Chatbot to Facilitate Opinion Formation in Web Search

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Abstract. In this study, we proposed a Chatbot that prompts users who generate opinions while conducting web searches on a particular topic with questions to encourage a deeper understanding of the topic. The proposed Chatbot(called Questioning Bot) is embedded in a web search engine. The Questioning Bot suggests a question to promote reflection on a particular aspect when it determines that a user is searching the web for a specific aspect among the various aspects required necessary for forming an opinion. The system suggests questions about aspects where web search is lacking and questions to promote a deeper understanding of the web-searched aspects where more research on opinion formation is necessary. Based on a deeper understanding of this theme, the system supports opinion formation by suggesting questions according to the web search status.

Keywords: Information retrieval · Interactive Search System · Search Behavior

1 Introduction

Currently, web search engines are employed not only for just research but also for learning and opinion formation. Information retrieval to comprehend a subject is conceptualized as Search as Learning [14]. To fully understand a learning topic, information retrieval for learning requires exploratory and iterative access to many documents [15].

Information retrieval for opinion formation is a type of information retrieval for learning. A valid basis is necessary to form a persuasive opinion and a thorough understanding of the topic. Thus, it is crucial to ensure the quality of the evidence supporting the opinion by comparing web pages and examining supporting information when searching the web to form an opinion [7, 19].

However, conducting web searches from a broad and critical aspect is challenging to form a persuasive opinion. Generally, most web searches are conducted alone. Few opportunities exist to receive feedback on information-seeking behavior and results. Thus, numerous users give up their search for information since they are unsure of the aspects to investigate, even if they want to gather information [9]. Additionally, there is a possibility of overlooking the aspects to be

examined or conducting biased information searches based on preconceptions. Therefore, they may not fully comprehend the theme and its surrounding information and may form opinions that lack evidence based on biased or erroneous information.

A web search interface that feeds back the degree of page browsing related to each subtopic of the search topic as an increase or decrease in the gauge has been proposed as previous research aimed at knowledge acquisition in web search behavior [3, 13]. Users users using the above search interface search the web exhaustively for various subtopics. However, the user's goal is to increase the gauge, and there is no substantial impact on knowledge acquisition. This shows that a web search interface in which the user's goal is to conduct thorough web searches does not contribute to the user's knowledge acquisition through web searches.

In this study, we propose an interaction for suggesting questions for users to acquire the knowledge required for opinion formation while actively searching the web. One of the most powerful tools for building learning environments and promoting successful performance is the use of questions. When learners understand a specific concept,, they tend to be overconfident in their understanding and may fail to continue learning. In such cases, it is asserted that active and practical learning activities can be elicited by asking questions that focus the learner on the topic under investigation [12]. In this research, based on this knowledge, we design a Questioning Bot that suggests questions to users during web searches to promote reflection on understanding of the topic under investigation and to support web searches for gathering and organizing the knowledge required for forming opinions.

The proposed system is designed as the Questioning Bot, which operates on a web search site. Figure 1 illustrates the behavior of the proposed system. The prototype of the proposed system comprises a chat area for questioning interaction and an opinion formation area where users enter the opinions they have formed through a web search. The questioning interaction by the Questioning Bot occurs in a chat on the right-hand side of the search results page. There are two types of questioning and two types of timing. The first is when a user searches the web for a certain aspect of opinion formation. To deepen the understanding of the aspect, Questioning Bot suggests a question of inquiry. For instance, consider a case where the user is forming an opinion on the topic "Do you agree or disagree with the Trans-Pacific Partnership (TPP)?". Here, the proposed system will ask, "What are the advantages and disadvantages of the TPP?" when the user searches the web for the advantages of the TPP to encourage the user to consider the advantages of the TPP while being aware of the disadvantages. Another time of questioning is when the user is describing his/her opinion in the opinion formation area. Questioning Bot estimates the aspects that lack research by web search and suggest questions about those aspects among the aspects necessary for opinion formation. For instance, suppose a user searching the web to write a report on TPP is presumed to lack research on

