Automatic Scaffolding and Measurement of Concept Mapping for EFL Students to Write Summaries

Yu-Fen Yang
Graduate school of applied foreign languages, National Yunlin University of Science & Technology, Taiwan // yangy@yuntech.edu.tw

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ABSTRACT

An incorrect concept map may obstruct a student's comprehension when writing summaries if they are unable to grasp key concepts when reading texts. The purpose of this study was to investigate the effects of automatic scaffolding and measurement of three-layer concept maps on improving university students' writing summaries. The automatic three-layer concept maps presented in this study include: (1) the central idea of the title, (2) the main idea of each paragraph, and (3) the supporting ideas in each paragraph. A sample of 107 university students who studied English as a Foreign Language (EFL) was divided into experimental and control groups, comprised of 54 and 53 students respectively. The results of this study indicate that the students of the experimental group made more significant improvement in reading comprehension and summary writing than those of the control group as they were able to identify the main idea from each paragraph and clarify relations among paragraphs after requesting the three-layer concept maps. They then modified their prior knowledge structure by revising the first-draft summaries to final ones. The students' perceptions toward the automatic three-layer concept maps to improve summary writing are also described in this study.

Keywords

Automatic scaffolding, Automatic measurement, Immediate feedback, Summary writing, Three-layer concept map

Introduction

A recent trend in evaluating students' language proficiency has been the assessment of their integrated reading and writing skills rather than corresponding discrete skills (Kırmızı, 2009). University students who study English as a Foreign Language (EFL) are required to be equipped with both reading and writing skills in order to assist themselves in grasping main ideas or selecting key elements from reading a large quantity of texts in highly demanding academic courses (Dreyer & Nel, 2003). In acquiring reading and writing skills, students need to identify keywords or phrases from each paragraph, construct concept maps to decode texts, and integrate main ideas or key elements into organized and logical summaries (Kırmızı, 2009). Reading and writing success depends on word identification, cognition, construction, and summarizing skills (Sung, Chang, & Huang, 2008).

Writing summaries is a particularly difficult task for EFL students to learn as they have to determine what content in a passage is the most important and then transform it into succinct statements in their own words (Yang, 2014). In determining what information is important in texts, the main idea of a passage is often not present in the surface structure (the exact wordings) of the text (Friend, 2001; Kintsch, 1998) and the cognitive process which converts surface structure to an understanding of a text is internal and largely unobservable in onsite instruction (Alfassi, 2004; Fischer, 2003). As such, EFL novice summary writers may encounter difficulties as incorporating source text information into their own writing in terms of low reading comprehension skills (Esmaeili, 2002; Plakans, 2009) and the restriction of their vocabulary size (Baba, 2009).

To grasp the main ideas necessary for writing summaries, concept mapping has been reported to be an effective strategy which graphically indicates the relationships between multiple concepts (Tseng, Chang, Lou, Tan & Chiu, 2012). Liu, Chen and Chang (2010) have proposed that concept mapping strategies provide students with a more systematic and organized way to clarify the important concepts necessary for enhancing reading comprehension, thereby improving summarizing skills. In particular, concept mapping facilitates students externalize their prior knowledge and combine it with new ones for reconstructing new language knowledge and learning experiences (Novak, 1990; Hwang, Hung, Chen, & Liu, 2014).

In light of the rapid growth of computer technology, computerized concept maps are helping to better students' reading comprehension and writing proficiency (Wu, Hwang, Milrad, Ke, & Huang, 2012). A concept map is a fill-

in-the-blank strategy, where students extract important words and phrases while reading a passage and then fill in the essential words or phrases in a map for comprehension and summary writing. Keyphrases, which include two or more keywords, are formed to represent important concepts (Mangina & Kilbride, 2008). Zha (2002) proposes that keyphrases and summaries comprise word-to-sentence relationships in terms of information retrieval generated by deleting unnecessary information, extracting keyphrases in each paragraph, and integrating keyphrases and main ideas to complete a summary. In forming concept maps, nodes refer to the main ideas, and links represent the associations between the main ideas (Adesope & Nesbit, 2013; Novak, 1993).

A concept map is also a useful assessment tool for measuring students' reading comprehension and summary writing. Traditional paper-based concept maps cannot help the teacher immediately evaluate a student's comprehension. As a result, students are unable to receive timely feedback from their teacher or peers. With the assistance of technology, computerized concept maps facilitate the modification of nodes and links and make the task easier for students to fill in the keyphrases, revise their previous maps, and automatically receive feedback for scoring (Liu, Chen, & Chang, 2010). As such, computerized concept maps not only provide a scaffold to help students visualize and grasp main ideas, and clarify any connected relations between them (Liu, 2011; Sturm & Rankin-Erickson, 2002), but they also offer students immediate feedback and scoring to modify their summaries without waiting a long time for teacher feedback (Wu, Hwang, Milrad, Ke, & Huang, 2012).

Self-regulated learning, which comes from cognitive psychology, refers to students consciously make efforts to manage and direct complicated learning activities in which they are required to learn independently (Zimmerman & Martinez-Pons, 1988). Self-regulated learning is defined as "an active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment" (Pintrich, 2000, p. 453). By receiving immediate feedback and scoring from technology-enhanced language learning, students are provided with the opportunity to perform self-regulated learning without the restrictions of time and space (Wang, 2008). To foster students' self-regulated learning, the automatic scaffolds of three-layer concept maps become effective tools to enable students to develop their language understanding beyond the given information, phasing out the teacher's assistance as students' reading and writing competence increases (Azevedo & Hadwin, 2005).

Statements of problems

While previous studies have examined the scaffolds of concept maps on reading and writing, few studies have focused on an explicit instruction which helps students construct their own maps when learning to write summaries. First, many studies (e.g., Cordero-Ponce, 2000; Friend, 2000; Irwin, 1991) have merely proposed general and unclear rules for writing a summary. Without many opportunities to observe their teacher or peers' modeling on how to write summaries through log files, novice students are still unaware of what main ideas are missing or what irrelevant details are included in a summary (Liu, 2011).

