



Using wiki-mediated collaboration to foster L2 writing performance

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Abstract

This study investigated the effect of wiki-mediated collaborative writing on the development of learners' individual writing in a second language (L2). Participants were 52 learners of English as a foreign language enrolled in two intact junior writing classes at a Taiwanese university. One class was assigned to be a wiki-collaborative writing group (n = 26), and the other an individual writing group (n = 26). Both classes participated in an individual pre-test writing, a writing task, and an individual post-test writing over a 9-week period. Students in the wiki group worked in pairs via wikis to produce an expository essay; students in the individual group produced their essays alone. Learners' written production on the pre-test and post-test was analyzed in terms of content and organization, and linguistic complexity and accuracy. Results indicated a significant effect for wiki-mediated collaborative writing on the content quality and linguistic accuracy of learners' individual writing in L2. Its effect on the organization and linguistic complexity, however, was less evident.

Keywords: Collaborative Learning, Computer-Mediated Communication, Instructional Design, Writing

Language(s) Learned in This Study: English

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Introduction

Writing is not simply an individual act; it is also an interactional and social process. To create meaningful contexts and authentic purposes for writing, as well as to emphasize accuracy in formal language, a number of researchers (e.g., Kowal & Swain, 1994; Swain & Lapkin, 1998) argue that second language (L2) writers should collaborate throughout the writing process. Such collaboration, during which time learners jointly produce a text, may promote a sense of co-authorship and hence encourage learners to exchange feedback, notice linguistic and organizational problems, and in turn contribute to decision making on all aspects of writing: content, organization, and language (Storch, 2002, 2005; Swain & Lapkin, 1998).

Social technologies, such as wikis, Google Docs, and chats, have simplified collaboration opportunities between learners and brought renewed attention to L2 collaborative writing (Arnold, Ducate, & Kost, 2009; Aydin & Yildiz, 2014; Bikowski & Vithanage, 2016; Elola & Oskoz, 2010; Kessler, 2009; Kessler, Bikowski, & Boggs, 2012; Lee, 2010; Mak & Coniam, 2008; Miyazoe & Anderson, 2010). Wikis, as a form of asynchronous computer-mediated communication, are increasingly adopted in writing instruction (Lamb, 2004) to support collaborative learning (Richardson, 2010).

With the development of computer-based technologies for L2 instruction and learning, research on how L2 learners transfer knowledge and skills they have gained from wiki-mediated collaborative writing to subsequent individual writing deserves further investigation (Li & Zhu, 2013). Several studies have attempted to investigate this process, with a majority of them focusing on (a) the process of wiki-mediated collaborative L2 writing such as revisions by learners collaborating on projects using wikis, (b) learner perceptions of and attitudes toward incorporating wikis in writing instruction (e.g., Arnold et al., 2009;

Aydin & Yildiz, 2014; Elola & Oskoz, 2010; Kessler, 2009; Kost, 2011; Lee, 2010; Mak & Coniam, 2008; Storch, 2005), and (c) how learners branch out from individual contributions to collective production. They have not, however, explicitly addressed how wiki-mediated collective production helps individual L2 writing performance. The present study aims to fill this gap.

Collaboration in L2 Writing

Over the past two decades, research has shown that learner collaboration facilitates L2 acquisition (Kim, 2008; Lapkin, Swain, & Smith, 2002; McDonough, 2004; Storch, 1999, 2004; Swain & Lapkin, 1998). Collaborative learning is grounded in the social-constructivist paradigm of language learning. In this paradigm, learning begins as a social process that involves a community whose members share and build L2 knowledge together to accomplish a joint task (Pavlenko & Lantolf, 2000; Vygotsky, 1978). Language use is not only a means of communication, but also a cognitive tool enabling learners to work together to solve linguistic problems or co-construct language and knowledge (Donato, 2000; Swain & Lapkin, 1998). Since no two learners have the same strengths and weaknesses, when they work together, they can pool their different linguistic resources to provide scaffolded assistance to each other and achieve a performance level that is beyond their individual levels of competence (Ohta, 2001; Storch, 2005). Therefore, activities that foster interaction and co-construction of knowledge in the use of the target language are vital for the language learning classroom.

Allowing L2 learners to complete a writing task together gives them the chance to interactively and collaboratively develop their writing skills (Storch, 2005). Such collaborative processes can enhance L2 learning through joint scaffolding, “allowing learners to identify gaps in their own knowledge, to hypothesize about language, and most importantly, to discuss these aspects of language through the process of developing a jointly constructed text” (Wigglesworth & Storch, 2012, p. 365). Previous studies of L2 collaborative writing have shown that in the process of co-authoring, learners consider not only lexis and grammatical accuracy, but also discourse (DiCamilla & Anton, 1997; Storch, 2002; Swain & Lapkin, 1998). L2 collaborative writing has also found support when compared to individual writing. For instance, Storch’s (2005) research showed that collaborative texts are superior in terms of syntactical complexity and grammatical accuracy. Studies by Fernández Dobao (2012), Storch and Wigglesworth (2007), and Wigglesworth and Storch (2009) also reported positive effects of collaboration on grammatical and lexical accuracy. A work by Shehadeh (2011) showed further that learners’ content and organization, as well as lexical accuracy, improved as a result of collaborative writing activities. Taken together, these studies suggest that pooled knowledge in collaborative writing activities enables L2 learners to produce texts of better quality. In addition, the collaboration may impact the composing processes and serve to lessen the cognitive load for the learners (Wigglesworth & Storch, 2009, 2012), leading to enhanced accuracy and complexity, as well as improved content and organization.

Wikis and L2 Collaborative Writing

Web 2.0 tools such as wikis and their support of social-constructive learning have increased their potential for L2 collaborative writing (Aydin & Yildiz, 2014; Kessler et al., 2012; Lee, 2010). A wiki is a web-based collaboration tool that allows users to easily create, view, and modify content in a participatory manner, using any web browser at any time. Collaboration is thus no longer bounded by the four walls of a classroom. The open editing and review structure of a wiki allows L2 learners to co-construct L2 knowledge by negotiating, arguing, and making revisions in knowledge, making a wiki a suitable tool for supporting collaborative writing outside the classroom (Castañeda & Cho, 2013; Parker & Chao, 2007). A wiki’s asynchronous support of online collaboration allows learners more opportunities to focus on form, due to the additional time available for reflection (Kessler, 2009; Lee, 2010). Its revision history indicates what changes have been made and by whom, increasing author accountability. Wikis thus offer writing instructors new opportunities to combine all the vital parts of writing instruction by allowing writers to focus on structure, organization, grammatical accuracy, and audience awareness, while still supporting the

revision and drafting processes (Elola & Oskoz, 2010; Lund, 2008; Mak & Coniam, 2008).

