SearchParty: Real-time Support for Social Learning in Synchronous Environments

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ABSTRACT
This paper describes SearchParty, a new tool to support social learning in synchronous environments. By providing a web-based tool for aggregating student activity as it occurs, students can both learn from each other, and teachers can better understand what is going on in the classroom. We observed 9 small classes using this tool to learn how to search, and we describe our observations and design lessons.

Author Keywords
Education; massively open online courses; collaborative learning; learning.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms
Design; Experimentation.

INTRODUCTION
Students have long used technology to access class content outside of the classroom. These technologies range from the relatively old technology of books such as encyclopedias and technical reference books to more recent Internet technologies such as Wikipedia, YouTube, and a variety of electronic mailing lists, forums, social networks and more comprehensive domain-specific solutions such as Piazza [16]. Traditionally these materials are supplementary to lectures delivered during class time.

Recently, massive open online courses (MOOCs) have gained a lot of attention. MOOCs offer students another way to gain access class materials including lectures electronically. MOOCs leverage Internet technologies to deliver these materials and facilitate communications among students and teachers. Some of the most popular MOOCs distribute lectures as digital video recordings and student examinations as online questionnaires [e.g., 7, 12, 17]. Internet technologies offer the potential benefit to deliver classes to hundreds of thousands of students worldwide [8]. Online classes can support a larger number of students than traditional classrooms.

Internet technologies also offer the potential to enhance traditional classrooms. For example, methods of accessing

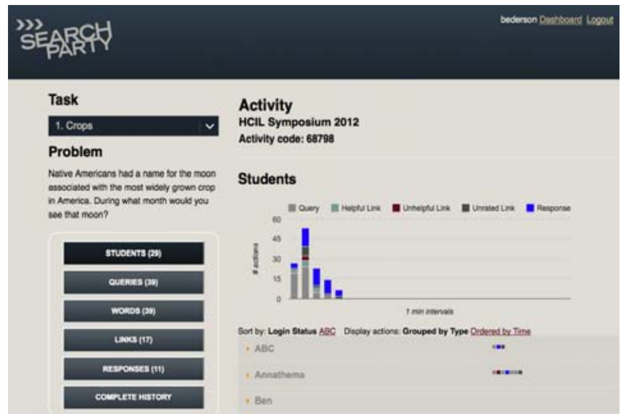

Figure 1. Teacher view showing the activity of 29 students working on a search related to crops. Graph shows what students are doing as they do it. Buttons on left show data that can be displayed including student list, the queries they performed, the words in those queries, the links they followed, the responses they gave, and a complete temporally ordered history of all student activity.

content and communication allow teachers to deliver lectures to students outside of the classroom, allowing them to spend more time in classes actively engaging in problem solving, discussions, or collaborating on hands-on activities. These methods address limitations of the traditional lecture format. Lectures are often one-way, not accompanied by discussion, student questions about lecture topics, or hands-on activities, despite their value to students for learning. The potential of leveraging these during class time to help students learn has popularized the so-called “flipped classroom” among education researchers and practitioners [9].

In a flipped classroom, events that traditionally take place in the classroom take place outside the classroom, allowing more time for other in-class activities [9]. Flipped classrooms mix technology and hands-on activities [4]. Because teachers are not lecturing during class time, a higher degree of interactivity between students and teachers is possible. Students gain freedom to engage in more diverse ways, allowing them to learn in ways that are effective for them. Teachers can provide instruction to students by tutoring them as they work on in-class activities

[2, 22]. Students can also help each other by sharing their knowledge. This higher degree of interactivity provides students with opportunities to learn by observing their peers as they apply their knowledge in learning activities.

Flipped classrooms have been used broadly in a wide range of participant—i.e., economics [9], software engineering [4], and biology [13]. Well-organized flipped classrooms provide a social context that allows meaningful learning to take place through interactions among students and teachers [22]. Interactions among teachers and students can take place during hands-on activities, discussions, observation of peers, and so on. Each of these presents opportunities for students to learn from one another—for social learning. Technology can support this social learning among students and teachers [15]. There are multiple advantages to supporting social learning in flipped classrooms. In flipped classrooms, students can engage teachers and other students by asking their own questions that arise from engaging the concepts in class materials and hands-on activities. Technology can capture student activity engaging questions to share with other students and teachers. This enables students to learn from the activity of their peers. Teachers can use this information as a way to monitor student activity and develop a general sense of classroom activity and guide their instruction during class time.

