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Computer-Supported Collaborative Learning
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Scaffolding collaborative technical writing with procedural facilitation and synchronous discussion

Shiou-Wen Yeh · Jia-Jiunn Lo · Jeng-Jia Huang

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Abstract With the advent of computer technology, researchers and instructors are attempting to devise computer support for effective collaborative technical writing. In this study, a computer-supported environment for collaborative technical writing was developed. This system (*Process-Writing Wizard*) provides process-oriented scaffolds and a synchronous online chat room to facilitate real-time collaborative writing practice. It allows multiple students to work synchronously on collaborative writing tasks via the Internet. It also helps develop collaborative writing strategies, such as creating team agendas, brainstorming, creating team outlines, and generating team articles. An experiment was conducted to examine the effect of the system on EFL (English as a Foreign Language) students' collaborative writing experiences. First, an attitude questionnaire was used to evaluate learners' perceptions, acceptance, attitudes, and continuing motivation toward the functionalities and guidance provided by the system. Second, students' writing products were examined to evaluate the effect of the system on EFL students' collaborative writing quality, especially on content and organization. Finally, this study analyzed and coded students' synchronous chats with three categories (article-related interactions, social interactions, and system operation-related interactions) to evaluate the effect of the system on students' interactions. The results of the experiment showed: (1) the students had positive attitudes toward the system and continuing motivation to use the system in future writing tasks; (2) analysis of writing products suggested that students produced better content and organization with the support of the system; (3) the procedural facilitation provided by the system successfully scaffolded students to converse more in the category of article-related interactions. Limitations and future research directions are also discussed.

S.-W. Yeh
Institute of Teaching English to Speakers of Other Languages, National Chiao Tung University, Hsinchu, Taiwan, Republic of China
e-mail: shiouwen@mail.nctu.edu.tw

J.-J. Lo (✉) · J.-J. Huang
Department of Information Management, Chung Hua University, Hsinchu, Taiwan, Republic of China
e-mail: jlo@chu.edu.tw

J.-J. Huang
e-mail: mi89065@mi.chu.edu.tw

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Introduction

Background of the study

In the globally linked world, international exchanges are becoming increasingly frequent, and more and more technical experts are collaborating to write reports, proposals, articles, and other technical documents (Nelson 2000; Rice 2009; Stratton 1989). As defined by researchers, technical writing deals with precise information that is often presented in a sequential format and is designed to satisfy an audience's understanding, particularly regarding how things work (Kelly 2003). It has a specific audience and is purposeful, usually intended to solve a problem for that audience or convey technical information and ideas accurately and efficiently (Reis 1997). Most importantly, the area separating technical writing from other forms of writing is it is often collaborative, that written works are created by many people *collaboratively* rather than *individually* (Duin 1991). In the age of information, since writing has become part of the job in all technical careers (Reis 1997), technical writers not only need to be highly skilled in information manipulation and abstraction (Johnson-Eilola 1996), they also need to possess abilities as defined by OECD (Organization for Economic Cooperation and Development) as "key competencies" for individuals to survive in the interconnected world. The key competencies include: (1) using tools interactively (both language and technology), (2) interacting in heterogeneous groups, and (3) acting autonomously (OECD 2001).

In today's workplace, collaborative teams often require people to use real-time communication tools (such as message boards, videoconferencing) to provide immediate feedback of various kinds or to make decisions. However, traditional technical writing instruction often operates in isolation from other components of students' communication education (Carter et al. 2003), and students often lack the interaction and dialogue with others (Nagelhout 1999). Another challenge comes from the systematic nature or processes of technical writing that is particularly demanding for novice writers (Kelly 2003). For instance, for EFL (English as a Foreign Language) students who have diverse English proficiency levels, using English to produce collaborative technical writing can be even more challenging for those who do not have opportunities to be exposed to the target language (English) in everyday situations. Therefore, as Rice (2009) suggested, the primary challenge the information-economy presents is how researchers and educators will create new teaching strategies that "address the coordinative, polycontextual, crossdisciplinary work that link together activities separated by time, space, organizations, and objectives" (p. 303). In the context of EFL instruction, there is a great need for researchers and educators to construct an interactive, multi-task, and multi-user learning environment where EFL students can practice co-composition and real-time collaboration effectively and efficiently.

Online discussions are now a widespread medium for learning (Palmer et al. 2007). With the advancement of computer technology, researchers and instructors are attempting to provide computer supports for collaborative writing to promote a more social view of the writing process (e.g., Elola and Oskoz 2010; Parker and Chao 2007; Rice 2009). For instance, Rice (2009) proposed the "social and recursive" collaborative writing methods found in Web 2.0 practices help reconsider collaborative writing to better address the contexts and methods of the information economy. Each tool is not only a practical tool, but

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also a "fluid, dialogical situation" existing among writers (Rice 2009, p. 306). Specifically, technical writing instruction can move away from models based in individual knowledge and toward a more collective knowledge production. The use of these tools also allows researchers to observe how writers deal with writing challenges through a novel medium (Elola and Oskoz 2010). However, as Gorsky and Caspi (2005) cautioned, simply encouraging learners to get more involved in online discussions and Web-based tools may not necessarily lead to better learning results. There is a need to find out the prominent factors in online interaction that might enhance learning.

In the context of L2 (second language) learning, Larsen-Freeman (2000) contended "it is not the group configuration that makes collaborative learning distinctive; it is the way students and students or students and teachers work together that is important" (p. 164). Nunan (1993, p. 4) also suggested an important question to be considered: In collaborative language learning, "what patterns of classroom organisation and types of classroom tasks are most beneficial for language acquisition?" It has been argued, "those tasks in which learners are required to negotiate meaning among themselves in the course of completing an interactive task are particularly suited to language development" (cited in Nunan 1993, p. 4). Pata et al. (2005) further proposed collaborative writing teams could be enhanced by applying collaborative supports in a synchronous environment. Englert et al. (2007) also noted a technology providing "procedural facilitators and prompts" is likely to be influential in eliciting writing strategies that need to be developed. To expand the research in computer-supported collaborative writing, this study proposes collaborative technical writing in the EFL context can be enhanced by providing computer-supported procedural facilitators and online synchronous discussions.

Purpose of the study

The purpose of this study is two-fold. First, the researchers developed a process-oriented collaborative writing system (*Process-Writing Wizard*) which includes a step-by-step mechanism to scaffold teams of students to complete the collaborative writing tasks. A synchronous chat room is also embedded to stimulate collaborative parallel writing (Sharples et al. 1993) in that synchronous communications are commonly required skills in many professional careers. Second, an experiment is conducted to examine the effect of the system on EFL students' collaborative writing experiences. In the experiment, three instruments were used to evaluate *Process-Writing Wizard* from different perspectives. An attitude questionnaire was used to evaluate learners' perceptions, acceptance, attitudes, and continuing motivation toward the functionalities and guidance provided by the system. Students' writing products were also examined to evaluate the effect of the system on EFL students' collaborative writing quality, especially on content and organization. Finally, this study analyzed and coded students' synchronous online chats into three categories (article-related interactions, social interactions, and system operation-related interactions) to evaluate the effect of the system on students' interactions.

