A GRAPHIC ORGANIZER FOR SUPPORTING SUMMARY WRITING IN WEB-BASED INVESTIGATIVE LEARNING

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ABSTRACT

Web-based investigative learning is a form of learning where learners investigate Web resources to construct knowledge on a question. In our previous work, we have designed a learning model and a cognitive tool named iLSB to support learners in expanding the initial question into sub-questions so as to deepen and widen their investigation, and in creating their own learning scenario. The learning model consists of two processes of "knowledge construction" and "knowledge linearization". Learners are expected to construct knowledge using iLSB in the former process, and to linearize their knowledge to prepare a paper for report on their investigation in the latter process In this paper, we focus on how to help learners to make a summary of the paper by means of graphic organizers, which embed five types of information structure in expository text. This paper demonstrates how iLSB allows learners to build text structure of a summary with graphic organizers. We also report a case study whose purpose was to assess the effectiveness of it. The results suggest that graphic organizers function effectively as a scaffold for building comprehensive summary with fewer efforts.

KEYWORDS

Web-Based Investigative Learning, Summary Writing, Graphic Organizer, Learner-Created Learning Scenario

1. INTRODUCTION

The Web opens people to new opportunities for knowledge acquisition, and the skill in exploring information effectively is becoming ever more important. As such, learning systems that targets searching information on the Web are becoming more widespread in educational settings (Chen et al, 2006). On the other hand, unstructured information on the Web poses a challenge for learners to explore and select relevant information to restructure in a meaningful manner (Lawless et al, 1997). While learners have more freedom over navigation between information they explore (Lawless et al, 1997), they are required to constantly keep a mental model of the navigation path in order to effectively learn and build knowledge (Henze and Nejdl, 2001).

Recent related work on navigation on the Web to construct knowledge has been focused on modeling learners (Jeong, 2016; Lau et al, 2017). On the other hand, little is done on modeling navigational learning on the Web, with which this paper deals. Given this background, we have defined Web-based investigative learning (WBIL for short) as a form of learning where learners use search engines to investigate any question with Web resources to construct knowledge. We have also considered ways to support learners by designing a learning model and a cognitive tool named interactive Learning Scenario Builder (iLSB for short).

In our previous work, two main challenges for learners to conduct WBIL were identified (Kashihara and Akiyama, 2016). First, learners tended to use a single search query to investigate on a given question, and looked no further than several prioritized Web resources/pages of the search results. Investigation in this manner leads to a narrow viewpoint for the question, and induces learners to construct superficial and shallow knowledge. To construct comprehensive knowledge on the question, learners must deepen and widen their investigation by expanding the initial question into related sub-questions, and constructing knowledge for each sub-question. In navigating between Web resources for each sub-question, in addition, learners also need to keep track of the path between sub-questions. This suggests the lack of a learning scenario in investigating on the Web (Kashihara and Akiyama, 2016). While traditional learning resources such as textbooks and lectures provide a linearly organized information (Lawless et al, 1997), there is no pre-defined sequence for exploring information on the Web. Learners must accordingly create their own learning scenario while navigating Web resources, which is the second challenge in WBIL.

To address these challenges, we have designed a learning model for WBIL consisting of “knowledge construction process” and “knowledge linearization process”, and developed iLSB (Kashihara and Akiyama, 2016). In the learning model, learners begin with an initial question to investigate, expand it into sub-questions from knowledge constructed from the initial question, and cyclically repeat their investigation for each sub-question. iLSB encourages learners to make a wider and deeper investigation in a systematic way, and to build their learning scenario in a self-directed way. Our previous work with iLSB has confirmed that iLSB could help learners create their own learning scenario while navigating Web resources, and linearize their knowledge by creating a table of contents for a paper for reporting their findings (Kashihara and Akiyama, 2016; Hagiwara et al, 2019; Kashihara et al, 2020; Morishita et al, 2020). On the other hand, support for writing the actual contents of the paper and assessment of the paper have not been done yet.

