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Peer editing using shared online documents: the effects of comments and track changes on student L2 academic writing quality

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ABSTRACT

While the use of collaborative peer editing is widespread in some online learning contexts, little is known about how constituent editing behaviours impact student writing quality when using shared online documents as the mediating tool. Therefore, the present study ($n=176$) examines the effects of English language learners' peer editing behaviours (comments and track changes) within the Google Docs platform on their subsequent academic writing quality at both individual and group levels. To better understand peer editing, the current study further divided track changes into either adding words or deleting words. Given the data's complexity, a two-level correlation analysis was used. The results showed that, at the individual level, words deleted by editors were positively associated with students' individual writing quality in the Introduction section. Further, words added by editors in the Introduction section were negatively associated with student individual writing. At the level of the peer editing group, there was a positive statistically significant correlation between words added and student writing quality in the Introduction and Discussion sections. Interestingly, comments had little association with student writing at the individual or group level.

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KEYWORDS

Online peer editing; comments; words added; words deleted; writing quality

Introduction

Peer editing, also called peer feedback, peer review, peer assessment, and peer response, occurs when students provide and receive written and/or oral feedback on their peers' writing in pairs or small groups (van

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Heerden & Bharuthram, 2021). Peer editing has garnered considerable attention from writing researchers and practitioners around the world (Dao et al., 2021; Li et al., 2020; Pham, 2022). Moreover, peer editing has been widely used as a teaching strategy in L2 writing courses as a means to motivate students to offer suggestions on the drafts of their peers in order to improve their own writing (Huisman et al., 2018; Pham & Usaha, 2016; Yu & Lee, 2015; Zhu & Liu, 2020). Peer editing is thought to have the potential to raise audience awareness (Yu & Lee, 2015), foster student reflective thinking (Li, 2018), increase attention to language structures and discourse (Li, 2018), and provide writers the chance to jointly review the emerging text and apply newly acquired knowledge (Hyland & Hyland, 2019).

There are many easy-to-use online applications for second language learners to collaborate and use language to engage in various tasks (Rahimi & Fathi, 2021). The emergence of Google Docs in recent years has refocused experts' attention on collaboration in L2 writing contexts. As for methods of online peer editing, Google Docs allows students to make corrections by offering thoughts and suggestions for improvement in the form of embedded comments and making direct tracked changes to the text, such as adding or deleting words from a student's original writing by tracking changes inside a shared document (Cunningham, 2019). The interaction among students, the effect of online collaboration on writing scores, and students' perceptions of joint work have been the primary areas of research on online collaborative writing thus far (Abrams, 2016; Woodrich & Fan, 2017). Track changes and comments as two behaviours of online peer editing that allow students to discuss ideas and questions, as well as review, critique, and edit each other's work by making suggestions and responding to them, all of which have been associated with activating these key cognitive processes (Carless, 2022; Zhu & Carless, 2018). Such learner-generated feedback is useful for analysing learner behaviour and contextualising the educational process. In this way, peer editing has the potential to impact at least two different levels: (1) within the group (individual writing) and (2) between the groups (dyadic writing).

Although some studies have provided useful explanations for the effects of individual reception and implementation of peer feedback on the quality of writing that students produce as assessed by the course instructor (hereafter referred to as 'writing quality') when writing collaboratively, most of the previous studies focused on how peer editing improves student writing from the instructor/researcher perspective, and there is no study looking into student writing documents and comparing the two behaviours of peer editing in Google Docs (comments and track changes) or any other online collaborative writing context to examine the

effects of this learning activity. Moreover, most of the research regards student academic writing as a whole; however, each manuscript section has unique characteristics and should be analysed separately. For instance, objective issues such as research rationale, study background, and a brief technical summary of the experimental approach are presented in the introduction section. Similarly, the facts of statistical evaluation and tests ought to be presented in the methodology and results sections. However, more subjective opinions such as data interpretation, consequences of findings, and prospective directions for further research ought to be given in the discussion section. Therefore, how different peer editing behaviours affect different manuscript sections should be investigated separately. Moreover, the present study investigates the effects of online peer editing behaviours on students' L2 academic writing quality by using Google Docs as a platform. The study attempts to address a gap in the literature that separates different sections of academic writing from each other and to add to the expanding corpus of research on the impact of different student peer editing behaviours on L2 writing quality. Surprisingly, few studies have looked at dyadic (group) writing quality and how comments and track changes, two popular methods in online peer editing, affect student writing quality in different sections of scientific writing at both the individual and group (dyadic) levels. However, involvement in online peer editing may not only impact individual writing quality but may also function in a reciprocal-type way between two individuals (Martin & Bolliger, 2018). Therefore, both individual and group levels were examined in the current study to fill the research gaps. In addition, the effects of comments and track changes on writing quality were investigated in the present study. In the current study, students were asked to write several manuscript sections after online lessons as writing assignments, and quality of writing was measured by examining students' capacity to generate well-written, well-structured writing assignments according to the guidance of the instructor at the end of each lesson section, and a more detailed description of writing assignments and how writing quality was assessed is provided in the 'Research Design' subsection. This study was guided by the following research questions:

RQ1: How do different forms of peer editing behaviour (comments and track changes) affect the writing quality of individual students within academic writing assignments?

