

Losses and Gains in Collaborative Search: Insights from the Middle School Classroom

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ABSTRACT

New systems to support Collaborative Information Seeking and Retrieval (CIS&R) must consider the constraints and desired outcomes of a wide range of contexts, including K-12 education. This paper summarizes findings from a mixed-methods study of collaborative information seeking in the middle school classroom. This work takes a problem-solving perspective with regard to search and retrieval, recognizing that search is not an end in itself, but an activity that furthers a productive goal, in this case the learning objectives of a classroom assignment. The paper includes recommendations for design based on the findings of this study, and challenges system developers to consider the complexities of collaborative search, as well as the metrics used to assess system performance.

Categories and Subject Descriptors

H5.3 [Information interfaces and presentation]:
Group and Organization Interfaces – Computer supported cooperative work.

General Terms

Design, Experimentation, Human Factors,

Keywords

Collaboration, Education, Information-seeking, Learning, Children and Youth

1. INTRODUCTION

Our interactions with others strongly influence how we work, learn, play, and understand the world. Furthermore, it is becoming clear that the skills necessary for success in the 21st Century include the ability to communicate effectively and efficiently with others, to collaborate in solving ill-structured problems, and to reflect on group goals and processes [2, 6]. Group learning is being integrated into school curricula, emphasizing authentic tasks that bring

students together in collaborative learning situations [10,17]. Traditional models of information seeking and information retrieval, however, which guided the development of information systems, services, and research for decades, were based on the assumption that the information seeker is an individual [13, 22, 23]. In these models, other social actors took on the roles of help providers or interpersonal information sources, but they were not directly involved in the search as collaborators. Consequently, many search tools and learning interventions were designed to support the individual information seeker, rather than the group [9, 20, 23, 25]. The “IR paradox” [20] is increasingly salient in education, which has built its information systems (print and digital) around individual student learning and performance.

An emerging body of research on collaborative information seeking and retrieval (CIS&R) seeks to challenge this traditional oversight. This work includes theoretical models of collaboration (e.g. [9, 22, 23]) empirical examinations of group search and retrieval processes (e.g. [4, 8, 11, 12, 18, 19]) and the development of systems that may assist asynchronous and synchronous search tasks (e.g. [1, 15, 20]). While this body of work has taken the field forward philosophically and empirically, several important questions persist about which the research literature provides little guidance. In this workshop, I would like to explore the following questions:

- How do we (or should we) analyze collaborative search and retrieval practices?
- What metrics exist that might allow use to compare collaborative search systems, against each other as well as individual search?
- At what stage(s) of the search process is collaboration most beneficial?

There is still a great deal we do not understand about collaboration even as we attempt to leverage it for work and learning outcomes. Collaborative search systems most often focus on the middle stages of search, namely query development, resource access, and selection. Relevant work in information literacy suggests that the information search process is not a monolithic enterprise; rather, it is a series of

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conceptual stages comprising moves or patterns of behavior. Document discovery and retrieval is only one of those stages, and is arguably the least difficult. Just as past research has found that collaboration is more likely to benefit certain kinds of tasks above others, collaborative search systems are more likely to provide benefits during some aspects of information behavior but not all.

To further the discussion of these questions, this paper summarizes select findings from a mixed-methods study that examined the complexities of solving information problems in the context of K-12 education. 120 grade seven students (ages 13-14) from four middle school science classrooms completed information seeking tasks on health and wellness topics in two order-balanced conditions: individually, and in small groups of three students. Each student completed an individual and group task, providing participants with the opportunity to critically reflect on their work under different conditions.

This work takes a problem-solving perspective with regard to search and retrieval, recognizing that search is not an end in itself, but an activity that furthers a productive goal, in this case the learning objectives of a classroom assignment. Similarly, we do not collaborate simply to work socially; we expect that collaborative conditions provide benefits for those working in concert in terms of search success, conceptual development, or motivation.

2. THEORETICAL FRAMEWORK

Solving information problems collaboratively involves the interplay of three related processes: 1) information seeking; 2) learning; and 3) management of group work and attention. Information seeking involves not only the acquisition of information and resources to resolve the problem, but also the identification of the problem, development of strategies, information use, and the assessment of the solution or deliverable [6, 14]. Analysis of group interactions, both face-to-face and remote, has further focused on issues of awareness, symmetry, and agency. From this perspective, collaboration can be said to have both process losses and gains [21]. Working with others can make tasks easier, so long as the cost of managing the interaction does not outweigh the benefits in terms of time, effort, and motivation. Finally, work in cognate domains, namely cognitive science and social psychology, suggest various reasons why small group work should result in positive outcomes, both for group performance and individual learning [16, 24]:

- Individuals bring a wide array of knowledge, skills and experiences to bear on a problem when they work together in small groups. Leveraging these combined talents and ideas to generate a unique solution is often referred to as *resource pooling*.

