Collaborative information seeking in student group projects

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Abstract

Purpose – The purpose of this paper is to gain a better understanding of the collaborative information seeking (CIS) behaviors of students conducting authentic group work projects, and the features of a collaborative search system that are most useful to these students.

Design/methodology/approach – An exploratory study was conducted with 41 participants in ten groups working on an in class, for-credit group project assignment utilizing a collaborative search system. Quantitative and qualitative data were gathered on the everyday search practices of students over the course of the group project, along with quality scores for the sources found.

Findings – Results showed that student behavior during their CIS related to the quality of their search outcomes, as the effective and efficient searchers found better quality sources. Students' pre-task attitudes and experiences toward group work also relate to the quality of their search outcomes. Student feedback demonstrated the importance of making collaborative search tools convenient, lightweight, and easy to use.

Practical implications – These findings may be useful to researchers designing and studying the effectiveness of collaborative search tools, and to instructors planning to incorporate group projects into their classes.

Originality/value – In this paper, the authors document the authentic behaviors and attitudes of students conducting group projects in an classroom setting, and offer specific recommendations for developers of collaborative search systems. These findings provide greater context for CIS research into the collaborative search behaviors of students conducting group work projects.

Keywords Information seeking behaviour, User study, College students, Group work, Collaborative search, Collaborative search systems

Paper type Research paper

Introduction

Collaboration is an important aspect of human-centered information retrieval (González-Ibáñez *et al.*, 2013). Researchers in information science have explored how users seek information during collaborative search (Paul and Morris, 2009; Shah and Marchionini, 2010; Shah, 2014). A growing body of research suggests that users often have a strong social inclination throughout the search process (Evans and Chi, 2010) and that active collaboration on search tasks among users with shared information needs is common (Morris, 2013). However, while collaborative group work is a common requirement in educational settings, how students work together while conducting such tasks is not well understood (Toze and Toms, 2010). There is little research on how collaborative information seeking (CIS) behaviors relate to the quality of search outcomes. Another important factor is students' pre-existing attitudes toward collaborative work, which some research (Prichard *et al.*, 2006) has shown to influence the quality of results.

The use of CIS environments has been understudied (Shah and Marchionini, 2010). Greater understanding of specific aspects of CIS, such as communication, behaviors, and

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performance, is important for designing systems that can better support collaboration in searching, assessing, and making sense of information (González-Ibáñez *et al.* (2013). Effective tools can structure and support student collaborative work and maximize the benefits while reducing the challenges, however, research is needed on which specific features of collaborative search systems are most useful to students.

Existing CIS tools have primarily been studied under laboratory conditions in which study participants searched on assigned tasks. Such laboratory studies do not provide information about how systems are used in real-life collaborative search practices over the longer term (Kelly and Payne, 2014). Studying how students actually conduct their collaborative research in an authentic setting is important since it helps researchers understand student information seeking behaviors and to design collaborative search systems that best support students' needs. In order to address these issues, an exploratory study was conducted of students using a collaborative search system while conducting real-life group project assignments. The research questions addressed by the study were:

RQ1. How do student activities during CIS relate to the quality of their search outcomes?

RQ2. How do students' pre-task attitudes and experiences toward group work relate to the quality of their search outcomes?

RQ3. What features of a search system are most useful to students conducting group information seeking?

Literature review

There are multiple definitions of CIS in the literature. For instance, Poltrock *et al.* (2003) defined it as "the activities that a group or team of people undertakes to identify and resolve a shared information need" (p. 239). Foster (2006) described CIS as "the study of the systems and practices that enable individuals to collaborate during the seeking, searching, and retrieval of information" (p. 330). Shah (2008) referred to CIS as a process of information seeking "that is defined explicitly among the participants, interactive, and mutually beneficial" (p. 1). CIS research focusses on "an information-seeking process that takes place in a collaborative project (possibly a complex task) among a small group of participants (potentially with different set of skills and/or roles), which is intentional, interactive, and mutually beneficial" (Shah and Gonzalez-Ibanez, 2011, p. 219). While students engage in this type of work, they engage in an array of "systems and practices that enable individuals to collaborate during the seeking, searching, and retrieval of information" (Foster, 2006, p. 330). The core processes of CIS have been defined as: awareness, division of labor, and persistence (Morris and Horvitz, 2007); communication, discussion, and exchange (Hyldegard, 2009); and information sharing, coordination, and awareness (Shah and Marchionini, 2010). These core processes are fundamental to the information seeking activities undertaken during collaborative work.

Researchers have identified a number of skills that students can develop through collaborative work. Lazonder (2005) examined the influence of collaboration on student web search behavior and search outcomes, and found that pairs scored higher than individuals on search outcomes, found sources faster, and produced a greater number of correct responses to the tasks. Morris (2008) found that effective collaborative Web search can offer benefits such as increased coverage of relevant information, higher

confidence in the quality of search findings, and greater productivity due to a reduction in redundant effort. Schellens and Valcke (2006) suggest that collaboration can effectively promote knowledge construction. Shah and González-Ibáñez (2011) found that collaborative search has the potential to yield better results than individual search through the synergic effect of shared effort. O'Farrell and Bates (2009) suggest that collaborative work can help students develop teamwork and sharing of information resources. Kiili *et al.* (2012) found that collaborative group work helps students explore different viewpoints on an issue, evaluate usefulness of information, and extract main ideas from sources. Kiili *et al.* (2012) also found that actively collaborating student pairs achieved higher group essay scores than individually working students. Morris (2013) argues that collaborative search can provide benefits including achieving greater recall, improving search skills through exposure to others' behavior, and strengthening social connections. Todd and Dadlani (2013) suggest that collaborative learning can improve teamwork and increase altruistic behaviors. This literature provides the inspiration for the current study's investigation of the impact of student CIS.

