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Using Google Keyboard in L2 Writing: Impacts on Lexical Errors Reduction

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ABSTRACT

The current study investigated integrating Google keyboard (Gboard) into L2 writing and the associated effects on lexical error reduction. The participants were 47 intermediate level Turkish English as a foreign language (EFL) learners, who were divided into four groups (one control group and three experimental groups). During the study, they were asked to write paragraph-length responses to a number of topics during classroom hours. The participants in the control group used pencil and paper in their writing, yet the participants in two experimental groups produced four responses using Gboard and four responses using pencil and paper at different weeks, and one experimental group used Gboard for writing about all the topics. Data analyses indicated that the use of Gboard resulted in a significant reduction of various lexical errors and increased accuracy ratios in the participants' written responses. The implications of the study have been discussed.

Writing is one of the most important skills that second language learners need to develop. Over the past decades, interest in second language (L2) writing and approaches to teaching it have increased dramatically (Hyland, 2003, 2016). Considering the transitions in language teaching practices in formal and institutional contexts towards blended and online platforms (Meskill & Quah, 2012), traditional views of literacy have been challenged and the Internet and digital tools "have redefined literacies as social practices that are fluid, sociocultural, multimodal, and dynamic" (Chen, 2013, p. 143). In addition, it is argued that most of our daily literacy practices in areas such as education, work, and social life have moved onto the screens (Pennington, 2003). In this regard, there is a major upheaval for a "reevaluation of literacy, writing genres, and associated instructional practices in the L2 classroom" (Elola & Oskoz, 2017, p. 5).

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Digital technologies have dramatically reshaped the forms and purposes of writing in general (Chun et al., 2016), and nowadays students are engaged in a variety of technology-induced literacy activities beyond the classroom including text-messaging, emailing, and chatting through computer-mediated mediums (Zheng & Warschauer, 2017). In this context, all teachers, schools, and higher education faculties are challenged to respond to the changing nature of writing (Li et al., 2017). Moreover, despite the developments in computer-mediated communication (CMC) technologies, our knowledge regarding the changing nature of writing in these new environments is still fairly limited (Li & Storch, 2017).

Technological advancements have also motivated an increased interest in mobile-assisted language learning (MALL) pedagogy (Nazari & Xodabande, 2020; Wrigglesworth & Harvor, 2018). Despite the fact that many studies have investigated the potentials of new technologies for developing various language skills (Burston, 2013), L2 writing has received scant attention, and a recent review concluded that it has been neglected in MALL studies to a large extent (Duman et al., 2015). As current students attend classes with their mobile or tablet devices on which they do most of their reading, searching, and learning (Zhang, 2015), knowing about the affordances of these learning environments is significant because it helps us better understand the learners' associated behaviours and performances (Ko, 2017). Li and Storch (2017) stress that the affordances of these new environments for developing L2 writing have not yet been adequately explored. One such environment is Google keyboard (Gboard). Gboard is a virtual keyboard app developed by Google for Android and iOS devices, which supports a variety of languages. In this regard, the current study aims to investigate the benefits of using Gboard in L2 writing and more specifically the way it provides learners with affordances to produce more accurate written texts with fewer lexical errors.**2.**

2. Literature Review

Educational technology in its various forms has long provided insights into language teaching/learning (Farr & Murray, 2016), and over the last three decades language learning has become one of the most popular areas of education in the application of new learning technologies (Thomas et al., 2012). There is a growing body of knowledge indicating that the application of various educational technologies has generally been effective in enhancing students' learning and performance (Golonka et al., 2014; Liu et al., 2014; Schmid et al., 2014; Tamim et al., 2011). In this regard, mobile technologies have also been claimed to enhance learning outcomes, particularly writing.

One of the language skills that constitutes a great share in CMC-driven interpersonal communications is writing. As a result of significant developments in various digital technologies, this line of research has gained increasing attention in language pedagogy (Li, 2018). Within this line of thinking, a number of studies have investigated the role of various technologies in improving the writing competencies of language learners in different contexts (e.g., Abrams, 2016; Alharbi, 2020; Amiryousefi, 2017; Dizon, 2016; Purcell et al., 2013; Shadiev et al., 2017; Wang, 2015; Zhu et al., 2016; Zou et al., 2016). There is growing recognition that computer-based writing and its various types improve the overall writing quality (Bikowski & Vithanage, 2016; Elola & Oskoz, 2017; Wang, 2015). Among these types, earlier research has investigated the applications of Google Docs (e.g., Abrams, 2016; Alharbi, 2020; Ebadi & Rahimi, 2017; Seyyedrezaie et al., 2016), Google Drive (e.g., Marandi & Seyyedrezaie, 2017), and blogs (e.g., Arslan & Şahin-Kızıl, 2010; Kashani et al., 2013) in L2 writing instruction, all highlighting the potentials of these new technologies in improving the learners' writing performance.

2.1. MALL and L2 Writing

MALL has been the focus of many studies in regard to how various mobile-related technologies enhance the quality of writing. This line of research has examined the application of MALL to L2 writing

across school-level students (Ahmadpour & Yousefi, 2016; Al-Hamad et al., 2019; Chen et al., 2017; Estarki & Bazyar, 2016; Hwang et al., 2014; Lee, 2020; Malekzadeh & Najmi, 2015; Yamaç et al., 2020) and university-level students (Andujar, 2016; Li & Hegelheimer, 2013). For example, Yamaç et al. (2020) investigated the effects of digital writing with tablet devices on 96 primary-school students' writing performance and writing knowledge. This study reported that stories written by tablets were qualitatively better and had/included a higher number of words compared to stories written by paper and pencil.