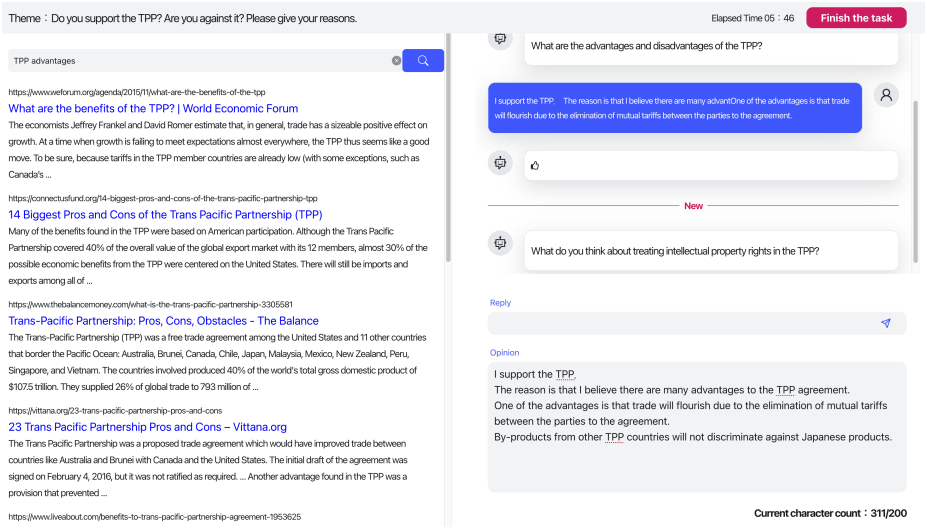

Fig. 1. The behavior of the proposed system

intellectual property rights. In that case, the Questioning Bot suggests, "What do you think about the treatment of intellectual property rights in the TPP?"

2 Related Works

2.1 Search as Learning

Search as Learning is research field of systems and functions for understanding the learning process and facilitating learning in information retrieval, and has attracted considerable attention recently [5]. Roy et al. introduced an active learning tool that supports user learning by highlighting and leaving notes in exploratory information retrieval. The proposed system substantially changes the search behavior of search users on some indicators [11]. Cˆamara et al. proposed a web search system to support learners in acquiring knowledge while conducting web searches. The proposed system influenced the search behavior; however, the effect of enhancing the learners' knowledge acquisition was unconfirmed [3]. Yamamoto et al. proposed query priming, a query recommendation approach based on the results of cognitive psychology, to stimulate critical thinking attitudes in the web search process [18].

2.2 User Support by Questioning

For a web search system to return search results that match the user's intentions, Aliannejadi et al. proposed a questioning system to understand the user's

search intentions behind a query [1]. Ren et al. proposed a framework for conversational recommendation systems that models user preferences employing a structured knowledge graph and generates questions to comprehend detailed preference information of users [10]. Yamamoto proposed a system that enhances the awareness of credibility verification during web search by revealing sentences on topics related to the query disproved on the web (e.g., the Atkins diet is said to be ineffective) [17].

2.3 Collaborative Search

Search behavior in which many people share a common goal and cooperate is called cooperative search in the field of information retrieval [4]. Morris investigated the prevalence of cooperative search, the information needs that motivate it, and the level of satisfaction with cooperative search. To support collaborative web search, Ringel et al. proposed a web search interface called WeSearch, a table-type display. Findings of collaborative search experiments employing WeSearch showed that WeSearch can promote common understanding among members and effectively support decision-making [8]. Luyan et al. proposed an interface for collaborative search called PairSearch and examined how search behavior and communication during web search affect users' knowledge acquisition [16]. The study's findings demonstrated that the knowledge acquisition rate was higher for groups that exchanged messages and that the more communication was employed to share information found during a web search, the higher the knowledge acquisition rate.

3 Proposed System

We assume a scenario in which a user forms an opinion on a specific topic and writes an opinion text about it in this study. We propose a web search system that periodically suggests questions to encourage the user's active web search to acquire the knowledge required for the user to form an opinion and to promote the user's reflection on the topic during the web search.

As shown in Figure 2, the proposed system consists of three areas. The ① is the search screen area. For the queries entered in the search window, it retrieves and shows web search results. The area where the proposed system suggests the question is ②. To promote understanding of the topic, the Questioning Bot suggests questions to the user during the web search. The user can reply to the suggested questions. The Questioning Bot suggests questions to encourage an exhaustive web search for the aspects required for opinion formation and questions to deepen the comprehension of the aspects of the target of the web search. The opinion formation area is ③, where users can enter the opinions they have formed through a web search.