However, students conducting group work often do not collaborate effectively. Lakkala *et al.* (2005) and Johnson *et al.* (2010) also found that students often used collaborative environments and tools in individualistic rather than collective ways. Sormunen *et al.* (2013) studied the activities of students conducting a collaborative source-based writing assignment, and found that while some student groups truly collaborated together (planning the work, searching, assessing and reading sources, and writing), many instead conducted loosely coordinated individual efforts. Kelly and Payne (2014) conducted a qualitative field study of real-world collaborative search, and found that students generally showed minimal effort, did not utilize all of the tools' functions, and preferred ad hoc methods of communication. Todd and Dadlani (2013) suggests that students may conceive group work as a matter of dividing labor and pursuing individual goals rather than truly collaborating, and that educators may need to understand and adjust student perceptions of group work prior to engaging them in a collaborative environment. Prichard *et al.* (2006) studied the collaborative behaviors of students over the course of two semesters, and found that students with previous teamwork training were more successful, and that an important outcome of collaborative learning is that it supports student abilities for doing group work. This study seeks to identify how students' pre-existing attitudes toward group work relate to the search outcomes.

Nearly all commercial search technologies are designed for single-user scenarios (Morris, 2013). These commercial tools may not effectively support searchers to share, save, collaborate, or revisit their information (Pickens *et al.*, 2008). However, some researchers have developed custom tools to support CIS. These CIS-enabled systems employ features such as shared query histories, ratings, tags, chat/instant messaging, filters, explicit sharing of results, and visualizations, all of which support awareness and coordination in a collaborative search (Capra *et al.*, 2013). Examples of such collaborative tools include SearchTogether (Morris and Horvitz, 2007), Cerchiamo (Golovchinsky *et al.*, 2008), CoSense (Paul and Morris, 2009), Coagmento (González-Ibáñez and Shah, 2011), Querium (Golovchinsky *et al.*, 2011), ResultsSpace (Capra *et al.*, 2013), and CollabSearch (Yue *et al.*, 2013). These CIS tools offer explicit support for collaborative search through facilitating group awareness, persistence, and sensemaking (Kelly and Payne (2014). Awareness of the activity of other users has been identified as one of the most important features of CIS tools (Shah and Marchionini, 2010), and is an important feature of the system used in this study.

Prior studies have shown that collaborative search tools can also have potential drawbacks for users. Capra *et al.* (2010) suggest that searchers may employ workarounds using familiar "tools-at-hand" (e.g. blogs, text documents) rather than adopt unfamiliar new systems. Morris and Horvitz (2007) discussed the friction inherent in having to switch from tools currently being used to a special purpose new tool. Morris (2013) elaborated that users may repurpose simpler communications technologies that are part of their everyday routines (e-mail, texting, instant messaging, phone calls, and social networking) as a way to extend status quo solutions. Kelly and Payne (2014) state that collaborative tools can be seen as difficult and time-consuming, and users may reject any additional effort above and beyond an equivalent ad hoc solution. Hearst (2014) states that people may be resistant to switching from a standard search tool to a custom collaborative search tool, because the additional value of the tool may be unclear, or it may not yet be easy enough to use. The exploratory study described in this paper contributes to the growing body of knowledge about the CIS practices of students conducting group projects in an authentic classroom setting.

Methods

An exploratory user study was conducted with college undergraduate students recruited from two sections of an introductory communications course. During the study, participants researched a for-credit group project on topics of their own choosing. This helped ensure that the search task was more authentic and relevant to the participant's lives, rather than an artificially assigned task, and helped to gather more authentic behavioral data. Over the course of the semester, study participants worked on the assignment on their own time, synchronously or asynchronously, as they chose. Thus, the CIS behaviors of each group consisted of the cumulative work of the group members over the period of the study. Parallel research based on this study examines pre- and post-test survey responses regarding the strategies that students use during collaborative search, the obstacles they encounter while conducting collaborative work, and changes in their attitudes toward collaborative work as a result of their group project experience. The current research focusses on investigating how student behavior during the CIS related to the quality of their search outcomes.

Initial registration consisted of 50 participants in 11 groups. During the course of the study, one group of four students dropped out. The final active participation in the study consisted of 46 participants (35 male, 11 female) in ten groups. Group sizes consisted of two groups with three members, one group with four members, five groups with five members, and two groups with six members, for an average group size of 4.6 members. Participants were given a $40 incentive payment, with an additional $20 per person given as a bonus to one group from each section that demonstrated the greatest amount of participation based on the number of searches, bookmarks, snippets completed. These incentives encouraged students to use the tool consistently throughout the period of the study, and to participate fully through the end of the study period.

