Creativity Support: Information Discovery and Exploratory Search

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ABSTRACT
We are developing support for creativity in learning through information discovery and exploratory search. Users engage in creative tasks, such as inventing new products and services. The system supports evolving information needs. It gathers and presents relevant information visually using images and text. Users are able to search, browse, and explore results from multiple queries and interact with information elements by manipulating design and expressing interest. A field study was conducted to evaluate the system in an undergraduate class. The results demonstrated the efficacy of our system for developing creative ideas. Exposure to diverse information in visual and interactive forms is shown to support students engaged in invention tasks.

Categories and Subject Descriptors
H5. Information interfaces and presentation (e.g., HCI).

General Terms
Design, Experimentation, Human Factors.

Keywords
creativity support tool, visual composition, field study.

1. INTRODUCTION
People search the Web not only for finding certain facts. They also engage in creative intellectual activities. The need for better support for such tasks is addressed by information discovery and exploratory search. In *information discovery*, the user's task is to develop new ideas while finding and assembling relevant information [3]. Similarly, *exploratory search* behavior comprises a mixture of serendipity, learning, and investigation [4].

Evaluating systems that support information discovery and exploratory search is challenging [2]. Typical metrics for search tasks, such as accuracy and time, are of minimal value. For example, if the task is to develop ideas, taking 50% longer, but developing much better ideas, is often a preferred result. Unexpected information may be more important than that originally sought. Divergent thinking measures [3] and user experience reports can be combined to develop a multidimensional evaluative picture. To form such analysis, interaction behavior must be defined, logged and analyzed. Experience reports and ratings need to be recorded directly by users. In this paper, we are presenting the evaluation of a creative support system, as it has been applied in education on student invention projects.

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2. CREATIVITY SUPPORT SYSTEM
We developed a system, combinFormation, to support creativity in education and research [1][2]. combinFormation assembles results from multiple search queries. Users are able to collect and compare found information through visual clippings, forming conceptual relationships. Like bookmarks, the clippings function as surrogates for source documents. A fluid interface enables users to express interest (i.e., provide relevance feedback) in each surrogate in-context, with minimal effort. The system agents respond to interest expressions by crawling, retrieving, and presenting relevant information. While interacting with information, users can learn and develop new ideas.

One way to start combinFormation is by mixing multiple queries. Each time a query is entered, another query input box is dynamically displayed [1]. For each search query, users can select a search engine or social information service, such as Google, Yahoo, Flickr, or Delicious. combinFormation processes each search by sending the query to the selected engine, obtaining the result set, downloading the result pages, and extracting image and text information clippings. The image and text clippings function as semiotic and navigational surrogates that represent the result documents. The system agent selects these surrogates one at a time, and, over time, combines them visually into a composition space for the user. The user can concurrently interact with the image and text surrogates in the composition space by rearranging, resizing and changing design. Agent and user actions are interleaved, in a mixed-initiative architecture [2]. Transparent borders, which create visual connection, can be turned on or off for each surrogate. The color of text shading and the font can be manipulated. When the user brushes a surrogate with mouse-over, s/he sees in-context metadata details on demand (see Figure 1). S/he can navigate to the source web pages using the navigate tool. While browsing the web, s/he can also drag and drop interesting information into the composition space, and make notes (annotate) using the text edit tool.

3. FIELD STUDY
Environmental and Design Science 101, *The Design Process* (ENDS) is an interdisciplinary undergraduate course. There were 182 students in the class, of which 47% were women and 53% were men. Academic majors were distributed, including 44% science and engineering, 33% architecture and liberal arts, and 17% business. The course engages these diverse students in group projects aimed at developing creative innovation by inventing