The design of the questioning interaction, the generating questions procedure, and the hypotheses about the proposed system are explained in detail below.

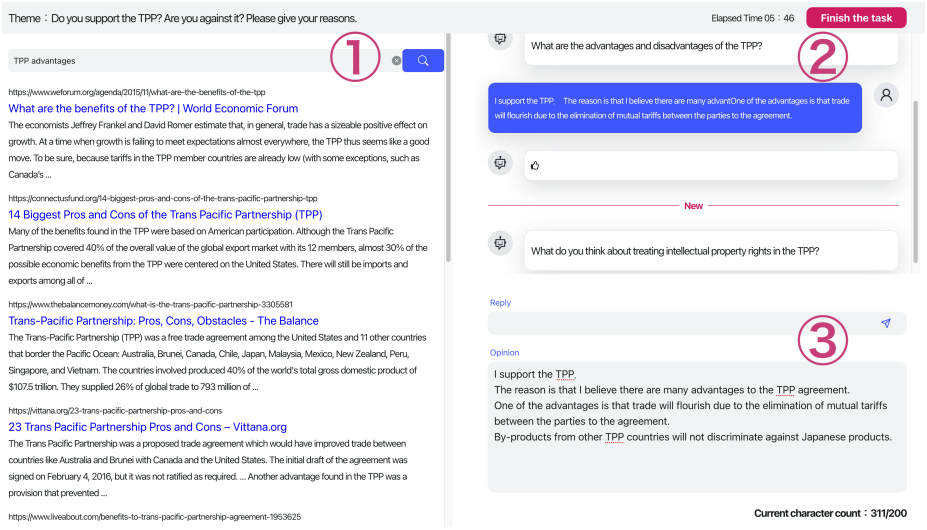

Fig. 2. Proposed system features

3.1 Questioning Interaction

The proposed system suggests questions to deepen the understanding of search topics during a web search. The Questioning Bot suggests the following two types of questions.

- Questions to promote a deeper understanding of the aspects being explored on the web.
- Questions to encourage web searches for aspects for which information exploration is lacking.

Figure 3 illustrates the relationship between the structure of topics and aspects in web search and the expected behavior of web search users when the Questioning Bot suggests questions. Aspects A, B, and C must form an opinion about a search topic, and to gain a deeper understanding of each aspect, the lower-level aspects A', B' and C' are required. Some users may give up searching for information since they do not know which viewpoints to search on the web [9]. Therefore, the web search for the aspects to be studied may be insufficient if there are no suggested questions, or the final opinion may be formed with an insufficient understanding of the aspects. Thus, the Questioning Bot suggests two types: questions that encourage web searches for aspects for which information search is lacking and questions that encourage a deeper comprehension of web-searched aspects.

Figure 4 demonstrates the flow of the questioning interaction. The first type of questioning interaction promotes a deep understanding of the aspect being explored on the web. The second type of questioning interaction promotes web

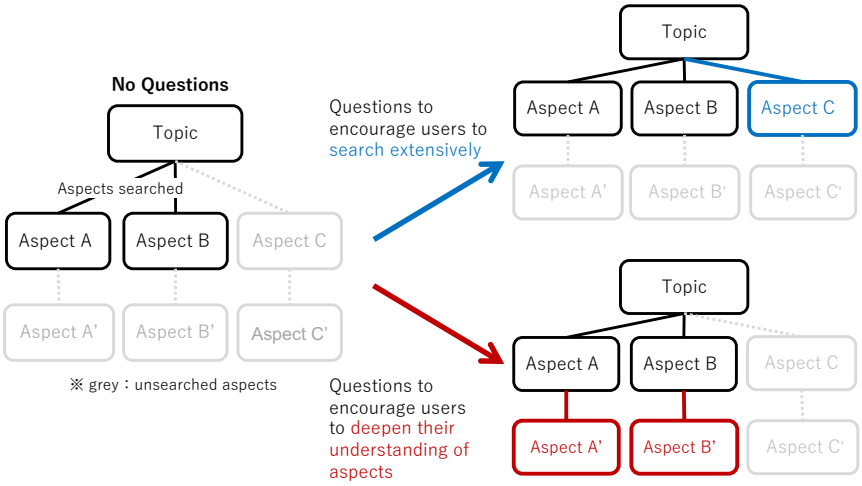

Fig. 3. the relationship between the structure of topics and aspects in web search and expected web search user behavior by suggesting two types of questions