While researching their topic during the study, participants used the Coagmento collaborative search system (González-Ibáñez and Shah, 2011). This system (available at: www.coagmento.org) is designed to support CIS by providing support for multiple people, working in collaboration, to communicate and to search, share, and organize information (Shah and Marchionini, 2010). This study builds on

prior research on CIS employing Coagmento (González-Ibáñez *et al.*, 2013; Kelly and Payne, 2014; Shah *et al.*, 2015; Wu and Yu, 2015), Coagmento consists of a Firefox browser plugin with three primary components: a toolbar that contains buttons to bookmark pages, save snippets of text, open a collaborative text editor; a sidebar displays the groups history of bookmarks and snippets saved, as well as group chat; and an integrated collaborative text editor (see screenshot in Figure 1). When the text editor is not in use, the current web page in the browser appears in the space. Since Coagmento stores the user actions and collected objects (bookmarks, snippets, chat messages) on the server and pushes the new information to the clients in real-time, the users could login and logout, or even use a different device anytime without the loss of any data. This feature allows them to work synchronously as well as asynchronously.

Participants used the Coagmento system in their browsers when researching online for information sources on the assignment. Students could review the description of the group assignment at anytime by clicking on the "Assignment" button in the toolbar, helping them to stay focussed on their topic while searching. Each group member could see the results of all group members' actions in the history section of the sidebar, as well as chat with each other. They could write collaboratively (synchronously or asynchronously) in the text editor. Participants could also access a homepage for their group, which displayed a real-time summary of the total number of bookmarks, snippets, and searches conducted by each group member to promote awareness of group activity. During the study, all participants' actions were recorded by a server log, including searches, pages viewed, bookmarks, snippets saved, notes, chat messages, and the text of the group text editors.

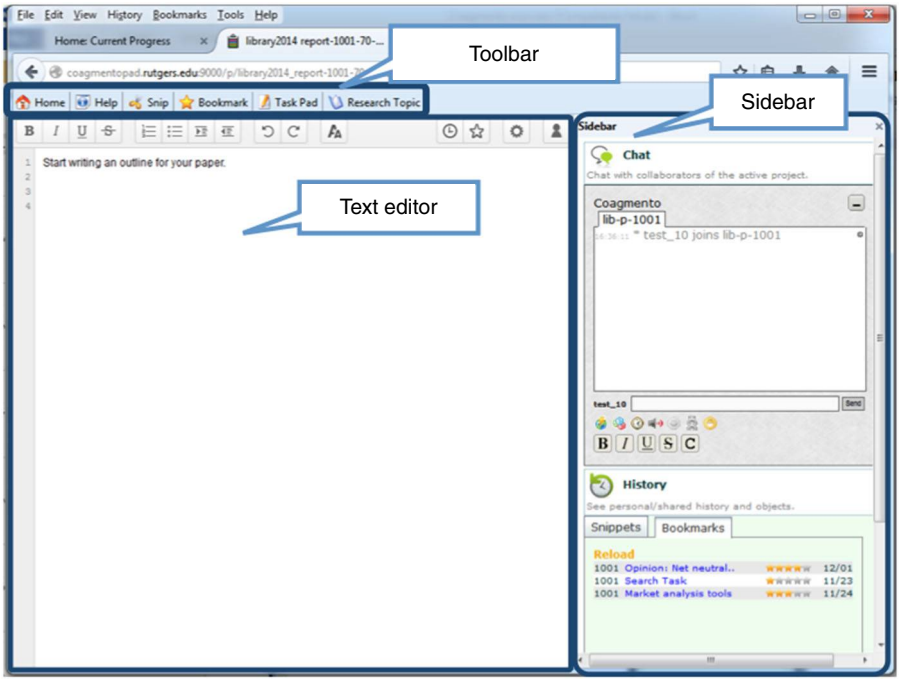

Figure 1.
Coagmento search system

The study ran over a period of eight weeks, from initial research for sources on their topic to the submission of the final paper. An outline of the study procedure is shown below:

(1) pre-study: in class study introduction, recruitment and registration, pre-task questionnaire, groups form and select topic;

(2) week 1: participants begin working on group project;

(3) week 3: group work questionnaire 1;

(4) week 5: group work questionnaire 2;

(5) week 7: group work questionnaire 3; and

(6) week 8: post-task questionnaire, final papers submitted.

Before the study began, the researchers announced the study in class and invited all groups to participate in the study, with the condition that all members of a group must participate. The researchers described the study's purpose and demonstrated the system that groups would use during the study. Students could voluntarily choose to participate or not, and were assured that participation had no impact on their class grade. A few groups chose not to participate and conducted their research outside of the study. Students who agreed to participate signed a consent form describing the study procedure.

During registration, participants answered a pre-task questionnaire that included demographics as well as questions regarding their prior group work experience, satisfaction, topic knowledge, search experience, and motivation (see the Appendix for full questionnaire). Response options were a four-point Likert scale of Not at all/A little/ Some/Very. During the study, participants answered three questionnaires at two-week intervals that asked them about their current group work behaviors outside of Coagmento. At the end of the study, participants completed a post-task questionnaire that asked about their experience using Coagmento.

During the study, both quantitative (log data of online activity) and qualitative (questionnaire responses) data were gathered. The student research reports were not made available by the instructors due to student privacy concerns. Instead, this study relied on rating the quality of bookmarked sources, and analyzing the patterns of online behavior as well as survey and questionnaire responses.

