental group. Afterward, the computerized L1 glosses containing the meaning of the words in L1 (Persian) were presented immediately to the reader by clicking on the target words; then the second group was exposed to the meaning of the target words immediately by clicking on the words in L2 (English). In the third group, the participants who received delayed L1 (Persian) glosses were exposed to the meanings of the target words after fifteen seconds by clicking on the words. The participants in the fourth group were treated to the target word L2 (English) glosses in the same way as the third group. Finally, the control group read the computerized reading comprehension passages with no glosses.

Data Analysis

Both descriptive and inferential statistical analyses were used for data analysis. To ensure the groups' homogeneity before applying the treatment, two one-way ANOVA tests were run: one for reading comprehension pre-test and another for vocabulary learning pre-test, and a MANOVA analysis was employed to answer the respective research questions. All the analyses were performed via the SPSS software.

Results

Verifying the assumptions for MANOVA

As the first step, the Kolmogorov test was run on all the pre-tests and post-tests to ensure the normality of the distributions. Moreover, the skewness and kurtosis test was calculated to further establish the normal distribution of the data. The results confirmed the normality of distribution for all the pre-tests and post-tests (all the Asymp. p values > .05). Also, the Levene's test the results revealed no violation of homogeneity of variances for the VKS [F (4 95) = 1.505, p = 0.207] and reading comprehension [F (4 95) = 1.164, p = 0.239] post-tests. Consequently, the researchers were able to run the required ANOVA and MANOVA tests to answer the research questions of the study.

Results for the homogeneity of the groups

To ensure the homogeneity of the participants across the five groups regarding their performance on reading comprehension of ESP text pre-tests, a one-way ANOVA test was used before treatments. There was no significant difference between the groups [F (4 95) =2.044, p =. 09>. 05]. Therefore, the homogeneity of the groups was confirmed for reading comprehension as the first dependent variable of the study. Likewise, another one-way ANOVA was run for the homogeneity of the groups regarding target vocabulary knowledge before treatments. There was no significant difference between the groups [F (4 95) =1.051, P=.38>. 05]. Thus, the homogeneity of the groups was confirmed.

MANOVA Results

As mentioned earlier, the MANOVA test was deployed as the main statistical procedure to answer the research questions of the study. The test results for this analysis are presented in Tables 1 and 2 below.

Table 1
Multivariate Tests

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Pillai's Trace	.249	15.221	2.000	92.000	.000	.249
	Wilks' Lambda	.751	15.221	2.000	92.000	.000	.249
	Hotelling's Trace	.331	15.221	2.000	92.000	.000	.249
	Roy's Largest Root	.331	15.221	2.000	92.000	.000	.249
Pre Reading	Pillai's Trace	.850	261.166	2.000	92.000	.000	.850
	Wilks' Lambda	.150	261.166	2.000	92.000	.000	.850
	Hotelling's Trace	5.678	261.166	2.000	92.000	.000	.850
	Roy's Largest Root	5.678	261.166	2.000	92.000	.000	.850
Pre VKS	Pillai's Trace	.653	86.644	2.000	92.000	.000	.653
	Wilks' Lambda	.347	86.644	2.000	92.000	.000	.653
	Hotelling's Trace	1.884	86.644	2.000	92.000	.000	.653

	Roy's Largest Root	1.884	86.644	2.000	92.000	.000	.653
Group	Pillai's Trace	1.191	34.207	8.000	186.000	**.000**	.595
	Wilks' Lambda	.084	56.167	8.000	184.000	**.000**	.709
	Hotelling's Trace	7.588	86.319	8.000	182.000	**.000**	.791
	Roy's Largest Root	7.131	165.805	4.000	93.000	**.000**	.877

As is evident from the table above, significant differences were found between the groups' performances on the pre-tests and post-tests, which suggests a meaningful effect of the independent variables (L1 immediate glossing, L2 immediate glossing, L1 delayed glossing, L2 delayed glossing) on the dependent variables (VKS and reading comprehension) [(F (8 184) = 56.167, p = .000; Wilks' Lambda = .84].