searching for an exhaustive aspect. It is expected that users will be able to form their final opinions based on their understanding of the structure of the topic by suggesting two types of questions to encourage the user to search the web for an exhaustive aspect and by suggesting questions to encourage a deeper understanding of the investigated aspects which is necessary for forming their opinions.

First, in ①, we describe the questioninig interaction. In this interaction, we determine the aspect from which the user is exploring the web and suggest a question that deepens the user's understanding of the content of that aspect.

In this study, we determine the aspect of the web page the user is browsing using the following approach. Let t be the search topic and $A = \{a_1, a_2, ...a_n\}$ be the aspect keyword set. The top 30 search results are obtained employing the Bing Web Search API[3] for every combination of t and aspect keyword set $A = \{a_1, a_2, ...a_n\}$, with the search topic and aspect keyword as input queries. For a given web page, the aspect keywords in the input query when the web page appears as the highest-ranked search result are the aspects of the web page. For instance, suppose that web page w appears in the first, third, and fifth positions of each search result when the queries "t a_1","t a_2" and "t a_3" are employed to search the web. Here, w is considered a web page about aspect a_1 since the query for which w ranks highest in the search results is "t a_1".

[3] https://learn.microsoft.com/en-us/rest/api/cognitiveservices-bingsearch/bing-web-api-v7-reference?source=recommendations

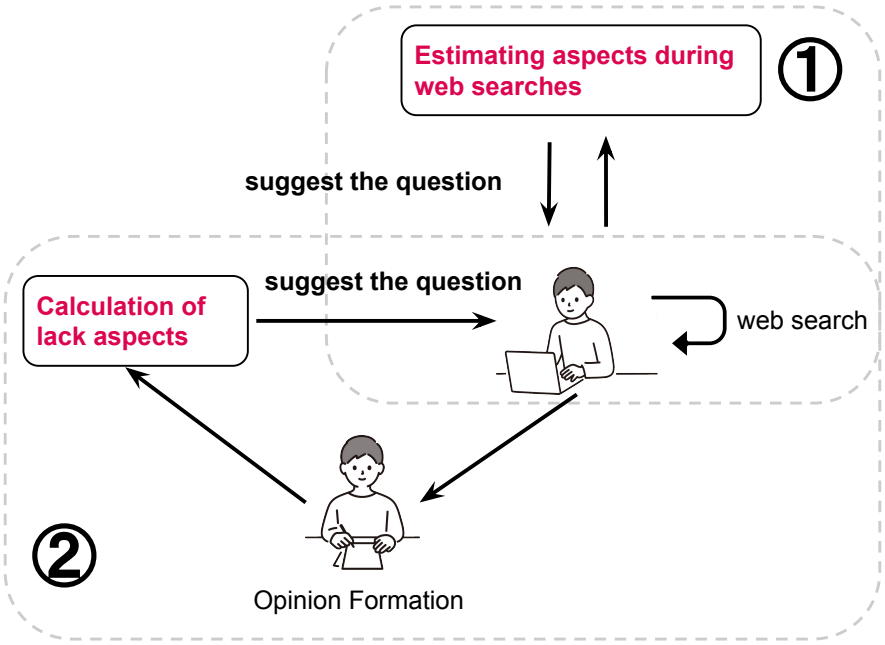

Fig. 4. questioning interaction flow

The proposed system considers that a user is searching the web from aspect a when a is the aspect of the web page the user is browsing. The proposed system considers that the user has started a web search for aspect a when a user browses a web page related to aspect a for the first time and suggests a question to deepen the user's comprehension of aspect a. The proposed system determines the aspect from which the user is searching the web by monitoring the user's behavior during the web search and periodically suggests questions to deepen the user's comprehension of that aspect.