In a study exploring the benefits of instant messaging on 80 Spanish university students, Andujar (2016) examined ESL writing accuracy and complexity of the students in WhatsApp platform across their interactions. A pre-test-post-test quasi-experimental design was employed where the students were divided into two control and experimental groups. Data analyses revealed significant differences between the two groups, attesting to the outperformance of the experimental group. In another study comparing the written texts composed via pencil-and-paper and smartphones of 1449 Japanese undergraduate university students, Lee (2020) found that the texts written on paper were longer than those written on smartphones. Lee concluded that students should be trained in how to use smartphones and there are caveats that should be heeded in designing mobile-oriented activities. This body of knowledge highlights examining writing proficiency in light of fluency, accuracy, and complexity of the texts, particularly lexical development of the students.

2.2. MALL and L2 Vocabulary

A dominant thread among the studies exploring the contributions of mobile technologies to L2 writing is the examination of vocabulary. This line of research has explored how mobile technologies could be employed to enhance lexical development of students (Alemi et al., 2012; Basal et al., 2016; Vurdien, 2017; Wong et al., 2016; Wu, 2015; Xodabande & Atai, 2020). For example, Alemi et al. (2012) examined the application of SMS to 45 Iranian EFL university students' Academic Word List learning and retention. The participants were divided into a control and an experimental group, with the former receiving instruction via dictionary and the latter using SMS to learn the words. Data analyses indicated that while in the post-test the groups did not differ in their performance, the experimental group outperformed the control group in the delayed post-test in learning and retention of the target words. In another study, Basal et al. (2016) investigated the application of WhatsApp to 50 Turkish first year university students' idiom learning. The participants were divided into a control and an experimental group. The control group received hand-outs to learn the idioms and the experimental group learned the idioms through WhatsApp. The results indicated the outperformance of the experimental group in comparison to the control group in the post-test.

Studies of this line of inquiry have often taken the form of comparing control and experimental groups on their vocabulary learning via mobile technologies of various types. While the above literature points to the effectiveness of mobile technologies in improving vocabulary learning, these studies have treated vocabulary learning holistically and little attention has been paid to the process of vocabulary learning. That is, the way such learning could be mediated developmentally by using mobile technologies to focus on lexical properties of vocabulary development has received inadequate attention. One important feature of lexical development is errors, which can hinder successful communication and lower the accuracy of texts, especially considering the fact that "lexical errors serve as quality predictors and show evidence of lack of lexical knowledge and low language proficiency in general" (Llach, 2007, p. 4). A significant gap in this line of research, thus, relates to how mobile technologies could be employed to reduce lexical errors.

2.3. Lexical Errors

Broadly speaking, a lexical error refers to orthographic or phonological deviations in form or meaning of a target-language word (Llach, 2011). Studying lexical errors is important due to several reasons. Research on second language acquisition has dominantly explored grammatical errors, and lexical errors have been underrepresented in the literature (Llach, 2007). Additionally, despite the fact that lexical errors outweigh grammatical errors (Llach, 2007), they have been little studied and their important role in communication exchanges has been overlooked. In the same vein, Llach (2007) argues that lexical errors are often seen as a measure of communication breakdown/success, being "considered to be the most destructive and are judged most severely by native speakers, non-native judges, and L2 learners" (p. 2). Lexical errors exert a substantial impact on interpersonal connectivity and code (mis)interpretation, on the way individuals come to contribute to mutual understanding, and on the way meaning is conveyed among individuals (Hemchua & Schmitt, 2006). Moreover, lexical errors have been associated with academic success (Hawkey & Barker, 2004; Llach, 2011) because "they turn out to be useful as quality indicators of learners written work and as predictors of lexical progress, of the lexical proficiency of the learners, and of their general academic achievement" (Llach, 2007, p. 2).

There are various typologies of lexical errors, which have classified the errors based on their orthographic, phonological, and syntactico-semantic types (Hemchua & Schmitt, 2006; James, 1998; Keshavarz, 2017). In a pedagogically-oriented classification, Hemchua and Schmitt (2006) inclusively classified lexical errors into 24 categories and divided them into (a) formal errors including misselection (suffix type, prefix type, vowel-based type, consonant-based type, and false friends), misformation (borrowing, coinage, and calque), and distortion (omission, overinclusion, misselection, misordering, and blending), and (b) semantic errors encompassing confusion of sense relations (general term for specific one, overly specific term, inappropriate co-hyponyms, and near synonyms), collocation errors (semantic word selection, statistically weighted preferences, arbitrary combinations, and preposition partners), connotation errors, and stylistic errors (verbosity and underspecification).

Lexical errors also have a direct relationship with the accuracy ratio of the writing (Llach, 2011; Nation, 2013). Accuracy ratio is calculated by dividing the word count by the number of errors and it provides a better picture of quality of written answers (Llach, 2011). It is apparent that as a function of decrease in lexical errors, the accuracy ratio of the text increases and vice versa. This is a point that makes it more significant to explore how intervention in the means of text composition mediates the connection between lexical error reduction and accuracy ratio. Moreover, the connection between lexical errors and text length is not always mutual. For example, 20 errors in a 150-word response with the same number of errors in a 200-word response would not be the same and text length influences the frequency of error occurrence. It thus seems to be difficult to consider lexical errors and text differences without accuracy ratio.

What is noticeably lacking in the body of knowledge on lexical errors is how mobile technologies could be employed to deal with and reduce such errors. Considering the widespread use of mobile technologies in today's educational contexts and the vast amount of communication among L2 learners in online media, it follows that learners need to pay particular attention to the accuracy of the texts they compose to avoid errors that hinder successful communication. Lexical errors need to be addressed and mobile technologies can provide affordances to increase the accuracy of the texts learners compose. Nevertheless, there is little concerted effort to increase such accuracy and reduce the lexical errors via interventions of any kind in the literature.