A number of studies have explored wiki-mediated L2 collaborative writing (e.g., Aydin & Yildiz, 2014; Elola & Oskoz, 2010; Kessler, 2009; Kessler & Bikowski, 2010; Kost, 2011; Lee, 2010; Oskoz & Elola, 2010) and concluded that wikis engage learners in content brainstorming and foster collaborative scaffolding during which time learners can help each other re-organize content and correct errors. Lee (2010), for example, reported that during wiki collaboration, learners linguistically scaffolded each other to detect and correct errors at the sentence and the word levels. Learners were also found to make suggestions for improving content and organization, which resulted in reworking, refining, and fine-tuning already written content and organization (Oskoz & Elola, 2010). Additional studies on collaborative wiki writing (e.g., Aydin & Yildiz, 2014; Kessler, 2009; Kessler & Bikowski, 2010; Kost, 2011) also reported learners making both form- and content-related changes to the joint texts. Some studies reported more form-related than content-related changes (e.g., Kost, 2011), while others revealed the converse (e.g., Aydin & Yildiz, 2014; Kessler, 2009). Nevertheless, both groups of studies agreed that when co-producing texts, learners not only self-edited their own writing, but also were also not hesitant to edit their peers' postings, and both self- and peer-corrections resulted in a high level of accuracy.

Taken together, through wiki-collaboration, learners are exposed to input from others, encouraged to produce enhanced output, given more opportunities to practice, and afforded the chance to provide linguistic feedback for themselves and peers (Ortega, 2007; Oxford, 1997; Swain, 1995; Vygotsky, 1978). Interestingly, however, except for studies by Wang (2015) and Bikowski and Vithanage (2016), none appear to have investigated the effect of wiki-mediated collaborative writing on L2 learners' individual writing development, despite the various reported advantages of wiki collaborative writing.

Wang (2015) divided his students between a wiki group and a non-wiki group. The students in each group worked in sets of four to draft, peer-edit, and revise the same two written assignments over a 12-week period. Pre-tests and post-tests were compared to determine the effect of wiki collaborative work on students' improvement in their individual business writing. The results showed that though both groups improved over time, the wiki group achieved greater improvement in terms of audience awareness, organization, content and style, grammatical accuracy, and sentence structure in their business writing performance than their non-wiki counterparts. However, in Wang's study both the wiki and the non-wiki groups involved group writing, and it could not be determined how much effort the students in the non-wiki group contributed to the collaborative texts. The effect of wiki-mediated collaborative writing on individual L2 writing development thus remains unknown when compared to the effect of individual writing (a common practice in L2 writing class).

Bikowski and Vithanage (2016), using Google Docs, an online wiki-like platform, reported a similar result. Students were divided into collaborative writing and individual writing groups. The collaborating students worked in groups of three or four to complete four different writing tasks. Pre- and post-test individual writings were compared. Like Wang (2015), Bikowski and Vithanage (2016) reported that both groups experienced gains in their overall individual writing; however, the students engaged in collaborative writing showed significantly higher mean gains from their pre- to post-test scores than the students engaged in individual writing. Nevertheless, in the study by Bikowski and Vithanage, the collaborative writing tasks were done in class and monitored by an instructor. It was unclear whether out-of-class collaboration could achieve a similar effect, and, if so, in which L2 writing aspects. Arnold and Ducate (2006) suggest that the collaborative learning experience can be affected by context.

The present study was conducted to cover these gaps. This study contributes to the existing literature by examining not only how collaborative wiki writing helps individual student writing, but also how collaborative wiki writing helps individual student writing in an unmonitored context, outside of class.

Research Questions

Two research questions (RQs) are addressed in this study:

1. How does out-of-class wiki-mediated collaborative writing help L2 English writers improve their individual writing's content and organization?
2. How does out-of-class wiki-mediated collaborative writing help L2 English writers improve their individual writing in linguistic complexity and accuracy?

Method

Design of the Study

This study followed a pre- and post-test design that aimed to examine the effect of wiki-mediated collaborative writing on L2 individual writing development over a 9-week period. The study was carried out with two intact junior English composition classes from an applied linguistics department at a Taiwanese university. The two writing classes followed a standardized curriculum and syllabus, used the same textbook, were given the same number of writing assignments, used standardized grading criteria, and met on the same day for two hours each week. One class ($n=26$) was assigned to be a wiki-collaborative writing group while the other class ($n=26$) was assigned to be an individual writing group (both are described more thoroughly below). Both classes participated in an individual pre-test writing, a writing task, and an individual post-test writing. All three writing tasks required the students to write expository prose essays.

Participants

A total of 52 students (16 males and 36 females), between 20 and 21 years old, participated in the study. Prior to the study, all the students had taken four semesters of required writing instruction (grammar, paragraph writing, and essay writing). They all had received instruction on how to produce grammatically correct sentences, organize them into paragraphs with clear topic sentences, and formulate well-organized academic essays with thesis statements and supporting and concluding paragraphs. They had also learned how to conduct peer reviews and respond to peer feedback for revising and editing. To ensure that the two classes had comparable writing proficiency, independent t -tests were run on students' pre-test writing (described below). The results are displayed in [Table 1](#). They confirmed no statistically significant differences between the two classes in the quality of content ($t = -0.06, p = .957$) and organization ($t = 0.30, p = .763$), as well as in linguistic complexity (mean number of clauses per T-unit [C/TU]: $t = 1.74, p = .089$; mean length of T-unit [MLT]: $t = 1.90, p = .064$; lexical variety [LV]: $t = -0.08, p = .941$; lexical sophistication [LS] $t = 1.21, p = .232$) and accuracy (weighted clause ratio [WCR]: $t = 0.54, p = .595$). Each of these measures is described in greater detail below.

[Table 1](#). *Difference Between Groups on Pre-Test Writing*

Measures	Wiki Collaborative Writing Group		Individual Writing Group	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Content	3.88	1.25	3.90	1.29
Organization	4.58	1.18	4.48	1.11
C/TU	2.20	0.45	2.01	0.37
MLT	15.48	2.80	14.11	2.40
LV	7.98	0.99	8.00	0.63
LS	0.17	0.03	0.16	0.03
WCR	0.74	0.88	0.72	0.77

Instruments

Two writing tests (see [Appendix A](#)), designed in parallel form, were used in this study. The two writing

tests were administered as pre- and post-tests. The time allowed for each task was 90 minutes. The topics of the two tests were chosen for their relevance to the participants' immediate environment (i.e., food safety and media). Using Ellis' (2003) criteria for evaluating language tasks, it was determined that the two writing tasks were similar in task difficulty since they involved similar amounts of task input, allotted the same amount of task completion time, required the same genre (i.e., expository), and resulted in the same outcome (i.e., a 4-paragraph written essay). The two tasks were also verified by two experts from the researchers' department and were ascertained to be comparable in terms of difficulty.