Figure 5 demonstrates the example of employing the proposed system to form an opinion on "Do you agree or disagree with the TPP"? The proposed system assumes that the user is searching the web for the advantages in this example, so Questioning Bot asks, "What are the advantages and disadvantages of the TPP"?

Next, we describe the questioning interaction in ②. In this interaction, the proposed system suggests questions to encourage web searches for aspects for which information search is lacking. Every time the number of characters in the opinion text entered in the opinion formation area increases by 100 characters, the proposed system suggests a question. At this time, the proposed system suggests questions about aspects necessary for opinion formation but for which

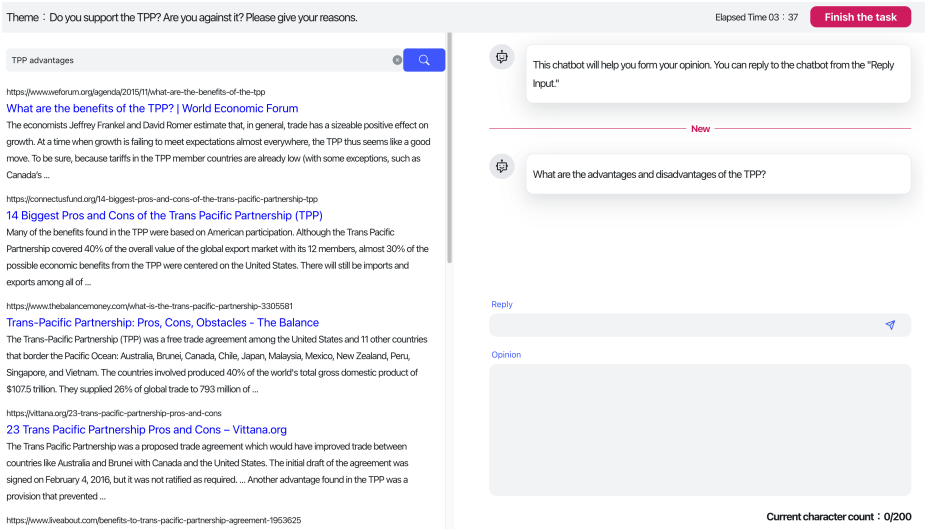

Fig. 5. Suggesting a question to improve users' understanding of the advantages of the TPP

the user's information search on the web is insufficient. The aspects for which the user has not yet conducted a web search are those for which information search is insufficient among the predefined aspects necessary for opinion formation, and the proposed system suggests questions about these aspects. The aspects for which the user has already searched for information are identified in the way described in the ① questioning interaction.

Figure 6 demonstrates an example where the proposed system suggests a ② question immediately after a user who had performed a web search on the advantages of the TPP wrote an opinion statement. The proposed system determined that the user had not conducted a web search on "intellectual property rights," so the proposed system suggests the question "What do you think about intellectual property rights in the TPP?" to encourage users to search the web and form an opinion from different aspects than the "advantages."

4 User Study

An online user experiment was performed to test whether questioning interactions during web searches contribute to the formation of highly persuasive opinions. The user experiment was designed as a one-factor between-subjects design with the search interface as a factor. The experiment was performed in January 2023. We recruited 200 Japanese participants using Lancers.jp[4]. We