Table 2
Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Post VKS	10229.002[a]	14	730.643	53.911	.000
	Post Reading	1365.886[b]	14	97.563	102.757	.000
Intercept	Post VKS	126.751	1	126.751	9.352	.003
	Post Reading	23.890	1	23.890	25.162	.000
Group	Post VKS	23.071	4	5.768	.426	.039
	Post Reading	21.853	4	5.463	5.754	.000
Pre VKS	Post VKS	492.092	1	492.092	36.309	.000
	Post Reading	10.057	1	10.057	10.592	.002
Pre Reading	Post VKS	3.672	1	3.672	.271	.604
	Post Reading	219.486	1	219.486	231.170	.000
Group * Pre VKS	Post VKS	368.150	4	92.037	6.791	.000
	Post Reading	24.004	4	6.001	6.320	.000
Group * Pre Reading	Post VKS	107.074	4	26.769	1.975	.106
	Post Reading	11.561	4	2.890	3.044	.021
Error	Post VKS	1151.988	85	13.553		
	Post Reading	80.704	85	.949		
Total	Post VKS	952475.000	100			
	Post Reading	243609.000	100			
Corrected Total	Post VKS	11380.990	99			
	Post Reading	1446.590	99			

It is understood from the table above that the independent variables had significant effects on VKS [F (1 98) = 36.309, p = 0.000 <. 05] and reading comprehension [F (1 98) = 231.170, p = 0.000 <. 05].

As shown in Tables 3 and 4 below, there was a significant difference between the L1 immediate glossing and the control groups' performances on their ESP reading comprehension post-test (MD = 2.68, $p < 0.5$). Likewise, a significant difference was found between the L1 immediate glossing and the control groups' performance on the target vocabulary learning post-test (MD = 18.03, $p = 0.000 < 0.05$). This means that computerized immediate L1 glossing significantly contributed to the group's performance on reading comprehension and target vocabulary learning.

Table 3
Pairwise Comparisons for Reading Comprehension (five groups)

Dependent Variable	(I) Group	(J) Group	Mean Difference	Std. Error	Sig.[b]	Lower Bound	Upper Bound
Post Reading	L1 Immediate	L1 Delayed	-4.272*	.381	.000	-5.367	-3.177
		L2 Immediate	1.333*	.427	.024	.107	2.560
		L2 Delayed	-1.147*	.378	.031	-2.234	-.060
		Control	2.683*	.364	.000	1.637	3.730
	L1 Delayed	L1 Immediate	4.272*	.381	.000	3.177	5.367
		L2 Immediate	5.606*	.366	.000	4.552	6.659
		L2 Delayed	3.125*	.353	.000	2.110	4.140
		Control	6.955*	.393	.000	5.825	8.086
	L2 Immediate	L1 Immediate	-1.333*	.427	.024	-2.560	-.107
		L1 Delayed	-5.606*	.366	.000	-6.659	-4.552
		L2 Delayed	-2.480*	.366	.000	-3.533	-1.428
		Control	1.350*	.449	.034	.059	2.641
	L2 Delayed	L1 Immediate	1.147*	.378	.031	.060	2.234
		L1 Delayed	-3.125*	.353	.000	-4.140	-2.110
		L2 Immediate	2.480*	.366	.000	1.428	3.533
		Control	3.830*	.398	.000	2.686	4.975
	Control	L1 Immediate	-2.683*	.364	.000	-3.730	-1.637
		L1 Delayed	-6.955*	.393	.000	-8.086	-5.825
		L2 Immediate	-1.350*	.449	.034	-2.641	-.059
		L2 Delayed	-3.830*	.398	.000	-4.975	-2.686

Table 4
Pairwise Comparisons for VKS (five groups)