Procedure

The study was conducted at the beginning of the semester. Each student in the two writing classes took the pre-test in the form of individual essay writing.

Wiki Collaborative Writing Group

For this group (7 males and 19 females), the instructor (the first author) designed a class wiki using Wikispaces (for a screenshot, see [Figure 1](#)). The students were experienced with computers and had experience working collaboratively on joint assignments in other courses; however, their wiki experience was limited. To familiarize these students with the wiki environment, the instructor demonstrated the features of the wiki (i.e., edit, comment, discussion, history) in class and designed a trial wiki page to provide further practice with the features before the actual wiki writing. After the trial, the students self-selected partners (two to three in a group; 12 groups were formed) to create their own wiki pages. The students were allowed to self-select their partners to promote comfort and interaction. Though self-selected groups might have resulted in symmetrical (i.e., equal ability) as well as asymmetrical (i.e., expert–novice) groupings, studies (e.g., Donato, 1994; Ohta, 1995; Storch, 2002, 2005) have suggested that when learners work together, they can take turns acting as experts and support each other in the completion of a shared assignment, no matter the type of grouping. Lee (2010) cautioned that individual contributions and collaborative effort were less likely to occur without proper guidance. The instructor thus provided the students guidelines ([Appendix B](#)), which were modeled after the studies by Lee (2010) and by Li, Chu, and Ki (2014).

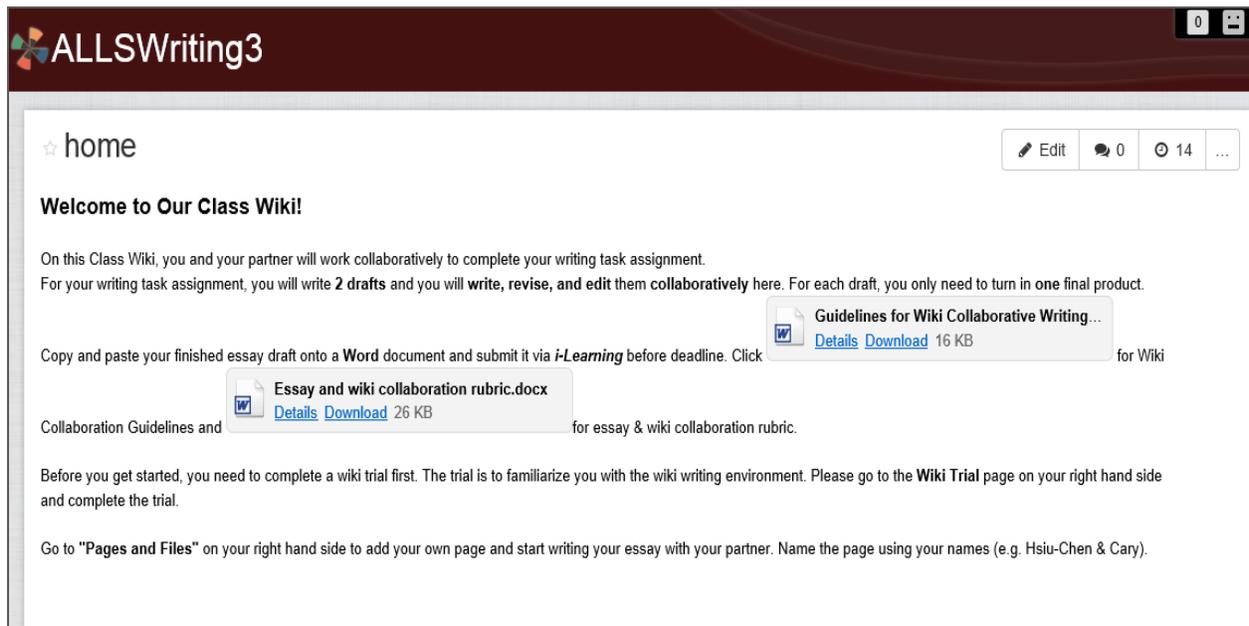


Figure 1. This is a screenshot of the class wiki page.

The students were required to collaboratively write an expository essay out of class with at least four paragraphs and to create two drafts using the wikis. Each group was allowed to select their own topic but

was told to select a topic relevant to their immediate environment. Some topic brainstorming was done during a class meeting prior to wiki writing. Sample topics selected by the students included the European refugee crisis, reasons for divorce in Taiwan, the effects of staying up late, the stray dog issue in Taiwan, the effects of smartphones on teenagers, the benefits of eating organic foods, and the effects of low birth rate in Taiwan.

Each group took two to three weeks to complete each draft, and each group submitted one joint essay. After the students turned in Draft 1, the instructor gave feedback regarding content, organization, and grammar. Following Lee (2010), the instructor's assistance was kept to a minimum, and only global feedback was given, to encourage peer scaffolding. Upon receiving feedback, the students then made revisions collaboratively and turned in Draft 2. To hold students accountable for the writing task, the wiki essays were graded using (a) the essay grading rubric modeled after Neumann and McDonough (2014), and (b) the wiki grading rubric modeled after Lee (2010). The rubrics can be found in [Appendix C](#). This project counted for 20% of the entire course grade.

To examine whether the students interacted and collaborated during the collaborative writing processes, the wiki pages (including their comments, discussion spaces, and history pages) created by the 12 groups were analyzed for learner–learner collaborative dialogues, focusing specifically on negotiations over content, organization, and language. To identify language-related collaborative dialogues, the wiki pages were analyzed for the occurrence of language-related episodes (LREs), defined as “any part of a dialogue where the students talk about language they [produced], [questioned] their language use, or [corrected] themselves or others” (Swain & Lapkin, 1998, p. 326). Similarly, to identify content (and organization) related collaborative dialogues, the wiki pages were analyzed for the occurrence of content- and organization-related episodes, defined as any part of a dialogue where the students talked about content messages they produced, questioned the clarity and relevance of information, or discussed the sequencing of information. (Details are reported below.)