The group project assignment involved writing a research report on an information technology market sector that received a class grade. The instructors' assignment description read:

> A Market Sector Analysis considers the prospects for the Sector as a whole, evaluates and compares the prospects for the different companies within the sector, and suggests which companies might be winners and which losers in the Sector. You should construe the IT Market Sector Analysis Project as providing a report, on request, to a potential investor in the Sector. Thus, the final report to the investor is aimed at informing that person/group about the recent history of the sector and the actors within it, the current condition of the Sector and its various actors, and the future prospects for the Sector and the various actors within it.

Groups could choose the specific market sector that they would research. The sectors that students chose for their projects were:

- cybersecurity;
- gaming;

- networking;
- smartphones;
- virtual reality;
- wearable computing;
- drones;
- self-monitoring health devices;
- productivity software; and
- electronic medical records.

During weeks 3, 5, and 7, participants answered a group questionnaire about their group work experience in the prior two weeks:

Q1. How did you coordinate tasks with your group?

Q2. What goals did your group accomplish?

Q3. What technology did you use to collaborate with your group outside of Coagmento?

Responses were open-ended text. The goal of these questions was to identify any project-related activities that occurred outside of the Coagmento system, in order to gain a better understanding of group work dynamics beyond the automatically recorded server log data. At the end of the study, the third questionnaire also asked participants to reflect on their experience (open-ended text).

After the completion of the study, the quality of the sources bookmarked by the participants was analyzed. To measure the quality of the sources found by participants, a scoring rubric was developed based on how well each source met the requirements of the research assignment. The four main components of the assignment description were divided into separate criteria:

(1) the recent history, current condition, and future prospects for the sector as a whole;

(2) the recent history, current condition, and future prospects for companies within the sector;

(3) which companies might be winners and/or losers in the sector; and

(4) information which would be important to a potential investor in the sector.

This scoring rubric allowed for comparative ratings of the extent to which each source provided substantive information addressing the students' information need, and thus representing a successful or unsuccessful search result. Scoring was based on a scale of 1-5 (low-high) on each of the four criteria, for a possible maximum score of 20 points. Sources that received higher scores provided specific information addressing each criterion, such as significant market conditions, business data or product plans, comparisons of multiple companies, or stock price analysis. Sources which did not provide specific, substantive information on the assignment criteria received Low Scores. The ratings were conducted by one of the researchers and a graduate student in LIS. An initial set of 5 sources was first coded independently by both coders, and the codes were reviewed and differences in scores discussed and resolved. Then the two coders each coded a set of 12 additional sources and a Cohen's κ test was run to

determine the level of inter-coder reliability. There was a moderate level of agreement between the two coders, $\kappa = 0.536$, $p < 0.01$. Given that each source was independently coded on four different criteria, this level of agreement was considered to be sufficient. The two coders then divided the remaining sources and proceeded to code them according to the rubric.

Findings

Survey responses

Background data gathered from participants through registration surveys identified their prior experiences and attitudes. Participants were asked if they had previously worked on a group project in class, with 31 students reporting that they had. Of these, 1 participant reported that they were "Not at all" satisfied with their prior group project experience (3 percent), 15 reported they were "A little" satisfied (48 percent), 9 reported "Some" (29 percent), and 6 reported "Very" (19 percent). For their level of satisfaction with the outcome of the prior group project, 1 participant reported that they were "Not at all" satisfied (3 percent), 17 reported they were "A little" satisfied (55 percent), 6 reported "Some" (19 percent), and 7 reported "Very" (23 percent). All 45 participants were asked how knowledgeable they were about the research topic, with 5 participants reporting that they were "Not at all" knowledgeable (3 percent), 15 reporting they were "A little" knowledgeable (33 percent), 22 reporting "Some" (49 percent), and 3 reporting "Very" (7 percent). All participants were also asked how experienced they were with tasks that require searching for information from multiple sources and synthesizing it in a report, with 0 participants reporting that they were "Not at all" experienced (0 percent), 18 reporting they were "A little" experienced (40 percent), 11 reporting "Some" (24 percent), and 16 reporting "Very" (36 percent). All participants were also asked how motivated they were to work on this project, with 1 participant reporting that they were "Not at all" motivated (2 percent), 14 reporting they were "A little" motivated (31 percent), 16 reporting "Some" (36 percent), and 14 reporting "Very" (31 percent). These preliminary survey responses were used to compare each group's pre-task attitudes and experiences with the quality of their search outcomes, as described below.

Quantitative findings

All participant activity during their group project work was automatically recorded in server logs. Total bookmarks per group ranged from a high of 34 to a low of 4 with an average of 18.6 and median of 22.0; total queries per group ranged from 86 to 6 with an average of 34.1 and a median of 35.0; total visited pages per group ranged from 445 to 16 with an average of 169 and a median of 143.0; and visited Search Engine Results Pages (SERPs) ranged from 220 to 27 with an average of 100.3 and a median of 91.5. Multiple visits to one SERP were each recorded separately. The average time spent using Coagmento ranged from a high of 4 hours to a low of 16 minutes with an average of 1 hour and 34 minutes and a median of 1 hour and 12 minutes. These time totals may not reflect the actual amount of time spent working on the project, as some group members worked with other tools outside of Coagmento. A summary of group activity (total bookmarks, unique queries, visited pages, SERPs viewed, and average amount of time spent using Coagmento) is shown in Table I.