Second, most studies generated concept maps only from corpora (e.g., Cimiano, Hotho & Staab, 2005). This makes the measurement of concept maps questionable since the various sizes of corpora may influence the complexities of concept maps. The criterion for evaluating students' concept maps is not clearly revealed in previous studies as "each individual might have very different ways in generating his own concepts." (Yang, Wong, & Yeh, 2008, p. 174).

Finally, many concept maps are developed using numerous key concepts with a large quantity of nodes and links. For example, Liu (2011) has proposed that using the concept mapping software program named *Inspiration* could improve ESL learners' writing proficiency. However, complicated concept mapping in *Inspiration* did not provide students with the main idea in each paragraph. EFL students may still miss the key concept in each paragraph which hinders their comprehension when writing summaries as the software only presented the main concept of a text.

Background of the study

This study attempts to investigate the effects of automatic keyphrases, three-layer concept maps, and scoring on EFL students' learning to write summaries. According to Novak and Gowin's study (1984), a concept map consists of main concepts, sub-concepts, and important details from the central to the external within three layers. Many concept

mapping software programs provide students with the main concept to comprehend a reading passage. However, students still have difficulties writing summaries when using these software programs without a hierarchal structure for grasping the main idea in each paragraph. When the teacher's support is decreased, immediate feedback, such as automatic map and scoring, becomes important for the students to clarify their text misunderstanding and evaluate the quality of maps for summary improvement.

This study developed an automatic three-layer concept map as scaffolding and measurement for university students' learning to write summaries. Before forming a map, the system automatically extracted important keyphrases by self-developed algorithms. Then, according to the keyphrases, the three-layer concept maps was represented in three layers (see Figure 1) including (1) the central idea in the title, (2) the main idea in each paragraph, and (3) the supporting ideas in each paragraph. The numbers of nodes (main idea) in the second layer depend on how many paragraphs are included in a text. Students can write their first sentence of a summary based on the keyphrases in the title, and then complete the following sentences in terms of the main idea from each paragraph. As students completed their maps, the system automatically measured their maps by providing immediate feedback of scoring. The criterion of scoring is to compare the automatic map generated from the system.

To fulfill the research purpose of this study, which was to investigate the effects of automatic keyphrases, three-layer concept maps, and scoring on university students' learning to write summaries, three research questions were addressed: (1) To what extent does students' reading progress differ between a group using automatic three-layer concept maps and a group using paper-based concept maps? (2) To what extent does the students' use of automatic three-layer concept maps help students learn to write summaries and enhance their reading comprehension?; (3) What are the students' perceptions of the value of using automatic three-layer and paper-based concept maps for improving their reading comprehension and summary writing?

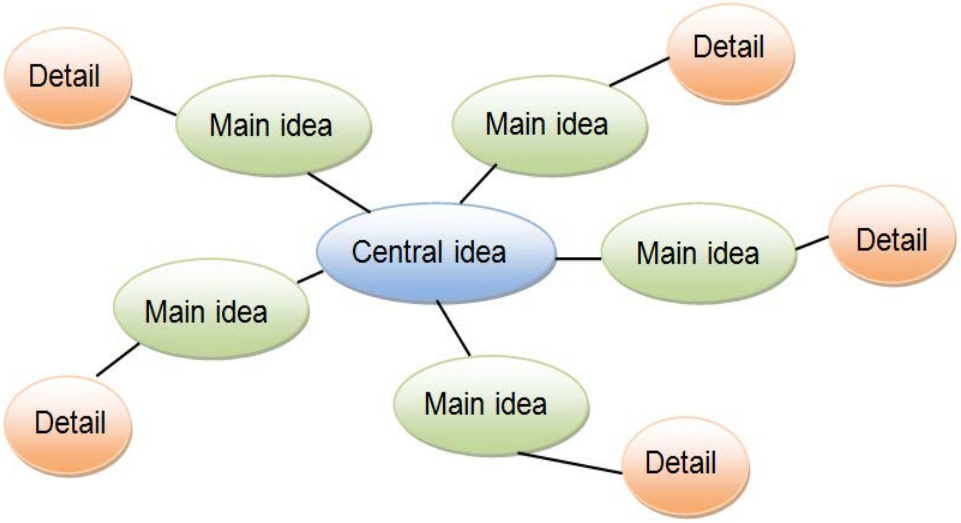


Figure 1. New three-layer concept map in this study

Method

Participants

A total of 107 first year university students at a technological university in central Taiwan were recruited to learn how to write summaries and had their work compared to determine whether there was any improvement for writing summaries and reading comprehension after using automatic scaffolds and measurement of three-layer concept maps and paper-based concept maps. They undertook the course "Reading and Writing" to improve their academic proficiency. According to the results of the university survey, most of them (94%) did not have any experience in writing summaries in English or had attended online summary instruction. The students were set biweekly

assignments to read multiple types of academic texts, such as business documents and reports, ranging from 850 to 1500 words, and then were required to write summaries of the texts.