Individual Writing Group

As for the individual writing group (9 males and 17 females), the same procedure described above was followed except for the wiki collaboration. The students wrote an expository essay out of class with at least four paragraphs and to create two drafts. Each student selected a topic relevant to their immediate environment. Topic brainstorming was done during a class meeting prior to individual writing. The topics selected by the students included the European refugee crisis, the negative effects of nuclear power, the reasons for boycotting barbecue in Taiwan, the effects of water pollution, the benefits of student volunteering, the prevention of dengue fever in Taiwan, and the benefits of having a college education. Each student took two to three weeks to complete each draft. Each member of the group turned in individual drafts. After the students turned in Draft 1, the instructor (the second author) gave feedback regarding content, organization, and grammar. The instructor's assistance was kept to a minimum, and only global feedback was given, to encourage self-repair. To accord with the wiki group, writing guidelines were given to the students ([Appendix B](#)). Upon receiving feedback, the students made revisions independently and turned in Draft 2. The individual essays were graded using the essay grading rubric ([Appendix C](#)).

Measures

The pre- and post-test essays from the learners in the two groups were analyzed for complexity and accuracy as well as for content and organization. To avoid bias, the pre- and post-test essays were photocopied; the student names and group information were replaced with random numbers. The absence of such information helped ensure that the assessment would be blind. The post-test was administered in both classes at the end of the project. Each student wrote another individual expository essay. [Figure 2](#) summarizes the instruction for the two groups in the study.

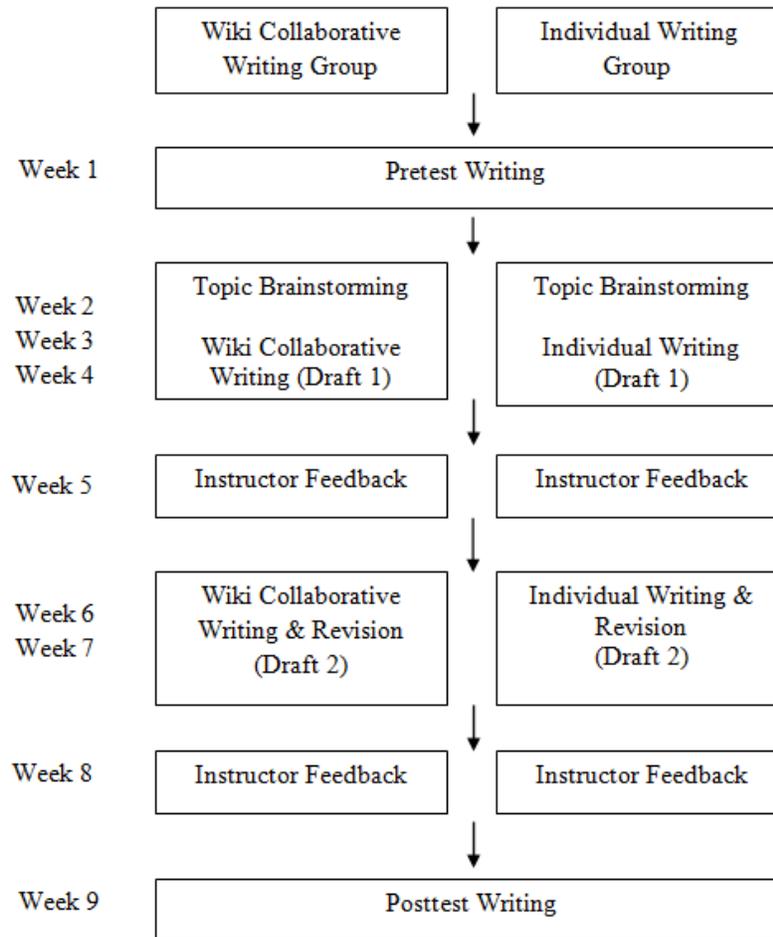


Figure 2. This shows the timeline and procedure of the study.

Content and Organization

In the pre- and post-test essays, content and organization were rated on an 8-point analytical rating scheme (see [Appendix D](#)) modeled after the study by Neumann and McDonough (2014). The content of each essay was assessed by analyzing the development of the thesis, the coverage of the topic, the relevance of supporting details, and the conclusion of the main points. The organization of each essay was assessed in terms of fluency of expression and sequencing of ideas. The authors of this study first met to discuss the rating criteria and rated selected benchmark essays. Then, the authors compared each sample piece and discussed how it should be rated. After agreement was reached on the benchmark essays, the formal rating began, and the authors independently assessed the remaining essays. To determine inter-rater agreement, Pearson's correlation was performed. For the pre-test, a correlation coefficient $r = .881$ was obtained for content and $r = .830$ for organization. For the post-test, a correlation coefficient $r = .857$ was obtained for content and $r = .828$ for organization. The average of the two authors' scores was used for analysis.

Complexity and Accuracy

Unlike content and organization, linguistic complexity and accuracy of the pre- and post-test essays were evaluated using the complexity and accuracy measures described below. The decision to use these measures was based on the argument that rating language samples on the two dimensions using analytical schemes could be too general to reflect the multidimensionality of the two aspects and might not be sensitive enough to capture occurring changes in the two dimensions of L2 production (see Brindley, 2009; Tonkyn, 2012).

For our study, we examined four measures of complexity (syntactic and lexical) and one measure of accuracy. The measures were largely the same as those used in other L2 collaborative writing research (e.g., Fernández Dobao, 2012; Storch, 2005; Wigglesworth & Storch, 2009) and were recommended in the theoretical literature (e.g., Foster & Wigglesworth, 2016; Jarvis, 2013; Norris & Ortega, 2009).

The following complexity measures were used:

- **C/TU:** C/TU was calculated by dividing the total number of separate clauses by the total number of T-units.
- **MLT:** MLT was calculated by dividing the total number of words by the total number of T-units.
- **LV:** This index of Guiraud, or root type-token ratio, was calculated by dividing the number of lexical types by the square root of the number of tokens.
- **LS:** LS was calculated by a web-based lexical complexity analyzer (Ai & Lu, 2010; Lu, 2012) as the ratio of the number of sophisticated word types to the total number of word types in a text.

Accuracy was measured by a WCR (see Evans, Hartshorn, Cox, & de Jel, 2014; Foster & Wigglesworth, 2016). To calculate WCR in our study, clauses were assigned to one of four levels (i.e., entirely accurate, level 1, level 2, and level 3) based on their error gravity and received an accuracy score of 1.00, 0.80, 0.50, or 0.10, respectively. WCR was calculated by adding the total clause ratings for an essay and dividing the sum by the total number of clauses.