To address these, this paper proposes a systematic method of writing a summary of the paper. The summary is intended to act as an advance organizer for the paper. It could inform the readers (instructors or peers) what to expect from the paper, which is necessary for learners to clearly convey their findings to the readers. However, writing a summary in a comprehensive and concise way is not an easy task.

A summary of WBIL is one example of an expository text. Compared with narrative text, expository text is a non-fiction text whose objective is to convey information. According to Roehling et al. (2017), an expository text embeds information structure that can be categorized into one of the following five types: *description*, *sequence and order*, *cause and effect*, *compare and contrast*, and *problem and solution*. Roehling et al. (2017) also introduces graphic organizers as a way to teach learners to make expository text with the five types, which graphically represent the corresponding information structure with nodes and edges.

In this paper, we use graphic organizers to help learners make a summary of the paper for their learning scenario created with iLSB. We also propose a method for learners to construct text structure to be embedded into a summary with graphic organizers, which is implemented within iLSB. This paper also describes a case study with it. The results suggest that graphical organizers function effectively as scaffold for constructing comprehensive summary with fewer efforts.

2. WEB-BASED INVESTIGATIVE LEARNING

2.1 Learning Model

This paper proposes a learning model for Web-based investigative learning (WBIL), which consists of the following two processes: (1) knowledge construction process and (2) knowledge linearization process. Each process further has several learning phases. The learning model designed in our previous work (Kashihara and Akiyama, 2016; Kashihara et al, 2020; Hagiwara et al, 2019) corresponds to (1). In our subsequent work (Morishita, 2020) and this paper, we are attempting to extend this model to include (2).

2.1.1 Knowledge Construction Process

In the knowledge construction process, learners investigate a question (initial question), which is often represented such as “What is X?” They are then expected to search and explore Web resources by means of search engine with keyword (called q-keyword) representing the question and to build comprehensive knowledge. Such knowledge construction process is composed of the following three phases (Kashihara and Akiyama, 2016): (1-a) search for Web resources, (1-b) navigational learning, and (1-c) question expansion.

In (1-a), learners are expected to search Web resources with the initial q-keyword. Using the searched results, they are next expected to compare multiple resources to find out Web pages suitable for understanding the initial question. In (1-b), learners are expected to navigate and learn the Web pages, and to combine the contents learned at each page and construct their knowledge. In the model, learners extract keywords from the Web pages representing the contents learned to make connections among these keywords in constructing their knowledge for the corresponding q-keyword. In (1-c), learners are expected to find out sub-questions to be further investigated from knowledge constructed. In other words, learners expand the initial question into sub-questions. They are expected to cyclically repeat the three phases for each sub-question until no further question expansion occurs. The question expansion results in a tree structure called question tree as shown in Figure 1, which represents learning scenario for learners' WBIL. The root node corresponds to the initial q-keyword, and the other nodes correspond to q-keywords representing the corresponding sub-questions.

2.1.2 Knowledge Linearization Process

In the knowledge linearization process, learners are expected to write a paper from their learning scenario (question tree) created in the knowledge construction process. It includes findings in their investigation and its summary. In writing a paper, they are allowed to use their question tree to linearize their knowledge constructed. We have developed a support for learners to generate table of contents (TOC) from question tree (Morishita, 2020). TOC has a hierarchical structure, in which each node corresponds to q-keyword in the question tree. The nodes represent chapters, sections, subsections, etc. of the paper to be written. The relationships between a chapter and its sections, and the ones between a section and its subsections are represented as a link in iLSB. Each link has one of the 14 attributes such as "class", "instance", and "effect". As for how TOC is generated, refer to (Morishita, 2020).

