How to Evaluate Searching as Learning

Yuka Egusa
National Institute for Educational Policy Research
3-2-2 Kasumigaseki, Chiyoda, Tokyo, Japan
yuka@nier.go.jp

Masao Takaku
University of Tsukuba
1-2 Kasuga, Tsukuba, Ibaraki, Japan
masao@slis.tsukuba.ac.jp

Hitomi Saito
Aichi University of Education
1 Hirosawa, Igaya-cho, Kariya, Aichi, Japan
hsaito@auecc.aichi-edu.ac.jp

ABSTRACT

We are interested in evaluating interactive retrieval systems from the user's perspective. In this paper, we introduce several user studies evaluating the cognitive change in users' knowledge by using concept maps. We also propose a platform for user studies, including analysis tools, task descriptions, evaluation tools, and data sets.

Categories and Subject Descriptors

H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval—Measurement, Performance

Keywords

concept map, exploratory search, task models, user experiments, user studies

1. INTRODUCTION

In recent times, the Web has become an important source of information in daily life.

Our focus is evaluating changes in a user's knowledge before and after search. In order to evaluate retrieval tools to support "searching as learning," we need more user-centered metrics to supplement traditional evaluation metrics such as precision and recall. We propose methods for using concept maps to evaluate the knowledge acquired by users and changes in their knowledge structure as a result of searching for information on the Web. We introduce the concept map in Section 2. We describe user studies that employ the concept map in Section 3, and then describe our tools in Section 4.

This paper is a position paper for the Searching as Learning (SAL) Workshop. In order to provide our perspectives to the attendees, our definitions and approaches are explained as follows:

- A definition of learning and an explanation of how that relates to our work: We define learning in our perspective as the change users' knowledge representation during their various activities, such as searching on the Web, discussing with other people, reading books or papers. The goal of our study is to capture the change of learners' knowledge using the concept maps.
- A definition of searching and an explanation of how that relates to our work: We focus on the exploratory search on the Web.
- A statement on the disciplinary context or perspective that informs our work.: Domain of our group members are cognitive science and educational technology and library and information science. We have studied about a user-centered evaluation and information seeking behavior. We use experimental approach and quantitatively analysis of experimental results. We also have interests in developing tools for experiments, where we can easily test and analyze the data such as a video annotation tool, a baseline retrieval system and a browser logging tool.

2. CONCEPT MAP

The concept map is a graphical representation that allows people to represent their knowledge explicitly [4]. Figure 1 illustrates an example of a concept map about plants. The concept map consists of concept words, arrows that connect the concept words, and linking words on the arrows.

- Concept words (nodes): Nouns that represent objects or concepts, such as a car, cleaning, a dog, learning, a chair, and a birthday party. Concept words are enclosed in circles.
- Linking words (link labels): Verbs, adjectives, and conjunctions that represent the relationships among the concept words in the concept map, such as have, like, and is. Linking words are written on the arrows as labels.
- Arrows (links): Relationships among the concept words. Connected concept words and linking words make up sentences such as "plants have flowers." In this case, the arrow is drawn from "plants" to "flowers" and labeled "have."

Concept maps have been used as measures to assess learner knowledge and understanding. Meagher [3] reported that the graph structures of concept maps become more complex from the first class in a course through the final exam. Rebich and Gautier [6] also showed that the total number of useful items on post-course concept maps increased, whereas the total numbers of weak items and misconceptions decreased.

In the IR community, there have been several studies using concept maps as a means of measuring change in a user's knowledge. Pennanen and Vakkari [5] explored how a student's conceptual structure is related to search tactics and successful searching. They reported that, between the beginning and end of an overall task, different features of a student's conceptual structures were connected to a successful search in terms of the useful documents they found.

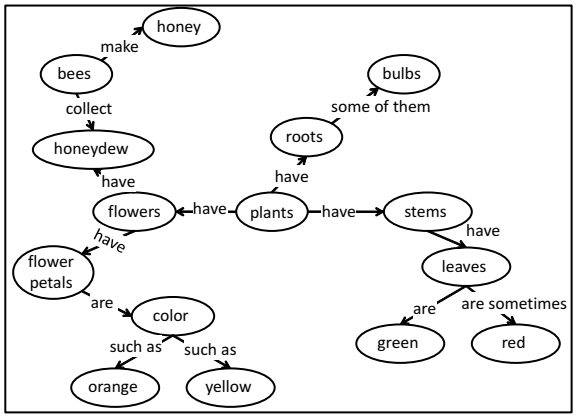


Figure 1: Example of a concept map about plants (Source: Egusa et al. [1], p.176)

3. USER STUDY

We conducted user studies examining how concept maps capture changes of users' knowledge. The following experiences, participants drew each concept map in pencil on a blank sheet of paper with a single center node for the assigned topic, i.e. environmental issue. We analyzed these concept maps.

3.1 User Study 1

Egusa et al. [1] investigated how a user's concept map differs before and after a search and how the differences between the topics, scenarios, and browser types influence the user's concept map. A comparative analysis of concept maps between pre-search and post-search maps indicated that users significantly changed their knowledge structures on a topic through an exploratory search.