[4] https://www.lancers.jp/

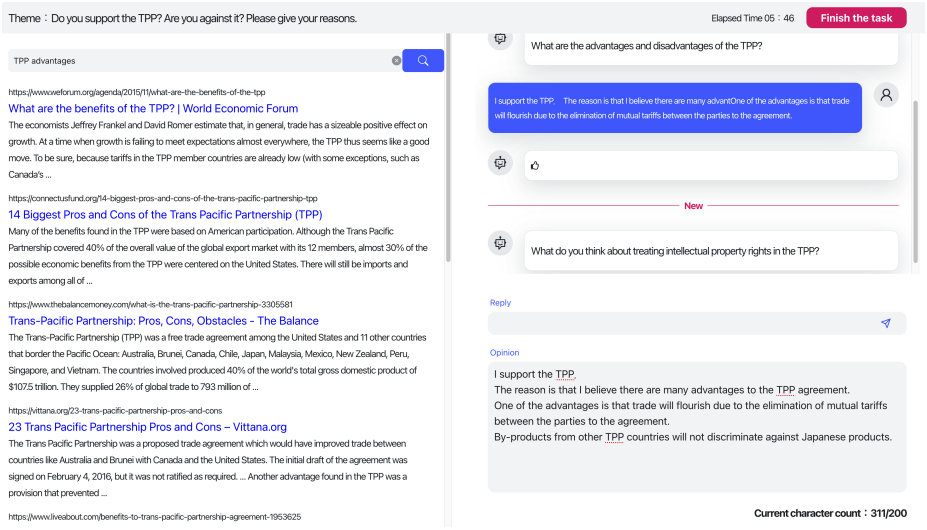

Fig. 6. Suggesting a question about intellectual property rights in the TPP

paid 250 yen to each participant. The details of the experiment are explained below.

4.1 Task

We asked participants to perform a web search on a specified topic and an opinion-forming task. We asked participants to answer in sentences of at least 200 words. The topics for opinion formation in this user experiment were the following two, using the topics provided by the subtasks on subtopic mining in the NTCIR INTENT-1 and IMine-1[5] tasks.

- **Air Pollution Topic**: Describe the best way to prevent air pollution, with reasons for your choice.
- **Vietnam Travel Topic**: Describe your best Vietnam travel plans, with the reasons for your choice.

4.2 Experimental System

We prepared three types of search UIs in this experiment. The three search UIs imitate common web searche engines, including Google and Yahoo, and the information displayed in the right area of the web search results list varies depending on the UI.

[5] https://www.nii.ac.jp/dsc/idr/ntcir/ntcir-taskdata.html

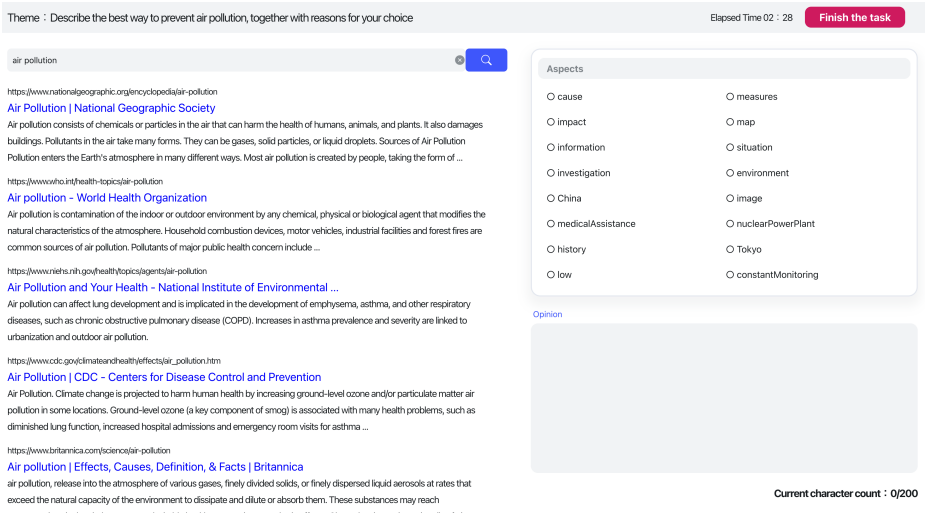

Fig. 7. AspectUI that displays a list of aspects on a search topic

The first is **QuestionUI**, which performs questioning interaction during a web search. **QuestionUI** corresponds to the proposed system in this study. The aspects defined for the "air pollution" and "Vietnam travel" topics in the NTCIR INTENT-1 and IMine-1 tasks were employed to generate the questions suggested by the Questioning Bot during the search task and to determine the search aspect of the participant during a web search. To ensure the experiment went smoothly, the questions for each aspect were generated in advance, before the start of the user experiment.

The second is **AspectUI**, which does not perform questioning interaction but suggests a list of aspects on the search topic. Figure 7 illustrates **AspectUI** suggests a list of search topic aspects to the right of the web search results area.

The third is a **ControlUI**, which does not perform either questioning interaction or suggestion of a list of aspects. **ControlUI** corresponds to the search UI of a common web search engine.