To establish inter-rater reliability, another rater was trained. The rater and the first author coded 10 percent of the essays for T-units, clauses, and WCR. Inter-rater reliability for T-units, clauses, and WCR was 98%, 95%, and 92%, respectively.

Results

Content Quality and Organization of L2 Individual Writing

To answer RQ1, paired-samples *t*-tests were performed on the rating scores obtained within groups for quality of content and organization between the pre- and post-test writing, after checking the assumptions for using the *t*-tests. Likewise, independent *t*-tests were performed between groups on the rating scores attained on the post-test writing. From pre- to post-test (Table 2), the wiki collaborative writing group demonstrated a mean gain of 1.02 on content and 0.86 on organization. The individual writing group, in contrast, demonstrated a mean gain of 0.25 on content and 0.37 on organization. Results of paired-samples *t*-tests found statistically significant improvement in the wiki collaborative writing group in the quality of content ($t = -6.00, p < .001, d = 0.87$) and organization ($t = -5.64, p < .001, d = 0.70$). The individual writing group also scored higher in quality of content and organization, but the improvement did not reach statistical significance ($t = -0.86, p = .397, d = 0.18$ and $t = -1.84, p = .078, d = 0.34$, respectively). Table 3 shows the results of independent post-test *t*-tests for the two groups. The results indicate that the quality of content produced by the wiki collaborative writing group was significantly better than that produced by the individual writing group ($t = 2.10, p = .041, d = 0.59$). The scores for quality of organization produced by the wiki collaborative writing group were better than those produced by the individual writing group, but this difference did not reach statistical significance ($t = 1.81, p = .076, d = 0.51$).

Table 2. Differences in Content and Organization Between Pre- and Post-Test Within Groups

Group	Measure	Pre-Test		Post-Test		<i>t</i>	<i>p</i>
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Wiki Group	Content	3.88	1.25	4.90	1.09	-6.00	.000*
	Organization	4.58	1.18	5.44	1.28	-5.64	.000*
Individual Group	Content	3.90	1.29	4.15	1.46	-0.86	.397
	Organization	4.48	1.11	4.85	1.09	-1.84	.078

* $p < .001$

Table 3. Differences in Content and Organization of Post-Test Between Groups

Measures	Wiki Group		Individual Group		<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Content	4.90	1.09	4.15	1.46	2.10	.041*
Organization	5.44	1.28	4.85	1.09	1.81	.076

* $p < .05$

Linguistic Complexity and Accuracy of L2 Individual Writing

To answer RQ2, paired-samples *t*-tests were performed on the measures of complexity and accuracy between the pre- and post-test writing within groups, after checking the assumptions for using the *t*-tests. Likewise, independent *t*-tests were performed on the measures of complexity and accuracy on the post-test writing between groups. Table 4 displays the results between pre- and post-tests of paired-samples *t*-tests. The results indicate that the wiki collaborative writing group produced both syntactically more complex (C/TU: $t = -2.19$, $p = .038$, $d = 0.48$) and lexically more varied language ($t = -4.74$, $p < .001$, $d = 0.71$) in post-test writing than in pre-test writing. The wiki collaborative writing group also produced more accurate language in post-test writing than in pre-test writing (WCR: $t = -5.46$, $p < .001$, $d = 0.78$). Regarding the individual writing group, the group produced syntactically more complex (C/TU: $t = -3.51$, $p = .002$, $d = 0.87$; MLT: $t = -2.43$, $p = .023$, $d = 0.46$) and lexically more varied language ($t = -5.68$, $p < .001$, $d = 1.23$) in post-test writing than in pre-test writing; however, no significant result was found for accuracy (WCR: $t = -1.98$, $p = .059$, $d = 0.40$). Table 5 presents the results for the two writing groups of independent post-test *t*-tests. These results demonstrate that the wiki collaborative writing group produced significantly more accurate language than the individual writing group (WCR: $t = 3.09$, $p = .003$, $d = 0.87$). No significant results, however, were found for complexity (C/TU: $t = 0.93$, $p = .359$, $d = 0.26$; MLT: $t = 0.37$, $p = .712$, $d = 0.10$; LV: $t = -0.81$, $p = .423$, $d = 0.23$; LS: $t = -0.40$, $p = .693$, $d = 0.11$).

Wiki Collaboration

During the wiki collaborative writing processes, the 12 wiki writing groups generated a total of 341 learner-learner collaborative dialogues ($M = 28.42$, $SD = 12.13$). Of the 341 collaborative dialogues, 91 (27%) were content-based (i.e., discussion of topic development and supporting details; $M = 7.58$, ranging from 2 to 23 per group), 14 (4%) were organization-based (i.e., discussion of ideas sequencing, 12 of which were through outlining; $M = 1.17$, ranging from 1 to 3 per group), and 236 (69%) were language-based (i.e., detecting and correcting formal mistakes; $M = 19.67$, ranging from 6 to 38 per group). These data indicate that the learners in the wiki collaborative writing group interacted and collaborated with their partners during the out-of-class wiki collaborative writing processes, providing fidelity of implementation.

Table 4. Differences in Complexity and Accuracy Between Pre- and Post-Test Within Groups

Group	Measure	Pre-Test		Post-Test		<i>t</i>	<i>p</i>
		<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Wiki Group	C/TU	2.20	0.45	2.44	0.55	-2.19	.038*
	MLT	15.48	2.80	15.54	3.11	-0.10	.919
	LV	7.98	0.99	8.65	0.90	-4.74	.000**
	LS	0.17	0.03	0.17	0.03	0.15	.881
	WCR	0.74	0.09	0.80	0.06	-5.46	.000**
Individual Group	C/TU	2.01	0.37	2.32	0.34	-3.51	.002*
	MLT	14.11	2.40	15.24	2.56	-2.43	.023*
	LV	8.00	0.63	8.84	0.73	-5.68	.000**
	LS	0.16	0.03	0.17	0.04	-1.48	.151
	WCR	0.72	0.08	0.75	0.07	-1.98	.059

* $p < .05$, ** $p < .001$

Table 5. Differences in Complexity and Accuracy of Post-Test Between Groups

Measure	Wiki Group		Individual Group		<i>t</i>	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
C/TU	2.44	0.55	2.32	0.34	0.93	.359
MLT	15.54	3.11	15.24	2.56	0.37	.712
LV	8.65	0.90	8.84	0.73	-0.81	.423
LS	0.17	0.03	0.17	0.04	-0.40	.693
WCR	0.80	0.06	0.75	0.07	3.09	.003*

* $p < .05$

Discussion

Improvement in Content Quality and Organization of L2 Individual Writing

In our study, students in the wiki collaborative writing group demonstrated greater improvement in developing a topic (i.e., better content quality): this included covering the topic, developing the ideas, and using relevant details to support their thesis. The wiki group was engaged in an environment where the students had opportunities to read each other's work and both give and receive feedback—opportunities missing when students write individually (Storch, 2005). Peer feedback, as Rollinson (2005) suggests, “encourages a collaborative dialogue in which two-way feedback is established, and meaning is negotiated between the two parties” (p. 25). Peer feedback allows learners to know if their messages are effective and encourages them to reformulate their writing for better quality. According to the results of the learners' wiki collaboration analyses, the wiki writers were indeed involved in giving each other feedback on content changes. During the collaborative writing processes, the wiki writers helped each other identify points of irrelevance, redundancy, and incomprehensibility. This, in turn, led to deletion of details (Example 1) and clarification or elaboration of information (Example 2).