RQ1a: How does the number of received comments affect the writing quality of individual students on academic writing assignments?

RQ1b: How does the number of words deleted affect the writing quality of individual students on academic writing assignments?

RQ1c: How does the number of words added affect the writing quality of individual students on academic writing assignments?

RQ2: How do different forms of peer editing behaviour (comments and track changes) affect the dyadic writing quality within academic writing assignments?

RQ2a: How does the number of received comments affect the dyadic writing quality of students on academic writing assignments?

RQ2b: How does the number of words deleted affect the dyadic writing quality of students on academic writing assignments?

RQ2c: How does the number of words added affect the dyadic writing quality of students on academic writing assignments?

Literature review

Theoretical framework

Computer-supported collaborative learning (CSCL) and Vygotsky's socio-cultural theory of learning were theoretical frameworks that provided strong support for the growing use of peer editing in L2 academic writing settings over the past 20 years (Huang, 2018). Recent research has shown that making appropriate pedagogical use of CSCL environments can create a natural environment to help students conduct online peer editing naturally while fostering links between information, communication, and argumentation among students and other cognitively challenging tasks that can promote higher-order interactive inquiry processes compared to independent learners (Greenhow & Askari, 2017; Li et al., 2020). Online peer editing is conceptualised as a process that takes place when there is contact between students through the utilisation of technology in CSCL (Cress et al., 2021). CSCL supports both synchronous and asynchronous contributions to a shared learning object, regardless of place or time. Students who review, provide comments, and track changes together to complete peer editing using shared online document platforms, such as Google Docs, can profit not just from cooperation with one another but also from the final written product created by those interactions. However, there is a need to explore how different elements of peer editing behaviour impact students' writing quality.

The significance of social interaction with peers for learning was also emphasised in the zone of proximal development (ZPD) by the sociocultural theory of learning (Vygotsky, 1978), where students develop from their actual levels of writing to prospective writing levels with the assistance and scaffolding of their peers after receiving comments and/or track changes in the process of online peer editing. In other words, peer editing mediated by shared online documents, such as Google Docs, creates an

instructional opportunity that is beneficial for both editors and authors to work within their respective zones of proximal development (Yu & Hu, 2017). According to the collaborative learning paradigm, knowledge is socially constructed through dialogue with other knowledgeable members of a society. Some types of knowledge about writing can be learned through peer collaboration (Zhang, 2020). The collaborative learning paradigm states that conversing with other informed members of a community allows for the social construction of knowledge, and the process of peer cooperation can be used to learn some forms of L2 academic writing skills (Yang, 2016). Also, Rouhi and Vafadar (2014) justified that feedback from web-based peer editing promotes cooperative action, mutual scaffolding, consciousness-raising, and the process of creating social meaning.

Google Docs as a tool to facilitate L2 writing

Numerous digital educational tools have been developed to encourage students' online participation in order to foster active learning (Harris et al., 2020). Google Docs allows users to simultaneously write and/or modify pieces of writing in real time. A shared Google Doc can be accessed by students, who can then interact with the content of the document by tracking changes and adding and/or deleting text, or by making suggestions as embedded comments (Das et al., 2019). While CSCL approaches to instruction suggest that student learning is driven by their collaboration with the use of technology, further research is needed to more precisely understand how specific online peer editing behaviour impacts student quality (Stahl et al., 2006). Given the lack of empirical work in this specific area, the purpose of this study is to identify how the different forms of online peer editing behaviour mediated by Google Docs (comments and track changes) might be associated with improved student learning and writing quality.

How track changes affect individual writing

As tracking changes in student writing becomes more frequent within an online learning space, the influence of such modifications on student academic writing ability has become a new line of enquiry (Lee & Hannafin, 2016). Changing others' writing has been shown to be effective in assisting students in becoming active learners, as research suggests that reviewing writing and attempting to correct errors is a useful way for students to actively explore the information they read or double-check their own knowledge (Al-Samarraie & Saeed, 2018).

Although this could appear to be a natural and distinctive characteristic of Google Docs, not all students agree with the notion that their

created content can be modified or edited by others. According to Gillis and Krull (2020), for instance, students found it awkward to edit the work of others because of a crisis of authority in which students may perceive their own changes to others' writing as positive or beneficial to the document's quality, while original authors may view the changes made by others as detrimental. Although it has been demonstrated that peer editing improves student writing, students themselves consider that peer editing is intrusive and uncomfortable because it involves changing the content of others, which may degrade the quality of the writing (Blau & Caspi, 2009). In addition, some studies showed that the number of revisions and whether the revisions constituted words added or deleted might indicate the quality of a piece of writing (Hattie & Clarke, 2018). These studies did not, however, examine the various behaviours of peer editing using Google Docs or contrast the influences of comments and track changes on the development of student improved work.

How receiving comments affects individual writing

Comments from peers can be seen as a key component in encouraging students to write and thus should be carefully considered when investigating student writing quality (Hyland & Hyland, 2006; Yu et al., 2020). Within the context of this article, 'comments' refer to the dialogic interaction among students using embedded comment functions within Google Docs. Since sometimes students are unwilling to change others' writing directly, embedding comments is an alternative to directly modifying someone else's original text. Students are able to engage in thoughtful criticism of other student writing and make suggestions when they use the comment approach, which typically involves the use of criteria that have been previously set in rubrics (Carless, 2019). Students may participate more actively in the revision process after self-reflection, which might assist them in becoming more autonomous and independent learners and, in turn, more proficient writers (Thanh, 2019).