2.4. The Present Study

Our scrutiny of the literature indicated that mobile technologies have been little employed to deal with lexical errors. Lexical errors tend to occur frequently in the writing of second or foreign language learners (Llach, 2011). Such errors are important to be scrutinized as they directly influence message

conveyance, successful communication, and interlocutor perceptions. In this regard, Carter (1998) argued that "mistakes in lexical selection may be less generously tolerated outside classrooms than mistakes in syntax" (p. 185). Additionally, considering the current bulk of international communication among people of different countries, they engage in various types of textual interaction. Most of these interactions happen using technologies of various types, particularly mobile technologies. For people of various businesses, successful communication is of paramount importance and a major venue to have such communication is via the texts people compose. One major indicator of successful communication is texts that enjoy high levels of accuracy to facilitate successful flow of information (Olson, 2009). Such a situation is also the case with educational purposes, especially language learning in which the content of the interactions is the subject learners learn. It is thus more important for language learners to produce texts with fewer errors of various types, particularly lexical errors.

A technological advancement that can be leveraged to deal with lexical errors is Gboard. Gboard has a predictive typing engine suggesting the next word or phrase depending on the context. This facility of Gboard makes it particularly beneficial in composing texts that are both accurate at a lexical level (i.e., spelling) and an intersentential level (i.e., writing error-free texts). These potentials of Gboard facilitate the process of text composition and associated reader understanding in terms of imposing less cognitive loads on the reader (Hyland, 2003). Moreover, such potentials move the writer/reader communication to a higher level with regard to attending to the communicative loads of text composition/understanding more than the cohesive, sentential ties. However, the potential of Gboard (or similar keyboard applications) for reducing lexical errors has been little addressed in the literature. It is thus significant to examine whether Gboard mediates the process of lexical error reduction and if so, how error reduction occurs and in what areas. The present study sought to address this aspect of Gboard usage. To this end, the following research question was formulated:

Does using Google keyboard significantly influence the reduction of lexical errors, the length of written responses, and accuracy ratios in L2 writers' composed texts?

3. Methodology

The current study used a pre-test and post-test design with three experimental groups and one control group. The pre-test aimed to ensure the participants' homogeneity in terms of lexical errors production in EFL writing, and the post-test measured changes in the students' errors. The study also used different experimental groups with different treatments across the study to further control the role of intervening variables such as exposure to language beyond the classroom. The following sub-sections provide related information with respect to the participants.

3.1. Participants

The participants of the study were 47 Turkish EFL students from four different classes selected conveniently from two private language teaching schools. The proficiency levels of the participants were intermediate according to the records of the schools. All the participants were male students with at least 4 years of English learning experience in state-run schools (age from 15 to 18) and at the time of conducting this study, they were taking a general English course in the schools (two groups per school). In order to ensure the homogeneity of the participants, initially, the New General Service List Test (NGLST) (Stoeckel & Bennett, n.d.) was administered. NGSLT is a test of written receptive knowledge of the New General Service List (NGSL) (Browne et al., 2013), which contains 100 items grouped in five levels, each with 20 multiple response question types. According to test developers, the test is a reliable measure of NGSL and

shows very high reliability (over .90), and every level represents approximately 560-word bands from the NGSL. As the schools enacted similar policies of student selection and placement, we relied on the test to measure the students' knowledge. The data obtained from three participants who scored more than 10 points higher or lower than the mean score of all participants on NGSLT were excluded from the final analysis.

The invitation to participate in the study was delivered to the students by their teachers and they were informed that participation in the research is entirely voluntary. The data were collected during the summer of 2019 and the participants were only attending private language schools to receive English language education as state schools in Turkey are off during summer. In line with the purpose of the study, the participants were randomly assigned to four groups: One control group (N = 12, Institute A) and three experimental groups. Of the 35 participants in the three experimental groups, 28 used their smartphones (26 Android, 2 iPhone) for writing. Most of the devices employed by these participants had screen sizes ranging from 5 to 6 inches. The remaining 7 participants used their Android tablet devices with the screen size of 7 inches. Two participants in the experimental group 1 (N = 10, Institute B), four participants in the experimental group 2 (N = 11, Institute B), and one participant in the experimental group 3 (N = 14, Institute A) were tablet users. All the participants in the experimental groups received instructions for activating (enabling) predictive text, next word suggestion, and auto correction settings for Gboard installed on their mobile/tablet devices.

3.2. Data Collection and Analysis

To collect the data, 12 descriptive writing prompts (Table 1) were selected from ESL Gold website (ESLGold, n.d.), and were randomly assigned for the six weeks of the study (each session one new topic to control for the negative impact of topic familiarity). During the first two weeks, the participants were asked to write paragraph-length responses for four general topics given to the learners (four sessions in two weeks, each session one writing) in English in a limited time of 15 minutes by using pencil and paper in the classroom. It must be mentioned that the selection of the topics to be administered to the students was done by shared understanding and discussion with the teachers. The learners of each group wrote about the same topic each week. The aim of this stage (pre-test) was to find out if there were any differences in the number of lexical errors, length, and accuracy ratios in the produced responses before treatment.

Table 1
The Prompts the Learners Wrote Paragraphs about

The Prompts the Learners Wrote Paragraphs about
1- Write about one of your best childhood memories.
2- Describe a memorable birthday celebration.
3- What would you do if you got lost in an unfamiliar city?
4- Describe an interesting person you know.
5- Describe a place you will never forget.
6- Write about a time when you lost something.
7- What would you do if your best friend stole something from you?
8- Briefly write about a movie you saw recently.
9- What would you do if you left something in a locked building?
10- Describe someone you respect deeply.
11- Write about what you should do in an earthquake.
12- Describe your childhood home.