Learners are expected to write a summary of the paper in the following two phases: (2-a) text structuring with graphic organizers, and (2-b) text writing. In (2-a), learners are expected to use graphic organizers to structure a text to be included in the summary. In the model, they reorganize the nodes in TOC with graphic organizers to visually represent the text structure to be embedded in the summary of their paper. In (2-b), they are then expected to compose sentences from the text structure with graphic organizers. In writing the summary, learners are expected to make connections between individual q-keywords, which leads to a deeper understanding of the initial q-keyword, and which allows them to gain an overview of their knowledge from a perspective different from the question tree. Moreover, learners could effectively communicate the summary as for what they learned to their instructors. The instructors can use it to evaluate the learners' investigation.

Through the linearization process, learners could reflect on their knowledge constructed, and write a summary of the paper to report on their investigation. In this work, we focus on how to help learners build a summary for the paper with graphical organizers.

2.2 iLSB

iLSB is a cognitive tool developed as a Firefox add-on to scaffold WBIL as modelled. For the knowledge construction process, iLSB provides a search engine for searching Web resources, keyword repository for collecting keywords extracted from the resources during navigational learning, and question tree (Figure 1) for expanding questions into their sub-questions.

For the knowledge linearization process, iLSB scaffolds creation of TOC from the question tree created in the knowledge construction process. Figure 2 shows an example of TOC created from the learning scenario shown in Figure 1. iLSB displays nodes (represented as q-keywords) in the question tree as a list. Learners are expected to select several nodes as chapters of TOC from the list, and then to select nodes of sections (called section nodes) to be included in each chapter. They are next expected to make part-of relationships among the section nodes to define sub-sections in each section, and finally to sort the sections/sub-sections/chapters to define the order of nodes that is best suited for explaining the initial question.

In addition to these scaffolding functions, we are developing a scaffold of iLSB for helping learners write a summary with graphical organizers.

3. SUMMARY WRITING FOR WBIL

Let us next explain how we scaffold summary writing. We currently plan to scaffold summary writing as follows. The requirements for the scaffolding are 1) to help learners write a comprehensive and concise summary that follows the TOC, and 2) to reduce cognitive load of summary writing to enhance the quality of the summary.

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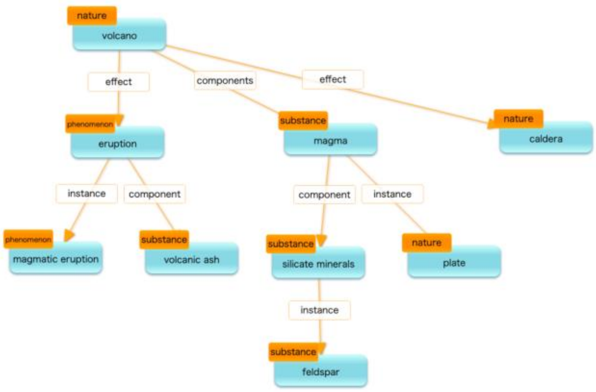

Figure 1. An example of question tree

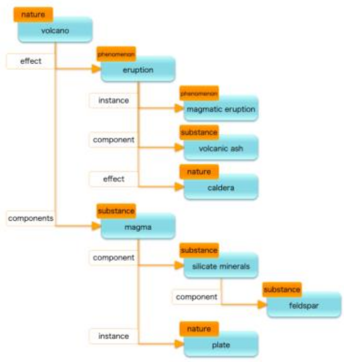

Figure 2. An example of TOC

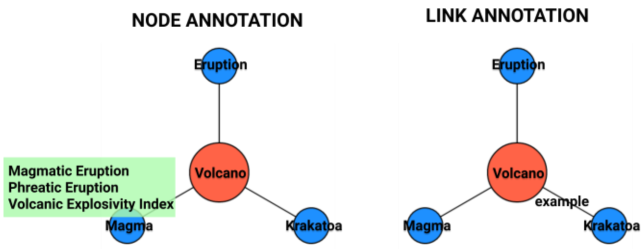

Figure 3. Text structures with node and link annotations

3.1 Framework

After completing TOC, learners use iLSB to write a summary. TOC includes nodes represented as q-keywords. Using TOC, iLSB first generates text structure involving the q-keywords, which are represented with graphic organizers. Graphic organizers have five basic structure types: *description*, *sequence and order*, *cause and effect*, *problem and solution*, and *compare and contrast* (Roehling et al, 2017). iLSB then allows learners to add two types of information to nodes and links in the generated text structure as **node** and **link annotations**. Node and link annotations enable them to supplement the contents of node and the relationships between nodes. They are expected to write the text of the summary using the text structure with annotations.