However, little research has concentrated on the effect of the number of comments on text revisions and students' writing quality in the online context, and previous studies have looked at the student essays as a whole and have not examined what the impact of the comments is on the different sections of the essay respectively. However, different sections of the manuscript have different writing priorities. For instance, the writing in the introduction, methodology, and results sections is more objective (Korstjens & Moser, 2018), and in results, it is more difficult for students to provide comments to improve others' writing, especially when they are not familiar with the specific topic their peers' are writing about. In contrast, the discussion section generally includes more subjective

perspectives on data interpretation, conclusions, and future study (Chen et al., 2015), which makes it easier for students to give their opinions to their peers. Thus, the effect of peer editing may be different in different manuscript sections. For this reason, the effects of comments on various manuscript sections should be investigated separately to more fully understand all aspects of peer to peer editing.

How deleting words and adding words affect student writing

Adding and/or deleting text within their peers' writing during online peer editing are two methods of track changes in the Google Docs platform. A variety of arguments have been made in support of the claim that such changes can facilitate the process of writing and revising (Wallace & Hayes, 2020). Since all the revisions and changes are highlighted, using Google Docs might help L2 writers develop awareness of language use in writing as all deleted and added words are shown in a way (an alternative colour) that allows students to quickly check them (Zhang, 2020).

Also, locating and correcting spelling or grammatical errors might help to improve the quality of writing. Receiving mere grammatical changes, however, might lead students to doubt their peers' capabilities to review and may lower their motivation to write (Liu & Edwards, 2018). In other words, as simply correcting spelling only highlights mistakes, it is possible for students to interpret these changes as direct criticism, which could be detrimental to their future writing development (Storch, 2018). In direct contrast to this, sometimes students view a lack of revisions as a sign of disengagement or indifference, which could also have a detrimental influence on their writing and engagement with the task (Li et al., 2015). Moreover, some studies pointed out that additive or subtractive changes to the content of the documents had different effects on students' subsequent writing quality. Specifically, additive responses were found to be useful for student writing quality; however, subtractive changes were found to be harmful (Fanguy et al., 2023). More research is needed on how words added and words deleted link to writing quality within an online learning space.

Why should we care about between-dyad effects?

The effects of online peer editing might vary depending on intrapersonal and interpersonal dynamics associated with student learning motivation, self- and peer-perception, and the connection between the peers during editor and author roles (Yim et al., 2017). For example, a study by O'Donnell et al. (1986) suggested that dyads significantly outperformed individuals in terms of the quality of their writing tasks. Research has

suggested that when students are encouraged to reflect on their own piece of writing through conversation and engagement with their peers, they may review and emulate distinct and/or higher-level papers from their group members when writing or editing jointly; as a result, students may replicate these strategies to obtain a greater degree of writing competence (Yim et al., 2017). However, little empirical research has been undertaken on how different behaviours of peer editing impact student writing quality at the dyadic level. It may be that a preponderance of the same feedback between students in a dyad generates higher levels of writing quality for the dyad. For example, if both individual students in the dyad tend to add a lot of words when editing, this may result in improved average writing quality in the dyad. However, a large number of deleted words for the dyad may result in the opposite effect. To the best of the authors' knowledge, no studies have explored how different types of dyadic editing might be especially useful for improving the writing of specific written scientific sections.

The present study

Existing research suggests that online peer editing will benefit students' academic writing and improve the quality of the paper compared to writing individually. Although the CSCL and sociocultural theoretical perspectives offer a helpful method for analysing the online collaborative writing that students participate in as well as the digital artefacts that they produce, they lack an explanation of how different peer editing behaviours influence student L2 academic writing quality when mediated by the Google Docs platform, especially the impact of comments and track changes on the dyadic level of writing. Therefore, the present study looks into students writing documents as well as the relationships between two methods of peer editing (comments and track changes) and student academic writing scores at the individual and dyadic levels. In addition, previous research on writing in collaboration has primarily concentrated on producing truly collaborative documents that are owned equally by all of the authors (Blau et al., 2020). The present study measures the number of comments and track changes are tested but does not examine their quality. This is because the effect of the quantity of peer editing behaviour on student writing quality is the first stage of a multiple-stage research agenda that aims to provide an overall picture of how online peer editing affects student academic writing quality. The present study represents the first step in understanding how student-to-student online editing behaviour affects both authors and editors. In addition, open-source learning analytic visualisation platforms can automatically harvest large amounts of information regarding the addition and deletion

of text by peer editors as well as their embedding of comments within Google Docs. Such knowledge can be utilised by instructional designers to better understand online peer editing and adopt instructional design strategies to improve student writing.