For the next four weeks, the participants were asked to write their responses to eight more writing assignments during class hours (two sessions each week, overall eight sessions) in the same amount of time. The topics chosen were the same for all the groups and they responded to the prompts. The participants in the control group used pencil and paper for all their writings, and participants in the experimental group 3 used Gboard only. However, in order to control for the role of ongoing instruction given to the participants in the school, two experimental groups used Gboard at different times. Thus, participants in experimental group 1 used pencil and paper in the third and fourth weeks and Gboard during the fifth and the sixth weeks, while experimental group 2 did the opposite (Table 2).

Table 2
Tools Used by Each Group at Each Week

	Control	Experimental	Control	Experimental
Week 3	PaP	PaP	Gboard	Gboard
Week 4	PaP	PaP	Gboard	Gboard
Week 5	PaP	Gboard	PaP	Gboard
Week 6	PaP	Gboard	PaP	Gboard
Week	PaP	PaP	Gboard	Gboard
Week 3	PaP	PaP	Gboard	Gboard

Note. PaP refers to pencil and paper.

In the present study, Gboard functioned as the intervention. As we noted earlier, Gboard has a predictive facility that could guide the individual in successful delineation of the correct form of words. This function of Gboard could be effectively leveraged in mediating language learners' vocabulary learning and contribute to the enhancement of the correct usage of lexical words with fewer errors. This application of Gboard was contextualized in the current study by having two other experimental groups (Ex1, Ex2), which could better sketch out whether Gboard significantly results in lexical error reduction. Moreover, we changed the mode of writing for Ex 1 and Ex 2 to examine how relative exposure to each mode influences their lexical errors.

The participants produced responses to the assigned topics without knowing about the real focus of the study. This was important to ensure the internal validity of the study with regard to overriding the possibility of Hawthorne effect (Ary et al., 2014). Responses written using pencil and paper were collected immediately after the assigned time span by the teachers and those written by the Gboard group were submitted to the teachers by the students at the end of the allotted time using two locally popular social media networks (i.e. Telegram and WhatsApp). The same procedures were applied for both writing conditions and the participants were given 15 minutes to write their responses and had no access to any writing aids, such as dictionaries, textbooks, websites, etc.

After collecting the data, all the produced responses were typed (in the case of pencil and paper using the original format) or copied (in the case of Gboard) into a Microsoft Word document as they were written by respondents and then were printed on paper. This was useful in counting the number of words in the texts. In order to ensure the internal validity of the study, each response was read twice blindly by two trained raters (experienced English language teachers) for identifying and counting lexical errors based on the taxonomy of lexical errors proposed by Hemchua and Schmitt (2006). This taxonomy was used as it has integrated the previous ones and is pedagogically oriented. Additionally, to establish rater familiarity, a discussion meeting was held in which the scale, its functioning, and the nature of lexical errors were discussed with the teachers. This familiarity was important to establish due to the classification of the errors in the scale. The Pearson Product-Moment Correlation coefficient was calculated for inter-rater reliability

between the two readers and the results revealed a correlation coefficient of r = 0.81, which is acceptably high (Pallant, 2016).

Furthermore, the researcher reviewed the errors classified differently by the two raters and areas of disagreement were accordingly resolved by discussion. Descriptive statistic techniques were employed to calculate word counts (length of responses), maximum and minimum number of lexical errors, means and standard deviations, and accuracy ratios (calculated by dividing the total number of words in responses by the number of associated lexical errors (Llach, 2011)). Moreover, using IBM SPSS (version 23), Kruskal-Wallis Test as the non-parametric alternative for one-way between-groups ANOVA was conducted to compare the groups' performance in terms of lexical error production, length of responses, and accuracy ratios. This statistical test which is used for comparing more than two groups on continuous variables, converts the scores to ranks and then compares the mean rank for each group (Pallant, 2016).

4. Findings

4.1. Lexical Errors of the Learners

For the first two weeks, learners in all the groups produced written responses to four general writing topics using pencil and paper. Table 3 indicates sample errors of the learners.

Table 3
Sample Errors of the Learners' Responses

Error type	Category	Example
Formal	Misselection (suffix, prefix)	Include/inclusion, dependent/dependence, bakerer/bakery Incomfotable/uncomfortable, unsimilar/dissimilar
	Misformations (borrowing, coinage, and calque)	Read/study hard, mother/native country, wanted/asked my teacher to…
	Distortions (omission, overinclusion, misselection, misordering, and blending)	Aple/apple, abot/about, sault/salt, teiste/taste, massage/message, berth/birth, intresting/interesting
Semantic	Confusion of sense relations	I sat on the furniture (chair). They took a siesta after lunch.
	Collocation	Afraid from/afraid of, in the third floor/on the third floor, arrived to/arrived in, married with/married to
	Connotation	Juvenile/young students He is a peculiar (unique) person in helping people in need.
	Stylistic	By the use of (using) mobiles, people can communicate better.

Table 4 summarizes the obtained results regarding the number of lexical errors, word counts, and accuracy ratios on the first stage of the study (i.e., pre-test).