Dependent Variable	(I) Group	(J) Group	Mean Difference	Std. Error	Sig.[b]	Lower Bound	Upper Bound
Post VKS	L1 Immediate	L1 Delayed	-5.108*	1.506	.010	-9.437	-.779
		L2 Immediate	10.960*	1.686	.000	6.112	15.808
		L2 Delayed	6.383*	1.494	.000	2.086	10.680
		Control	18.035*	1.439	.000	13.898	22.172
	L1 Delayed	L1 Immediate	5.108*	1.506	.010	.779	9.437
		L2 Immediate	16.068*	1.448	.000	11.906	20.231
		L2 Delayed	11.491*	1.395	.000	7.478	15.503
		Control	23.143*	1.554	.000	18.675	27.612
	L2 Immediate	L1 Immediate	-10.960*	1.686	.000	-15.808	-6.112
		L1 Delayed	-16.068*	1.448	.000	-20.231	-11.906
		L2 Delayed	-4.578*	1.447	.021	-8.738	-.418
		Control	7.075*	1.775	.001	1.972	12.178
	L2 Delayed	L1 Immediate	-6.383*	1.494	.000	-10.680	-2.086
		L1 Delayed	-11.491*	1.395	.000	-15.503	-7.478
		L2 Immediate	4.578*	1.447	.021	.418	8.738
		Control	11.653*	1.573	.000	7.128	16.177
	Control	L1 Immediate	-18.035*	1.439	.000	-22.172	-13.898
		L1 Delayed	-23.143*	1.554	.000	-27.612	-18.675
		L2 Immediate	-7.075*	1.775	.001	-12.178	-1.972
		L2 Delayed	-11.653*	1.573	.000	-16.177	-7.128

As evident from Table 3 above, a significant difference was found between the L1 delayed glossing and the control groups' performance on the ESP reading comprehension post-test (MD = 6.955, p = 0.000 < 0.05). Likewise, as indicated by Table 4, there was a significant difference between the L1 delayed glossing group and the control group's performance on the target vocabulary learning posttest (MD = 23.143, p = 0.000 < 0.05). Consequently, the answer to the second research question was in the affirmative. This means that computerized delayed L1 glossing significantly contributed to the group's performance on reading comprehension and target vocabulary learning.

As is clear in Table 3, there was a difference between the L2 immediate glossing and the control groups' performance on the ESP reading comprehension post-test (MD = 1.350, p = 0.034 < 0.05). Also, as indicated by Table 4 above, a significant difference was found between the L2 immediate glossing and control groups regarding their performance on the target vocabulary test (MD = 7.07, p = 0.001 < 0.05). As a result, the third research question was also answered positively. This means that computerized immediate L2

glossing significantly contributed to the group's performance on reading comprehension and target vocabulary learning.

As revealed in Table 3 above, a significant difference was found between L2 delayed glossing and the control groups' performances on the ESP reading comprehension post-test (MD = 3.830, p = 0.000< 0.05). Likewise, according to Table 4 above, a significant difference was found between the delayed L2 glossing and control groups' performances on the target vocabulary learning post-test (MD = 11.653, p = 0.000< 0.05). Hence, the answer to the fourth research question was also in the affirmative. This means that computerized delayed L2 glossing significantly contributed to the group's performance on reading comprehension and target vocabulary learning.

As for the experimental groups' performances on reading comprehension, for both L1 and L2 gloss types, as understood from Table 3, delayed glossing was more effective than immediate glossing ($MD_{L1} = 4.27$; $MD_{L2} = 2.48$). Also, delayed L1 glossing was more effective than delayed L2 glossing (MD = 3.12). By the same token, immediate L1 glossing was more effective than immediate L2 glossing (MD = 1.33). Delayed L1 glossing was far more effective than immediate L2 glossing (MD = 5.60). In conclusion, it can be said that, apart from the fact that all gloss modalities were effective, (a) both delayed and immediate L1 gloss types were more effective than their L2 counterparts, (b) delayed L1 gloss type was the most effective glossing, and (c) delayed L2 glossing was more effective than immediate L2 glossing.

Concerning the experimental groups' performances on target vocabulary learning, as understood from Table 4, delayed glossing was more effective than immediate glossing ($MD_{L1} = 5.10$; $MD_{L2} = 4.57$). Also, delayed L1 glossing was much more effective than delayed L2 glossing (MD = 11.49). By the same token, immediate L1 glossing was more effective than immediate L2 glossing (MD = 10.96); delayed L1 glossing was far more effective than immediate L2 glossing (MD = 16.06). In conclusion, it can be said that, apart from the fact that all gloss modalities were effective, a) both delayed and immediate L1 gloss types were more effective than their L2 counterparts, b) delayed L1 gloss type was the most effective glossing, and c) delayed L2 glossing was more effective than immediate L2 glossing.