SearchParty

In this paper, we explore how technologies can support social learning in the classroom, focusing on the flipped classroom. We present SearchParty, a tool for supporting social learning through peer awareness in environments such as flipped classrooms. SearchParty is a tool to teach how to search the web. It collects the search activity (e.g., queries), of students and generates a summary of students' activity on a large, shared display, visible to all students. This shared summary of activity provides students and teachers with a degree of shared awareness in the classroom. Shared awareness of activity can help students develop a complete understanding of the activity or concepts used in the activity. SearchParty allows students to observe the activity of their peers, providing a basis from which students can share with and learn from others as they develop their own understanding through hands-on activity. For example, in the context of search, a student may observe the queries formulated by his or her peers, then formulate new queries based on the observed queries. Students may use different words or operators in their queries that others can learn through the shared awareness provided by SearchParty.

SearchParty provides teachers with an overview of the classroom that can be useful for quickly developing a sense of the work that students are doing and a basis for guiding class discussions. Teachers can use SearchParty as a classroom management tool and to do the virtual analogue of peering over students shoulder to gain insight into their search process. We deployed SearchParty in classrooms and other environments that afford possibilities for collaboration around assigned and authentic questions. These classes serve as case studies in which we explore different configurations of SearchParty and communications technologies to support social learning. The goals of our case studies are to understand how technology can support social learning and to improve the design of SearchParty as a tool to do so. This goal supports our long-term vision of SearchParty as a platform that supports a wide variety of synchronous activities—not just searching.

Our research using SearchParty is motivated by the work of Morris and Horvitz on SearchTogether [14] and Moraveji et al. on ClassSearch [15]. SearchTogether allows groups of people, geographically remote from each other, to collaboratively search, synchronously or asynchronously. SearchTogether is designed specifically to support collaborative search. Morris and Horvitz do not deploy SearchTogether in classroom environments and do not design to support the flipped classroom. In contrast, SearchParty supports collaborative search behavior as a special case of its more general goal, to support shared awareness of activity. Our research focuses on deployments in classrooms of students searching synchronously.

ClassSearch also supports collaborative search activity, but its focus was on deployments in classroom environments, not focus on supporting flipped classroom environments and flipped teaching. Our research using SearchParty focuses on support for the flipped classroom. SearchParty also represents an exploration of how much can be pushed to a web application in a real-time, collaborative setting.

The SearchParty code is completely open source, and is publicly available at https://search-party.googlecode.com. In addition, the service is freely available for all to use at http://search-party.appspot.com.

DESIGN

As mentioned, SearchParty was motivated by ClassSearch by Moraveji et al. [15]. ClassSearch is a system consisting of a native server application and a browser plugin for students' machines. Given the locked-down nature of many school computing environments, we decided to see how far we could get with an entirely web-based solution. As will be seen, we kept the server application web-based, and we explored multiple browser solutions for the student. We also explored numerous variations in the design of the interfaces.

The key design approach, as with ClassSearch, was to create a "teacher's" view to manage the activities that students would perform, and then during the actual exercise, to present a real-time aggregation of student activity designed to be displayed to the whole class on a projected display (or alternatively to be shared with remote participants through screen sharing). The students then have an interface for performing their activities.

We used Google App Engine [6] which provides not only hosting, but also two key features which makes SearchParty possible. The first is "channels" which provide real-time push from the server down to the client (so we can update the teacher and student aggregated views as students perform activities). The second is "presence" which very rapidly (typically in under one second) notifies the server when a student web view disconnects – which can happen not only by logging out, but also by navigating to another page or simply closing the browser. These two features enable us to create the real-time teacher view which shows who is connected and exactly what students are doing, as they do it.

There are a number of basic design issues which we addressed including authentication and what data to collect from student activity. For the teacher display, we considered how to display the aggregated student activity in a way that would both enable students to see what the class was doing at a glance, and to enable teachers to drill down to see in more detail what was going on so that they could direct the class to interesting student actions, and to help individual students where they needed it. That is, we wanted to use the teacher view to enable classroom management – which could be useful not only in face-to-face settings, but even in synchronous remote situations.

Authentication

Authentication involving students that are potentially children is tricky because those students may be protected by various laws. For example, the U.S. Children's Online Privacy Protection Act of 1998 (COPPA) [21] significantly limits what kind of personally identifying information can be collected from children under the age of 13. We also wanted to manage usability – by not requiring students to have email addresses nor to require any participants to create and remember yet another password.