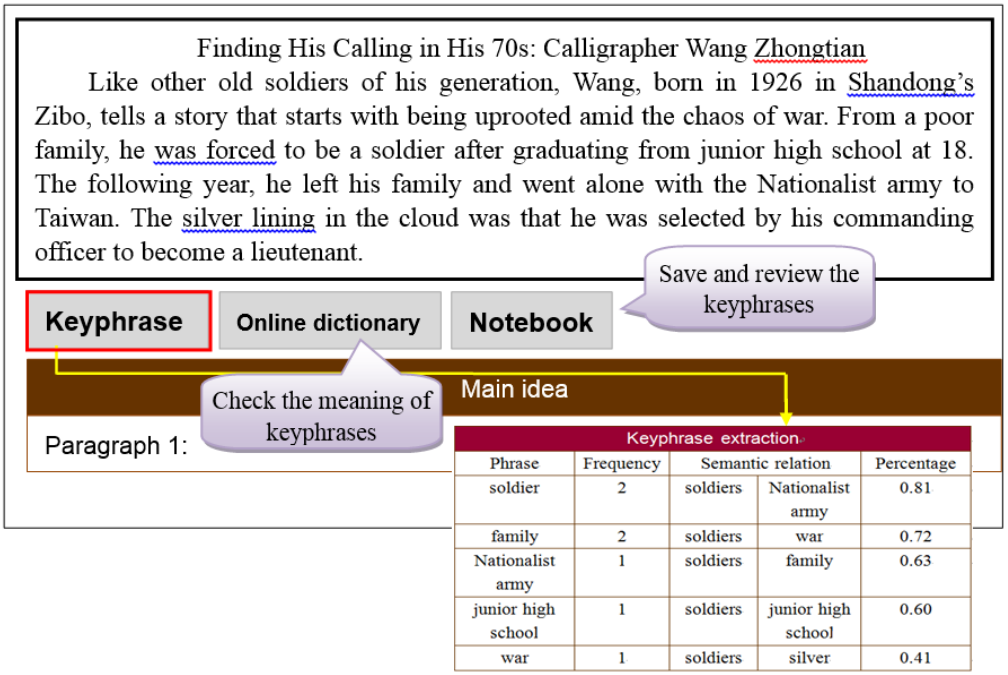
Before receiving summary instruction, the students were asked to take the reading section of a standardized test, Test of English for International Communication (TOEIC), as a pre-test to identify their English reading proficiency. The maximum score on the TOEIC test for the reading section is 495, and the reliability of the TOEIC test is reported to be 0.90 (Educational Testing Service, 2007). According to the TOEIC pre-test, the 107 students were grouped into an experimental group (*N = 54*) and a control group (*N = 53*). The mean score and standard deviation of the 54 students in the experimental group was 287.51 and 33.64 on the pre-test, while the mean score and standard deviation of the 53 students of the control group was 283.39 and 30.16. Significant differences were not determined for the two group's proficiencies in the pre-test ($t(51)= -1.22$, $p > .01$).

System development

The automatic system of keyphrases, three-layer concept map, and scoring, includes the student interface and the teacher interface.

The student interface

Keyphrases are regarded as brief summaries of a text (Ercan & Cicekli, 2007). They may appear in important places (i.e., the title and topic sentences) within a text. To further construct semantic relations between keyphrases to form the three-layer concept maps, Wikipedia Miner served in this study as a referential source containing algorithms, a database package, and an open-source toolkit. The Wikipedia Miner includes algorithms for generating semantic relatedness measures, which quantify the extent to which different words or concepts relate to each other (Milne & Witten, 2013).



Keyphrase extraction

Phrase	Frequency	Semantic relation		Percentage
soldier	2	soldiers	Nationalist army	0.81
family	2	soldiers	war	0.72
Nationalist army	1	soldiers	family	0.63
junior high school	1	soldiers	junior high school	0.60
war	1	soldiers	silver	0.41

Figure 2. Keyphrase extraction

For example, as shown in Figure 2, when users entered words, such as *soldier*, *Nationalist army*, *war*, *family* and *junior high school*, into Wikipedia Miner to conduct a trial for the calculation of sematic relatedness, the results indicated that the word *soldier* is 81% related to *Nationalist army*, 72% related to *war*, 63% related to *family*, and 60% related to *junior high school*. The five keyphrases were correlated to each other in a given text based on the

semantic relationships of synonyms, hypernyms, and hyponyms. In this study, we developed our algorithms and used Taiwan Panorama's database to extract and compare word semantic relatedness and help students construct their three-layer concept maps for writing summaries as they read Taiwan Panorama's articles. With the scaffold of keyphrase extraction, students were able to understand which keyphrases were important to describe the same key concepts in a paragraph. The reliability of the keyphrase extraction in this study is 0.82 (Tsai, Hsu, Yang & Yeh, 2012).

The new three-layer concept map in this study contains three hierarchical and definite layers, with the keyphrases grouped into these three layers. According to keyphrase extraction, this study developed a fill-in-the-blank concept map for students to visualize their knowledge structures (Novak, 2002). The first layer in the center of the concept map is the central idea of the text. The title may become a central idea if it contains high-frequency and related content words and phrases. The second layer of the concept map is the main idea in each paragraph. The numbers of nodes in the second layer of the concept map depends on the numbers of paragraphs in a text. The calculation of the frequency of each verb or noun phrase appearing in the topic sentence as well as in the content of each paragraph is taken into account. The outer third layer is the collection of supporting ideas in each paragraph. As shown in Figure 3, the new concept map is automatically provided by the system after students partially fill in their keyphrases for each paragraph.