- Individuals working in groups may confront their peers with alternate strategies, solutions, or points of view. This clash of ideas may prompt individuals to reflect on their own thoughts, reassess their viewpoints, and resolve differences between their own perception of the problem and that of others. This process is called *socio-cognitive conflict*.
- Working in groups provides individuals with the opportunity to verbalize their thought processes. Providing and receiving explanations of how individuals analyze problems, assess information, or select resources to arrive at a solution can enhance the learning process. Such explanations permit the reorganization of thought process and the internalization of successful strategies, particularly for novices. This process of mediating problem solving through dialog is referred to as *cognitive elaboration*.
- Working in concert with others can provide a positive affective experience. Youth between the ages of 10 and 16 years are particularly drawn toward opportunities to interact socially with peers. This *social-motivational* effect may be an important aspect of group work for middle school age students.
- From an instructional perspective, group work may provide the opportunity to address more complex, information-intensive problems. This provides some instructional diversity, and may appeal to the differing cognitive strengths and experiences of group members.

There is also the potential for groups to produce results that are less than the sum of individual efforts. For example, resource pooling can cause information overload, particularly if students are unable to assess and affirm correct solutions. Cognitive conflict and elaboration strategies can increase uncertainty just as readily as they can reduce it. While some group configurations can make group work enjoyable, personal disagreements can lead to negative emotional experiences, disjointed processes, wasted time, and poor group products [5]. There may exist tensions among the three dimensions of collaborative problem solving, particularly in the K-12 learning context. For example, while working in small groups may be motivational for students, it may distract from the instructor's intended learning outcomes. Additional research is needed to understand how and when these factors affect problem solving processes and outcomes [3, 26].

3. METHOD

To explore the complex nature of collaboration in the school setting, a mix method design was implemented, involving a field-based experiment, qualitative process capture, and a participant questionnaire. Information seeking tasks were completed by 120 grade seven students

(ages 13-14) from four middle school classrooms using a pretest-task-posttest field experimental design. The tasks and learning assessment tools (pretests and posttests) were developed in coordination with the classroom educators and integrated into the seventh grade health and microlife unit. In this two-month unit, students explored microscopic life (including bacteria, viruses, protists), microbiomes, diseases prevention, and personal hygiene. The information seeking tasks were presented in the form of a multi-part scenario; students performed research online using classroom computers to answer a series of related questions. The first scenario (Task 1) involved a hypothetical salmonella outbreak at school. The second scenario (Task 2) engaged students around the proper use of antibiotics and probiotic supplements to treat a classmate's illness. Task 1 and Task 2 plus related assessments were administered two weeks apart. In addition to the tasks and assessments, the process of information seeking (screen capture plus audio) was recorded for a subset of each condition, totaling eight individual and eight group processes. After the second task, students participated in a 30-questions survey to gather their impressions of the group and individual research.

4. FINDINGS

This paper focuses on the preliminary findings from the resulting data set, namely: 1) learning outcomes measured by the posttests; 2) the information seeking outcomes demonstrated in the information seeking tasks; 3) socio-affective responses from the 30 question survey provided to students after the completion of these two tasks. The assessments consisted of 15 multiple-choice questions. The tasks were composed of nine subtasks worth a total of 18 points. The survey consisted of three parts: five-point Likert-scale responses (12 questions in four groups), open-ended written response (4 questions), and a reflective process analysis (14 questions). Students' numerical and scaled responses (quantitative) were analyzed using SPSS 17; written responses (qualitative) were scored and/or coded using Atlas Ti. The response rate for the survey was 90% (108 of 120 students participated).

4.1 Learning Outcomes

The information seeking intervention resulted in significant student knowledge gains based on the difference between pre-test and post-test performance. However, the small difference between conditions was not statistically reliable. That is, the students did not demonstrate greater conceptual gain as a result of performing the problem-solving intervention in groups of three compared with the equivalent intervention performed as individuals. "Gain score" analysis was also performed to illuminate the lack of a significant result. The researcher noticed that the range of gain scores for both conditions was large, and many

students made strong gains in one condition or the other, but rarely did well under both problem-solving conditions. This offsetting pattern of individual performance, doing well in one condition and poorly in the other, may explain why there appears to be no reliable difference between groups of students in these two conditions. Students may have an individual "collaborative preference" that supports or constrains successful learning in this condition.