3.1.1 Methods

Thirty-five undergraduate students recruited from various departments and universities participated in our experiment. The participants were instructed to search for and gather Web pages for the task of writing a term paper on two given topics, politics and media, while working in either of the two scenarios: "Selective scenario" (identifying only ten Web pages as important) and "As-Many-As scenario" (collecting as many Web pages as possible). The participants were divided into two groups: one group searched for both topics in the Selective scenario, and the other searched for them in the As-Many-As scenario. They composed their concept maps before and after searching.

3.1.2 Results

We defined the following measures to illustrate the differences before and after a search to analyze the concept maps made by the participants: common, new, and lost map components like nodes, links, and link labels. We used these measures to compare the results from different topics, scenarios, and browser types. The results showed that the concept maps changed significantly after searching. The average ratio of the common nodes in the post-search concept maps was 26%, and five participants made post-search concept maps with simply a single common node (Fig. 2). The figure clearly shows that the post-search concept maps are not just slightly revised versions of the pre-search concept maps but contain many new concepts and relationships. On the other hand, two scenarios has no effect in changes between pre- and post-search concept maps. A comparative analysis of the concept maps between the pre- and post-search maps indicated that the users significantly changed their knowledge structure on a topic by completing the exploratory search task.

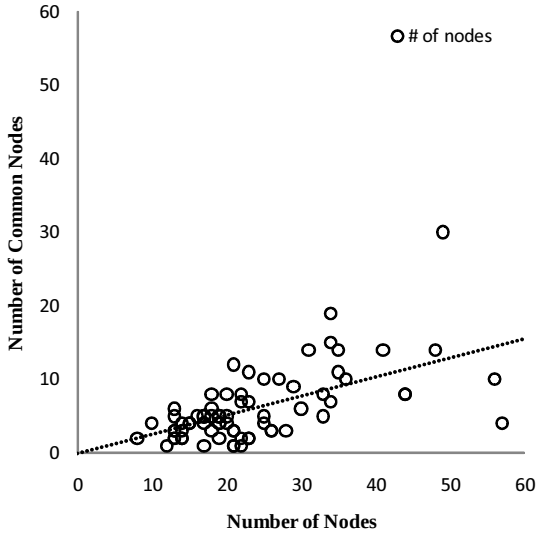


Figure 2: Number of nodes and common nodes in post-search concept maps (n=70). The dashed line represents the average ratio of the common nodes to all the nodes (26%). (Source: Egusa et al.[1], p.182)

3.2 User Study 2

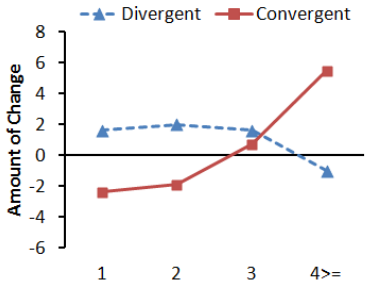
Saito et al. [7, 8] confirmed the effects of scenarios on their search activities and knowledge structures.

3.2.1 Methods

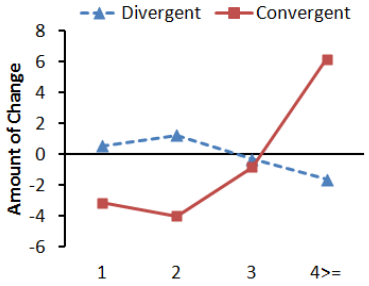
In the experiment, the participants were required to gather information on the Web in preparation for a regular feature in a magazine. Thirty-two undergraduate students aged 20 to 23 years participated in this study. The participants were divided into two scenario groups: divergent and convergent scenarios. In the divergent scenario, the participants were required to gather web pages for a series of articles to be a regular feature in the magazine. In the convergent scenario, they were required to gather pages for a single article of the regular feature. We prepared tasks for each scenario of the two topics.

3.2.2 Results

The results showed the differences between the two scenarios. In the divergent scenario, the nodes near the center node increased, whereas the nodes far from the center node decreased before and after search. Conversely the opposite patterns were found in the convergent scenario. The participants' maps changed dynamically before and after search. Next, we examined whether there were any differences in the position of each node in the map between scenarios and

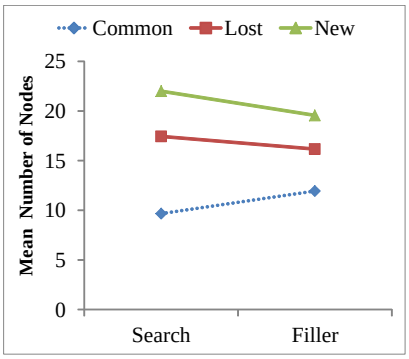


(a) Environment

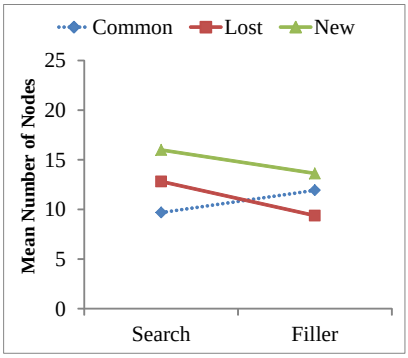


(b) Travel

Figure 3: Differences from pre to post-search in the number of nodes at each distance. (Source: Saito et al. [7], p. 956)



(a) Convergent



(b) Divergent

Figure 4: Mean number of common, lost, and new nodes in each task for two conditions (Source: Egusa et al. [2])

topics. Figure 3 shows the amount of change at distances 1, 2, 3, and 4 or more for the two topics in each scenario.