Our solution was to use Google authentication for the teachers (using their existing, or freely available Google account credentials). When teachers log in, they access a dashboard where they create student activities. Each activity automatically generates a 5 digit numeric code. Then students log in with just a first name (or pseudonym) and that numeric code which is visible on the teacher's display. This simple approach is somewhat ephemeral and is designed for each of access—so students can go from sitting down at a computer to being logged in and ready to work for the first time in under a minute. This approach

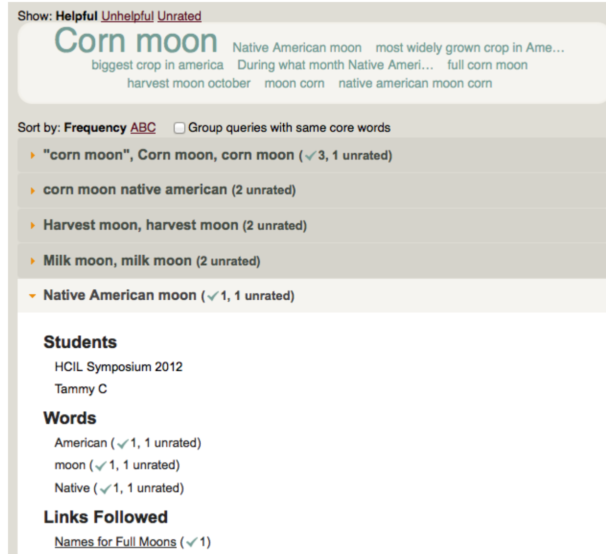

Figure 2. Teacher view showing student queries. Top of view shows a "cloud" where larger queries are performed more frequently. Expanded query shows which students performed that query, and which links were followed as a result of performing that query.

would be less suitable for testing, or an environment where reliable identification of each participant was required.

Collected Data

Since SearchParty runs in the background and potentially could observe all web activity, we had to make a clear (and clearly communicated) decision about what student activity we would monitor. In the end, we decided to collect search terms and links followed – and to disable SearchParty on a fixed set of popular "web app" sites (such as mail and document editing sites). In this way, we were sure to avoid having the potential of collecting passwords, emails, or personal information (except to the extent that such information is encoded in URLs). We also ask students to

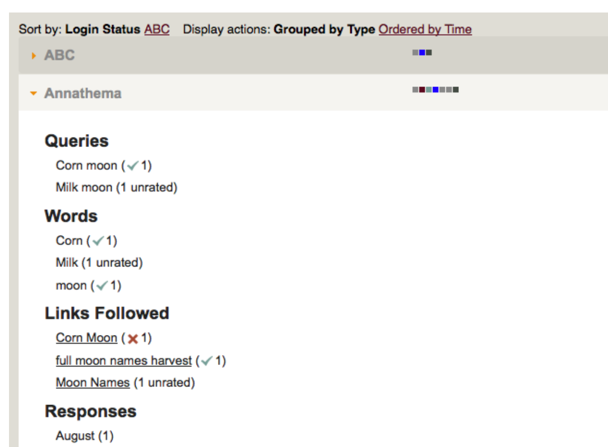

Figure 3. Teacher view focused on a single student's activity (grouped by type).

rate pages as being helpful or unhelpful in accomplishing the current task. And finally, we offer the students the option of providing a specific "response" or notes regarding the current page. In this way, we try to balance student's privacy with the ability of the teacher (and thus everyone in the class) to get a clear sense of what the students are doing.

Teacher View

When a teacher first logs in, they are presented with a "dashboard" that shows all of the activities they have defined along with the ability to create new activities, and stop and start existing activities. Each activity contains a list of tasks which students can then select among when they connect to a particular activity.

Once an activity is selected, there are a number of views which show both an aggregation of overall student activity as well as the ability to drill down into individual student actions going as far as a complete history of what a student does. Figures 1, 2 and 3 show selected teacher views.

Student View

We wanted students to be able to see and select among different tasks, to perform web searches, to rate those searches, to give answers for their tasks, and to see a history of their own or their peer's activity.

We ended up implementing three versions of the student view with different basic deployment strategies based on our use of a Rapid Iterative Testing and Evaluation (RITE) method [11]. We used each version with a number of classes (as reported in the next section), and then tried a variation in the design based on the deficiencies of what we saw at each stage.