3.2 Representing Text Structure with Graphic Organizers

Using graphic organizers to help learners in reading or writing a text has been already a widely used method in conventional education (Roehling et al, 2017). In this work, we attempt to apply the same method to WBIL. Graphic organizers visually represent basic structures of expository text. The left structure in Figure 3 shows an example of graphic organizer for description about the subject of “Volcano”, in which the keywords “Krakatoa”, “Eruption”, and “Magma” are objects used for describing the subject. It allows learners to compose a text such as “Volcano has eruption, and contains magma. An example of volcano is Krakatoa”.

In this work, learners can annotate nodes and links in text structure represented with graphic organizers. Node annotations allow learners to add keywords to any node, which supplement the node. The left structure in Figure 3 shows the node “Eruption” has annotations including “Magmatic Eruption”, “Phreatic Eruption”, and “Volcanic Explosivity Index”. Link annotations also allow learners to add keywords to any link, which supplement it. In Figure 3, the link between “Volcano” and “Krakatoa” is annotated with “example”. These annotations allow learners to refer to the annotated keywords to write sentences for summary writing.

3.3 Summary Generation in iLSB

In accordance to the learning model, learners are expected to build text structure with graphical organizers after creating TOC, which will be divided into four steps. First, iLSB shows TOC to allow learners to review the nodes, relationships, and hierarchical order as shown in Figure 2. Second, iLSB automatically generates text structure of a summary from TOC to present. Let us explain the procedure for generating text structure with graphic organizer with an example of TOC shown in Figure 2 as follows.

iLSB groups q-keywords included in TOC into chapters/sections/sub-sections. In this example, the groups are: {volcano, eruption, magma} as chapters, {eruption, magmatic eruption, volcanic ash, caldera} and {magma, silicate minerals, plate} as sections, and {silicate minerals, feldspar} as sub-sections. Following the attributes attached between q-keywords in each group, iLSB then selects a basic structure of text corresponding to each group.

Table 1 shows the correspondence between attributes attached between q-keywords in TOC and types of basic structures. If there are multiple attributes in the group, iLSB splits the group for each basic structure. In the group {eruption, magmatic eruption, volcanic ash, caldera}, for example, the attribute attached between "eruption" and "caldera" is "effect", the one between "eruption" and "magmatic eruption" is "instance", and the one between "eruption" and "volcanic ash" is "component". The attribute "effect" corresponds to the basic cause and effect, while the attributes "instance" and "component" correspond to description. The group will be accordingly split into the two sub-groups {eruption, caldera} and {eruption, magmatic eruption, volcanic ash}. As a result, iLSB generates text structure embedding the six basic structures as shown in Figure 4 from TOC shown in Figure 2.

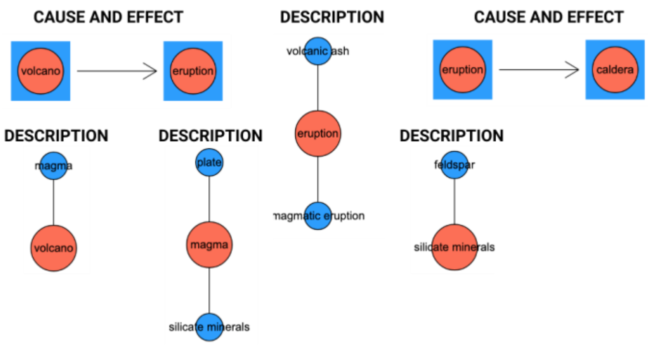

Figure 4. An example of text structure with graphic organizers

Table 1. Correspondence between attributes and basic structure

Attributes attached between q-keywords in TOC	Basic structure of text
class, instance, component, structure, characteristic	Description
origin, background	Sequence and Order
cause, effect, principle, action	Cause and Effect
measure	Problem and Solution
similar concept, contrasting concept	Compare and Contrast