Literature review

Collaborative writing

The term collaborative writing is defined as: activities involved in the production of a document by more than one author (Dillon 1993) with group responsibility for the end

product (Elola and Oskoz 2010). In fact, the collaborative approach to writing, editing, and producing technical documents has been utilized in professional settings for decades (Bradney and Courbat 1998; Stratton 1989). Lunsford and Ede (1986) conducted a survey study on collaborative writing in on-the-job contexts and found, "87% [of their 530 respondents] reported they sometimes wrote as part of a team or group" (cited in Stratton 1989, p. 178). Research into collaborative writing also revealed this pedagogical approach has significant potential in both the first language and second language instruction (Elola and Oskoz 2010).

The components of collaborative writing include pre-draft discussions and arguments as well as post-draft analyses and debate (Dillon 1993). Collaboration supports include social interaction support among co-authors and commenters, and cognitive support for co-authoring and external commenting (Spring 1997). As elaborated by Spring (1997), the communication requirements of the collaborative writing task include: task division, brainstorming, editing, general discussion, and goal setting. Task division is related to assigning tasks and communicating the related requirements and deadlines. Brainstorming means generating and recording ideas to be used in producing the text. Editing involves members indicating their comments about and enhancements for the text. These comments and suggestions will be used to revise the existing text. General discussions can include formal team meeting as well as casual, impromptu conversation. Based on the writing tasks, Sharples et al. (1993) summarized three main strategies for collaborative writing: sequential, reciprocal, and parallel. In sequential group writing, jobs are passed from one individual to another for further refinement. In reciprocal group writing, all group members work together on all writing tasks. In parallel group writing, jobs are divided into individual tasks.

Collaborative technical writing is also a methodological innovation for second language teaching. In collaborative technical writing, students work together to achieve shared learning goals (Nunan 1993), and language acquisition is facilitated by students interacting in the target language (Larsen-Freeman 2000). According to Nunan (1993), through collaborative learning, learners themselves are important resources for their own learning. Besides, collaborative learning can help students use their own prerequisite knowledge to go beyond what they currently think. Collaborative technical writing indeed accommodates the principles of social constructivism as proposed by Vygotsky (1978). As Vygostsky's zone of proximal development suggests, individual learning is mediated through either adult guidance or collaboration with a more capable peer. Moreover, collaborative technical writing is consistent with communicative language learning and Krashen's (1985) assumption of second language acquisition, emphasizing while learning a second language, learners need to interact with the external environment actively, and such a learning environment is worth investigating.

As Nagelhout (1999) advocated, one of the most important benefits of collaborative writing instruction is it makes students aware that writing is a recursive process, allowing them to focus on each phase of the writing process. Semones (2001) also explained, the process of writing builds on the action-reaction responses. Through this evolving communicative process, unskilled writers are pushed to achieve higher levels of writing as they learn from others, and skilled writers have the opportunity to exchange ideas and think critically about their writing before a teacher evaluates it. In the situation of collaborative technical writing, "…students demonstrate a tendency toward scaffolding" (Semones 2001, p.308). That is, each member of the group contributes a particular skill in his or her area of expertise to help complete a task. In this way, students simplify the task and keep one another motivated and in constant pursuit of a goal.

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However, implementing collaborative writing is not without challenges. Although "collaboration stimulates students to do their best work, or at least better work" (Chisholm 1990, p. 106), Chisholm identified four common problems in collaborative writing, namely, "resistance, inexperience, friction, and fairness". He further suggested strategies for coping with the problems. For students' resistance to invest the time and effort that a group project requires, he suggested breaking the project into phases and working on a specific aspect of the task during each phase. For coping with the problem of inexperience, Chisholm suggested instructors devise methods for groups to develop a unified plan, including the main idea, outline, and content. In addition, it is important to provide a way for teams to reconsider, revise, and redraft the specifications and outline as their project matures. Facilitating support at every stage of the writing process is also helpful for students to get together in groups to review the work of others. Some strategies to cope with interpersonal conflict and fairness include: Students participate in brainstorming and discussion sessions, train them how to discuss problems openly, and help them devise strategies for coping with the problems for implementing the strategies.

In addition to the above strategies, in the information age, collaborative writing on a computer network is a type of communicative process that can be especially valuable for writers. Many researchers who have studied the impacts of social Web technologies, such as wikis, blogs, and chats on L2 collaborative writing (e.g., Boulos et al. 2006; Elola and Oskoz 2010; Palmer et al. 2007; Parker and Chao 2007; Rice 2009; Wang and Turner 2004), have generally agreed that these Web-based applications facilitate "authoring flexibility, content creation, and the generation of new knowledge" (Elola and Oskoz 2010, p. 51). In Elola and Oskoz's (2010) study examining eight Spanish majors' learning approaches to the writing task in the wikis, the results showed that when working collaboratively, the overall quality of their work improved. Analysis of drafts also showed that learners focused primarily on "content and organization", either when working collaboratively or individually. The analysis of the chats revealed "content of the essay" obtained most of the negotiations occurring in the chats (51.94%), followed by suggesting methods of structuring (15.55%). Other components included sources (14.84%), grammar (7.77%), organization (6.71%), vocabulary (2.12%), and editing (1.07%). The researchers also examined students' perceptions of writing individually and collaboratively and the usefulness of technology for collaborative writing. They concluded that learners' positive perceptions about the use of technologies confirmed previous findings supporting the use of social tools, especially for content development (e.g., Lee 2010). The authors further suggested the need for more research in the area of collaborative writing and its possible benefits for L2 development; such research needs to be based on theoretical models that illuminate social interaction with the support of social technologies.

Online discussion

Online discussion has been defined as a hybrid with elements of both written and spoken language. As explained by Black (2005), such discussion may be in real time, as in a chat room where students engage in synchronous discussion, or it may be through the use of a bulletin board as in asynchronous discussion where students are able to "read and respond at any time and create a text of talk or a written product of their discussion" (p. 9). In the age of information, social Web technologies such as chats and teleconferencing are considered real-time synchronous environments. Within synchronous environments, learners can participate in one-to-one, one-to-many, or many-to-many conversations (Zoran 2006). Online discussion is also considered a crucial element of learning and

understanding, particularly for distance education (Gorsky and Caspi 2005). The idea that peer interaction fosters learning has been widely accepted (Veerman et al. 2000; Black 2005; Palmer et al. 2007; Rovai 2007).

Although there are advantages of online discussions, researchers have raised some concerns. For instance, how do learners' interaction patterns change through using computer mediation? Researchers (e.g. Hew and Cheung 2010; Orvis et al. 2002) claimed that online interactions between learners follow certain patterns. With the purpose of developing higher-order cognitive skills (such as knowledge synthesis, decision-making, and collaborative problem solving), Orvis et al. (2002) conducted a study to analyze the communication patterns during a synchronous Web-based military training course in problem solving. A total of 6,601 acts of chat were coded into one of three interaction categories (on-task, social, or technology-related) and analyzed the frequency and relative change over time. The results of the study showed there were clear patterns of collaborative interactions in synchronous problem solving. Overall, student chats were categorized as on-task 55%, social 30%, and technology-related 15%. The authors suggested, "student performance can be enhanced through the scaffolding afforded through collaboration" (Orvis et al. 2002, p. 785). In addition, for tasks requiring some degree of problem solving, especially when performed in collaborative learning, the benefits of online synchronous instruction need to be considered (p. 794).