Discussion

This study investigated the effectiveness of four different types of computerized glossing on improving reading comprehension and vocabulary learning of ESP learners at the University of Zanjan, Iran. Based on the findings, there was a significant difference between the efficacy of L1 delayed, L2 delayed, L1 immediate, and L2 immediate computerized glossing on reading comprehension and vocabulary learning development in an ESP learning context. This finding can be said to give more credit to those research findings indicating the positive impact of glossing on L2 vocabulary learning and reading comprehension (Boers, 2022; Fakher Ajabshir, 2022; Ko, 2012; Sadeghi et al., 2016; Yanagisawa et al., 2020).

The first research question explored the effectiveness of L1 immediate computerized glossing on the participants' reading comprehension of an ESP text and their target vocabulary learning. Based on the findings, the reading comprehension of an ESP text and target vocabulary learning of the first experimental group improved

considerably compared to their counterparts in the control group on the posttests. This finding is in line with previous research supporting the effectiveness of L1 glossing in L2 vocabulary development (Cakmak & Ertin, 2018; Cheng & Good, 2009; Fakher Ajabshir, 2022; Ha, 2016; Rouhi & Mohebbi, 2012; Sadeghi et al., 2016; Tadayonifar et al., 2021; Yanagisawa et al., 2020).

The second research question was posed to explore the efficacy of L1 delayed computerized glossing on the participants' reading comprehension of an ESP text and their target vocabulary learning. The results indicated that the reading comprehension of an ESP text and target vocabulary learning of the second experimental group who were exposed to L1 delayed computerized glossing improved significantly in comparison with their counterparts in the control group on the post-test. The results of similar studies conducted on the effects of LI glossing on L2 reading comprehension and vocabulary learning are mixed and controversial (Davis, 1989; Jacobs et al., 1994; Lomicka, 1998; Taylor, 2006; 2009; 2013). Miyasako (2002) claimed that L2 glosses were more effective than L1 glosses in enhancing vocabulary learning of L2 learners; while according to Taylor (3013), the chance of better text comprehension is significantly high for learners exposed to L1 glossing either in a CALL environment or otherwise. In addition, L1 computerized glossing has generally been more effective (Taylor, 2006, 2009; 2013). Although the findings for this research question are in line with the general spirit of other findings in favor of L1 gloss types, it can reveal the need for further probing to better clarify the picture of the related literature and decrease the number of mixed results to the extent possible. Also, it is worth mentioning that the concept of delayed glossing is a novel aspect in this study; from this perspective, the study is exploratory, which is why comparison against respective relevant findings by other studies is hardly feasible.

The third research question investigated the effectiveness of L2 immediate computerized glossing on the participants' reading comprehension of an ESP text and their target vocabulary learning. The results revealed a little improvement of the participants' reading comprehension of an ESP text in comparison with their counterparts in the control group; on the other hand, a significant difference was found between the L2 immediate glossing and the control groups' performances on the target vocabulary learning post-test. In other words, target vocabulary learning of the third experimental group improved considerably in comparison with their counterparts in the control group on the post-test. This finding is also in agreement with similar findings in the related literature (Ko, 2012; Miyasako, 2002).

Regarding the fourth research question of the study, the results rejected the null hypothesis, which means that L2 delayed computerized glossing enhanced the reading comprehension and vocabulary learning of the EFL learners in ESP text.

The main findings revealed that all the four different modalities of computerized glosses were effective in enhancing the participants' reading comprehension of an ESP text and their target vocabulary learning in comparison with their counterparts in the control group; these findings are in line with the findings of several studies that showed learners with CALL glossing do better than with no glossing in L2 reading comprehension and/or vocabulary learning (Chen & Yen, 2013; He, 2019; Plass et al., 2003, Zuo, 2020).

Chen and Yen (2013) examined the impact of three different computerized glosses (annotation formats) as three different experimental conditions on hypertext reading comprehension and vocabulary acquisition of non-English-majored university students in Taiwan. The results indicated that the reading comprehension performance of

the groups with CALL glossing improved considerably more than those without CALL glossing. In another study, Taylor (2009) suggested several reasons for the efficacy of CALL glosses, (a) providing more glossed items for L2 readers, (b) more options and selectivity are provided for L2 learners by CALL glosses. In addition, in this meta-analysis study, Taylor (2009) suggested that about 81% of the learners who read the computerized glossed version of passages performed higher on tests of reading comprehension than those who read no glossed version of the passages.