To compare the activity of participants to outcomes of their search, the quality scores of sources bookmarked by participants were compared, based on the scoring rubric described above. Scoring was based on a scale of 1-5 (low-high) for each of the 4 criteria, with a maximum possible score of 20 points. Scores for individual sources

Table I.
Summary of group activity based on server logs

Group	Bookmarks	Queries	Visited pages	SERPs	Ave time (hrs:mins)
1	8	40	176	145	1:07
2	22	86	183	220	1:03
3	23	33	79	79	0:31
4	4	11	16	27	0:16
5	27	40	106	108	1:31
6	27	24	110	68	1:01
7	34	37	445	91	2:52
8	22	24	248	92	2:02
9	4	6	110	29	1:18
10	15	40	217	144	4:02
Ave	19	34	169	100	1:40

ranged from a low of 5 to a high of 16, with an overall average score for all groups of 10.13. Average scores per criteria are shown in Table II.

These results suggest that information about specific companies was easiest to find, while comparative information about the sector overall was hardest to find for these students.

To investigate how search activities may relate to the quality of the search outcomes, quality scores for each group were compared to group activities to find any relationships between activities and outcomes. The average source scores for each group were calculated, and groups were sorted by average score from highest to lowest. To enable comparisons based on overall quality of outcomes, the groups were divided into three equivalent size groups categorized as High Score, Medium Score, and Low Score (Table III). The average score for the High Score category was 11.15, the average for the Medium Score category was 10.01, and the average for the Low Score group was 8.17. Scores were calculated out of a maximum of 20 points.

Activity data by groups was then compared to quality scores. The groups in the High Score category averaged 26.33 bookmarks, 31.33 queries, 257.33 visited pages, 87.33 viewed SERPs, and 1 hour 48 minutes using Coagmento. The Medium Score groups averaged 18.00 bookmarks, 51.50 queries, 179.50 visited pages, 154.20 viewed SERPs, and 1 hour and 58 minutes on using Coagmento. The Low Score groups averaged 11.67 bookmarks, 13.67 queries, 78.67 visited pages, 41.33 viewed SERPs, and 52 minutes using Coagmento. Thus, the High Score group averaged a higher number of bookmarks and visited pages. The Medium Score groups averaged the highest number of queries, viewed SERPs, and time spent using Coagmento. The Low Score group averaged the smallest number of bookmarks, queries, visited pages, viewed SERPs, and time spent.

To visualize the differences in group behavior, group averages for bookmarks, queries, visited pages, and viewed SERPs are shown in bar chart format in Figure 2. The groups are displayed left to right in order from high to low quality scores.

Table II.
Average quality scores per criteria

Criteria	Ave score
Companies	3.26
Investor	2.72
Winner/loser	2.09
Sector	2.05

Range	Group	Ave score	Bookmarks	Queries	Visited pages	SERPs	Ave time
High	8	11.33	22	24	248	92	2:02
	7	11.16	34	37	445	91	2:52
	3	10.96	23	33	79	79	0:31
	Ave	11.15	26.33	31.33	257.33	87.33	1:48
Medium	5	10.70	27	40	106	108	1:31
	2	10.43	22	86	183	220	1:03
	1	9.80	8	40	176	145	1:07
	10	9.11	15	40	217	144	4:02
	Ave	10.01	18.00	51.50	170.50	154.25	1:56
Low	4	8.75	4	11	16	27	0:16
	9	8.00	4	6	110	29	1:18
	6	7.76	27	24	110	68	1:01
	Ave	8.17	11.67	13.67	78.67	41.33	0:52

Table III.
Group activity by source quality score

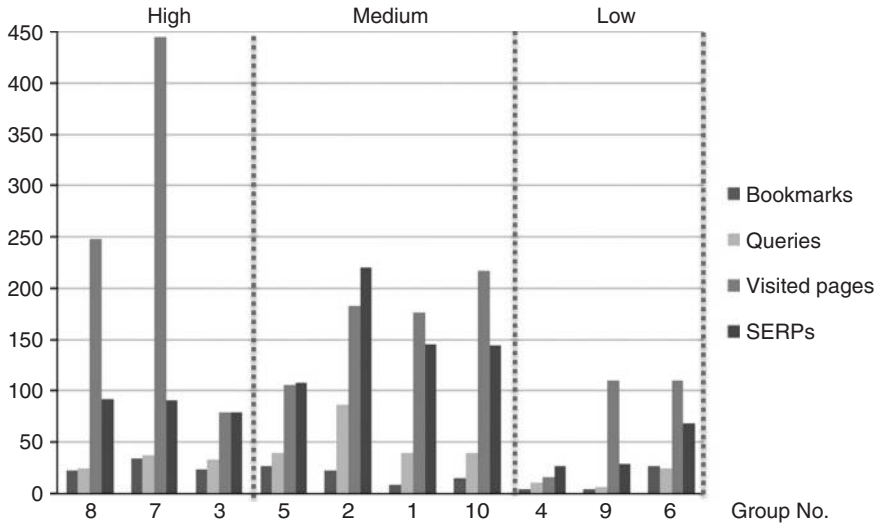

Figure 2.
Group activity by quality score

Figure 2 shows the higher average bookmarks and visited pages for the High Score group (1-3), higher average queries and viewed SERPs for the Medium Score groups (4-7), and the lowest average bookmarks, queries, visited pages, viewed SERPs for the Low Score group (8-10). These results suggest that the greater effort expended by the High Score group, shown through viewing pages and saving bookmarks, corresponded to higher quality sources. While the Medium Score groups conducted more queries and viewed more SERPs they ended up with lower quality sources, which suggests that they may be less effective searchers. The Low Score group exerted the least effort with resulting lower quality of outcomes.