While the above literature suggests using of synchronous online instruction to enhance collaborative writing, currently, there is a shortage of such scaffolding tools and environments for L2 learners. To expand research in the area of collaborative writing and examine its possible benefits for L2 development, one of the goals of this current study was to develop a computer-supported system with procedural facilitators and a synchronous chat room to scaffold EFL students in writing collaboratively with peers.

Design parameters and research questions of the study

The current study developed a multi-user online system–-*Process-Writing Wizard*, providing a procedural facilitator and a synchronous chat room to scaffold students' collaborative writing. The design parameters are based on the theoretical underpinnings of *Collaborative Writing* and *Online Discussion* as discussed in the Literature Review section. They are summarized as follows: (1) realizing the step-by-step nature of technical writing which is demanding for novice writers (Kelly 2003; Spring 1997); (2) realizing collaborative learning in peers (Carter et al. 2003; Kelly 2003; Nagelhout 1999); (3) providing opportunities for students to engage in discipline-specific practices to develop effective strategies for exploration (Nagelhout 1999), such as creating team agendas and plans, team brainstorming, creating shared team outlines, and creating team articles; (4) supporting communication about comments to increase interaction between writers; (5) examining and managing the writing processes, so students can understand the act of technical writing (Glendinning and Howard 2003); (6) providing multi-user functionality to let multiple students work synchronously and help students feel comfortable in multi-task, multi-user environments (Nagelhout 1999); and (7) supporting collaborative parallel writing (Sharples et al. 1993).

An experiment was also conducted to examine the following research questions:

Research Question 1: What are students' perceptions and attitudes towards using the Process-Writing Wizard in collaborative technical writing? Although the system provides

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procedural facilitators and a synchronous chat room to scaffold teams of students to complete collaborative writing tasks, it is necessary to examine users' perceptions, acceptance, attitudes, and continuing motivation towards the functionalities and guidance provided by the system. The attitude questionnaire used in this study is based on Davis' (1989) Technology Acceptance Model (TAM), which has been widely applied in the areas of information systems (Lee et al. 2003) and online consumer behavior (Bruner and Kumar 2005). It has received empirical support from numerous studies (Porter and Donthu 2006). The constructs of the questionnaire include: (1) perceived ease of use, (2) perceived usefulness, (3) attitude to use, (4) intention to use, and (5) perceived response time from peers.

Research Question 2: What is the effect of the Process-Writing Wizard on the content and organization of students' writing product? Past research categorized factors influencing students' knowledge construction into three divisions: (1) students' learning styles, (b) design of the discussion task, and (c) facilitation of roles or techniques (cited in Hew and Cheung 2010). In an online discussion forum, student facilitation may be viewed as a plausible factor, possibly affecting students' knowledge construction. Some of the useful facilitation techniques include: seeking to reach consensus, encouraging, reinforcing student contributions, and focusing the discussion on specific issues (Lu and Jeng 2006). The *Process-Writing Wizard* developed in this study is a collaborative writing system combining the process writing approach (procedural facilitation) and social interactive approaches (synchronous chat room) to support EFL writing development. In this regard, our study examined the effect of the system on EFL students' collaborative writing, especially on "content and organization" of the writing product.

Research Question 3: What is the effect of the Process-Writing Wizard on students' synchronous chats in collaborative technical writing? As defined by Orvis et al. (2002, p. 789), "an act of chat is a single, uninterrupted verbalization, typed in the message box". Past research has found students' chats in online discussions are often limited. For example, Hew and Cheung (2010) found that students were more interested in merely "voicing their opinions to their classmates' queries (sharing of information)…rather than moving onto higher-level knowledge construction". To cope with this challenge, researchers (e.g., Hew and Cheung 2010; Schellens et al. 2005) proposed the task or assignment should be "matched" to the available knowledge and skills of students. In addition, it is important to design tasks leaving enough room for discussion. Our study also examined the effect of the *Process-Writing Wizard* on students' synchronous chats. In this study, we adopted Orvis' et al. (2002) coding scheme and categorized synchronous chats into three categories: (1) article-related interactions, (2) social interactions, and (3) system operation-related interactions. As facilitators are instrumental in shaping or influencing the chats, it is assumed that the procedural facilitation provided by the system will scaffold students into producing more chats in the category of article-related interactions.

Design and development of process-writing wizard

The system was developed using a Client/Server architecture (Fig. 1), in which the client end includes Create Article, Wizard Interface, Writing Interface, and Article List. The server end consists of an Article Database and a Log Database (Yeh et al. 2007). The

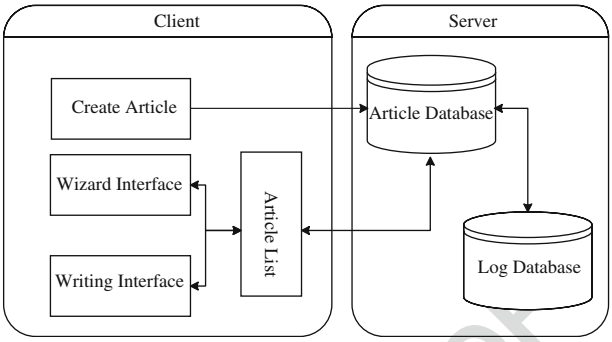

Fig. 1 System Architecture of the *Process-Writing Wizard*

prototype structure of the wizard presented in this paper is based on the rhetorical form of comparison and contrast, as suggested by Gillie et al. (2001, Chapter 6). To reduce the verbalization demands for EFL learners, the interface of the prototype system was presented in Chinese.

The team interaction at each stage of the collaborative writing process is supported by a synchronous chat room and a framework presented in an outline form. It provides the collaborative teams with a sequence of dialog boxes that lead the learners through a series of well-defined steps. To begin the system, all team members login to the system, and each team assigns a student to be the team leader to coordinate the writing process. In this study, the process to create a collaborative comparison and contrast article consists of four steps (Gillie et al. 2001, Chapter 6): Step 1: Brainstorming a topic and subjects for comparison and contrast; Step 2: Brainstorming for similarities and differences; Step 3: Selecting an organization style for comparison and contrast writing; and Step 4: Outlining the paragraphs and assigning authors.

Step 1: Brainstorming a topic and subjects for comparison and contrast A topic is the general focus of the article, such as "cultural differences". Subjects are any objects or instances that can be compared and contrasted within the topic, such as "eastern culture and western culture". Students use the online synchronous chat room to discuss the topic and two subjects for comparison and contrast. The team leader then inputs the results from the synchronous chat room into the system (Fig. 2). In this study, students were advised to create a topic suitable for the rhetorical form of comparison and contrast, i.e., a topic with

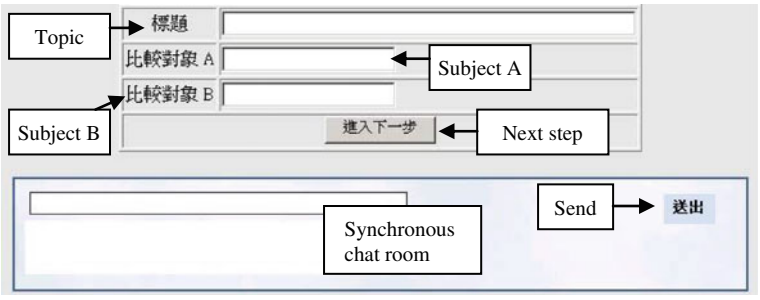

Fig. 2 Screenshot of Step 1: Brainstorming a topic and subjects for comparison and contrast

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enough similarities and differences. For better descriptions of the system, English translations of the Chinese words on the screenshots are provided in white labels.