The above three search UIs employ the Bing Search API, allowing the participant to conduct web searches with arbitrary queries. In familiar with all UIs, there is a text box in the bottom right-hand area of the proposed system for the input of opinions formed by the participants.

4.3 Experimental Procedure

Each participant conducted the task according to the following procedure: (1) user registration, (2) web search task, and (3) post-questionnaire.

First, the participants registered as users at Lancers.jp and were redirected to the user experiment website. The topic for opinion formation and UI conditions

were randomly assigned to the participants when the participants were registered on the user experiment website (QuestionUI = 68; AspectUI = 60; ControlUI = 72).

We presented an explanatory text about the task flow before the task started. The Questioning Bot features and the aspects list presentation feature were explained to the participants employing **QuestionUI** and **AspectUI**, respectively. We asked participants to form opinions about the suggested topics using the assigned search UI after explaining the task. The web search findings for the queries specified by the authors were displayed (topic air pollution = "air pollution," topic Vietnam travel = "Vietnam travel") at the beginning of the search task. We set no time limit for the task, and the participants were asked to complete it when they felt they had formed a reasonable opinion. A character limit of at least 200 characters was set for the number of opinion sentences. Participants could only complete the task when the number of opinion sentences entered was 200 characters or more. We asked the participants to complete a post-questionnaire after completing the web search task. In the post-questionnaire, we asked participants to answer questions about their demographics, such as age, gender, and education, and their web search behavior during the web search task. Below is a list of the questions asked in the post-questionnaire (excluding demographic attributes).

Q1 Do you think you could perform a web search on the topic given in the task from a broader aspect?
Q2 Did you better understand the topic given in the task becaouse of your web search?
Q3 Do you think the opinions you formed in the task were persuasive?
Q4 Are you satisfied with the opinions you formed in the task?
Q5 Did you find the suggestion of the questions helpful in checking your understanding of the topics given in the task?
Q6 Do you think that the questions suggested periodically during the web search were suggested when you needed them?
Q7 Do you think the questions suggested during the task were natural as Japanese sentences?
Q8 Did thinking about the questions suggested in the task help you to understand the given topic more deeply?
Q9 Was it useful to think about the content of the questions suggested in the task to formulate your opinion?
Q10 Do you think that a web search system with a questioning interaction is easy to use?
Q11 Would you like to use a web search system with the questioning interaction you used this time when you use web search to formulate your opinions in the future?
Q12 Please describe any other impressions you have about the web search system with the question presentation function.

Table 1. Results of the post-questionnaire evaluation (numbers outside the brackets represent the mean, and numbers inside the brackets represent the standard deviation).

	Evaluation Item	UI Factors		
		QuestionUI	**AspectUI**	**ControlUI**
Q1	Do you think you were able to conduct a web search on the topic given in the task from a broader perspective?	3.44(0.89)	3.63(0.89)	3.59(0.84)
Q2	Did you better understand the topic given in the task as a result of your web search?	4.15(0.73)	4.25(0.56)	4.24(0.58)
Q3	Do you think the opinions you formed in the task were persuasive?	3.16(0.93)	3.75(0.59)	3.35(0.85)
Q4	Are you satisfied with the opinions you formed in the task?	3.46(1.07)	3.68(0.93)	3.64(0.94)
Q5	Did you find the suggestion of the questions helpful in checking your understanding of the topics given in the task?	3.00(1.24)	-	-
Q6	Do you think the questions suggested periodically during the web search were suggested when you needed them?	2.80(0.94)	-	-
Q7	Do you think the questions suggested during the task were natural as Japanese sentences?	4.11(0.95)	-	-
Q8	Did thinking about the questions suggested in the task help you to understand the given topic more deeply?	3.08(1.11)	-	-
Q9	Was it helpful to think about the content of the questions suggested in the task to formulate your opinion?	2.97(1.22)	-	-
Q10	Do you think a web search system with the questioning interaction is easy to use?	3.02(1.15)	-	-
Q11	When you use web search to formulate your opinions in the future, would you like to use a web search system with the questioning interaction you used this time?	2.75(1.30)	-	-

To perform a subjective evaluation of the participant's web search task, we prepared **Q1∼Q2**. To perform the subjective evaluation of the opinions formed through the web search task, we prepared **Q3∼Q4**. To perform the subjective evaluation of questioning interactions during a web search, we prepared **Q5∼Q9**. To evaluate the web search system for questioning interactions, we prepared **Q10∼Q12**. Only the participants assigned to the **QuestionUI** group were asked to answer the questions for **Q5∼Q12**.