4.2 Information Seeking Outcomes

As with the analysis of student learning outcomes, groups did not outperform individuals on average for the information seeking tasks. There were statistically reliable differences in task performance, however, which emerge through disaggregation of the tasks. Some important findings include:

- Individuals outperformed groups when providing explanations of a phenomenon or process. It is suspected that the conversation among group partners takes the place of the written response; hence, students in the group condition were more succinct and less elaborative in their written responses (though no less accurate).
- Questions where groups outperformed individuals in the information seeking task emerged as identifiable differences in the learning outcomes measure, suggesting that information seeking success is a likely predictor of learning outcomes.
- Analysis of process capture revealed that finding enough relevant information was rarely the problem. Students had difficulty making sense and drawing inferences from documents, even when they selected high-quality sources.

4.3 Socio-Affective Outcomes

Results of the survey illuminate student attitudes toward working alone and with others while solving information problems, in terms of perceived (in contrast to actual) learning outcomes, socio-affective concerns, and technical considerations. Drawing from Steiner's theory [21] of process losses and gains, as well as process models of information seeking and use, the survey focused on how the students perceived that the group process contributed to or detracted from their information seeking experience on a holistic and granular level. Survey questions explored issues of affective motivation, learning motivation, task efficacy, and task fairness. Preliminary findings include:

- Students reported strong affective motivation for group work, most students citing that group work was preferred to individual work. Students also acknowledged *resource pooling* and *constructive elaboration* as key benefits to the group process.
- Student affinity for the group work experience was tempered by concerns for fairness and efficacy of group

tasks. While students felt they learned more when working in groups, they also reported greater levels of distraction and issues with task management.

- Students offered mixed opinions of sharing technology during the information seeking process. While some student expressed frustration with the experience of using one computer in a group of three students, others found this configuration beneficial to maintaining task focus and facilitating discussion.
- Process reflections reveal that students find neither configuration perfectly suited to all information seeking stages; rather, a mix of individual and group work appears to be preferred. Students identified that stages of problem identification, resource assessment, and product evaluation are best performed socially, while searching and reading stages may be best performed alone.

5. IMPLICATIONS FOR DESIGN

The findings of this study raise questions not only about the process of collaborative search in K-12 environments, but also about its efficacy. Strong within-subject differences suggest that students react very differently to working with peers, and this can have a significant impact on their learning outcomes. Not all students work well in collaborative environments; tools to support collaboration in schools will need to take this factor into account. Furthermore, while students found working in groups to be fun, they were critical of doing the entire project together, finding that some stages were best performed alone, and others in a group. The stages best performed alone were those related to search and retrieval, while group efforts were most valuable during ideation and evaluation stages.

Many students found that sharing technology in a small group helped, rather than hindered, the process of making sense of information. Many projects designed for young people (e.g. Amershi & Morris' CoSearch [1]) follow from the assumption that co-located search with limited equipment creates problems within a work group. Student responses suggest that computer "hogging" is an acute, if not widespread, problem during the search phase, but not a large issue during the rest of the information problem-solving process. A mix of individual and collaborative process (flowing together and apart at different stages) may be an optimal approach. Designers should consider how their systems allow group member to work together and alone, supporting a range of user needs and preferences.

6. CONCLUSIONS

How do we assess the efficacy of our information systems? User satisfaction is a common metric, but this may be inadequate. While students enjoyed collaborating in the search process, they did not demonstrate better performance. Many of the cognitive benefits suggested by

theory were nullified by process losses, namely distraction, negative group members, or misconceptions generated in the social exchange of information. Researchers in CIS&R should focus on developing better metrics for the evaluation of information tools, including non-digital tools (group practices, learning interventions and curriculum) that support group problem solving. Outcome measures, such as whether users better solve problems using groupware, as well as reliable loss/gain analyses are necessary to turn demo applications into usable tools.

While many collaborative search and retrieval systems focus on document discovery, leveraging the power of groups to support more thorough searching, search seems to be the easiest of the tasks facing students. The search stages that perplexed most students included the initial ideation stage (figuring out what to search for) and synthesizing information from several documents to make inferences. Students did not need more information: they had sufficient trouble finding solutions in the relevant documents they obtained quickly through keyword searching. Search is easy, but sense-making is the challenge: collaborative search should emphasize how users can make collective sense of documents and arrive at correct inferences, not just more information.

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