Methods

Research site

This study included 176 scientific writing students. All participants in the study were recruited from the sections of an online writing course that were offered to help graduate students write a manuscript of their graduate research that will be submitted to a peer-reviewed scientific journal in 2021. For the purpose of the study, each student participant was paired with another participant to form a dyad (a total of 88 dyads). The average age of the sample was 24.9 (SD = 3.2). In terms of level of study, 103 (58.0%) were enrolled in a dedicated master's program, 25 (14.2%) were enrolled in a dedicated doctoral program, and 48 were part of an integrated master's/doctoral program. The sample participants were taken from 12 classes (or groups) exposed to a formal academic writing program at a Korean university. A majority of 117 were male (64.5%), with 59 comprising the female sample (33.5%).

Since 84% of the university's courses are delivered in English, English proficiency is required for admission. Although the majority of students at the university speak English as a foreign language, all students needed to pass the TOEFL exam with upper-intermediate and advanced English levels (approximately B2/C1 in The Common European Framework of Reference for Languages) prior to admission. All instruction and activities in the course under study, including peer editing, were conducted in English. While all students were at least fairly proficient in English, their writing skills tended to vary due to their command of the language and their education and experience in their degree program, as students were able to take the course from the first semester of their master's degree to the final semester of their PhD studies. In terms of departments, participants were from multiple STEM-related fields.

Research design

Course instructors administered a total of 12 sections of the scientific writing course examined in this study. The goal of this online academic writing course was to teach students how to prepare papers for scientific publications. The course was delivered online using pre-recorded videos that were uploaded to students' learning management systems, allowing

them to pause, rewind, and fast-forward the information at their own pace. There were 56 lecture films in total for the ten weeks, with four to eight lecture videos per week. The duration of the course videos varied, averaging roughly 12 min and addressing topics linked to STEM graduate writing. The ten weeks were made up of five two-week sessions with the goal of providing instruction on the four major sections of journal papers: 1) Introduction, 2) Methodology, 3) Results, and 4) Discussion & Conclusion, 5) Abstract. However, the abstract was not included in this study because it did not undergo a peer-editing process like the other sections. Each week, these sections were taught. In the first week of each two-week session, students watched movies related to their section of interest to learn the aim, function, features, and conventions. After that, students would use Zoom online meeting software to discuss the course with the instructor under university licence. After discussing the video's main points and answering student questions, the instructor split the class into small groups for online discussion to help students understand the lecture videos.

In the second week of each two-week session, students watched another set of lecture videos on writing style, vocabulary, and grammar related to the same journal paper section. After this video session, each student was encouraged to structure and lengthen their papers, that is, writing assignments assigned by the instructor, according to their field's journal writing guidelines with no word limit. They had to draft half the manuscript before the second Zoom meeting. These Zoom meetings included brief talks, questions, and peer editing advice from the teacher. Students answered a questionnaire about their field of research, degree program, research experience, and project titles at the first peer editing session. This data was collected in a spreadsheet and given to the class, allowing students to match up with peers with comparable research interests for peer editing. Then, the lecturer placed peer editing dyads (or triads in odd-numbered course sections) into Zoom breakout rooms to collaborate on Google Docs. Peer editing dyads were consistent throughout the semester and were asked to review each of the four sections of the scientific manuscript during each of the four peer editing sessions. The instructor created dyad-specific Google Docs documents to monitor peer editing. Students were instructed to copy and paste their journal manuscript parts into their Google Doc.

Procedures of data collection

Comments

Any written type of feedback that students get from a peer editing partner on their individual writing can be regarded as comments in the present study when students make use of the integrated comment functions

inside the Google Docs platform. The number of unique embedded comments and responses to comments within a single peer editing Google Doc acts as the comments variable. Editors and authors can also utilise embedded comments to engage in online discussions.

Words added

The words added variable is recorded by calculating the total number of words added to a specific Google Doc by a peer editor during a specific editing session. When students review others' writing, they may add their thoughts to the original author's pieces of writing. Prior research demonstrated that an increase in such changes by peers was positively associated with students' ability to write coherently and support their arguments with evidence (Yim et al., 2017).

Words deleted

In the present study, the total number of words removed from a specific Google Doc by a peer editor during an editing session can be regarded as the words deleted variable. When students review their peers' writing, in addition to adding their own ideas to the original author's text, they can also directly make deletions.

Writing assignments

Writing quality in the current study refers to students' ability to produce well-written and well-structured papers, and it is evaluated by the course instructor through the use of scores given using rubrics. The key sections of a research manuscript were the core tasks for the writing course of interest in this study: 1) Introduction, 2) Methodology, 3) Results, and 4) Discussion & Conclusion. The course instructor as well as the teaching assistant graded these writings using a customised rubric modified from Clabough and Clabough (2016). These rubrics were chosen for use in the present study because they showed high scoring reliability and because both instructors and students found them to be useful in the assessment of pieces of writing (Clabough & Clabough, 2016). The rubrics were slightly adapted from their original form, as the original rubrics created by Clabough and Clabough were designed for neuroscience research, whereas the course examined in the present study was geared towards a variety of science and engineering majors. Therefore, wherever necessary, the language of rubrics was made more general in order to better describe research writing from a variety of fields. As an example of this, for the Results section, the Clabough and Clabough rubric was written to describe statistical research, which is common in the field of neuroscience, the present study used an adapted version of

this rubric that used more general language to describe a wider variety of research methods. Students were given two days after the second Zoom meeting to think about the comments they received. Based on such comments, they were assigned to finish the final draft on the course learning management system, where the teacher offered comments, suggestions, modifications, and a final grade. A final instructor-assessed mark out of 10 was provided to each written piece, accounting for 10% of the student's course grade (with written sections accounting for 50% of the total grade points).