Example 1. *Deletion of Details*

The sentence “Spouses may easily get emotionally connected with the opposite sex whether in working places or in public through frequent interaction,” written by Yuri, was highlighted by Annie in the joint text, followed by the discussion via the comment feature.

Annie: Delete the sentence. It is not relevant.

Yuri: I see. Ok.

Example 2. *Elaboration of Information*

The sentences “The constitution of Germany gives the police the authority to supervise and enforce a ban on these people who treated dogs badly. In Germany, having a dog needs to pay the tax. The law has this special regulation because the German government wants to make sure the dog owner has a basic economic foundation,” written by Ann, were highlighted by Nancy in the joint text, followed by the discussion via the comment feature.

Nancy: Add “Being afraid of receiving a fine, dog’s owners won’t mistreat their dogs not to mention abandon them” after the sentence “The constitution of Germany gives the police the authority to supervise and enforce a ban on these people who treated dogs badly.”

Nancy: Add “For example, when their dogs are sick, they can afford the expensive medical expenses” at the end. This way meaning is made more clear.

Ann: I agree. Revised.

As revealed in these examples, the wiki-mediated collaboration contributed to raising learners’ awareness of how adequately their ideas were developed and expressed. The collaboration also pushed the learners to reflect on how they conveyed their messages and stayed more focused on topics. Through wiki collaborative writing, knowledge of formal academic writing in L2 was created in the interaction between learners co-constructing text together (Elola & Oskoz, 2010). It appears that such knowledge was subsequently applied to the individual writing task, leading to the production of better content quality in post-test writing than the individual writing group who received no such collaboration opportunities.

With regard to organization, no statistically significant difference was revealed between the wiki collaborative and the individual writing group in the post-test writing, which ran counter to previous research that found a positive effect of wiki-mediated collaborative writing on the organization of individual writing (e.g., Wang, 2015). One possibility for this difference could be insufficient treatment sessions in the current study. Unlike Wang (2015), who engaged his learners in collaborating on two writing assignments over a 12-week period, the current study only engaged learners in collaborating on one writing task over a 9-week period. Though the wiki collaborative writing group was able to make significant development in the organization and sequencing of ideas between the pre- and post-tests (Table 2), the collaboration opportunities may have been insufficient. Another possibility could be related to the type of genre writing using in this study. Wang had his students write business letters, whereas the students in the current study worked on expository essays. It is widely accepted that the nature of interaction among learners is affected by the type of task (Pica, Kanagy, & Falodun, 1993; Robinson, 2001; Skehan, 1996a). In fact, previous wiki-based writing studies (e.g., Aydin & Yildiz, 2014) have demonstrated that learners’ collaborative behavior was differentially affected by the type of writing task they were working on. Based on the results of the learners’ wiki collaboration analyses, though the wiki writers did collaborate on organizing and sequencing their ideas, their effort was limited to the beginning stages of the wiki writing and was often done through outlining. During the collaborative writing process, more collaborative effort was made on improving content and language forms. This may partly explain why the improvement of organization was less evident in the learners’ individual writing when compared with that of content quality. Future research is needed to explore these issues further.

Development of Linguistic Complexity and Accuracy in L2 Individual Writing

In addition to supporting improvement of content quality, the results of the current study reveal that wiki-mediated collaborative writing improves the linguistic accuracy of individual writing in the L2, which agrees with Wang's (2015) study. The analyses of the learners' wiki collaboration showed instances of learners detecting and correcting each other's formal mistakes.

Example 3. Detecting and Correcting Mistakes

Lily highlighted the word *making* in the sentence "For German, they had two reasons to accept refugees: bring skilled labor up to full strength, and making up for the Nazi's atrocity during World War II," written by Vicky, followed by the discussion via the comment feature.

Lily: Should be simple form: make, because the verbs should be parallel.

Vicky: Yes, should be parallel. I think I should change the verb 'bring' into 'bringing'. I think that verb should not be put at the start.

In [Example 3](#), Lily detected a mistake in Vicky's use of English parallel structure. She suggested that the gerund *making* should be changed into the verb base form *make* to make it parallel in form with the verb *bring*. Lily's comment brought the structure to Vicky's attention and led her to review and possibly rehearse the rule. Vicky then went on to modify the sentence accordingly.

Example 4. Detecting and Correcting Mistakes

Tim highlighted the word *take* in the sentence "In this case, with the smartphone usage proliferating all over the world, people should take seriously be aware of the negative effects caused by smartphones mentioned above," written by Eddie, followed by the discussion via the comment feature.

Tim: Redundant word.

Eddie: It's a verb phrase.

Eddie: I see.

In [Example 4](#), Tim detected Eddie's mistake of using two verbs in one sentence. Eddie seemed to be puzzled by Tim's comment at first and defended his sentence. A little while later, probably due to a re-analysis of the sentence structure, Eddie came to realize the kind of mistake Tim pointed out. He acknowledged it and went on to modify the sentence to *In this case, with the smartphone usage proliferating all over the world, people should take seriously the negative effects caused by smartphones mentioned above*. In line with previous findings (e.g., Arnold et al., 2009; Kessler et al., 2012; Kost, 2011; Lee, 2010; Wang, 2015), the use of wikis for writing activities provided learners with opportunities to edit and modify their text jointly, allowing them to detect and correct each other's mistakes. Such peer collaboration and linguistic scaffolding could have contributed to fostering learners' attention to form (Lee, 2010). That, in turn, could have led to improving the accuracy of the learners' individual L2 writing.