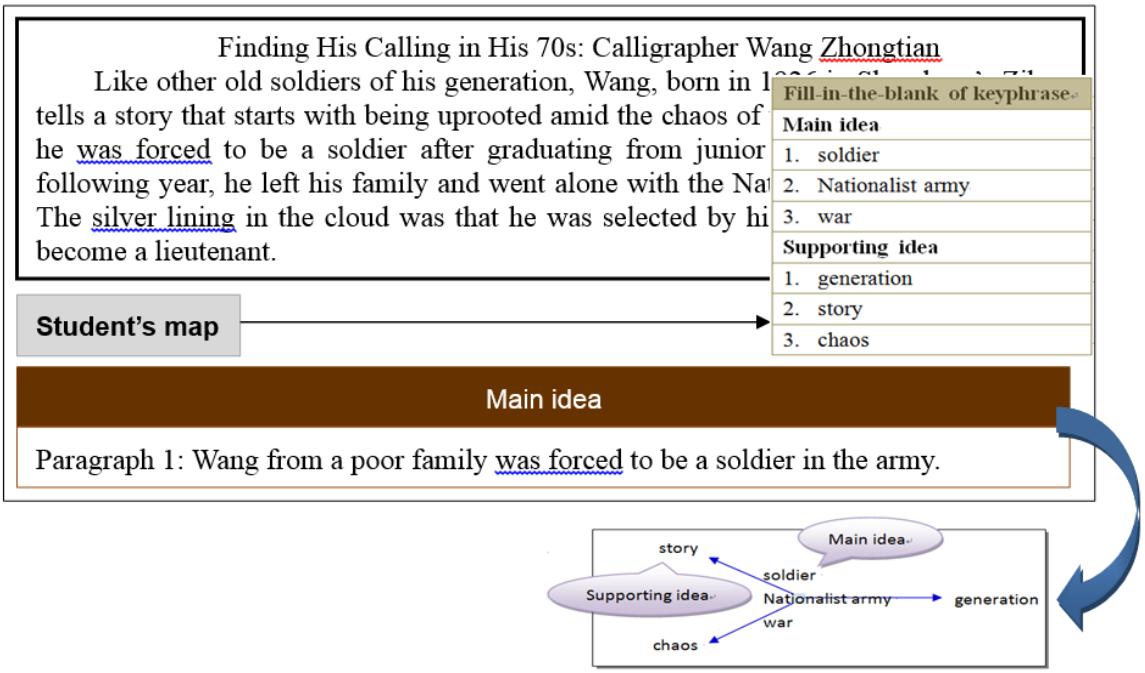


Figure 3. Automatic concept map for a paragraph

Ruiz-Primo and Shavelson (1996) have proposed that automatic scorings of the concept maps can be used by comparing student and teacher maps. The criteria could examine students' concept structure, semantic content, and their comprehension (Liu & Lee, 2013). After reading an English text, the students' three-layer concept maps are automatically scored by the system (see Figure 4). There are two purposes for automatic scoring in this study. First, it provides teachers with the opportunity to examine whether their students truly understand the texts or not. Second, it provides students with the opportunity to reflect on what they have understood in the texts and a chance to revise their first draft summaries into final ones.

The first sentence of the summary is calculated by the keyphrases of the first layer (central idea), and the following sentences are calculated by the second (main idea) and third (supporting idea) layers. Students are required to follow the sequence of nodes and links from each paragraph to write their summaries. For example, in Figure 5, the student received immediate feedback about their scoring (80 score points) and guidance after submitting his summary. The scoring of the summary was calculated by 3 keyphrases in central ideas such as "Wang Zhongtian," "70s" and "calligrapher" *15 score points (45/3=15), and 14 keyphrases in the main idea of the paragraph such as "solider,"

"Nationalist army" and "fitness officer"*2.5 score points (45/18 = 2.5), which amounted to a total score of 80 points. The boldface words of the summary are keyphrases calculated by the system, and the scoring of keyphrases are based on the automatic map.