To compare relative differences in the group activity totals in Table III, ratios were calculated for average queries per bookmarks, viewed pages per bookmarks, viewed SERPs per bookmark, and viewed SERPs per query (see Table IV). The High Score group averaged the most viewed pages per bookmark. The Medium Score groups

Range	Group	Ave score	Queries/ bookmarks	Pages/ bookmarks	SERPs/ bookmarks	SERPs/ queries
High	8	11.33	1.09	11.27	4.18	3.83
	7	11.16	1.09	13.09	2.68	2.46
	3	10.96	1.43	3.43	3.43	2.39
	Ave	11.15	1.19	9.77	3.32	2.90
Medium	5	10.70	1.48	3.93	4.00	2.70
	2	10.43	3.91	8.32	10.00	2.56
	1	9.80	5.00	22.00	18.13	3.63
	10	9.11	2.67	14.47	9.60	3.60
	Ave	10.01	2.86	9.47	8.57	3.12
Low	4	8.75	2.75	4.00	6.75	2.45
	9	8.00	1.50	27.50	7.25	4.83
	6	7.76	0.89	4.07	2.52	2.83
	Ave	8.17	1.17	6.74	3.54	3.37

Table IV.
Average queries per bookmarks by source quality score

averaged the most queries per bookmark and the most SERPs per bookmark. The Low Score groups averaged the most viewed SERPs per query.

These results suggest that the High Score groups were the most selective in bookmarking sources, as they viewed the highest ratio of potential sources per saved bookmark. The Medium Score groups conducted the highest ratio of queries per bookmarks and viewed the highest ratio of SERPs per bookmark, suggesting that they may have been inefficient or uncertain in their querying and evaluating of search results. The Low Score groups averaged the highest ratio of SERPs per queries, although they had the lowest ratios in the other three categories, suggesting that they spent most of their time viewing the results lists rather than actual sources.

To investigate how pre-task attitudes and experiences may relate to the quality of search outcomes, group response averages for the pre-task questionnaire were compared to the group quality scores. Group survey responses were sorted according to the group's score ranges (Table V). The questionnaire responses were converted from Likert scale (Not at all/A little/Some/Very) to 1-4 points (low to high).

Score	Group	Ave score	Experience satisfaction	Outcome satisfaction	Topic knowledge	Search experience	Motivation
High	8	11.33	2.00	2.33	2.67	2.67	2.00
	7	11.16	2.50	3.00	2.75	3.00	2.25
	3	10.96	1.83	2.17	2.33	3.17	3.00
	Ave	11.15	2.11	2.50	2.58	2.95	2.42
Medium	5	10.70	1.00	1.40	3.00	3.00	3.00
	2	10.43	2.80	2.80	2.80	2.80	4.00
	1	9.80	2.20	2.20	2.40	3.20	2.40
	10	9.11	1.33	1.00	1.67	3.33	2.33
	Ave	10.01	1.83	1.85	2.47	3.08	2.93
Low	4	8.75	1.60	1.60	2.80	3.60	3.67
	9	2.33	2.33	2.67	3.33	3.33	2.33
	6	1.83	2.00	2.33	3.17	3.67	3.20
	Ave	8.17	1.98	2.20	3.10	3.53	3.07

Table V.
Average pre-task responses for groups by source quality score

These results show that the High Score groups reported the highest average self-reported satisfaction with prior group work experience and prior group work outcome. This supports the findings of prior work in the research literature. The Low Score groups reported the highest self-reported topic knowledge, search experience, and motivation. This finding suggests that compared to their outcomes, the Low Score groups overestimated their own knowledge, experience, and skills, and indicates a significant lack of awareness of their state of knowledge, which also supports prior research.

Qualitative findings

Students responded to questionnaires over the course of the study. To investigate how collaborative tools can support group information seeking activities, the content of the qualitative responses to the bi-weekly questionnaires was analyzed to understand how the participants used tools during their group work. The open-ended text response questions asked:

Q1. How did you coordinate tasks with your group?

Q2. What goals did your group accomplish?

Q3. What technology did you use to collaborate with your group outside of Coagmento?

The most common reported coordination strategies were in-person meetings in or around class times, and dividing work among the group members. Participants stated "We coordinated our Scores by meeting in class to prioritize what tasks needed to be done" and "We talked in class about dividing the work evenly and fairly." Comments about goals also frequently referred to dividing work among group members. Participants stated "The goals we accomplished were to formulate a plan, assign everyone a company to research, and have everyone complete their portion of our assignments" and "We successfully worked on our tasks independently then combined them into one cohesive project." Participants' responses were often general, and did not describe specific coordination techniques or goals to be achieved on a weekly basis.