Regarding linguistic complexity, the results of the current study revealed significant improvement in LV and C/TU for both the wiki collaborative and individual writing groups, but no significant difference between the two groups was found, suggesting that the improvement of writing complexity did not come solely from using wikis, but also from natural growth or other variables such as classroom instruction. The effectiveness of wiki collaborative writing on the improvement of the linguistic complexity of learners' individual L2 writing was thus inconclusive. Since few, if any, studies have looked into the effect of wiki collaborative writing on L2 learners' individual writing complexity, more studies are needed to explore this issue further.

It should be noted, however, that although no significant difference was found for complexity between the two groups in post-test writing, the wiki collaborative writing group improved between pre- and post-test in both the complexity and accuracy dimensions ([Table 4](#)) of their individual L2 writing, whereas the

individual group improved in terms of complexity, but not accuracy. Complexity, accuracy, and fluency have all been viewed as goals of L2 learning (Skehan, 1996b, 1998, 2003). Nevertheless, according to Skehan's (1998) limited capacity model, there is a trade-off effect between linguistic complexity and the accuracy of L2 production; that is, committing attentional resources to one may lower performance on the other (see also Skehan, 2009). Wiki collaborative writing seemed to compensate for this effect, allowing for more balanced development in the two linguistic areas. Pooled knowledge in collaborative writing activities may have helped lessen the cognitive load for the learners (Wigglesworth & Storch, 2009, 2012), leaving them more room to attend to both the linguistic complexity and the accuracy of their jointly written product and leading them to the enhancement of both dimensions of language production in their post-test writing. The individual writing group members, on the other hand, seemed to devote more of their attention to the complexity dimension of their written products, and without input in the form of feedback from their peers seemed unable to improve accuracy to the level measured for the wiki group.

Limitations and Future Directions

Though the current study has shown the effectiveness of wiki collaborative writing on the development of individual writing in a L2, especially in the areas of content quality and linguistic accuracy, some limitations of the study must be acknowledged. First, the study was conducted in nine weeks with only one collaborative writing task implemented. This is a relatively short period and may be insufficient for such a study. Prolonged collaboration on more writing tasks may be necessary to allow other dimensions of L2 writing (e.g., organization and linguistic complexity) to develop further. Next, five measures of complexity and accuracy were used to index the students' linguistic development in their L2 individual writing. Some measures revealed significant results while others did not. More interesting findings may be revealed with different measurement tools (see Evans et al., 2014; Jarvis, 2013; Lu & Ai, 2015; Norris & Ortega, 2009).

Another limitation is related to the type of task adopted. The current study adopted expository writing. Since the type of task can affect collaborative behavior in wiki-mediated writing environments (Aydin & Yildiz, 2014) and lead to different learning outcomes (Kessler & Bikowski, 2010), caution should be taken in generalizing the results of the current study to wiki environments where different types of tasks are used. Replication studies in wiki contexts with different types of writing task are highly desirable.

A further point is that the grading of the wiki collaborative writing could have potentially affected the group writing processes. There might have been a tendency for the stronger group member to take control over the wiki project in order to earn a higher grade. Patterns of learner interaction in the wiki writing environment and how they led to different learning results were not explored in this study. This is certainly another area deserving further investigation (see Li & Zhu, 2013).

In addition to the aforementioned issues, this study did not keep track of the amount of time the students actually spent collaborating. Future studies might benefit from taking into the amount of time devoted to a task when measuring gains in writing.

Conclusion

With the development of computer-based technologies for instruction and learning, research into L2 development in technology-mediated contexts is necessary. This study reveals positive effects of using wikis on L2 writing development. Though not all the areas investigated (content, organization, linguistic complexity, and accuracy) demonstrated improvement, the findings still hold promise. The learners who engaged in wiki-mediated collaborative writing were able to make significant improvement in content development and linguistic accuracy of their individual L2 writing—all with little teacher intervention. Learners themselves were able to create learning contexts by collaborating and interacting with one another in wikis outside the classroom.

For L2 writing instructors, the findings indicate a potential for incorporating wiki-mediated collaborative

writing as a supplement to their writing classes. Such collaborative writing activities move learners from the more one-way interaction between the teacher and the student, where the student only receives the teacher's authoritative instruction and comments, toward the two-way interaction and negotiation between learners, where knowledge of L2 writing can be co-constructed. Through wiki collaborative writing, L2 learners can become more aware of how adequately and accurately their ideas are conveyed in words and develop the ability to more critically analyze not only their own writing, but also their partners' writing. Knowledge of academic writing regarding content development and linguistic accuracy in the L2 can be furthered in the interaction between learners constructing texts together via wikis. The adoption of wiki-mediated collaborative writing in L2 writing instruction can thus help create a space beyond the classroom setting that can be used to facilitate learners' writing processes and to foster the development of learners' individual L2 writing.

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Appendix A. Writing Topics

Pre-Test

Read the prompt.

The cooking oil scare has again raised huge concerns over food safety in Taiwan. It is not just that the people's health is at stake; Taiwan's reputation has also been compromised.

Write a 4–5 paragraph essay to explore in what ways this cooking oil scare has damaged Taiwan's reputation. Include at least 2–3 main points and any relevant details to support the main points.

Pay attention to content, organization, and language quality in your essay.

Post-Test

Read the prompt.

In the non-stop cable news cycles, media channels are doing everything to attract viewers and beat their competitors. As a result, many non-stories are dressed up with dramatic music and flashy graphics to portray drama or fear and capture the attention of Taiwanese viewers. On a regular basis, in breaking news situations, channels get the facts wrong and make bold connections with little or no evidence.

Write a 4–5 paragraph expository essay to explore the consequences of media exaggeration. Include at least 2–3 main points and any relevant details to support the main points.

Pay attention to content, organization, and language quality in your essay.

Appendix B. Guidelines

Wiki Collaborative Writing

1. How do you write your wiki essay?
 - a. Prewriting: Each pair needs to discuss the writing topic and agree on a general direction, using *Discussion*. Negotiate the division of labor and generate the main idea of each paragraph.
 - b. Drafting: Write the first draft on your wiki page. Each student needs to work on the same piece of writing and should organize the structure of the joint composition.
 - c. Revising: Read through the draft (both yours and your partner's) and revise the draft for logical sequencing of ideas, full development of topic, correctness of content, relevance of supports, and appropriateness of conclusion based on your own and/or your partner's feedback. Revise both your work and your partner's. Make known (explain) the revisions you make on the essay through *Discussion* or *Comment*.
 - d. Editing: Read through the entire draft and edit word choice, sentence structure, grammar, spelling errors, and punctuation problems. Make known (explain) the editing you make. Confirm the completion of your wiki writing, paste it onto a Word document, and submit it to i-Learning.
2. How much do you need to write/revise?