The teacher interface

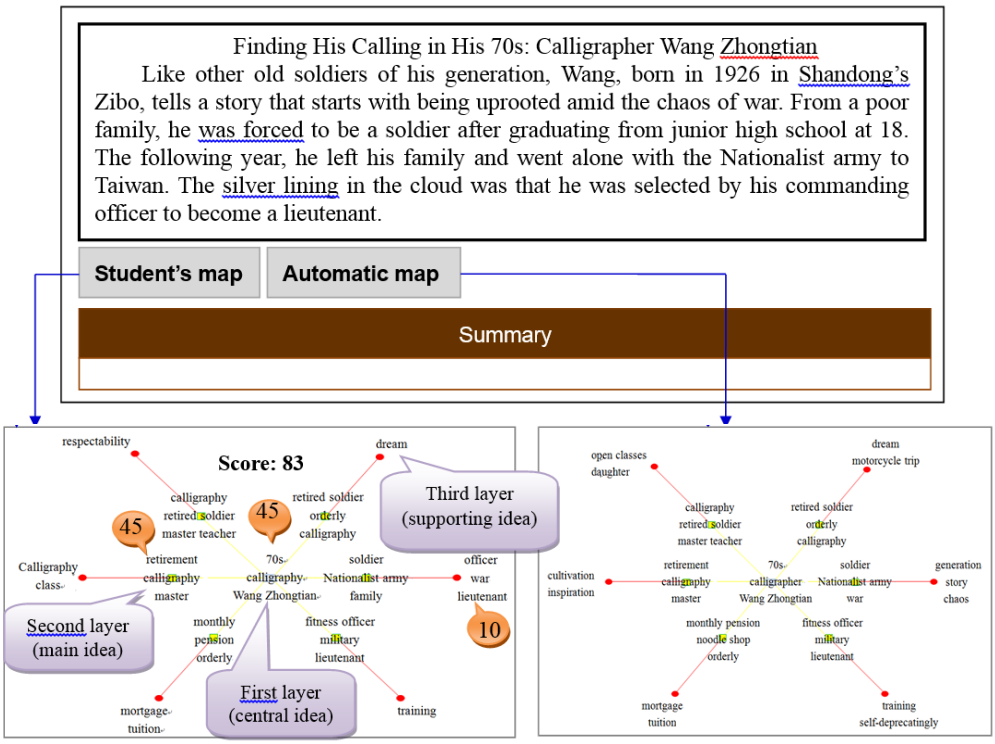


Figure 4. Scoring based on the student's map and automatic map

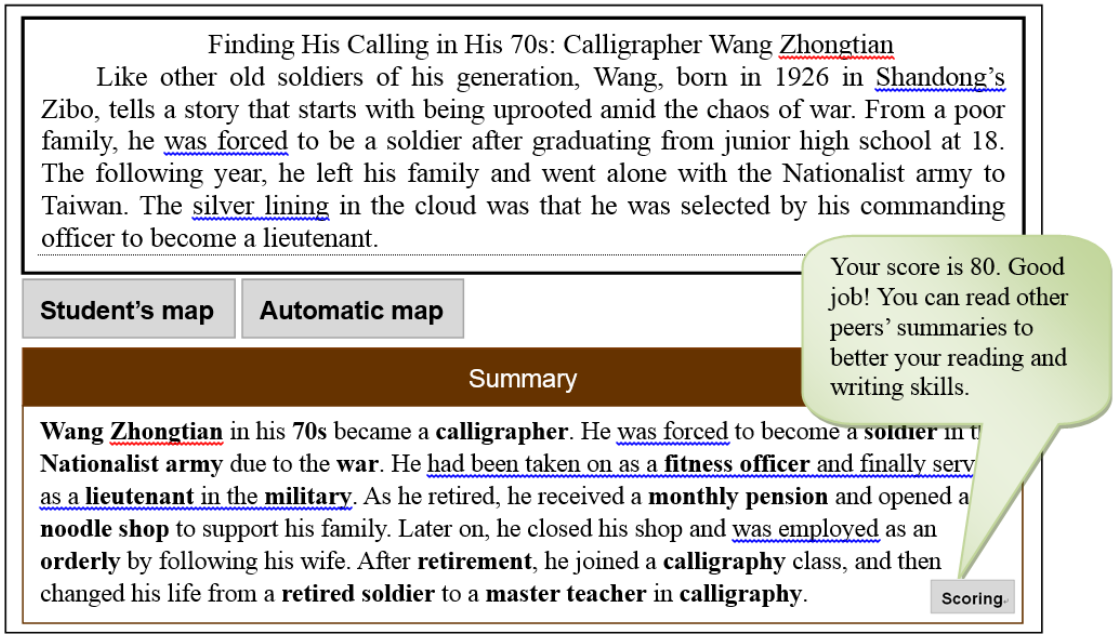


Figure 5. Automatic scoring of the summary

In the teacher interface, teachers can monitor their students' progress in writing summaries by observing the log files. The log files record students' actions in the system such as grasping central and main ideas, requesting automatic concept maps, receiving scores to evaluate their summaries, and facilitates teachers to provide individual scaffolding to solve their students' reading and writing difficulties.

Procedure of data collection

This study incorporated onsite instruction with the automatic system for a period of 18 weeks, including two different versions of TOEIC tests serving as pre- and post-tests. As shown in Figure 6, when the instruction began, the TOEIC pre-test was provided to identify the students' level of English language proficiency. In the first eight weeks (4 academic texts), the students were guided in how to obtain central ideas from the topic and grasp main and supporting ideas from each paragraph. They were required to delete irrelevant information, generalize each group of main and supporting ideas, and integrate each group of main ideas to write summaries of first drafts with onsite instruction.

After eight weeks of onsite instruction (2 hours per week and 4 academic texts), automatic scaffolding and measurement of three-layer concept maps were introduced to the students of the experimental group for another eight weeks (another 4 academic texts), while the students in the control group continued their onsite instruction, drew paper-based concept maps and received the teacher's feedback. The students in the experimental group first read academic texts online, received automatic keyphrases and three-layer concept maps, and measured their summaries by automatic scoring. Afterwards, they had to revise the same first drafts into their final drafts. As the students of the experimental group had requested and observed the keyphrases in three-layer concept maps, they could diagnose their summaries to consider whether they had recognized the central and main ideas or not. The students then received automatic scoring to measure their summaries and examine their improvement from the first to final drafts. In contrast, the students of the control group continued their onsite instruction, reading 4 academic texts and learning to draw paper-based concept maps with three layers. The teacher may have provided students with keyphrases when they encountered reading difficulties. The students then revised their first drafts into final ones after receiving teacher feedback for summary revisions and scoring.

At the end of the instruction, the university students were required to take a TOEIC post-test to examine reading improvement between the experimental and control groups. The comparison between first and final drafts examined the students' progress in writing summaries with a group using automatic scaffolding and measurement of three-layer concept maps and a group using paper-based concept maps. The students' action details on the request for automatic three-layer concept maps for writing summaries recorded in the system were also analyzed. Finally, the students' perceptions of using automatic three-layer and paper-based concept maps were revealed by two open-ended questionnaires.

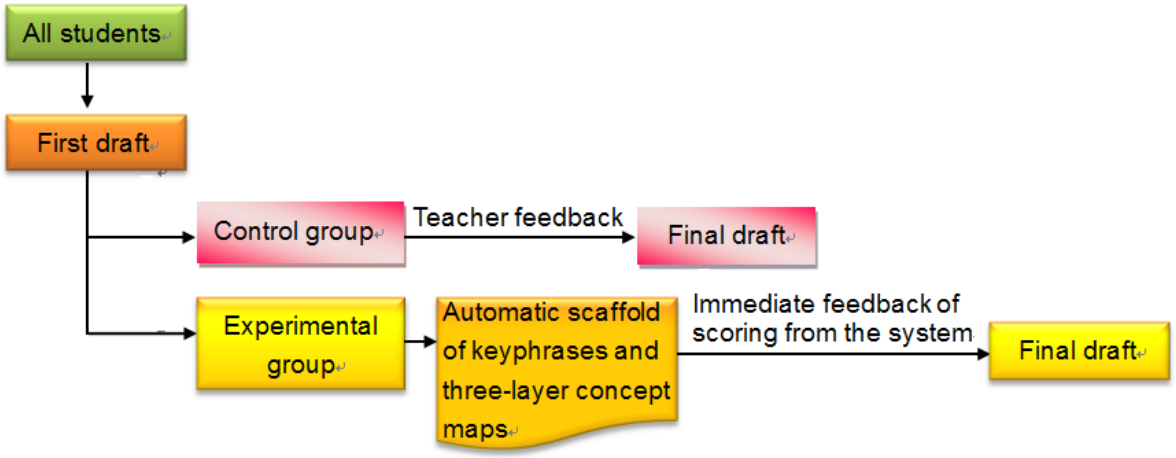


Figure 6. Procedure of experimental design

Procedure of data analysis

Data were analyzed in terms of the students' pre- and post-test scores, the process data of requesting automatic keyphrases, three-layer concept maps and scoring, the comparison between students' first and final drafts, and the open-ended questionnaires. First, the pre- and post-tests and the first and final drafts results of the experimental and control groups were compared by means of two paired-sample *t*-tests to examine the students' progress in reading comprehension. Second, the process data of requesting automatic keyphrases, three-layer concept maps and scoring for improving summaries was explicitly represented to show how the students of the experimental group improved their reading comprehension and summarizing skills based on the automatic scaffolding and measurement. Improvement in reading and writing from the students of the control group was examined by paper-based concept maps combined with teacher feedback. Finally, content analysis was administered to investigate the students' perceptions of a group using automatic three-layer and a group using paper-based concept maps for writing summaries.