Table 4
Descriptive Statistics for Results Obtained on Pre-test

	Group	Mean	SD	N
Lexical Errors	Control	80.08	6.802	12
	Experimental 1	80.40	5.758	10
	Experimental 2	82.55	4.719	11
	Experimental 3	84.21	5.989	14
	Total	81.96	5.967	47
Word Count	Control	664.75	27.595	12
	Experimental 1	659.60	20.549	10
	Experimental 2	659.36	15.416	11
	Experimental 3	652.71	23.480	14
	Total	658.81	22.201	47
Accuracy Ratio	Control	8.3554	.79550	12
	Experimental 1	8.2364	.56843	10
	Experimental 2	8.0189	.61085	11
	Experimental 3	7.7835	.56431	14
	Total	8.0810	.66212	47

Regarding the number of lexical errors, participants in the experimental group 3 had the highest number of errors with the mean value of 84.21 (SD = 5.98), followed by experimental group 2 (M = 82.55, SD = 4.71). The participants in the control group and the experimental group 1 were more similar and the mean of errors for these groups was about 80. As for the length of written responses, participants in the control group produced longer responses (M = 664.75, SD = 27.59) as compared to experimental group 1 (M = 659.6, SD = 20.54), experimental group 2 (M = 659.36, SD = 15.42), and experimental group 3 (M = 652.71, SD = 23.48). Finally, responses written by participants in the control group had higher accuracy ratios (M = 8.36, SD = 0.8), while the responses written by participants in the experimental group 3 had the lowest accuracy ratios (M = 7.78, SD = 0.56).

Table 5
Kruskal-Wallis Test for groups' performances on pre-test

	Lexical Errors	Word Count	Accuracy Ratio
Chi-Square	3.080	1.788	4.110
df	3	3	3
Asymp. Sig.	.379	.618	.250

The Kruskal-Wallis Test (Table 5) also revealed that the differences observed among the four groups (control, n = 12; experimental 1, n = 10; experimental 2, n = 11; and experimental 3, n = 14) in terms of the mean values for lexical errors ($\chi 2$ (3, n = 47) = 3.08, p = 0.379), word counts ($\chi 2$ (3, n = 47) = 1.788, p = 0.618), and accuracy ratios ($\chi 2$ (3, n = 47) = 4.11, p = 0.250) were not statistically significant.
Table 6 shows the results of descriptive statistics for the second stage of the study, where all the participants were asked to provide written responses to eight similar writing prompts under different conditions (writing with Gboard or pencil and paper).

Table 6
Descriptive Statistics of Results Obtained for Different Writing Conditions

	Group	Mean	SD	N
Lexical Errors	Control	167.83	9.173	12
	Experimental 1	133.10	9.146	10
	Experimental 2	134.82	6.983	11
	Experimental 3	99.57	5.626	14
	Total	132.38	26.703	47
Word Count	Control	1341.50	24.512	12
	Experimental 1	1349.40	38.251	10
	Experimental 2	1330.55	36.418	11
	Experimental 3	1328.71	32.013	14
	Total	1336.81	32.824	47
Accuracy Ratio	Control	8.0144	.44635	12
	Experimental 1	10.1721	.60264	10
	Experimental 2	9.8875	.46307	11
	Experimental 3	13.3844	.83368	14
	Total	10.5115	2.14905	47

For the participants in the control group, 2014 lexical errors were identified in all the produced responses, with the mean of 167.83 errors per individual (SD = 9.17). For participants in the experimental groups 1 and 2, the mean value of lexical errors decreased considerably, dropping to 133.10 (SD = 9.15) and 134.82 (SD = 6.98) respectively. Participants in the experimental group 3 displayed the fewest lexical errors (M = 99.57, SD = 5.62). Regarding the length of responses (measured by the number of words), participants in the experimental group 1 produced longer responses (M = 1349.4, SD = 38.25), and participants in the experimental group 3 produced shorter responses (M = 1328.7, SD = 32.01). As for accuracy ratios calculated by dividing the number of words written by the number of associated lexical errors, responses written by participants in the experimental group 3 demonstrated higher accuracy ratios (M = 13.38, SD = 0.83), compared to the control group (M = 8.01, SD = 0.44), experimental group 2 (M = 9.89, SD = 0.46), and experimental group 1 (M = 10.17, SD = 0.6). Figure 1 shows the relevant boxplots for the scores on the post-test.