Step 2: Brainstorming for similarities and differences In this step, the students use the chat room to brainstorm the similarities and differences between the two subjects. The team leader then enters the results into the corresponding spaces (Fig. 3). Users can freely add or delete any similarity and/or difference items during the discussion processes using the Add and Delete buttons. By using the Preview buttons, users can preview the entered similarities and differences before proceeding to the next step (Fig. 4).

Step 3: Selecting the organization style in comparison and contrast writing In this step, students decide on the organization style of their comparison and contrast writing. According to Gillie et al. (2001), comparison and contrast writing can be organized in two common ways: *All A/All B* style and *AB/AB/AB* style (Fig. 5).

Style 1: *All A, All B*. In this style, the article begins by introducing the two subjects, *A* and *B*, which will be compared or contrasted. In the following paragraphs, subject *A* is completely described and a complete description of subject *B* follows. Usually, four paragraphs are used and the article ends with a conclusion in the fourth paragraph.

Style 2: *AB/AB/AB*. In this style, the article also begins by introducing the two subjects, *A* and *B*. It differs from style 1 in that each supporting paragraph discusses a different aspect of both subjects. Within each paragraph, the details of comparison or contrast are limited to the particular focus of the paragraph. The number of paragraphs depends on the number of items to be compared or contrasted. The article ends with a conclusion in the last paragraph.

Step 4: Outlining the paragraphs and assigning authors An outline usually lists the main points discussed in an article. It helps ensure the article is unified and has plenty of support. In Step 4, users create an outline collaboratively through synchronous discussions (Fig. 6). The pull-down menu is provided for users to assign author(s) for each paragraph. The buttons Add Heading, Add Subheading, and Delete Heading allow users to modify or expand the outline. The paragraph structure is subject to the organization style selected in Step 3. The *Process-Writing Wizard* is a structured but flexible system. Although the

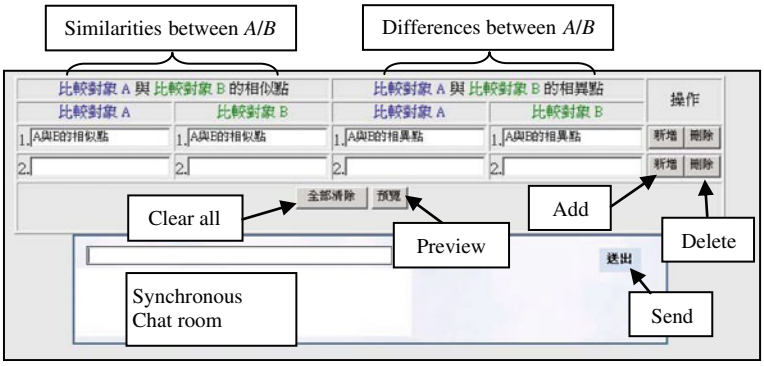

Fig. 3 Screenshot of Step 2(a): Brainstorming for similarities and differences

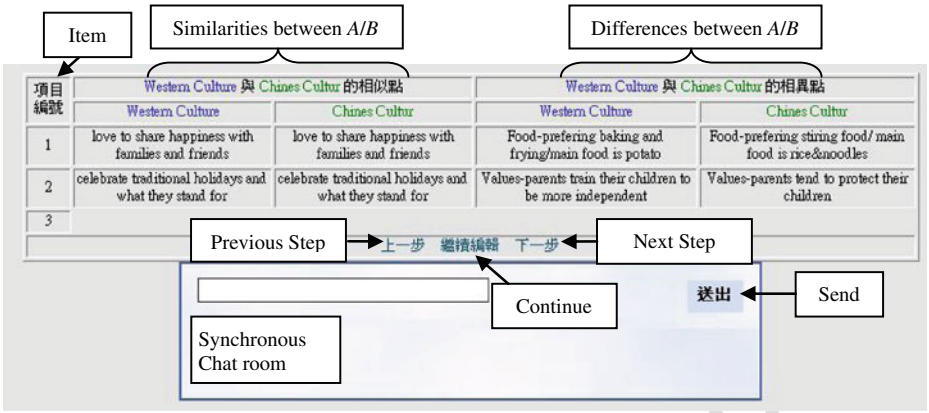

Fig. 4 Screenshot of Step 2(b): Previewing entered similarities and differences

organization style has been determined in Step 3, the lists of the similarity and difference items obtained in Step 2 can be retrieved to help users modify the outline. As a paragraph is added or deleted, the numbering of corresponding paragraphs will be updated accordingly.

As the four-step procedure is completed, the system presents the paragraph structure with the corresponding outlines and authors. The responsible authors then start writing their paragraphs using the Document Maker (Fig. 7). The system combines all paragraphs (with paragraph titles) written by all authors (Fig. 8). Finally, the system summarizes and presents the tasks of each step as illustrated in Fig. 9.

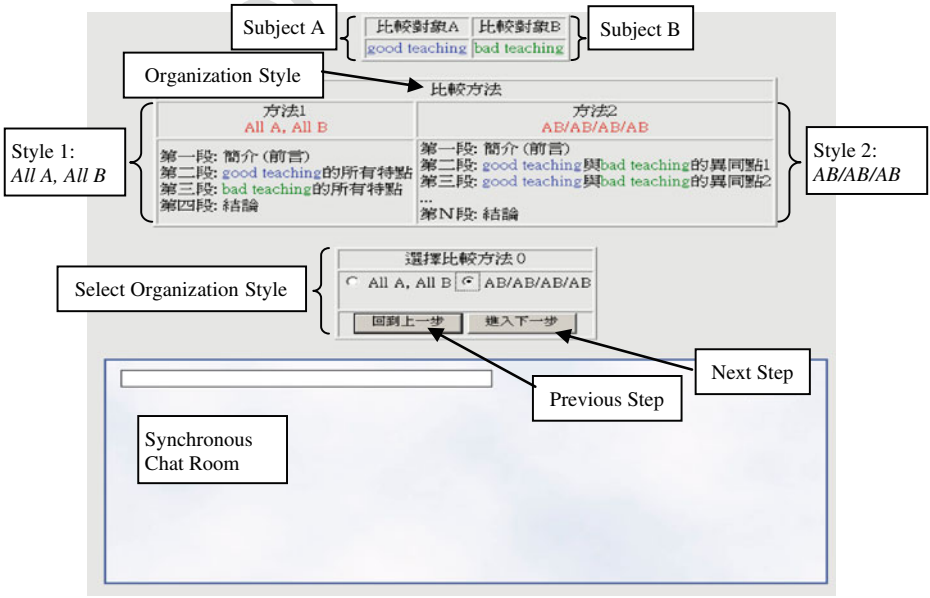

Fig. 5 Screenshot of Step 3: Selecting the organization style in comparison/contrast writing

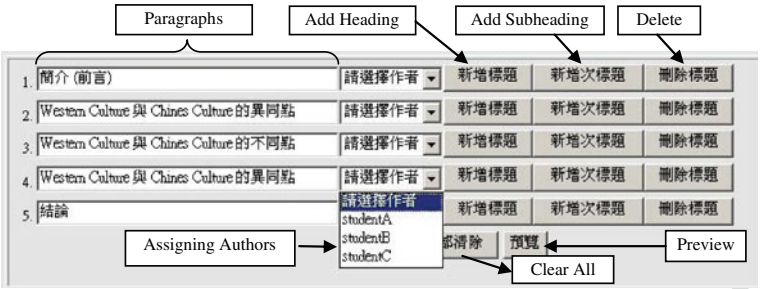

Fig. 6 Screenshot of Step 4: Outlining the paragraphs and assigning authors

Evaluation of the *process-writing wizard*

An experimental study with a control group design was conducted to examine the effect of the system on learners' attitudes, the article quality (content and organization), and synchronous chats.