The most commonly used technologies outside of Coagmento during the group project were text messaging and Google Docs along with e-mail. Although Coagmento provides integrated chat and text editing features that allowed group members to conduct all of their work within the browser, several participants preferred to use tools that they were already familiar with. In particular, groups relied on a mobile group messaging app, GroupMe, and online word processing with Google Docs. The GroupMe app works on smartphones running multiple operating systems, and creates a shared chat room that provides instant message notification. Participants described this app as "a convenient way to send a message that everyone could see instantly" which "allowed for easy communication" and helped "to keep connected and informed on when stuff is due." One participant stated "We talk to each other through our group text and keep everyone updated as to what each of us is doing, what we have accomplished, and what our next tasks are." When they were not on their computers, group members could still connect and share information regarding their project.

Likewise, some participants preferred using Google Docs. One participant stated that Google Docs helped them "collaborate virtually with ease." Others stated that they used it to "divide the work up and post it online" and "put all the work together for collaboration." In comparison to Coagmento, "Google Docs is much more useful and easier since we all have experience using it." While some groups did use the Coagmento

chat and text editing features, these comments reflect that many participants preferred the convenience and ease of familiar tools.

The third and final questionnaire included an additional open-text comment prompt that asked: "How did using Coagmento affect your group work experience?" Responses were open-ended text. The responses to this question were analyzed to determine what features of the tool impacted the participants' group work. One theme that emerged from these responses was the value of awareness of other group members' activity while working on the project. One participant stated:

> Coagmento allows everyone in the group to see what they searched, and it makes it easier to collaborate. We do not have to solely rely on each individual to get their information then have to put it together. Coagmento allowed everyone to find what they needed, then the group seen it (sic), which is a feature that I really enjoyed.

Another participant stated that the system "helped us to see when each other were doing searches." This awareness of others' activity helped to acknowledge contributions: "It was nice to see our names next to the snippet and bookmark so we can see who found what." Students mentioned that group awareness could also inspire new ideas: "It helps to sometimes see what your group is searching because it can help give you some ideas for what I should search." One student reflected on how awareness of others activity led to learning: "Coagmento especially helped with 'meta-knowledge,' or monitoring/ understanding how other members were progressing with their tasks. This made learning from one another much more common, sometimes even unintentional." This spontaneous mention of metacognition and unexpected learning suggests that the student realized the benefits of the group work process and the impact of the group awareness feature of the collaborative search system.

Discussion

In response to *RQ1*, the ranking of groups into ranges by quality scores when compared to group activities showed that differences in behavior were related to outcomes. The greater effort expended by the High Score group, shown through viewing pages and saving bookmarks, corresponded to higher quality sources. While the Medium Score groups conducted more queries and viewed more SERPs they ended up with lower quality sources, which suggests that they may be less effective searchers. The Low Score group exerted the least effort with resulting lower quality of outcomes. The High Score groups were also selective in bookmarking sources, viewing a higher ratio of potential sources per bookmark. The Medium Score groups conducted more queries relative to bookmarks, suggesting that they may have been inefficient or uncertain in their querying. These results demonstrate that effectiveness of search skills is critical, and that many students could benefit from explicit instruction in effective search skills.

In response to *RQ2*, this study's findings showed that satisfaction with prior group work experience and prior group work outcome corresponded to higher quality outcomes. This supports the findings of prior research such as Prichard *et al.* (2006) who found that students with previous teamwork training were more successful. Positive prior experiences with group work may have prepared these students to understand the benefits of collaboration, and to expect positive results, although it is possible that these students may naturally be more inclined to group work. However, self-reported topic knowledge, search experience, and motivation level did not correspond to better outcomes, which supports prior research findings that students often overestimate their abilities to find and evaluate online information (Gross and

Latham, 2007; Caspers and Bernhisel, 2005). One implication of this finding is that students, particularly those without prior group work experience, may benefit from explicit instruction on the process of collaborative work to better prepare them before they start a group project. This might help students understand the potential benefits and positive outcomes of group work as a focussed activity, rather than viewing it simply as an assigned task they must complete. These implications echo the suggestion by Todd and Dadlani (2013) that educators may need to understand and adjust student perceptions of group work prior to engaging them in a collaborative environment.

In response to *RQ3*, this study's findings showed that students appreciated the benefit of increased awareness of their group members' activities. Students valued the ability to see what sources other group members had found, to acknowledge contributions, and inspire new ideas. They indicated that the Coagmento system helped them work together more closely, stay "on the same page," and collaborate with their group members. These responses support the findings of Shah and Marchionini (2010) that awareness of the activity of other users is one of the most important features of CIS tools.

This study's findings regarding the relationship between group activities and quality scores of the sources they found suggest ways in which activities that led to high quality outcomes could be supported through the design of CIS tools. Results showed that greater search effort, as measured through average number of queries and visited pages, corresponded to higher quality outcomes. This suggests that collaborative search systems could support students' effort while searching, which could be achieved through designing features that support persistence in search by encouraging the use of more and diverse queries and viewing more pages, rather than settling for the first few queries and results. CIS tools could be addressing students' tendency to satisfice by providing tips on effective search such as how to structure effective queries and how to reformulate queries. One possible suggestion would be to display activity results such as "You've conducted X searches. You can find more information by conducting more searches" and "You've viewed X out of Y results. You can find more information by viewing more results." Another aspect of motivation is awareness of group members' activity. If students see that other members of their group have conducted a greater number of searches and viewed a greater number of sources, they may feel more motivated to contribute an equal amount of effort. Shah and Marchionini (2010) found this in a limited context outside of educational situations.