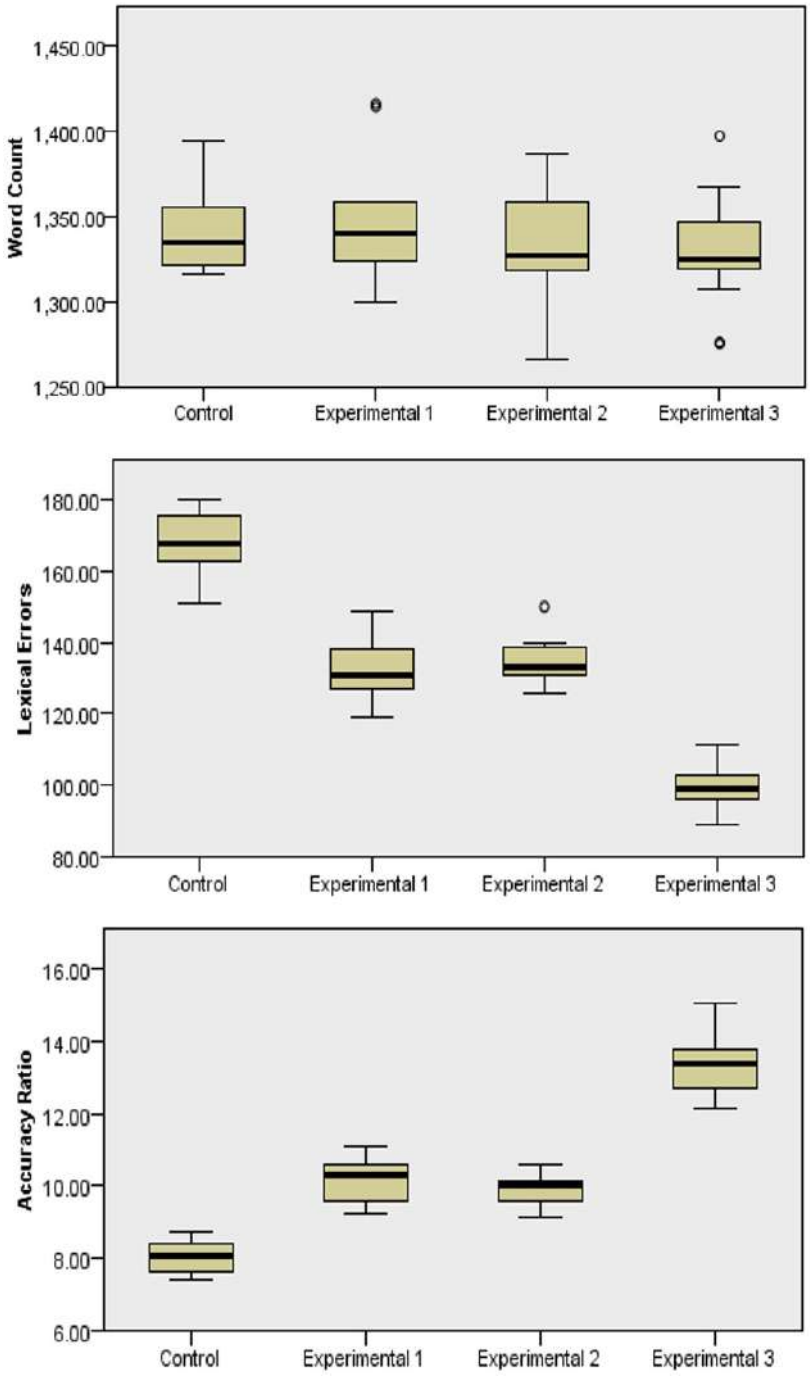

Figure 1. Visual representation of the four groups' performances on the post-test

As Figure 1 shows, the distributions of scores for the word count variable are similar across the four groups, nevertheless, for the lexical errors and accuracy ratio variables, the patterns of scores are different.

Table 7
Kruskal-Wallis Test for groups' performances on post-test

Test Statistics[a,b]			
	Lexical Errors	Word Count	Accuracy Ratio
Chi-Square	40.053	2.044	40.227
df	3	3	3
Asymp. Sig.	.000	.563	.000
a. Kruskal Wallis Test			
b. Grouping Variable: Group			

To explore whether the observed differences were statistically significant, the Kruskal-Wallis Test (Table 7) was conducted to compare the groups' (control, n = 12; experimental 1, n =10; experimental 2, n = 11; and experimental 3, n = 14) performances on the post-test. The results revealed that the differences in lexical errors production ($\chi 2$ (3, n = 47) = 40.053, p = 0.000) and accuracy ratios ($\chi 2$ (3, n = 47) = 40.227, p = 0.000) are statistically significant. Nonetheless, for the variable of word count the observed differences were not statistically significant ($\chi 2$ (3, n = 47) = 2.044, p = 0.563).

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Experimental 3-Experimental 1	16.600	5.674	2.925	.003	.021
Experimental 3-Experimental 2	18.318	5.522	3.317	.001	.005
Experimental 3-Control	34.000	5.392	6.306	.000	.000
Experimental 1-Experimental 2	-1.718	5.988	-.287	.774	1.000
Experimental 1-Control	17.400	5.868	2.965	.003	.018
Experimental 2-Control	15.682	5.721	2.741	.006	.037

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

Figure 2. Pairwise comparison for lexical errors (post-test)

Sample1-Sample2	Test Statistic	Std. Error	Std. Test Statistic	Sig.	Adj.Sig.
Control-Experimental 2	-14.955	5.723	-2.613	.009	.054
Control-Experimental 1	-18.200	5.871	-3.100	.002	.012
Control-Experimental 3	-34.000	5.394	-6.303	.000	.000
Experimental 2-Experimental 1	3.245	5.991	.542	.588	1.000
Experimental 2-Experimental 3	-19.045	5.524	-3.447	.001	.003
Experimental 1-Experimental 3	-15.800	5.677	-2.783	.005	.032

Each row tests the null hypothesis that the Sample 1 and Sample 2 distributions are the same.
Asymptotic significances (2-sided tests) are displayed. The significance level is .05.

Figure 3. Pairwise comparison for accuracy ratios (post-test)

The results of pairwise comparisons (Figures 2, 3) revealed that the participants in the experimental groups outperformed those in the control group in producing fewer lexical errors, and accordingly displayed higher accuracy ratios in their responses. Moreover, the participants in experimental group 3 outperformed the experimental groups 1 and 2 and the control group in both accuracy ratios and writing responses with fewer lexical errors. Furthermore, the analyses also indicated that the differences observed in the performance of the participants in experimental groups 1 and 2 were not statistically significant.