When text structure generated are presented to learners, they are third expected to understand the basic structures to be used in their summary and the q-keywords included. Fourth, learners are expected to add node and link annotations to the basic structures. The keywords used for node annotations are selected from the keyword repository in iLSB, which stores keywords representing the contents learned about the node. As for link annotations, learners could use their own keywords.

Through these phases, iLSB finally shows learners the generated text structure. By clicking on any node, learners could see the node annotations. Link annotations are visible without any operation from the learners. After building text structure, learners are expected to start writing a summary.

4. CASE STUDY

We have conducted a case study whose purpose was to assess the effectiveness of building text structure with graphic organizers from TOC before writing a summary.

4.1 Methods

We had 8 participants, all of whom were undergraduate and graduate students majoring in computer science. This study was conducted with between-participants design, in which the participants were equally divided into the experiment group (4 participants) and the control group (4 participants).

The participants differed from the actual users of the iLSB in that 2 of the 8 participants used the system for the first time. The same instructions were given to the participants as would be given to the actual users.

All participants were first required to use iLSB for investigating as the initial q-keyword “Civil Lawsuit”. They were next required to create TOC for the paper with iLSB to report on their investigation, and then to write a summary. In the summary writing, the experiment group was allowed to use graphic organizers to build text structure from their TOC. It was also allowed to look at the text structure to write a summary on paper. The control group, on the other hand, was required to write a summary on paper by means of TOC without graphic organizers.

In order to assess the effectiveness of summary writing with iLSB, we collected data from the following two sources: analysis of the resulting summary texts and peer assessment scores. As for the peer assessment, the participants were asked to review summaries written by other participants by means of the questionnaire including 5 questions shown in Table 2, each of which had a five-point scale. Q1-3 were the ones for confirming whether the summary generation promotes a comprehensive summary following TOC. Q4-6 were also the ones for confirming whether it enhances the quality of the summary.

Table 2. Peer assessment questions

Question number	Question
Q1	How exhaustively did the summary represent the keywords from the table of contents?
Q2	How well did the summary represent the relationships between keywords in the table of contents?
Q3	How accurately did the summary reflect the hierarchical relationship of the table of contents?
Q4	Was the summary coherent?
Q5	Was the information in the summary well organized and conveyed accurately what the learner learned?
Q6	Overall, how appropriate was the text as a summary for WBIL?

4.2 Results

As for the text analysis, we collected data about (1) exhaustiveness of summary, (2) length of summary, and (3) time taken to write summary. As for (1), we compared q-keywords in TOC with q-keywords included in summary. Table 3 and Table 4 show the ratios of q-keywords included in summary to the ones in TOC, the number of letters, and the average number of letters per q-keyword included in summary.

On average, the summary written in the experiment group covered about 89% (SD: 11) of q-keywords in TOC. On the other hand, the summary written in the control group also covered about 73% (SD: 16) of q-keywords in TOC. The coverage of q-keywords in the experimental group was higher than the one in the control group. As for the length of summary, the experiment group used 660 letters (SD: 328) on average, and the control group also used 273 letters (SD: 59). As for the average number of letters used per q-keyword, in addition, the experimental group used 45 letters (SD: 21) on average, and the control group used 21 letters (SD: 5.8). As for the time taken to write summary, it took 2.2 seconds per letter (SD: 0.40) on average in the experiment group. In the control group, it also took 3.1 seconds per letter (SD: 0.69). The time in the experimental group was shorter than the one in the control group.