Procedures of data analysis

Regarding the levels of writing quality, the number of words of the original author, and the extent of changes received by the dyadic partners, descriptive statistics were employed. Here, the means, standard deviations, minimum values, maximum values, and skewness were reported.

Regarding the proportion of variance within- and between-dyads for writing quality for the Introduction, Method, Results, and Discussion & Conclusion sections, were estimated with the assistance of the *misty R* package's `multilevel.icc` function (`method = 'lme4'`; see Yanagida, 2020, for details). For the current study it is important to disentangle the degree to which student writing quality varied within- and between-dyads. To do this, the intra-class correlation coefficient (ICC) is used to describe this (similar to the eta-squared value in a one-way ANOVA). To note, the ICC ranges from 0.00 to 1.00 with estimates closer to 1.00 reflecting the situation when there exist large systematic differences in average dyad (group) performance, and with estimates closer to 0.00 reflecting the situation when there exists large systematic differences in the performances between each student in the dyad (group). The current study follows the common convention whereby when ICC estimates for the performance outcomes are above .10 (i.e. 10% or more of the variation in performance is attributable to group effects), multilevel regression analyses is used to identify predictors of within- and between-group performance processes.

For RQ1 and RQ2, regarding the role of the independent variables on the writing quality for the four sections, four respective separate linear mixed-effects models were estimated with the assistance of the *lme4 R* package's `lmer` function (Bates et al., 2015). In order to estimate both within-dyad and between-dyad effects, only dyads exhibiting within-dyad variance for the single dependent variable and four independent variables were included in the analysis (within- and between-dyad variance is necessary for linear mixed effects modelling). This reduction resulted in some drop in sample size from 176 (88 dyads) for each of the four

models. This sample size is considered reasonable for the types of analysis this paper deals with, as well as when compared to the generally low sample size in research similar in scope. The sample size used in the present study is large enough to give an overview of the effects explained herein.

The four between-dyad variables were created by way of aggregating within-dyad variables for each dyad. Because some variables were highly skewed and exhibited very large differences in scales (e.g. volume of words vs. comments received), all within- and between-dyad variables were normalised with the assistance of the ‘normalr’ package (Courtney & Chang, 2018) and then transformed to z -scores using R prior to modelling. All four models converged successfully and interpretations were made as follows: $^{\dagger}p < .10$ (of possible interest), $*p < .05$, $**p < .01$, $***p < .001$.

Results

The first step in answering the research questions is to provide a description of the major variables used in the present study.

Dependent variables

The outcome variables of interest in this study were individual student writing quality for the following four sections: Introduction, Methods, Results, and Discussion & Conclusion. Written student material was marked by way of a section-specific rubric designed to gauge the level of quality writing and clarity of content. Each rubric was comprised of four to five items with alpha coefficients as follows: Introduction (alpha = .30, 5 items), Method (alpha = .40, 4 items), Results (alpha = .40, 4 items), and Discussion & Conclusion (alpha = .44, 4 items). Note that one of the five items for Methods, Results, Discussion & Conclusion needed to be deleted due to negative item-rest correlation. Due to the low number of items, it was expected that alpha would be low due to the coefficient’s bias against scales with a low number of items (Tavakol & Dennick, 2011). For each of the four scales, all final items correlated positively to the total score for the respective scales suggesting that each item contributed in a substantive way to the measured construct (Wu et al., 2016). Moreover, suggestive of discriminant validity, student writing quality on the four sections of the body of the manuscript (Introduction, Method, Results, and Discussion sections) tended to all be only slightly positively correlated (between $r = .20$ and $.44$), as shown in Table 1.

Table 1. Inter-scale correlation matrix.

Scale	Introduction	Method	Result	Discussion
Introduction	1.00	–	–	–
Method	.37***	1.00	–	–
Result	.27**	.26***	1.00	–
Discussion	.20**	.44***	.21**	1.00

Note.

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Table 2. Descriptive statistics for student writing quality for four sections.

	<i>M</i>	<i>SD</i>	min	max	skew
Introduction Section					
Funnel	1.54	0.51	0	2	–0.27
Context	1.68	0.48	0	2	–0.87
Purpose	1.76	0.47	0	2	–1.74
Language	1.39	0.53	0	2	0.04
References	1.6	0.65	0	2	–1.34
Total	7.97/10	1.35	4	10	–0.43
Methods Section					
Overview	1.42	0.79	0	2	–0.88
Repeatability	1.68	0.51	0	2	–1.2
Precision	1.62	0.52	0	2	–0.88
Justification	1.51	0.68	0	2	–1.04
Total	6.25/8	1.53	2	8	–0.92
Results Section					
Overview	1.42	0.73	0	2	–0.83
Interpretation	1.52	0.57	0	2	–0.67
Topical	1.77	0.44	0	2	–1.59
Figures	1.59	0.59	0	2	–1.09
Total	6.28/8	1.44	2	8	–0.71
Discussion Section					
Interpretation	1.58	0.58	0	2	–1.03
Comparison	1.44	0.67	0	2	–0.8
Structure	1.54	0.56	0	2	–0.73
Contribution	1.38	0.57	0	2	–0.24
Total	5.89/8	1.48	2	8	–0.36

Independent variables

Four main independent variables were included in this study: (i) number of words produced (by the original author), and number of (ii) comments received, (iii) words deleted, and (iv) words added by the dyadic editor. Metrics for these four variables were derived by way of Google DocuViz (Wang et al., 2015) and open-source Python code (Fanguy & Chang, 2021).