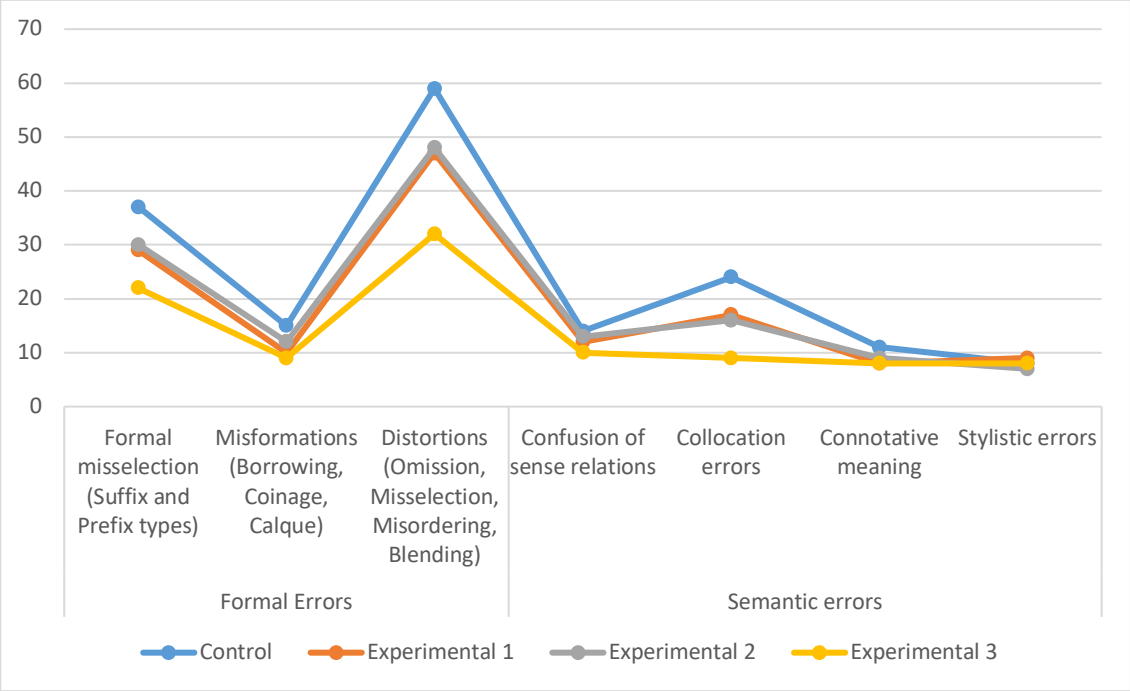

Figure 4. Comparison of the mean values for various error types among the groups in the post-test

Figure 4 provides further information regarding the mean values for the types of errors produced by the experimental and control groups, identified based on the taxonomy of lexical errors proposed by Hemchua and Schmitt (2006). As it is shown, the majority of produced errors belonged to the category of formal errors. In this category, the control group produced more distortion (M = 59) and misselection (M = 37) errors compared to the other groups. Experimental group 3 had the best performance and the mean values for distortion and misselection errors were reduced to 32 and 22 respectively. Furthermore, the same pattern was observed for misformation errors, and participants in the control group produced the highest errors (M = 16), and the experimental group 3 produced the lowest (M = 9) errors. Regarding the category of semantic errors, the mean values for different error types including the confusion of sense relations, connotative meaning, and stylistic errors were approximately the same for all the groups with minor differences. Nonetheless, for collocation errors, participants in the experimental group 3 produced the least lexical errors (M = 9), while those in the control group displayed the highest number of errors (M = 24). Participants in the experimental groups 1 and 2 also had the mean value of about 17 for this error type, producing more errors than the experimental group 3, but fewer errors as compared to the control group.

5. Discussions and Conclusion

This study aimed to investigate the contributions of a Gboard interventionist initiative to Turkish L2 learners' lexical error reduction. Preliminary descriptive statistics and further statistical analysis (Kruskal–Wallis one-way analysis of variance) techniques revealed that the use of Gboard resulted in significant reduction of lexical errors, and as a result increased accuracy ratios in the learners' writing. This is in line with a number of previous studies investigating the effectiveness of mobile technologies in enhancing L2 writing (e.g., Al-Hamad et al., 2019; Andujar, 2016; Hwang et al., 2014; Yamaç et al., 2020). Nonetheless, the use of Gboard in this study did not result in a significant change in the length of written responses. In this regard, our findings are incongruent with Lee (2020) who reported that handwritten responses by university students were significantly longer than those composed on a smartphone, and with Yamaç et al. (2020) where tablet based writing instruction resulted in longer responses for primary school students. Given the conflicting findings by these studies and the current study, further investigations are needed to shed more light on the impacts of mobile-assisted writing on the length of produced responses. In this regard, it seems that the proficiency level of the participants, their ages, and the types of devices employed in mobile assisted writing might have impacts on the length of the written responses.

The findings also indicated that the use of Gboard resulted in a considerable reduction in formal misselection, distortions, and collocation errors produced in responses written by Gboard on smartphones/tablets. This observation is partly in agreement with some previous studies investigating the effects of word processors such as Microsoft Word Office software in writing instruction (S. H. Lee, 2003; Zaini & Mazdayasna, 2015). Nonetheless, it should be emphasized that there are some differences in the nature of technologies employed in the present study and previous studies. Although Gboard provides the learners with affordances similar to technologies like Microsoft Word Office software, its availability, ease of use, and word suggesting functions have great potential in improving the lexical accuracy of responses and also correct use of collocations among learners. This is a feature that is unique to this particular technology employed as the writing medium in the present study.

It has been argued that language learners respond more positively if they find MALL studies and interventions of direct relevance to their daily and personal uses of technologies (Chwo et al., 2018). As many students are using such technologies in their everyday lives for text-messaging, emailing, and chatting (Zheng & Warschauer, 2017), the use of this particular app (i.e., Gboard) in L2 writing instruction is well justified and deserves further consideration. Indeed, it is the proactive facility of Gboard that makes it unique for language learning, particularly in the case of writing. That is, as mobile devices are providing

language learners' with much easier access to multimedia content and interaction with others (Stockwell, 2013) they need to develop competencies that facilitate the process of peer communication and negotiation. Gboard effectively facilitates such interpersonal communication via its associated utilities to convey the meaning more transparently and clearly by composing more accurate texts.