Table 3. Results of summary analysis in experiment group

Participant	Ratios of q-keywords included in summary	Number of letters in summary	Average number of letters per q-keyword
B	17/17 (100%)	1010	59
C	16/17 (94%)	237	15
E	14/19 (74%)	795	57
F	12/14 (86%)	597	50
Average	89%	660	45

Table 4. Results of summary analysis in control group

Participant	Ratios of q-keywords included in summary	Number of letters in summary	Average number of letters per q-keyword
A	14/15 (93%)	270	19
D	12/19 (63%)	356	30
G	14/17 (82%)	228	16
H	12/22 (55%)	236	20
Average	73%	273	21

For Q1-3 in the peer assessment, the score for each participant was calculated by taking the average of scores given by all other subjects from both experiment and control group. On the other hand, evaluation for Q4-6 was considered dependent on which group the subject was assigned to. The scores were accordingly calculated by taking the average of scores from other participants in the same group. For example, the score for participant B (experiment group) in Q4 was calculated by averaging the scores given by other participants in the experiment group: C, E, F. The results for the experiment group and the control group for each question are shown in Table 5.

Table 5. Peer assessment results by group

Question number	Question	Experiment group average	Control group average
Q1	How exhaustively did the summary represent the keywords from the table of contents?	4.63 (SD: 1.09)	3.97 (SD: 1.09)
Q2	How well did the summary represent the relationships between keywords in the table of contents?	4.41 (SD: 0.66)	4.34 (SD: 0.75)
Q3	How accurately did the summary reflect the hierarchical relationship of the table of contents?	4.31 (SD: 1.06)	4.34 (SD: 0.83)
Q4	Was the summary coherent?	4.17 (SD: 0.83)	4.42 (SD: 0.67)
Q5	Was the information in the summary well organized and conveyed accurately what this person learned?	3.92 (SD: 0.90)	4.08 (SD: 1.24)
Q6	Overall, how appropriate was the text as a summary for WBIL?	3.83 (SD: 0.83)	3.75 (SD: 1.29)

4.3 Discussion

Due to the small number of the participants in this case study, we could not statistically assess significant differences between the experiment group and control group, but we will consider the differences between the two groups. From the results of the text analysis, the participants in the experiment group tended to use more q-keywords in their summary from their TOC than those in the control group. This suggests that graphical organizers allow learners to write a summary including more exhaustive contents of their TOC.

The experiment group also tend to explain more as to each q-keyword, which can be seen by comparing the number of letters per q-keyword between the experiment and control group. This can be attributed to the node and link annotation scaffolding function in iLSB. This suggests that iLSB allows learners to identify keywords for explaining each q-keyword. It is also suggested that text structure with graphic organizers has the effect of reducing cognitive load of writing a summary, as the experiment group took less time to write their summaries compared to the control group.

As for Q1 of the peer assessment, the experiment group on average scored higher than the control group, supporting the results of the text analysis. This suggests that summary built by the experiment group is considered comprehensive from a subjective point of view. In addition, although there was little difference between the experiment and control group, the scores for Q2-Q6 for the former ranged from 3.83 to 4.4 on the five-point scale, and this considerably high score implies that using iLSB to build text structure with graphic organizers is effective in writing a summary for WBIL.

5. CONCLUSION

This paper addressed the issue of summary writing in Web-based investigative learning, which has not been dealt with in our previous work. In this paper, we proposed a writing strategy using graphic organizers to help learners write a comprehensive and concise summary. Five types of graphic organizers corresponding to the five basic structures (*description*, *sequence and order*, *cause and effect*, *compare and contrast*, and *problem and solution*) were used to reorganize nodes included in TOC created during the knowledge construction process in WBIL. Results of the case study has shown that using GOs guaranteed a certain level of the quality of the summary. We were also able to collect data about summaries for WBIL, which should be further evaluated in more detail. In future, we will prepare templates for explaining concepts, order of GOs, structuring paragraphs in the summary in order to better promote summary writing.

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