Experimental settings

This study was conducted at a university located in northern Taiwan, where the official language is Mandarin Chinese. Forty-eight EFL college students, who enrolled in *English Writing II*, were randomly assigned to one of two classes (with 24 students in each class). All the subjects were familiar with basic computer operations and Web page browsing. Students in Class A belonged to the experimental group and Class B to the control group. During the experiment, students in the experimental group used the *Process-Writing Wizard*

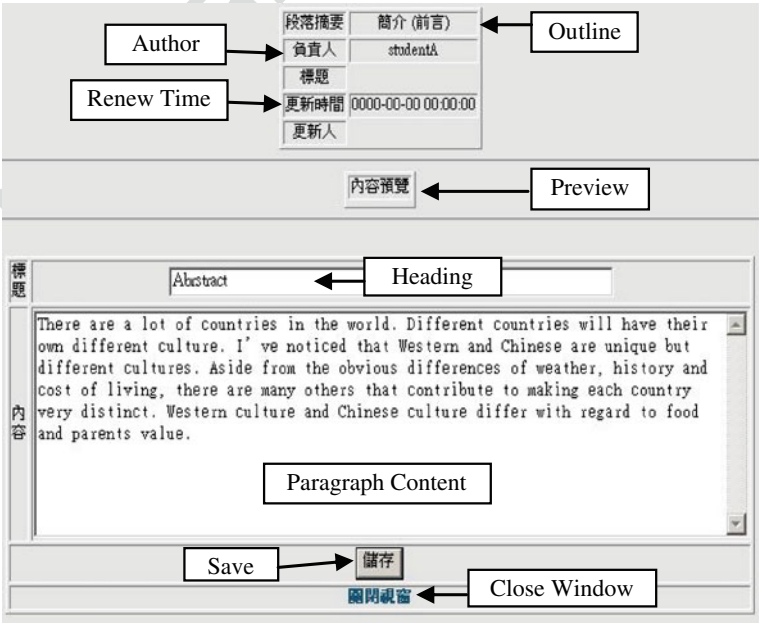

Fig. 7 Screenshot of Document Maker

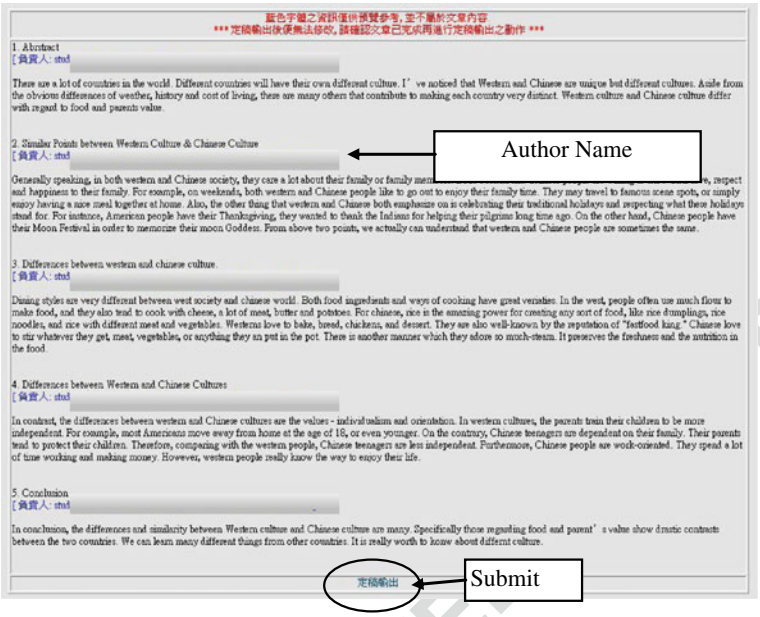

Fig. 8 Screenshot of collaborative article combining the works of a team of authors

to complete their collaborative articles. Each student had a password to access the course site on the Internet. When collaborating, students were seated at individual computers and worked on team projects using the *Process-Writing Wizard*. On the other hand, students in the control group did not use the *Process-Writing Wizard* to complete their collaborative articles. Instead, the control group students used a regular synchronous chat room—*Messenger*, without the "step-by-step guidance mechanism" as provided in the experimental group.

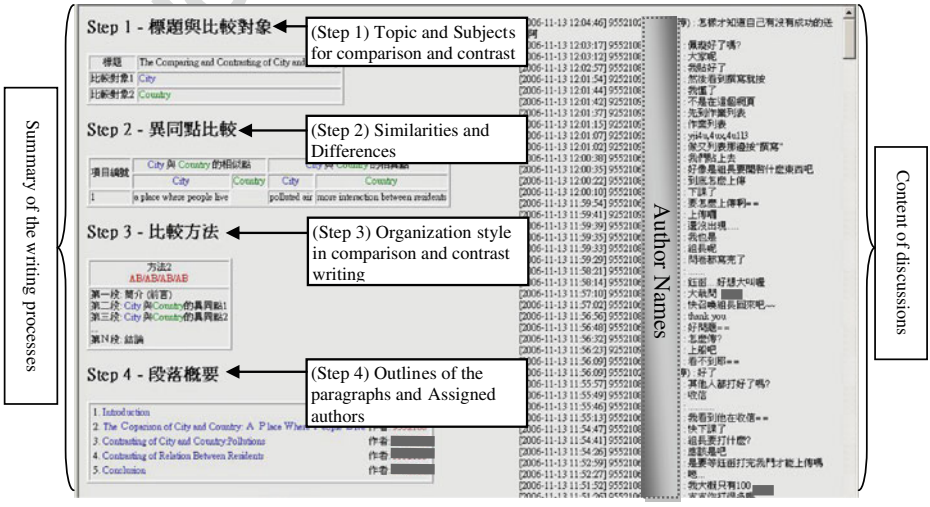

Fig. 9 Screenshot of the summary of the writing processes and the content of discussions

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During the experiment, the students conducted their online discussion in Chinese. They were put in teams of four or five to complete an article. Each team selected a writing topic of their interest. Both groups were scheduled to meet for 2 h in a computer laboratory. The teacher's role in the experiment was to monitor the collaborative progress and help solve the problems that students might encounter during the writing process. At the end of the experiment, five teams from both the experimental and control groups respectively completed their articles during the experiment.