At least 4 paragraphs, approximately 500–750 words. Each student must contribute half the amount of writing. A minimum of 15 revisions/edits must be made on draft 1 and a minimum of 7 revisions/edits on draft 2.
3. What kinds of revisions/edits should you make?

Be sure to (a) use a range of topic related vocabulary; (b) check the correctness of grammar (e.g., subject–verb agreement, number, verb tenses, etc.); (c) use a variety of sentence structures; (d) use cohesive devices (transitions) to present a logical progression of ideas; (e) check the development of the topic, the relevance of the thesis statement, topic sentences, and supporting details; (f) check spelling and punctuation; and (g) be original.

Individual Writing

1. How do you write your wiki essay?
 - a. Prewriting: Select a writing topic, decide on a general direction, and generate the main idea of each paragraph.
 - b. Drafting: Write the first draft on the selected topic. Be sure to organize the structure of the composition. Be original.
 - c. Revising: Read through the entire draft and revise the draft for logical sequencing of ideas (e.g., use cohesive devices or transitions to present a logical progression of ideas), full

- development of the topic, correctness of content, relevance of thesis statement, topic sentences and supporting details, and appropriateness of conclusion.
- d. Editing: Read through draft and edit word choice, sentence structure, grammar, spelling errors, and punctuation problems. Be sure to (a) use a range of topic related vocabulary, (b) check the correctness of grammar (e.g., subject–verb agreement, number, verb tenses, etc.), and (c) use a variety of sentence structures. Confirm the completion of your writing and submit it to i-Learning.
2. How much do you need to write?
At least 4 paragraphs, approximately 500–750 words.

Appendix C. Rubrics

Essay Rubric

Category	2 Points	1.5 Points	1 Point	0.5 Points
Grammar and Vocabulary	The essay contains no grammatical or lexical errors.	The essay contains some grammatical or lexical errors, but these errors do not detract from the meaning.	The essay contains many grammatical or lexical errors, and some of these errors detract from the meaning.	The essay contains many grammatical and lexical errors, and these errors fully detract from the meaning.
Thesis Statement	The essay contains only one thesis statement, which is placed in the right position and states the specific topic of the essay.	The essay contains only one thesis statement. The statement is not placed in the right position or the specific topic needs to be sharper.	The essay contains only one thesis statement. Either the statement is not placed in the right position or the specific topic is obscure.	The essay contains either no thesis statement or more than one.
Content	The topic is well developed. Topic sentences are clear and focused. Main ideas are supported by strong and convincing details. There are no irrelevant or redundant supports. The conclusion contains good summary of the main points.	The topic is adequately developed. There are occasional minor problems with depth of development and unity. Topic sentences are present but controlling ideas are imprecise. Main ideas are supported by mostly strong and convincing details. Supports are mostly relevant and appropriate. The conclusion contains an appropriate summary of the main points.	The topic is somehow developed. Topic sentences are not present or appropriate, or else controlling ideas are not evident. Main ideas are somehow supported by details. However, some of the supports are either irrelevant, redundant, vague, or insufficient. The conclusion contains a somewhat adequate summary of the main points.	The topic is inadequately developed. There is no clear central theme. Topic sentences are difficult to rate. There are too many irrelevant, redundant, vague, or insufficient details. The conclusion contains an inadequate summary of the main points.

Organization	Information is logically organized and effectively sequenced with effective use of transitions.	Information is mostly organized and sequenced with mostly effective uses of transitions.	Information is loosely organized and sequenced. There are several problems with cohesion, sequencing, and flow of ideas. Relationships between ideas are sometimes unclear.	There is an obvious lack of organization. Relationships between ideas are often unclear. It is difficult to follow.
Mechanics	The student masters conventions of spelling, punctuation, capitalization, paragraph indentation, and so forth.	There are occasional errors in spelling, punctuation, capitalization, paragraph indentation, and so forth that do not interfere with meaning.	There are frequent spelling, punctuation, capitalization, and paragraphing errors. The meaning is disrupted by formal problems.	There is no mastery of conventions due to the frequency of mechanical errors.

Wiki Rubric

Individual	3 Points	2 Points	1 Point
Content	contributed more than the necessary amount of content, put care and effort into the collaborative process resulting in a well developed essay	fulfilled basic requirements, put some care and effort into the collaborative process resulting in a somewhat developed essay	showed little effort, contributed insufficient information
Organization	put more than necessary amount of care and effort into the collaborative process resulting in a well organized essay	put some care and effort into the collaborative process resulting in a somewhat organized essay	showed little effort, disconnected discourse
Revision and Editing	participated actively in pair discussion, exceeded revision and editing (including content, organization, grammar, and vocabulary) requirements	had spotty participation in pair discussion, completed minimum revision and editing requirements	participated little in pair discussion, review, and the revision and editing processes
Wiki Trail			completed the wiki trail requirement

Appendix D. Analytical Scale for Quality of Content and Organization of Essays

	7–8 Points	5–6 Points	3–4 Points	1–2 Points
Content	The topic is well developed. The thesis statement states the specific topic of the essay. Topic sentences are clear and focused. Main ideas are supported by strong and convincing details. There are no irrelevant or redundant supports. The conclusion contains a good summary of the main points.	The topic is adequately developed. There are occasional minor problems with depth of development and unity. The thesis statement needs to be sharper. Topic sentences are present, but controlling ideas are imprecise. Main ideas are supported by mostly strong and convincing details. Supports are mostly relevant and appropriate. The conclusion contains an appropriate summary of the main points.	The topic is somehow developed. The thesis statement is obscure. Topic sentences are not present or appropriate, or else controlling ideas are not evident in the topic sentences. Main ideas are somehow supported by details. However, some of the supports are either irrelevant, redundant, vague, or insufficient. The conclusion contains a somewhat adequate summary of the main points.	The topic is inadequately developed. The essay contains either no thesis statement or more than one. There is no clear central theme. Topic sentences are difficult to rate. There are too many irrelevant, redundant, or vague details. The conclusion contains an inadequate summary of the main points.
Organization	Information is logically organized and effectively sequenced with effective uses of transitions.	Information is mostly organized and sequenced with mostly effective uses of transitions.	Information is loosely organized and sequenced. There are several problems with the cohesion, sequencing, and flow of ideas. Relationships between ideas are sometimes unclear.	There is an obvious lack of organization. Relationships between ideas are often unclear. It is difficult to follow.

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