As shown in Table 2, students performed well in their writing tasks, and all of their manuscript sections in the current research obtained similar mean scores, with a maximum mean score of 7.97/10 (79.8%) for the Introduction, and a minimum mean score of 5.89/8 (73.6%) for the Discussion section.

The descriptive statistics for the behaviour of the original author and dyadic editor are shown in Table 3. They are volumes of words of

Table 3. Descriptive statistics for original author and dyadic editor behaviour.

	<i>M</i>	<i>SD</i>	min	max	skew
Introduction Section					
Volume of Words of Original Author (OA)	615.44	431.06	0	3131	2.52
Number of Comments by Editor	4.17	4.72	0	31	2.06
Words Deleted by Editor	11.45	26.8	0	214	5.15
Words Added by Editor	41.03	82.72	0	1024	8.42
Methods Section					
Volume of Words of Original Author (OA)	707.88	493.65	0	2911	1.6
Number of Comments by Editor	3.38	3.99	0	24	1.99
Words Deleted by Editor	16.18	66.84	0	666	8.75
Words Added by Editor	49.09	96.78	0	1141	7.6
Results Section					
Volume of Words of Original Author (OA)	884.86	755.36	0	5675	2.48
Number of Comments by Editor	3.38	5.26	0	40	3.47
Words Deleted by Editor	13.9	69.25	0	947	12.04
Words Added by Editor	41.52	58.68	0	366	2.83
Discussion Section					
Volume of Words of Original Author (OA)	358.78	324.48	0	2292	2.87
Number of Comments by Editor	2.16	2.75	0	19	2.6
Words Deleted by Editor	5.22	11.96	0	114	5
Words Added by Editor	42.83	69.98	0	482	3.68

original author (OA), number of comments by editor, words deleted by editor, and words added by editor. The individual-level mean (i.e. overall, inclusive of all individuals) and standard deviation for the independent variables are also included in Table 3. In general, the original author has the most word volumes in the Results section and the least in the Discussion section, and students added more words to than they did delete from the original piece of writing.

With reference to the dependent variables in the study, the within- and between-dyad variance components for writing quality varied as follows: Introduction ICC = .22, Method ICC = .25, Result ICC = .21, and the Discussion ICC was = .30. This suggested that multilevel modelling was necessary for the regression analysis whereby the within- and between-dyad processes could be correctly accounted for.

RQ1: How do different forms of peer editing behaviour (comments and track changes) affect the writing quality of individual students within manuscripts?

The results for individual academic writing quality for all the manuscript sections are presented in Table 4. The findings indicate some effect of peer editing elements for the student writing quality at the individual level. Specifically, the volume of words of the OA had a substantive effect on the writing quality of the Introduction section ($= .51, p < .001$). Words deleted by the editor had a positive effect ($= .41, p < .05$) while words added by the editor had a negative effect ($= -0.60, p < .05$) on written quality in the Introduction. At the between-dyad level, words added by the editor had a positive effect on written quality in the Introduction ($= .69, p < .05$).

Table 4. Linear mixed-effects models for individual writing quality in four sections.

Section	Introduction	Method	Result	Discussion
Intercept	0.00***	0.00***	0.00***	.00***
Within-Dyad Effects				
Volume of Words of OA	.507***	.327†	.241	.375†
Number of Comments by Editor	– .027	– .101	– .246	– .028
Words Deleted by Editor	.406*	.108	.054	– .191
Words Added by Editor	– .600*	.074	.265	– .222

Note. OA = original author.

† $p < .10$,

* $p < .05$,

** $p < .01$,

*** $p < .001$.

Table 5. Linear mixed-effects models for dyadic writing quality in four sections.

Chapter	Introduction	Method	Result	Discussion
Intercept	0.00***	0.00***	0.00***	.00***
Between-Dyad Effects				
Volume of Words of the OA	– .126	.132	.166	.028
Number of Comments by Editor	– .115	– .043	.062	– .261
Words Deleted by Editor	– .250	– .037	.147	.172
Words Added by Editor	.689**	– .018	– .401†	.428*

RQ2: How do different forms of peer editing behaviour (comments and track changes) affect the dyadic writing quality within manuscripts?

The results for dyadic academic writing quality for all the manuscript sections are presented in Table 5. At the between-dyad level, words added by the editor also had a positive effect on students' writing quality in the introduction ($p < .05$).

Finally, of potential interest at the within-dyad level was the positive effect of volume of words on writing quality in the Methods section. Also, of interest at the between-dyad level was the negative effect of words added by the editor on the results section.