3.3 User Study 3

Egusa et al. [2] investigated the differences between search and non-search conditions for different tasks. Analysis of the changes in the concept maps showed different patterns for the two conditions and two tasks.

3.3.1 Methods

Thirty-five undergraduate students recruited from various departments and universities participated in the experiment. The participants were instructed to assume the role of a university student and gather information on the Web in preparation for a class discussion on two topics, i.e., environmental and educational issues. The participants were divided into two task groups: convergent and divergent tasks. In the convergent task, participants were required to gather pages for a specific and detailed discussion. In the divergent task, participants were required to gather web pages for a wide-ranging discussion. There were two conditions, a search condition and a filler condition. In the search condition, the participants searched the Web, whereas in the filler condition, they were instructed to play a typing game on a PC.

3.3.2 Results

We used the same measures which were defined in User Study 1 and 2. These measures were used to compare the results from different conditions and tasks. Analysis shows that the number of new and lost nodes in the search condition was greater than the number of new and lost nodes in the filler condition, and the number of common nodes in the filler condition was greater than in the search condition. These results indicate that the changes in the search condition are significant, whereas changes in the filler condition are insignificant.

4. TOOLS

For the analysis of concept maps, we developed VizCMap, an analysis tool for concept maps, and made it available online at http://cres.jpn.org/?VizCMap. This tool demonstrates an analysis and visualization on changes to the concept map before and after a search (Fig. 5). Once you transcribe concept maps into GraphViz (dot) format, this tool allows you to analyze what was changed between two concept maps. In the visualization of concept maps in Fig.5, the nodes encircled with red double lines represent the common nodes, the links drawn with double lines with large arrows are the common links, the nodes encircled by a dashed line are the lost nodes, and the links drawn with a dashed line are the lost links, the nodes encircled by a solid line are the new nodes, and the links drawn with a solid line are the new links. The number of each type of nodes and links are also shown along with the visualization.

We are currently developing a research platform that covers a standard dataset and baseline system. The platform, IRCEpedia (Fig. 6), uses a snapshot of Wikipedia content as its dataset. A source codes of the system is available at Github, https://github.com/masao/irce-wikipedia.

5. DISCUSSION AND CONCLUSION

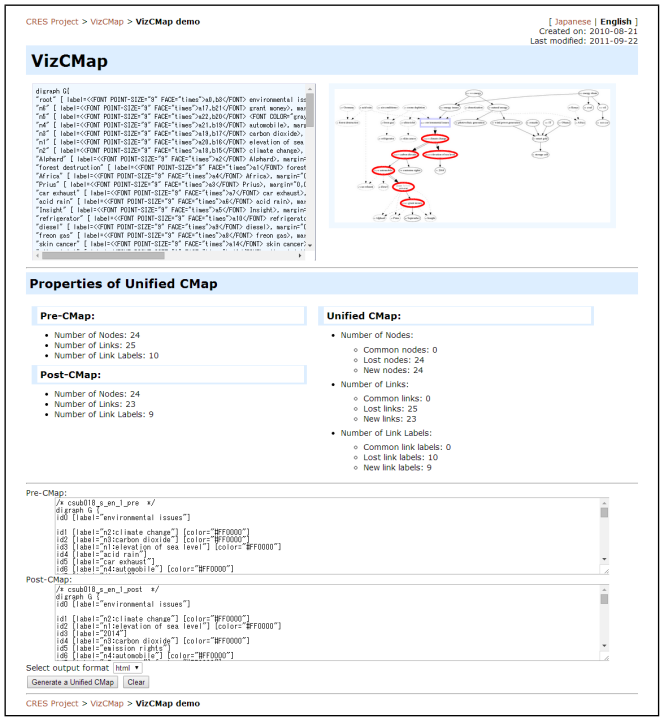


Figure 5: VizCMap tool to analyze concept maps

Figure 6: IRCEpedia, a search platform using the Wikipedia dataset

Our research project have studied how concept maps capture changes in a user's knowledge. In this context, concept maps have been used for direct evaluation of users, in terms of changes in user's knowledge and knowledge structures.

Furthermore, we may need a more standardized research protocol to exploit these research outcomes. This research protocol consists of the following components:

- Task descriptions, including topic and scenario sets
- Assessment and evaluation tools
- Data sets
- Baseline retrieval system

Establishment and standardization of the protocol remain as our future work. In order to facilitate the researches for searching as learning, it is desirable that these research platforms are available and open to the research community.

6. ACKNOWLEDGMENTS

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