Moreover, recent technological advances have necessitated using technology as a tool in the process of teaching and learning languages (Boulton & Cobb, 2017; Chen et al., 2020; Chwo et al., 2018; Schmid et al., 2014; Sung et al., 2015; Tamim et al., 2011) and ecological approaches to language learning consider the classroom context as an ecosystem in which various elements are interacting in complex relationships, and different affordances are perceived as a result of this interaction (Lier, 2004). In light of these advancements, mobile technologies should be considered as an emerging social and cultural tool, which is playing an increasingly important role in L2 development (Ma, 2017; Pegrum, 2014). Specifically, writing is a skill that could largely benefit from mobile technologies in curtailing the gap between the writer and the reader. To achieve such closeness, tools that could mediate mutual understanding between the writers and readers are required. Gboard has the potential to play such a role and move the writers and readers to a higher level of successful mutual understanding by first, decreasing the number of lexical errors at least at a linguistic level, and second, assisting with peer contribution as occurring in real-time interactions between both participants.

As it was observed in this study, responses produced in writings with Gboard were of a higher quality as compared to pencil and paper writing. As mentioned previously, Gboard potentiates spelling correctness by its predictive word composition potential, which seems to gradually constrain the process of linguistically-correct word writing. This potential of Gboard could be leveraged to deal with the "highly irregular and therefore virtually impossible to teach" nature of spelling (Thornbury, 1997, p. 144), especially if used in activities that highlight peer interaction.

Previous research has indicated that vocabulary development contributes significantly to writing practice (Muncie, 2002), and it is an essential component of successful L2 writing (Astika, 1993; Llach, 2011; Santos, 1988). Besides the importance of vocabulary in language learning in general, research has indicated that a large proportion of language is made up of multiword units or collocations (Erman & Warren, 2000; Sinclair, 1991; Vyatkina, 2016). In the literature of second language vocabulary acquisition, the importance of knowledge of collocation for second language learners is widely acknowledged (Lewis, 2000; Nesselhauf, 2003). It has been argued that a large proportion of errors produced in learner language is because of incomplete knowledge of collocations (Bahns & Eldaw, 1993; Nesselhauf, 2003). In this regard, the use of Gboard (with its predictive and auto-correction utilities) helps learners to use collocations correctly and increase both the accuracy and quality of their writing. This potential of Gboard particularly works for accelerating the process of collocation use by providing the correct form for the learners to grasp and gradually internalize the forms.

The exponential growth in digital technologies and increased access to the Internet in recent years have dramatically transformed our daily lives. Growing up in a digital age has had an enormous impact on the way the new generations think, and technology is part of nearly all aspects of human life. When it comes to second or foreign language writing, information and communication technologies have exerted a massive influence on every aspect of writing, including the reasons for writing, genres and the language we use, and the nature of the audience we aim to reach (Hyland, 2016). There is thus a need to further investigate emerging technologies currently incorporated into L2 writing activities and pedagogy (Li et al., 2017). This study moved along these lines and investigated the use of Google keyboard (Gboard) in L2 writing instruction for Turkish EFL learners. The results of data analyses indicated that the Gboard group significantly improved their writing.

Implications

The results of the study imply that Gboard could be effectively used to address the writing problems of L2 learners. Teachers of beginner-level students could use Gboard along with textbook materials to resolve the learners' spelling problems. They could use the word-predictive affordance of Gboard to give those learners more confidence in writing English words. This aspect of Gboard also seems to have great potential in lowering the negative feelings felt by students while writing in English, as it influences some of the mental factors underlying second language writing anxiety (Cheng, 2004). Additionally, teachers of higher levels could showcase examples of texts written via Gboard and other hand-written texts to spot the areas of difference and illuminate the way correct spelling could help with better communication and interlocutor perceptions of their ability. The auto-correction and next word suggestion potentials of Gboard could also assist learners with developing writing fluency as they directly increase the writing speed (Nation, 2009). Additionally, in conducting fluency development activities, such features help teachers to focus more on meaning and content rather than formal and linguistic aspects. Moreover, Gboard seems to help with time management of the teachers. Thus, teachers can use this potential of Gboard in better managing their instruction and meeting their lesson plans.

6. Limitations and Suggestions for Further Studies

The present study had a number of limitations. First, as it is mostly common to classroom-based research in second language acquisition, convenience sampling and intact classes were employed. Moreover, the participants of the study were at intermediate level and we were unable to include students from other levels in this study. As Wolfe and Manalo (2004) and Lee (2020) argued, proficiency level of learners needs to be considered when interpreting the results of studies investigating the effect of educational technologies on students' writing. Second, the study was conducted in a relatively short time period of six weeks and suffers from the same criticism levelled against short term studies in MALL and CALL, which may produce skewed data and questionable findings (Chwo et al., 2018). Related to this limitation, due to short-term intervention the study did not consider the impacts of auto correction made by Gboard on the participants' lexical knowledge development to see if the learners can intake the given feedback in mobile assisted writing conditions. Third, the participants of this study were asked to write short paragraphs in response to general questions and it is still unclear how applications such as Gboard can facilitate (or hinder) learner performance in writing longer responses and with different tasks. Finally, considering the small sample size of the learners, the results of this study should be interpreted cautiously, and further research is needed to illuminate more on issues investigated in this study. Despite these limitations, this study indicated that Gboard has a great potential in transforming learning and teaching foreign language writing in new ways. Future research can investigate the effects of similar keyboard applications not only on lexical errors, but also on other aspects of successful writing such as lexical richness, the stages of process writing, and the length of written responses through different mediums.

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