The improvement of reading comprehension performance and vocabulary learning of the learners exposed to L1 and L2 delayed glosses was higher than their immediate counterparts. This indicated that the rate of reading comprehension of ESP texts and vocabulary learning was higher when the meaning of the glossed target words appeared a few seconds after clicking on the unfamiliar words, where the learners have time to read the surrounding words before and after the unknown word to guess the meanings and benefit from context clues. It can be concluded that the process of thinking and guessing the meanings from the text facilitates comprehending and vocabulary learning in ESP passages.

Finally, the results showed that L1 delayed glossing was the most effective gloss among the four different modalities of glosses for both reading comprehension performance and vocabulary learning of the learners; this is while the L2 immediate gloss was the least effective one. According to Taylor (2006), the facilitating role of L1 glossing is dependent on several conditions (a) if there are enough L1 glosses for basic comprehension of the text, (b) if there is a fit between the learners' level and the text's level. These two conditions were present in this study. In addition, other variables can be associated with L1 glossing to enhance the facilitating role of L1 glossing on reading comprehension performance and vocabulary learning of L2 learners. The time element was also associated with L1 glossing in the current study, in which the meanings of the glossed words were visible a few seconds after clicking on the glossed word, facilitating guessing from the context.

Several studies confirmed the greater efficacy of L1 glossing in comparison with L2 glossing on improving reading comprehension performance. According to Taylor (3013), the chance of better text comprehension is significantly high for learners exposed to the L1 glossing either in the CALL environment or otherwise. In addition, L1 computerized glossing is generally more effective (Taylor, 2006, 2009, 2013).

Our findings are in contrast with the findings of a study conducted by Hu et al., (2014), who explored the efficacy of Chinese and English electronic-glosses on incidental English vocabulary learning on a less-researched student group in CALL, junior-high-school, (EFL) students. The students with a high level of proficiency exposed to L2 (English) glosses did better in the vocabulary learning test than those exposed to L1 glosses. In a similar study, Ko (2012) found no significant differences between L1 and L2 glosses on improving L2 vocabulary learning of low-intermediate to intermediate level university students. All these contradictory mixed findings may be justified because studies on the issue of glossing and gloss types are conducted on highly diverse conditions and contexts with samples from varied L1 and cultural backgrounds and diverse components of L1 and L2, each study being influenced by its intervening variables. Thus, the cherished merit of these mixed findings lies in the fact that they remind the interested researchers of the need for more relevant studies across the globe before a complete

picture of the conclusive results can be achieved. This study is hoped to be regarded as part of such globally required efforts in this regard.

Conclusion

It can conclude that delayed and immediate computerized glosses either in L1 or L2 are influential in enhancing the reading comprehension and vocabulary learning of the learners in an ESP text and that the time element played a more significant role in enhancing the vocabulary learning of the learners. The findings of this study carry with them a number of pedagogical implications for ESP teachers, learners, and practitioners. Electronic glosses could be utilized either in L1 or L2 to enhance the learners' vocabulary learning in an ESP context. In addition, comprehending ESP texts is a challenge to ESP learners. Thus, delayed L1 and L2 computerized glosses applied to such ESP passages could be considered as one way to improve upon some shortcomings encountered in the ESP textbooks published for ESP students to help them better develop their vocabulary and reading comprehension to be able to read and understand texts about their relevant fields of study. In short, the diverse types and modes of glossing can be deployed in ESP courses to enrich the input and contribute to higher rates of achievement in developing target vocabulary and reading comprehension performance in such ESP programs. Moreover, due to some limitations, the findings of this study need to be generalized with due reservation. The moderating role of gender was not checked in this study; thus, further studies could be conducted to explore any efficacy for the gender variable in this research context. Also, language proficiency level was limited to the intermediate level; further studies may focus on finding any different results across the male and female subjects. Likewise, the major of the target sample in focus was electrical engineering; further studies can take up other fields of study to help contribute to a clearer picture of the related literature. Finally, due to the flexibility of computer-mediated glossing, diverse gloss formats can also be taken into consideration by other studies in the same research context.

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