Four stages of content analysis were proposed in this study (Patton, 2002), including coding, categorization, description and interpretation. First, the researcher and the research assistant highlighted meaningful statements in the students' actions in the log files of the system and two open-ended questionnaires. Afterwards, the meaningful statements were grouped into categories with the students' perceptions on using the automatic three-layer concept maps and paper-based concept maps for learning to write summaries. Next, the researcher described the statements and summarized the main points. Finally, the researcher interpreted the main points by offering explanations, drawing conclusions and making inferences. The inter-rater reliability (the researcher and the research assistant) was 0.85. The disagreement between these two raters was resolved by discussion. Data interpretation driven by these methods is further explained in the following sections.

Results

To investigate the effects of automatic scaffolding and measurement of three-layer concept maps to improve students' reading comprehension and summaries, four categories were addressed in this section: (1) the comparison of the reading progress between the experimental and the control groups is provided by the TOEIC pre- and post-tests and the first and final drafts of summaries, (2) the influence of keyphrases and three-layer concept maps on summary writing and reading comprehension (i.e., process data of the students' three-layer concept maps and first and final drafts), and (3) the students' perceptions of summary improvement with a group using automatic scaffolding and measurement of three-layer concept maps and a group using paper-based concept maps.

Students' progress in reading comprehension and summary writing

Two paired-sample *t*-tests compare the mean scores of the pre- and post-tests in reading proficiency for both the experimental and control groups. The results show that the students of the experimental group made greater improvement in their reading comprehension, as their mean scores increased from 283.39 in the pre-test to 328.38 in the post-test. There is a significant difference between the pre-and post-tests in reading ($t(27)= -4.47$, $p < .00$). In contrast, the mean scores of the control group in the post-test (310.59) show that little improvement in reading occurred when compared with the mean score from the pre-test (287.51). A slight difference between the scores of the pre-and post-tests is noted ($t(23) = -2.83$, $p < .03$). Comparing the results of the students' first and final drafts of the two groups, as shown in Table 1, the findings indicate a significant principal effect for the students of the experimental group in their final drafts ($t(27) = -8.54$, $p = .00$) after receiving automatic scaffolding and measurement of three-layer concept maps. In contrast, the students of the control group made little improvement in their final drafts ($t(23) = -5.61$, $p = .05$) compared with their first drafts after receiving only teacher feedback. The results of reading progress by comparing the two groups' post-tests and summary improvement indicate that the students of experimental group using automatic scaffolds and measurement of three-layer concept maps to improve their summary writing and reading comprehension were superior to those of the students in the control group of using paper-based concept maps.

Table 1. Comparison between first and final drafts in the two groups (N = 107)

Summary	Experimental group				Control group			
	M	*SD*	*t*	*p*	*M*	*SD*	*t*	*p*
First draft	72.05	11.14	-8.54	.00**	76.68	6.52	-5.61	.05*
Final draft	84.53	5.20			81.24	5.89		

Note. $^{**}p < 0.01$. $^{*}p < 0.05$.

The process of requesting automatic three-layer concept maps for improving summaries and reading comprehension

The onsite instruction was conducted to help the students accumulate the fundamental knowledge necessary for drawing their concept maps and writing summaries. After identifying the main ideas in each paragraph, the students were encouraged to practice filling in keyphrases on a paper-based three-layer concept map as a "planning" stage before writing their summaries. However, the students had difficulties improving their summaries as they neither grasped the main ideas in each paragraph nor received immediate feedback of scoring. In addition, without the log files of process data, the students' summarizing processes of identifying the main idea were not documented. As a result, the teacher could not monitor the students' reading and summarizing difficulties.

In online instruction, the automatic scaffolding and measurement of three-layer concept maps to improve summaries and comprehension are described. The online system tracked and recorded students' concept-constructing processes. In this study, automatic keyphrases and three-layer concept maps demonstrate students how to construct their own maps and help them to clarify the relations in each group of main ideas and make a logical and well-organized summary. For online instruction, student A was one of the sample cases from the experimental group used to examine his summary improvement from first to final drafts after using automatic scaffolding and measurement.

Initially, student A was asked to post his first draft after the onsite instruction, "A question of numbers" in the system. A score was automatically generated and shown on the screen to inform him how good or poor his first summary draft was. He received a score of 68 points out of a full scale of 100 from the automatic system (see Table 2). After student A requested the automatic scaffolding of keyphrases and three-layer concept maps (see Figure 7), student A received a score of 87 points for his three-layer concept maps. The automatic map (see Figure 8) was also shown to clarify the connection between each group of main ideas and supporting details in the text. Based on his own concept maps and the automatic map, he then revised his first draft into a final by extracting central and main ideas again and obtained a score of 91 points in his final draft. That is, the automatic scaffolding of the keyphrases and three-layer concept maps facilitated student A to grasp more important main ideas and necessary details to write the summary. For example, "numbers" was a keyword in this article, but student A did not pay attention to the keyword "numbers" in his first draft. After receiving the automatic map, he discovered that he had to mention "38 neighbors" and "38 witnesses" while revising summaries from the first to final draft.