5 Results

Post-questionnaire data were collected from a total of 188 participants due to the user experiment. 12 of these collaborators were excluded from the analysis as outliers since they misunderstood the task content in the web search task or took an abnormally long time to perform the task[6]. Finally, we collected data from 176 participants.

Table 1 demonstrates the findings of the analysis of the post-questionnaire. We employ a nonparametric one-way analysis of variance (Kruskal-Wallis test) to analyze the post-questionnaire. The analysis findings indicated no statistically significant differences between the three UIs for any post-questionnaire item.

However, the following responses were obtained as positive evaluations of the questioning interaction from the free description in the post-questionnaire.

> *It is a fresh and good idea to have a system that tries to deepen the contents from different aspects according to the search words.*

Based on the findings of the above response, question-based interactions that aim to make users reflect on their understanding of the search topic can be effective

[6] The 1.5-fold interquartile range (IQR) rule was employed to identify participants whose task duration was an outlier

in deepening users' understanding of the topic and encouraging users to search aspects for which web searches were lacking.

Furthermore, the following responses were obtained as evaluations of the questioning interaction.

> *I thought it was very innovative and interesting. When I want to learn something, I am usually alone when I get knowledge by searching, but with the questioning function, I feel as if there is a partner, which makes me feel happy*

This shows that the proposed system with questioning interaction may motivate users to search the web and encourage active web searching in web searches that are generally conducted alone.

However, two points must be improved. The first is the content of the response of the Questioning Bot. In the proposed system, the Questioning Bot's response is an emoticon of a hand raising its thumb to express "like" uniformly when a participant responds to the questions suggested by the Questioning Bot. However, this response is insufficient to support web search users' knowledge acquisition. The following responses were obtained in the free description of the post-questionnaire.

> *I wish I could receive a written or textual response*

Based on the above, we can more effectively support the user's acquisition of knowledge for forming opinions if we can examine the user's responses, estimate the aspects that the user lacks understanding of, and provide responses to deepen the user's understanding of the topic.

The second is the timing of the suggestion of the question. In this **QuestionUI**, the question to promote exhaustive web searches of aspects was suggested according to the increase in the number of characters in the opinion text entered in the opinion formation area. The suggestion of the questioning text in response to the increase in the number of characters must be revised as timing for the suggestion of the question. The following responses were obtained regarding evaluating the questioning interaction from the free descriptions in the post-questionnaire.

> *I thought it was a good function, but I think it needs further improvement to be realized. The work required even more effort when I had to respond to questions while summarizing my opinions.*

The presentation of the questioning text may interfere with the user's opinion formation at the time of the presentation of the questioning text from the above responses. It is crucial to present the questioning text at a time that does not interfere with the user's input of opinion text and to present the questioning text regarding viewpoints necessary for opinion formation and for which web search must be improved. Additionally, in this study, we estimated the user's aspects during web searches from the web pages viewed by the user by mapping each web page to the aspects in advance. However, it is not easy to appropriately estimate

the user's aspects during web searches using the above approach. The mean value of the item "Q6 Do you think the questions periodically suggested during web search were suggested when you needed them?" An average value of 2.80 was insufficient to conclude that the questions were suggested at the necessary time. It is essential to estimate the user's search intention during a web search [6, 2] and to enhance the accuracy of estimating the aspect from which the user is searching the web.

6 Conclusion

In this study, we developed a questioning interaction to support web searches, encouraging users to evaluate their comprehension of the topics they are searching for and to acquire and organize the knowledge required for forming opinions. We conducted an online user experiment using crowdsourcing to verify the effectiveness of the proposed system for questioning interaction. Our user study showed that some participants who employ the proposed system to form opinions through web searches could write more persuasive opinions based on evidence than participants who do not employ the proposed system. In the future, it is crucial to enhance the accuracy of the content and timing of the question suggested in the questioning interaction in order to promote the acquisition of knowledge on the search topic without compromising the user's web search experience.

Acknowledgment

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