In the control group, before the writing task, students were given printed instructions from the instructor explaining how to complete the collaborative writing task. Students then had to login to the *Messenger* (Fig. 10), assign a team leader, decide on the writing topic, brainstorm the details, select the organization style, discuss the outline and paragraph assignment, and finally start to write paragraph(s) using the Document Maker (Fig. 11) and send the paragraph(s) to the team leader for combining.

Instrumentation and data collection

This study adopted Davis' (1989) Technology Acceptance Model (TAM) to design the attitude questionnaire. The constructs of the questionnaire include: (1) perceived ease of use, (2) perceived usefulness, (3) attitude to use, (4) intention to use, and (5) perceived response time from peers. *Perceived ease of use* refers to the extent to which a person believes using a system will be free of mental effort. *Perceived usefulness* refers to the extent to which a person believes the functionality and information provided by a system will be useful. *Attitude to use* refers to the appraisal and extent of satisfaction in using a target system. *Intention to use* is the subjective possibility users will use the system (Lo et al. 2009). *Perceived response time from peers* refers to the extent a person will wait for another peer to respond to his or her opinion.

Based on the above five constructs, the hypotheses to be tested included: (1) H_1: There is no significant difference in *perceived ease of use* between the experimental and control groups; (2) H_2: There is no significant difference in *perceived usefulness* between the experimental and control groups; (3) H_3: There is no significant difference in *attitude to use*

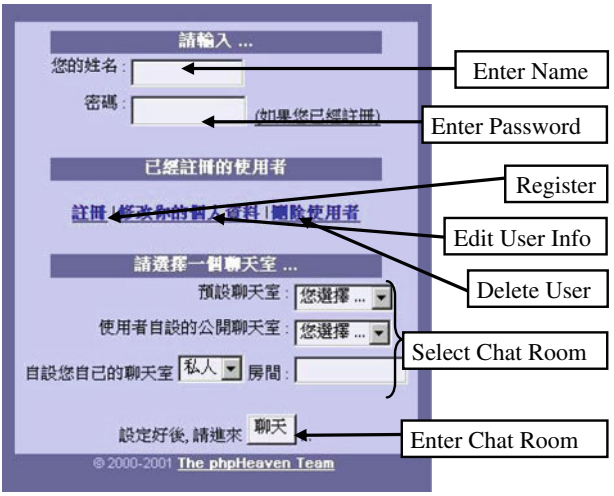

Fig. 10 Screenshot of *Messenger* for the control group students

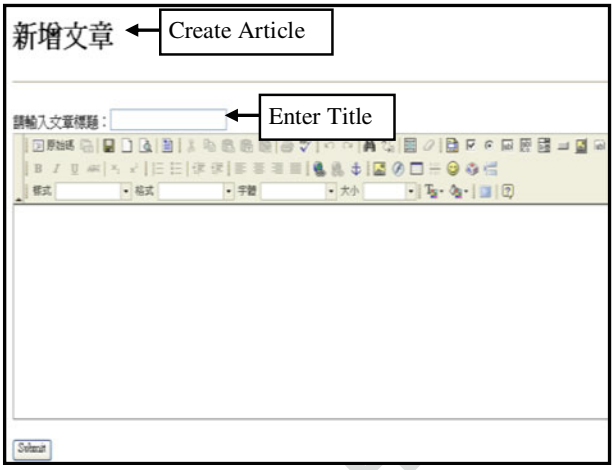

Fig. 11 Screenshot of Document Maker for the control group students

between the experimental and control groups; (4) H_4: There is no significant difference in *intention to use* between the experimental and control groups; and (5) H_5: There is no significant difference in *perceived response time from peers* between the experimental and control groups. To evaluate the above hypotheses, a seventeen-item questionnaire based on a 5-point Likert scale was developed (Appendix).

A grading rubric was developed to examine whether there were any differences in content and organization between the experimental and control groups. For content quality, each article was evaluated to see whether it was on topic, interesting, logical, and of appropriate length. The grading criteria included: "Is the content on topic?", "Is the content interesting?", "Is the content logical?", and "Is the content of appropriate length?" For organization quality, each article was evaluated in terms of the comparison and contrast method, thesis, supports, conclusion, and transitions. The grading criteria included: "Is the method of comparison/contrast development used consistently?", "Is there one main thesis?", "Are there adequate supports for the thesis?", "Is there a conclusion?", and "Are there transitions?" For each criterion, the scale of points ranged from 1 to 10 points. In the experiment, all articles were blindly graded by a trained English instructor with the grading rubric.

The synchronous chats from both the experimental and control groups were analyzed to examine how using the *Process-Writing Wizard* affects interactions among team members. In the past, researchers developed different coding schemes to understand how team members interact with one another. For instance, Lebie et al. (1996) constructed a four-category coding system to analyze chat data: (1) planning activity, (2) interactive composing activity, (3) the mechanics of the production process, and (4) interpersonal and social activity. Cooney (1998) coded synchronous chats as: (1) discourse about the content, (2) discourse about the task, and (3) off-task talk (Cited in Orvis et al. 2002). Based on Cooney's (1998) scheme, Orvis et al. (2002) constructed a three-category coding system to analyze synchronous chats: (1) on task, (2) social interaction, and (3) mechanics. In this study, the synchronous chats of both the experimental and control groups were coded with an augmented version of the above coding schemes. The coding scheme included three categories: article-related interactions, social interactions, and system operation-related interactions. The *article-related interactions* are any chats focusing on the writing task at hand, for instance, discussions on the article organization, article content, and how many

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paragraphs will be included. The *social interactions* included chats about team work that is not related to the writing task, such as discussions to ensure some team members are still online. The *system operation-related interactions* are discussions about operations of the system, such as how to post messages, problems with the system, etc. In this research, synchronous chats were analyzed in quantitative terms, namely, the occurrence of chats in each category. Besides frequency counts, percentages were utilized in order to standardize the results between the experimental and control groups.

Results and discussion

Analysis of perceived ease of use, perceived usefulness, attitude to use, intention to use, and perceived response time from peers

The questionnaire was analyzed with SPSS. The descriptive statistics and the MANOVA results of the questionnaire are reported in Tables 1 and 2. As Table 2 revealed, hypotheses H_1 and H_5 were supported, suggesting that there were no significant differences for *perceived ease of use* and *perceived response time from peers* for the experimental and control groups. The experimental results suggested even though extra tasks were required, the proposed synchronous scaffolding environment with the *Process-Writing Wizard* was still user-friendly and it did not impede the communication processes among peers. Table 2 also showed hypotheses H_2, H_3, and H_4 were not supported. The results indicated there were significant differences between the experimental and control groups for *perceived usefulness*, *attitude to use*, and *intention to use*. In other words, the experimental group revealed more positive responses than the control group did. Specifically, the significant positive effects on *perceived usefulness* suggested students believed the functionalities and guidance provided by the synchronous scaffolding environment were useful. The positive effects on *attitude to use* indicated students gave higher appraisal and were satisfied with the proposed synchronous scaffolding environment. Finally, for continuing motivation, the positive effects on *intention to use* suggested the students were willing to use the proposed system for collaborative writing in the future. The research results provided evidence of the effect of the *Process-Writing Wizard* during collaborative writing.