However, since the findings show that simply conducting more queries, viewing more SERPs, and spending more time using a system may still result in lower quality sources, effectiveness of search skills remains important. Since the findings showed that being selective in bookmarking sources corresponded to better quality outcomes, CIS tools could support these skills through incorporating critical thinking and source evaluation skills scaffolds. Tips and instruction on how to evaluate the quality of sources, such as the criteria for credibility analysis that should be conducted when researching online, could be built into CIS tools. Most current CIS tools do not incorporate these types of scaffolds. Methods for scaffolding these skills into online search have been explored in the fields of computer-human interaction (Gubbels *et al.*, 2012; Moraveji *et al.*, 2011; Schwarz and Morris, 2011) and library and information science fields (Leeder and Shah, 2016; Markey *et al.*, 2012). Designers and developers of CIS tools could incorporate the findings from this research into the creation of systems which support students in improving their search and evaluation skills.

This study supports prior findings that identified a challenge to developers of collaborative search tools: overcoming student preferences for the familiar tools they

are already accustomed to using. Many study participants expressed a preference for using, familiar, easy to use tools such as Google Docs and the GroupMe text messaging app. This supports the findings of Morris (2013) and Capra *et al.* (2010) who found that students prefer ad hoc adoption of existing tools, rather than adopting a new, unfamiliar system. Kelly and Payne (2014) suggested that complex collaborative search systems could be scaled back in favor of lightweight support for core collaborative search behaviors. Morris (2013) suggests that rather than creating dedicated tools for collaborative search, researchers should explore systems that offer integration and coupling between existing social and information seeking technologies. Designers and developers of integrated, customized, collaborative search systems need to be aware of this student preference and be prepared to address it, if they intend for their systems to be widely adopted.

This study had some limitations. Due to the nature of study, i.e., field testing in two different sections of a class with very limited control by the researchers, the groups of participants varied in size, which could have contributed to some of the variances observed among the groups. The study participants also consisted of more males (31) than females (10). Although this reflected the composition of the classes from which participants were drawn, and registration was voluntary, future research could seek to enforce gender parity. This study did not isolate differences in behavior based on gender. The qualitative findings are based on self-report by students in one college classroom working on one assignment. The quantitative findings involve a scoring system used to rate the quality of the student sources used multiple criteria based on the research assignment and results did not achieve high inter-rater reliability. These limitations affect the generalizability and reliability of the findings. To address these limitations, future work could involve students from multiple classes working on different assignments. The rating system could also be refined to achieve greater inter-rater reliability among the coders.

Conclusion

This study investigated the information seeking behaviors of students using a collaborative search system while conducting real-life group project assignments. The research contributes to our understanding of student CIS behavior by employing both quantitative and qualitative data analysis, using a rating rubric to score the quality of sources as well as behavioral data. This allowed for objective measures of student success in meeting the requirements of the assignment, which in turn allowed for assessment of research behaviors that were most and least successful. The findings showed that student activities during CIS relate to the quality of their search outcomes, as the effective and efficient searchers found better quality sources, based on providing substantive information addressing the requirements of the research assignment. Students' pre-task attitudes and experiences toward group work also relate to the quality of their search outcomes, as positive prior experiences with group work corresponded to better results. The findings also described the features of a search system that are most useful to students conducting CIS, as students appreciated the group awareness features of the collaborative search system, as well as emphasizing the pragmatic preferences of students for familiar pre-existing tools. Student feedback demonstrated the importance of making collaborative search tools convenient, lightweight, and easy to use.

In this paper, we have contributed to the growing body of knowledge about CIS by documenting the behaviors and attitudes of students conducting group projects in an authentic classroom setting, and offered specific recommendations for developers of

collaborative search systems. These findings may be useful to researchers designing and studying the effectiveness of such tools, and to instructors planning to incorporate group projects into their classes. These findings provide greater context for CIS research into the collaborative search behaviors of students conducting group work projects.

Future research building on these findings could investigate how collaborative systems can best integrate effective search skills, critical thinking, and evaluation skills support. Research could also explore why student prefer the use of convenient and familiar existing tools rather than adopting a customized collaborative search system that is built to fit their needs. What are the affordances of those existing tools that students tend to prefer? How can customized tools better adapt to users' preferences and attitudes, while still offering the advantages of structured collaboration? These questions will provide further data about the information seeking behavior of students conducting collaborative research.

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Appendix. Pre-task questionnaire

Thank you for signing up for this study. Please answer the following questions to complete your registration:

(1) Year in college (Freshman/Sophomore/Junior/Senior).

(2) Gender (Male/Female).

(3) Do you have a laptop or personal computer that you can use during this study? (Yes/No).

(4) Have you worked on a group project in class previously? (Yes/No).

(5) If yes, how satisfied were you with the outcome of your group project? (Not at all/A little/Some/Very).

(6) If yes, how satisfied were you with your group work experience? (Not at all/A little/Some/Very).

(7) How knowledgeable are you now about your research topic? (Not at all/A little/Some/Very).

(8) How experienced are you with tasks that require searching for information from multiple sources and synthesizing it in a report? (Not at all/A little/Some/Very).

(9) How motivated are you to work on this project? (Not at all/A little/Some/Very).

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