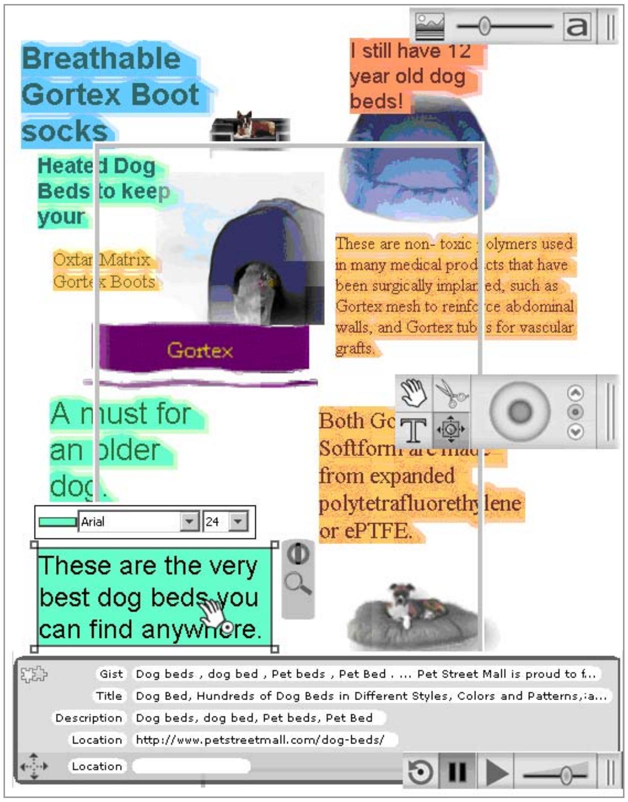

Figure 1. A student's example collection using our creativity support system, 'gortex + dog bed". Selected surrogate is shown with in-context metadata details on demand.

new products and services.

Student groups used the system on two invention assignments. Each group was also asked to develop a prior work collection to support creation of each invention, by searching the Internet and the Patent and Trademark Library, using either combinFormation or Google and Microsoft Word. On the first assignment, half of students groups used combinFormation and the other half used Google and Word. On the second assignment, the groups switched tools. An example of a student's prior work collection, developed using combinFormation, is shown in Figure 1. After students finished both assignments, they filled out a post-questionnaire to collect subjective data. 96 students voluntarily filled out the post-questionnaire using a web-based form.

4. FIELD STUDY RESULTS

Field study results demonstrated better support for information discovery and exploratory search using combinFormation in the Design Process than using Google and Word.

4.1 Objective Data

We recorded comparative objective data about students' performance on the assignments, using the two systems for forming the prior work collections [2]. As measured by teaching assistants, according to the course's evaluative criteria, including originality, practicality, and commercial transfer potential, students using combinFormation on prior work collections were found to develop better inventions than those using Google and Word, and the results were statistically significant [2]. They also found that for The Design Process, representations of collections assembled with combinFormation are more informative and communicative of meaning than those made with Word.

We also looked at how the participants used the capability of combining multiple searches to support creativity. Students combined an average of 3.25 multiple queries with combinFormation. Only 7.37% of students utilized a single query. The result showed that a single query was not adequate to address the information needs of their tasks of developing a prior work collection in support of creating an invention. Students saw a need to combine multiple queries.

4.2 Experience Data: Collection Originality

Students were asked which system better supported them to create materials that show more originality. The results showed that our system supports better in originality than Google and Word with statistical significance [X^2 (1) = 6.898, p = 0.009]. Student participants described the reason for better support in originality:

S20: With Google and Word, I tended to show only thoughts and ideas that are already developed by others. But, with combinFormation, I can mix, match, and draw up my own ideas from the fragments of what already exist. It gives me a basic feedback on which I can bounce my ideas off of.

S47: When using combinFormation, I learned that after you have all information gathered in one area, it is easier to play around and come up with something new. It takes in all the different ideas in our brains and just basically puts it on the table for us.

5. CONCLUSION

It is challenging to develop and evaluate a system that supports exploratory and creativity. The present approach is based on deployment and field study in a real class, which allows us to gather quantitative data through TA evaluations and logs, and students' subjective data. Exposure to diverse information in visual and interactive forms has been shown to support students engaged in invention tasks. The practice of invention involves interaction with and exploration of diverse information. The field study results elucidated students' experiences in using the system, shedding light on the process of creative invention, and the efficacy of the system's support for information discovery and exploratory search.

6. ACKNOWLEDGMENTS

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