Table 2. Comparison between student A's first and final drafts in the system

First draft	Summary = 68
The key of **bystander effect** is **question numbers.** It is a complicated **human reaction.** For example, Genovese was **murdered** but his **neighbors** did not call the police. Psychologists set up an **experiment** with **three groups** of students to prove this **theory**. It's just human nature. The results supported Darley & Latane's **theory**, and the **bystander effect** can apply to daily **situations**. However, **bystander effect** happens because of **the present of other people**.	
Final draft	Summary = 91
The key of **bystander effect** is **question numbers.** Proposed by **social psychologists, bystander effect** refers to **human** complex **reaction**. For example, **Genovese** was **murdered** but his **38 neighbors** did not do anything. Though there were **38 witnesses**, people decreased the **chances** and **responsibility** to help others. Darley and Latane also set up an **experiment** to group **students** into **three groups** to prove this **theory**. The results presented the **bystander effect** can be related to **large numbers** and happen in daily **situations**. However, **bystander effect** is one of the **factors** to affect people's **decision**.	

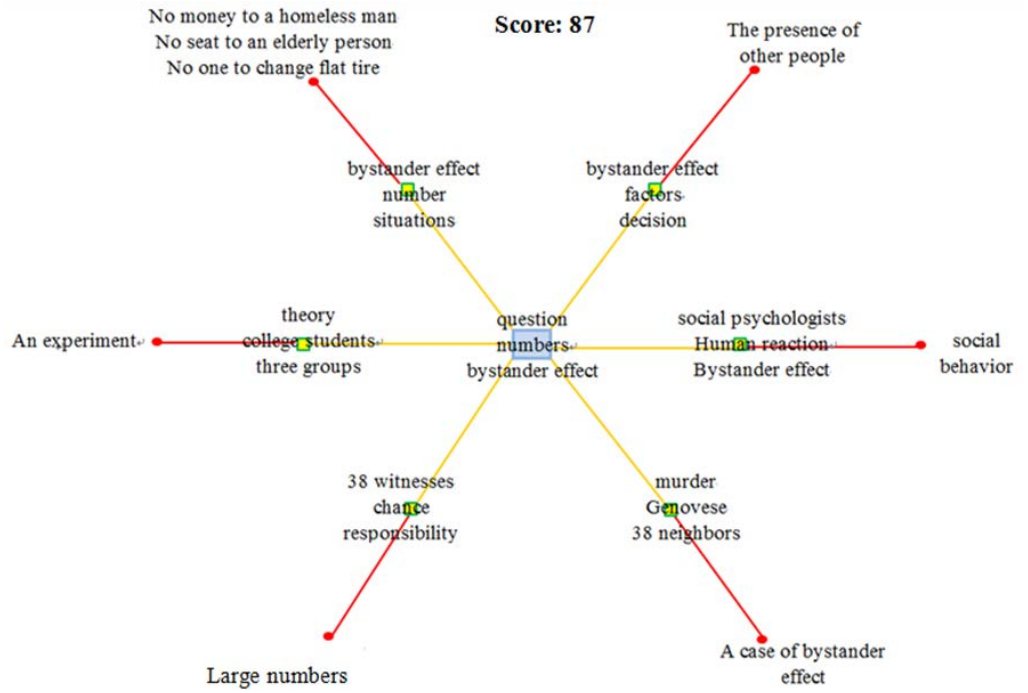


Figure 7. Example of student A's three-layer concept map

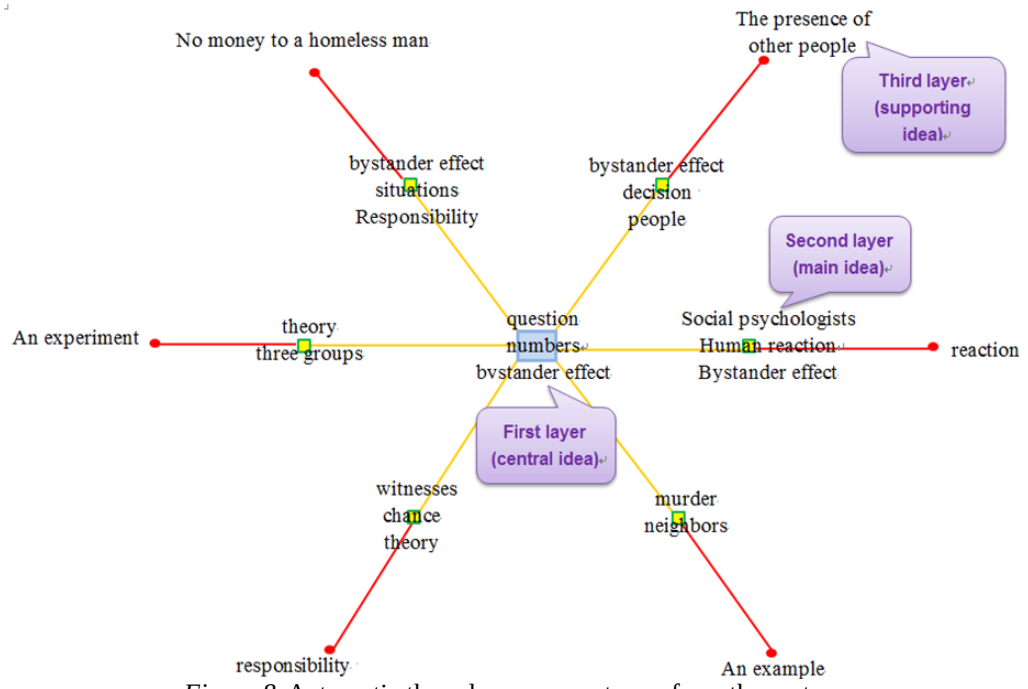


Figure 8. Automatic three-layer concept map from the system

The students' perceptions of using automatic three-layer and paper-based concept maps in reading comprehension and summary writing

According to the content analysis of two open-ended questionnaires between the experimental and control groups, all participants in the experimental group stated that the keyphrases and three-layer concept maps assisted them with identifying the central and main ideas for improving their reading comprehension and summaries. All of the participants from the experimental group indicated that the automatic keyphrases really helped them grasp the main

ideas in each paragraph and construct the three-layer structure of concept maps to clarify the logical relations across paragraphs. The automatic map and scoring also helped them understand the quality of their summaries (see Table 3). Most of the participants (93%) confirmed that the scaffold of the automatic map helped them to clarify what important keyphrases were missing and then improve their summaries. However, there were 15 participants (28%) who encountered difficulties grasping the main ideas while reading the passage. They usually reread the text and figured out what main ideas should be included while completing the fill-in-the-blank concept maps. The participants of the control group also agreed that using paper-based concept maps helped them to clarify text misunderstanding and improve reading comprehension. However, 27 participants (51%) claimed that they experienced problems with drawing the paper-based concept maps since they had trouble grasping the keyphrases and clarifying important information and irrelevant details for constructing the maps. Twenty-three participants (43%) proposed that they would like to read the automatic map or more-proficient peers' maps and compare those with their own for improving reading comprehension and summaries.