t1.1 **Table 1** Descriptive statistics of the experimental questionnaire

t1.2	Construct	Group	No. of subjects	No. of items	Mean	S.D.
t1.3	Ease of use	Experimental	24	5	16.9167	1.4116
t1.4		Control	24	5	16.2500	1.9393
t1.5	Usefulness	Experimental	24	4	13.9167	1.7425
t1.6		Control	24	4	13.0417	1.1602
t1.7	Attitude to use	Experimental	24	3	10.7083	1.3345
t1.8		Control	24	3	9.8333	1.2740
t1.9	Intention to use	Experimental	24	4	14.7500	1.8238
t1.10		Control	24	4	13.5417	1.7688
t1.11	Response time from peers	Experimental	24	1	3.7083	.8587
t1.12		Control	24	1	3.8750	.9470

Table 2 MANOVA results of the experimental questionnaire

Source	Dependent Var.	Type III S.S.	df	M.S.	F	P
Corrected Model	Ease of use	10.083[a]	1	10.083	3.868	.055
	Usefulness	9.188[b]	1	9.188	4.193	.046*
	Attitude to use	10.083[c]	1	10.083	5.878	.019*
	Intention to use	17.521[d]	1	17.521	5.429	.024*
	Response time from peers	.333[e]	1	.333	.408	.526
Intercept	Ease of use	13068.000	1	13068.000	5012.881	.000
	Usefulness	8721.021	1	8721.021	3980.160	.000
	Attitude to use	5043.000	1	5043.000	2939.531	.000
	Intention to use	9605.021	1	9605.021	2976.128	.000
	Response time from peers	690.083	1	690.083	844.625	.000
Group	Ease of use	10.083	1	10.083	3.868	.055
	Usefulness	9.188	1	9.188	4.193	.046*
	Attitude to use	10.083	1	10.083	5.878	.019*
	Intention to use	17.521	1	17.521	5.429	.024*
	Response time from peers	.333	1	.333	.408	.526
Error	Ease of use	119.917	46	2.607		
	Usefulness	100.792	46	2.191		
	Attitude to use	78.917	46	1.716		
	Intention to use	148.458	46	3.227		
	Response time from peers	37.583	46	.817		
Total	Ease of use	13198.000	48			
	Usefulness	8831.000	48			
	Attitude to use	5132.000	48			
	Intention to use	9771.000	48			
	Response time from peers	728.000	48			
Corrected Total	Ease of use	130.000	47			
	Usefulness	109.979	47			
	Attitude to use	89.000	47			
	Intention to use	165.979	47			
	Response time from peers	37.917	47			

[a] R^2 =.078 (Adjusted R^2 =.058)
[b] R^2 =.084 (Adjusted R^2 =.064)
[c] R^2 =.113 (Adjusted R^2 =.094)
[d] R^2 =.106 (Adjusted R^2 =.086)
[e] R^2 =.009 (Adjusted R^2 =−.013)
* $P<=.05$

Analysis of writing

The results in Table 3 show that the experimental group, using the *Process-Writing Wizard,* had better outcomes compared to the control group in overall performance [E_G=7.78; C_G=6.80], article content [E_G=8.15; C_G=7.20] and article organization [E_G=7.48;

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t3.1 **Table 3** Average grading results

t3.2 Grading criteria	Experimental group (E_G)	Control group (C_G)
t3.3 Article Content	8.15	7.20
t3.4 Is the content on topic?	9.0	9.2
t3.5 Is the content interesting?	7.6	6.8
t3.6 Is the content logical?	7.6	6.4
t3.7 Is the content of appropriate length?	8.4	6.4
t3.8 Article Organization	7.48	6.48
t3.9 Is the method of comparison/contrast development used consistently?	8.6	7.2
t3.10 Is there one main thesis?	8.2	6.6
t3.11 Is there adequate support for the thesis?	7.0	6.2
t3.12 Is there a conclusion?	6.6	6.6
t3.13 Are there transitions?	7.0	5.8
t3.14 Total	7.78	6.80

C_G=6.48]. Although both groups had similar scores in items, "Is the content on topic?" [E_G=9.0; C_G=9.2] and "Is there a conclusion?" [E_G=6.6; C_G=6.6], the experimental group outperformed the control groups in other items, such as "Is the content interesting?" [E_G=7.6; C_G=6.8], "Is the content logical?" [E_G=7.6; C_G=6.4], "Is the content of appropriate length?" [E_G=8.4; C_G=6.4], "Is the method of comparison/contrast development used consistently?" [E_G=8.6; C_G=7.2], "Is there one main thesis?" [E_G=8.2; C_G=6.6], "Are there adequate supports for the thesis?" [E_G=7.0; C_G=6.2], and "Are there transitions?" [E_G=7.0; C_G=5.8] (see Table 3). The results suggested the students produced higher quality articles in most grading criteria for both the article content and organization with the *Process-Writing Wizard*.

For EFL learners, writing is not simply a cognitive process that is highly individualistic and private (Hyland 2003). It is a much more complicated process involving "knowing not only one's own writing process…but also the purpose and the context of writing" (Zeng 2005, p. 70). In the collaborative writing process, students work jointly on the same task with shared goals. Learners construct knowledge that goes beyond what they already know. Therefore, the clearest advantage of collaborative writing can be recapitulated in the old Chinese saying, "Three cobblers with their wits combined equal Zhuge Liang the master mind", namely, "Two heads are better than one". The *Process-Writing Wizard* is a real-time communication environment with procedural facilitation, wherein team members receive process-oriented supports to write articles collaboratively. If utilized properly, the *Process-Writing Wizard* can be a powerful system to support EFL collaborative technical writing instruction.

Analysis of synchronous chat coding

In this study, text-messaging data were drawn from both the experimental and control groups. The content of dialogues were further coded and categorized into three categories (article-related, social, and system operation-related), as illustrated in Table 4 and Figs. 12 and 13. The results showed in the experimental group, 61% of the chats were in the article-

t4.1 **Table 4** Average number of dialogue categories

t4.2 Category / t4.3 Group	Article-related	Social	System operation-related	Total
t4.4 Experimental group	280.4 (61%)	158.2 (34%)	22.4 (5%)	461.0 (100%)
t4.5 Control group	254.0 (38%)	371.2 (56%)	38.8 (6%)	664.0 (100%)

related category, 34% of the chats were related to social interactions, and 5% of chats were in the system operation-related category. In the control group, 38% of the chats were in the article-related category, 56% of the chats were related to social interactions, and 6% of chats were in the system operation-related category.

Among these three dialogue categories, article-related dialogues are regarded as meaningful and contributive for article writing, whereas, social and system operation-related dialogues do not directly contribute to article writing. The results showed the dialogues of students in the experimental group were mostly related to discussions about writing the article (61%). On the other hand, students in the control group had almost one-third more dialogues in total, yet, they spent much less time on writing the article. Only 38% belonged to the article-related dialogues for the control group. They spent most of their time in social interactions. This implied the proposed synchronous scaffolding environment can effectively and efficiently help students focus their interactions on writing an article. The results can partly explain why the articles written by the experimental group were of higher quality. The lower total number of synchronous chats in the experimental group (461 vs. 664) might have been from the time spent on the *Process-Writing Wizard*.