Overview

To sum, results suggest that the measurement of student writing quality for the four sections exhibited adequate psychometric properties. Specifically, all items discriminated positively to the total scores for each respective scale; and, the relationships between the four scales were, expectedly, generally small and positive. Nevertheless, the number of items in the scales were minimal, e.g. four to five, so all results need to be considered alongside this measurement limitation. While writing quality in general was quite high, the marking rubrics provided sufficient variation in overall scores for each section (i.e. SDs were close to 1.5 for each section). The main results of the study were twofold. First, between dyads, i.e. pertaining to dyad average effects, the volume of words added by the editor positively contributed to dyadic writing quality on the Introduction and Discussion sections. Second, within groups, beyond the

volume of words by the OA, the number of words deleted by the opposing editor contributed positively to writing quality in the Introduction while the number of words added by the editor contributed negatively. Therefore, it would appear that as the dyad pair works together to add more words overall, this results in systemic improvements in the overall writing quality of the dyad pair for the Introduction and Discussion sections. However, for the dyad pairs themselves, as one editor tends to add asymmetrically more words, this results in a reduction in the writing quality for the OA. It may be that this somewhat anomalous negative effect was attributable to some degree of editor over-reach or some chance statistical artefact—note that $p < .05$ in this instance.

Discussion

Studies have established that peer editing can help improve students' writing. However, there has been little research on how comments and track changes as peer editing behaviour impact student writing quality when using Google Docs. This comprehensive study provides a broad understanding of how these two methods relate to student writing quality in different manuscript sections at both the individual and dyadic levels. T

Although comments are often seen as one of the most important factors in improving student writing, one of the most surprising results in the current study was the non-interaction between the number of comments received and student writing quality at either the individual or dyadic level, which does not support previous research that has illustrated that students who receive more comments will perform better on subsequent writing (Wu & Schunn, 2021). Three main reasons may explain this result. First, the likelihood of implementing the comments increased if a solution was offered. Note that comprehension of problems differs from comprehension of solutions. While it may seem impossible that someone could execute a solution without comprehending it, it is nonetheless possible to do so even if a student does not know why the method worked to solve the issue (i.e. without an understanding of the problem). Yet doing so could generate issues since if students do not understand the issue, they might implement the solution unsuccessfully. Secondly, it may have also been the case that students appeared to have a limited *ability* to evaluate peer editing behaviour before acting on it. Although CSCL approaches suggest that comments have the potential to improve student engagement in collaborative writing (Cress et al., 2021), it is also possible that authors lack confidence in their capacity to choose which comments to accept, leading them to passively apply or reject all information received, which may lead to minimal improvement of the

text quality (Gao et al., 2019). Therefore, this finding suggests that it would be better if some guidelines were provided before students reviewed the writing to assist them in determining the quality of the comments received. As a training activity, evaluating the quality of exemplary comments may be useful for reviewers in providing formative comments to their peers and benefit student reviewers to better self-assess their own work.

As for track changes, the results of this study showed that words deleted by the editor are related to significantly higher levels of individual writing quality (within dyads) for the Introduction section, which conflicted with previous work that found that subtractive changes were harmful for student academic writing quality (Gao et al., 2015). It may be due to the fact that many of the track changes made by the editor were remedial in nature, where the editor discovered some spelling, structural, or other systemic mistakes when tracking changes and helped others to delete problematic original text, which may have helped improve the quality of student writing. It is also possible that the deletion of content, as opposed to the addition of content, is a change based on the author's original thinking rather than imposing one's own meaning on the author. Moreover, the fact that only the Introduction section showed a significant result might be influenced by the characteristics of the Introduction section. The Introduction section is unlike the Discussion section in that it does not require one to provide numerous subjective judgments or inferences but only requires the demonstration of objective information, such as the background of the topic and gaps in existing research (Öchsner, 2013). Deleting words, phrases, and even paragraphs from another student's writing may improve the quality of Introductions by fixing problems in the original text while ensuring the coherence of thought.

On the contrary, words added as another behaviour of peer editing led to worse individual writing quality in the Introduction section (within dyads), which was in contrast with the work of Zhang (2020), who revealed that all types of modifications during online peer editing may help students gain a better understanding of how language is used in writing and how to avoid similar errors in the future. One possible explanation is that due to their lack of experience and inadequate instruction in academic writing, students may add inaccurate and unsuitable information to others' writing, although students can spot strong language and grammatical mistakes in a piece of writing because their evaluative judgments are contextual in nature (Tai et al. 2018). Yet, in this study, it is possible that students lacked domain and genre expertise, which prevented them from recognizing the standards for quality and using them to provide useful and correct information. This is

understandable when considering the thought coherence between the dyadic editor and the original author. Specifically, when content is added from the editor's perspective, there is a chance that the original intention of the author is changed, and students may consider the changes that they receive as an intervention that makes their written work worse (Ferris, 2011). Research has suggested that as a consequence of a large number of words added by an editor, the original author's reflection time rises, and the reviewer's abilities may be further questioned when it is found that the reviewer has deviated from his or her original objective, lowering the likelihood that the edits will be adopted and obstructing the writing improvement (Liu & Edwards, 2018). Moreover, a large number of comments received may point out errors, which students may interpret as direct criticism. This can be deleterious to students' subsequent writing improvement, diminishing their sense of psychological ownership (Ferris, 2011). More empirical research is needed to confirm these claims.