Table 3. Students' perceptions toward online and paper-based concept maps between experimental (N = 54) and control groups (N = 53)

	Statements	Frequency
Experimental group	1. I can have a basic understanding of and identify the main ideas in each paragraph through requesting automatic three-layer concept maps, and then receive immediate feedback through scoring to evaluate my summaries. I can examine how good my summary is.	54
	2. I like to read the automatic map and more-proficient peers' map to clarify what important keyphrases I missed.	50
	3. Each layer of the concept map helps me clarify the relationships between the main ideas in each paragraph for writing a good summary.	42
	4. Sometimes I have difficulties grasping main ideas while reading the text. I usually reread the text and figure out what the main points are in a paragraph.	15
	5. With the help of automatic three-layer concept maps, I can select relevant information and delete irrelevant details when writing a summary.	8
Control group	1. By drawing paper-based concept maps, I can distinguish the relationships across paragraphs while reading the passage.	53
	2. I think that drawing paper-based concept maps helps me write my summaries.	35
	3. I have difficulties in drawing concept maps because I was unable to grasp the key ideas and was even unable to clarify what important information and irrelevant details are.	27
	4. Though I received teacher feedback, I still wanted to read more-proficient students' maps to improve mine.	23
	5. I had to wait a long time to receive my teacher's feedback.	18

Table 4. Student perceptions toward writing summaries (N = 107)

Statements	Frequency
1. I think that the summarizing skill is important as I need to integrate each group of main ideas and represent my understanding of the text.	107
2. Based on the concept maps, I can construct my summaries without rereading the texts too many times.	93
3. I think I was unable to use accurate words or sentences to paraphrase the text in writing summaries, but now I can do with the support of the concept maps.	72
4. I may involve too much detailed information and lack transition words to connect my main points.	24
5. I have difficulties with how to use different sentence structures and key words to write a good summary.	15

As shown in Table 4, all of the participants (100%) in the experimental and control groups agreed that the summarizing skill was helpful for them to improve their reading and writing skills. Most of the participants (87%) indicated that concept maps helped them identify important keyphrases and examine what ideas were missing or irrelevant before writing their own summaries. However, 72 participants (67%) indicated that they were unable to paraphrase the texts with accurate English words or sentences when writing summaries. They could not completely use their own words to write summaries.

Discussion and conclusion

From the results of this study, it was found that the automatic scaffolding and measurement of three-layer concept maps had a distinct influence on the students' reading comprehension and summary writing skills (e.g., Sturm & Rankin-Erickson, 2002; Liu, Chen & Chang, 2010). This result is in line with previous studies that concept mapping is able to monitor students' comprehension and improve their reading accuracy (Redford, Thiede, Wiley & Griffin, 2012) and to externalize their internal language knowledge in self-regulated learning environment (Wang, Peng, Cheng, Zhou, & Liu, 2011). According to keyphrases which were extracted from Taiwan Panorama's database, this study developed three hierarchical and definite layers to indicate related keyphrases for grasping main ideas in each paragraph to construct a map for writing summaries.

First, compared with the students' pre-and post- test scores as well as first and final drafts between the experimental and control groups, the students of the experimental group made greater improvement in reading comprehension and summarizing skills after receiving automatic scaffold and measurement of three-layer concept maps. The automatic map was given to the students to aid them in clarifying what important words were missing and unnecessary details were included for improving concept map construction to write summaries. In contrast, the students of the control group made only little progress in reading comprehension and writing summaries since they increased cognitive loads to identify keyphrases and drew paper-based concept maps to write summaries without the automatic feedback from the system.

Second, in the traditional classroom setting, there are no explicit guidance and monitoring tools to help students how to learn writing summaries and record their summarizing processes. To visualize and externalize the students' mental thoughts while learning to write summaries, implemented by the automatic system of keyphrases, three-layer concept maps, and scoring, teachers were able to examine whether their students truly understood how to construct a map or not and students could reflect on what they had understood of the texts and revise their first drafts of summaries into final ones. In addition, the online learning environment also allowed the students to read more-proficient peers' concept maps and summaries, which can help them solve their own reading and writing problems. They further learned how more-proficient peers constructed their concept maps and how they write a well-organized summary.

Third, the investigation of the students' perceptions with a group using automatic scaffolding and measurement of three-layer concept maps and a group using paper-based concept maps to improve summaries and reading comprehension were illustrated. The majority of students in the experimental group agreed that the automatic keyphrases and three-layer concept maps facilitated them to visualize and organize the flow of ideas to structure key concepts as well as improve their reading comprehension. The automatic scoring and feedback provided by the system also helped them understand how good their summaries really were. In contrast, though the students of the control group drew paper-based concept maps and received the teacher's general feedback to improve the summaries, they still had difficulties in identifying each key concept in the paragraphs.

Some limitations were also found in this study. First, though 107 university students enrolled in this study to investigate automatic keyphrases and three-layer concept maps on EFL university students learning how to write summaries, the results of this study might not be representative of all the problems that EFL university students encounter and all of the solutions which can be solved by using automatic keyphrases, three-layer concept maps and scoring. Second, samples of the summary should be automatically provided by the system in future so that novice students can view good examples when learning to write summaries. Finally, the teacher's perspectives toward teaching summaries by the automatic three-layer concept maps could be further discussed by interviews. The teachers may play different roles in teaching as they act as a dominator in onsite instruction and a facilitator in online instruction.

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