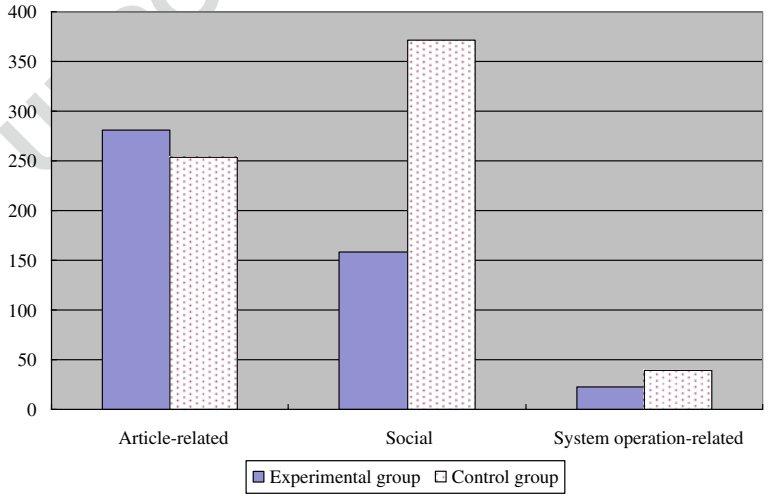

Fig. 12 Average number of dialogue categories

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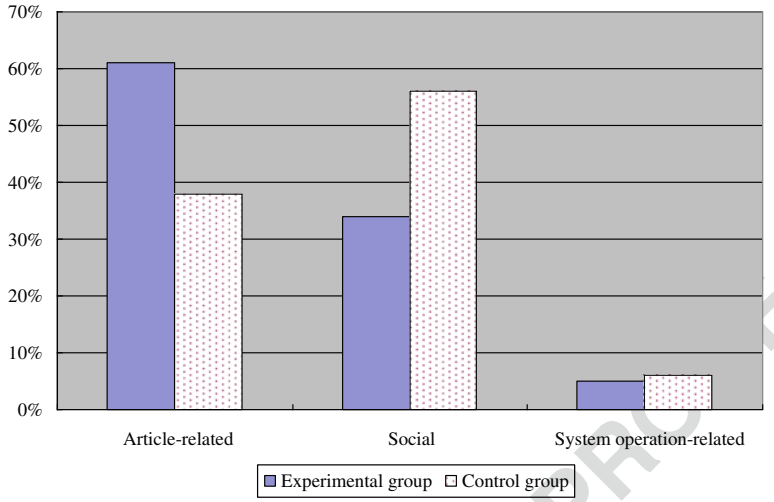

Fig. 13 Average percentage of dialogue categories

The results suggested the *Process-Writing Wizard* helped the students focus more on the writing tasks instead of social interactions.

Incorporating scaffolds into writing process is an instructional challenge. However, technologies can be designed to offer scaffolds that "lead cognitive functions that are newly emerging, and to prompt routines and processes in a timely way" (Englert et al. 2007, p.11). This study offers supporting evidence that the *Process-Writing Wizard* can be effective for EFL students to develop skills needed for the dynamics of the interconnected world. This is the case because such a system has a few clear advantages for collaborative writing instruction. First, it provides a systematic yet dynamic, rhetorical engagement with technical writing in English. It also helps students understand the systematic nature of technical writing, which is demanding for student writers. We believe this system can help scaffold the necessary writing skills that most students will use in their professional careers. Second, the real-time chat room allows students to collectively and synchronously compose or edit their writings. The *Process-Writing Wizard* can provide an environment conducive to, as Ede and Lunsford (1992, p. 15) stated, "social engagement in intellectual pursuits, and promotes the understanding that all writing is collaborative because all writing is social". Third, it provides opportunities for students to engage in collaborative writing, such as creating team agendas and plans, team brainstorming, devising shared team outlines, and writing team articles. By examining and managing the writing processes, the students can understand the act of collaborative writing. Finally, it provides multi-user functionality to allow multiple students to work synchronously and to help students feel comfortable in multi-task, multi-user environments. These advantages are in accordance with the L2 learning theories, such as communicative language learning and Krashen's (1985) assumption of second language acquisition, emphasizing while learning a second language, learners need to interact with the external environment actively.

There are several limitations to this study that need to be addressed in future research. First, the prototype structure of the wizard presented in this paper is based on the rhetorical form of comparison and contrast. Further research is needed to expand the system to include other rhetorical forms, such as cause-effect and argumentative, etc. Second, in the experiment, all the writing was blindly graded by an English instructor. Although the rater was trained in the proper use of the rubric, it would have been beneficial to have two graders to ensure consistency. Third, the experiment investigated the effect of the system on students' writing quality and online chats. Further research is needed to monitor and analyze students' collaboration and interaction behavior, rather than looking at overall effectiveness of the system. Notwithstanding the above limitations, the researchers believe this system contributes to the practical need for a computer-supported environment of training collaborative technical communicators. This study also provided a better understanding of what support computers can offer in collaborative technical writing instruction. Finally, the current study is significant because it empirically examined the effect of the system on EFL students' learning.

Conclusions

In different parts of the world, researchers and teachers search for proper methods to provide computer supports to students in developing their collaborative writing competencies. This study developed a synchronous scaffolding environment named the *Process-Writing Wizard* for collaborative technical writing instruction. *Process-Writing Wizard* is a real-time communication environment with procedural facilitation, wherein team members receive process-oriented supports to work synchronously to collaborate on their writing. It provides procedural scaffolds to help a team of students develop collaborative writing strategies, such as creating team agendas, brainstorming, creating team outlines, and generating a team article.

The experimental results are encouraging in that they are consistent with the research propositions. The proposed synchronous scaffolding environment is friendly to users and does not impede the communication process among peers, even though extra tasks are required. The results also suggested that students who used the *Process-Writing Wizard* had improved outcomes compared with the control group in terms of article content and article organization. Moreover, the analyzed results of team dialogues suggested the system can effectively and efficiently help students focus their interactions on writing an article. In the context of EFL learning, a good level of English writing ability is of paramount importance. In addition, a motivating learning environment is essential for EFL learners who have limited opportunities to be exposed to the target language in everyday situations. By creating and implementing the *Process-Writing Wizard*, the researchers hope this study will be useful to other educators and researchers engaged in efforts to apply computer technology to facilitate EFL learners' writing processes and interactions.

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Appendix

Table 5 The experimental questionnaire

Item	Descriptions
E1	The functions of the system are easy to use.
E2	I can understand the procedures to use the system.
E3	This system has a well-designed design interface.
E4	There is no burden from operating this system.
E5[a]	The online communication processes may impede collaborative writing.
U1	This system is helpful for collaborative writing.
U2	The functions of this system help enhance my collaborative writing ability.
U3	Through using this system, I can reach the goal of communication.
U4[a]	I think too much communication of ideas may impede the fluency of collaborative writing.
A1	I have a positive evaluation of this system.
A2	I am interested in using this system to facilitate collaborative writing.
A3	I feel using this system is a joyful learning experience.
I1	I will continue using this system in the future.
I2	I have a good recall of the content of discussions from the collaborative writing processes.
I3	I will recommend this system to others.
I4	I am willing to use this system as a tool for collaborative technical writing.
R1	I'm satisfied with the reply speed of team members during the discussions.

[a] negative items

E1-E5: *perceived ease of use*; U1-U4: *perceived usefulness*; A1-A3: *attitude to use*; I1-I4: *intention to use*; and R1: *perceived response time from peers*

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