As for the dyadic level, the results suggested that words added by editors are associated with higher average dyad writing scores in the Introduction and Discussion sections. These results echo evidence suggesting that reflecting on modifications that others make to their work might help students acquire insight into their collaborators' perspectives on their work (Pham, 2021), and students may understand the quality of their own work and be able to improve their own writing through dialogue and involvement with peers (Hattie & Clarke, 2018; Yim et al., 2017). However, this finding of the current research contrasts with previous literature that highlights the psychological ownership of academic products. Students were unwilling to change others' writing directly, even when instructors encouraged them to review and edit their peers' work (Pierce et al., 2003). The characteristics of the sections of the manuscript may also help to explain these findings. It is possible that in the Discussion section, authors may highlight how their work can help future researchers on comparable themes as well as the contribution of their studies, and it is much easier for students to exchange their ideas and negotiate based on such kinds of subjective descriptions in these parts compared to some objective, and often more technical, sections such as Results or Methodology. Students may concentrate on more in-depth revisions, such as substance, rather than simply providing criticism on spelling and grammar. It is difficult to explain why these findings are opposite to those observed within dyads, but the positive impact of words added on the dyadic writing level against the negative impact on the individual's writing level might be related to student language levels. Specifically, when engaging in self-reflection, students, particularly those in the lower proficiency bands, pay particular attention to 'those forms that are motivated by the learners' own needs and which are

consequently more likely to be within their linguistic knowledge range' (Storch, 2013, p. 54), which in turn affects their individual writing improvement.

This study is a first step in understanding how online peer editing behaviours on L2 compositions relate to student academic writing quality. When students continually edited their work and offered comments and/or track changes to others, both editors and authors displayed deeper thinking about both the texts written by others and their own writing during the process of online peer editing. This leads us to the conclusion that, in the long run, Google Docs or other similar platforms may be able to assist a larger group of students in developing their writing strategies and abilities. The results of this study have ramifications for both educational research and practice. The findings imply that the effects of comments and track changes during online peer editing are comparable in terms of individual writing quality as well as dyadic writing. However, the utilisation of technology-based feedback techniques like asynchronous peer engagement, synchronous online peer editing, and others might not always result in positive outcomes. To help students produce their best work, educators should be aware of the components of feedback in various versions that have the greatest influence on students' writing quality (Panadero et al., 2016). In order to properly utilise technology, its capacity should also be thoroughly assessed. However, its ability to instantly access or respond to any criticism and its capacity to watch how students engage with one another do in fact merit our full attention. Furthermore, teachers should be encouraged to use Google Docs to set up peer editing exercises in their classrooms because this platform has been shown to be sufficient for facilitating the process of mutual feedback.

Conclusion

Advanced online collaboration tools, such as the Google Docs used in the present study, promote research into students' online collaborative writing. However, few studies have examined the effects of comments and track changes as two forms of peer editing on student writing quality. The current research is an attempt to classify and establish a comprehensive connection between peer editing behaviour and student writing abilities. Very little past research on writing has focused on the effect of words deleted and words added on writing quality. Consequently, the evidence indicating the significance of track changes was a fresh contribution to the body of knowledge. Through in-depth research on online peer editing of writing within Google Docs, the present study investigated the association between peer editing elements and student writing quality for various manuscript sections. The results suggest that tracking

changes is effective for improving students' writing quality. Specifically, words deleted by editors were positively associated with student Introduction writing quality, while words added in the Introduction section harmed student writing. At the dyadic level, words added positively correlated with student writing quality in the Introduction and Discussion parts. However, unlike the results of previous research, this study finds that the number of comments has little impact on student academic writing in an online context.

While these results are beneficial to instructional designers and students, the current study has several limitations. Since the current study did not utilise a pretest/posttest design, it was unable to control student writing abilities before getting feedback, which may have influenced the results. Future studies might use this strategy to increase the reliability and generalizability of the findings. Furthermore, there may be links between peer editing behaviour and academic writing quality, but they may vary according to student cultural background and the contribution among group members; thus, more research is needed in such areas. Furthermore, how students interact with the comments and track changes that they receive during the online peer editing was not directly investigated. More research should be designed to check the relationship between feedback implementation and student writing improvement. In addition, the distribution of students into pairs for further peer editing was based on their preferences. Therefore, some additional interpersonal factors, like the relations between students, their appraisal of each other's writing quality and competence, etc., may have influenced the obtained results. The random assignment of partners for peer editing may offset the above limitation. Also, the findings in the current study are tempered by the fact that the precision of measurement of the quality of student writing could also be improved—more carefully-crafted and piloted rubric items, and perhaps rubric levels, could be crafted so as to improve the reliability of the scales. Finally, because participants in this study had a wide range of research topics, writing assessment was sometimes challenging for both the peer editors and writing instructors, and this may have affected scoring reliability. Future studies could be conducted in research writing courses for a particular field of study or area of research in order to alleviate this concern.

To sum up, encouraging students to participate in peer editing and providing more direct changes are possible ways to enhance student writing. The current study contributes by providing empirical evidence that students who participate in online peer editing can improve their writing skills through social interaction and peer editing. As a result, the authors suggest that more research needs to be done in order to build a systematic method to improve the function of online peer editing. A more comprehensive knowledge of online collaboration and the benefits of

online peer editing during the learning process may improve student-centred activities and collaborative learning opportunities.

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