Design 1: Web page with Google Custom Search

Our first solution worked as a standard web page. However, we quickly ran into a technical challenge which was that modern search engines (including Google, which we focused on) don't allow themselves to be embedded in HTML iframes. This is a problem because we require the ability to include some of our own user interface elements along with the ability to perform a search and see search results (and then follow links).

Our solution (Figure 4) uses a Google product called Google Custom Search which provides the ability to use an API to perform and display search results in a page that we own. This way, we were able to write some JavaScript code that could observe and record when a link was followed.

This solution worked reliably, but had several problems. First of all, Google Custom Search was limited in that it only performed basic text searches, which limited students use of images, maps, etc. Secondly, when a link was followed, the resulting page was displayed in an inline frame (replacing the search results)—embedding the page in our web page. This provided substantially reduced width, requiring a skinny rendering of the page. Just as importantly, browser security limitations prevented us from

Figure 4. Student view (design #1) shows a completely custom UI, including the use of Google Custom Search to perform and display search results. When a link is followed, the new page is displayed embedded in right portion of the screen (replacing the search results).

injecting JavaScript into an embedded page from another domain, and thus we weren't able to track when students followed links.

Design 2: Plugin with Popup Menu

These problems led us to abandon the goal of having a completely installation free user experience, and instead we wrote a Chrome browser plugin that enabled us to inject JavaScript into any web page. This enabled us to both use the google.com home page for full-featured search as well as track link following on all pages.

To provide a user interface to students, the plugin added a button to the top of the browser which when clicked, showed a popup window with a UI that was relevant to the currently displayed page.

This solution solved the technical problems of the first design, but introduced a problem, which was that the student focused UI was hidden unless the student explicitly clicked on the SearchParty browser button. We thought that with instruction, students would readily do this, but as described in the next section, many students never clicked the button – and so this solution was not very effective.

Design 3: Plugin with Banner UI

The final design extended the plugin from the previous design by injecting a display into the top of every page the student visited (Figure 6). This display ensured that the student would always be looking at a UI that reminded them of the task, let them rate the pages they visited,

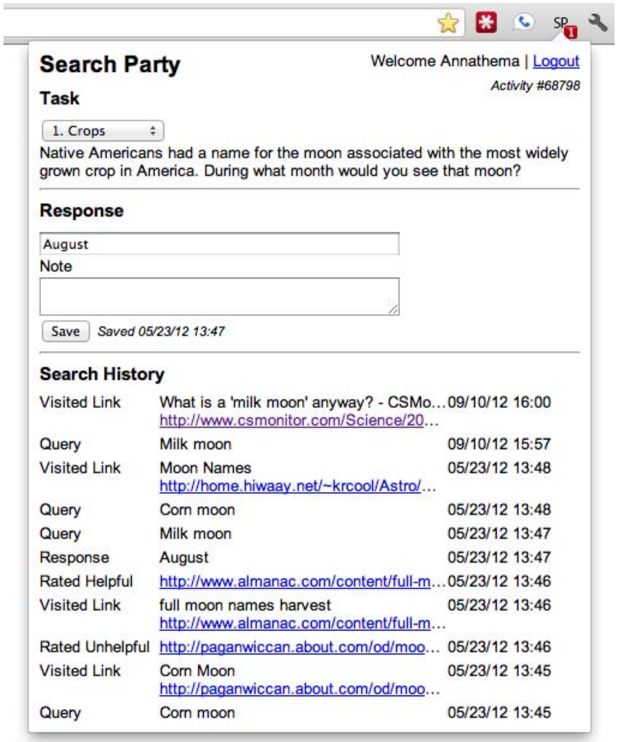

Figure 5. Student view (design #2) shows a Chrome browser plugin with a popup window showing the UI specific to the current activity. Includes the current task, place to provide a response, see search history, and rate helpfulness of a page (not shown here).

showed them information about what other students were doing, and gave them the chance to respond to the question.

Design for Good Behavior

Throughout the system, we designed for simplicity. While we expect the majority of students to exhibit good behavior, we recognized that would not always be the case. Since student activity was being collected and displayed on the shared teacher view, it was important to recognize that if students behaved inappropriately by, for example, searching for pornography, then those searches would appear in the aggregated view. Rather than building a system with real identities, logging, and strict enforcement techniques, we designed around the fact that SearchParty was intended to always be used in a synchronous setting.

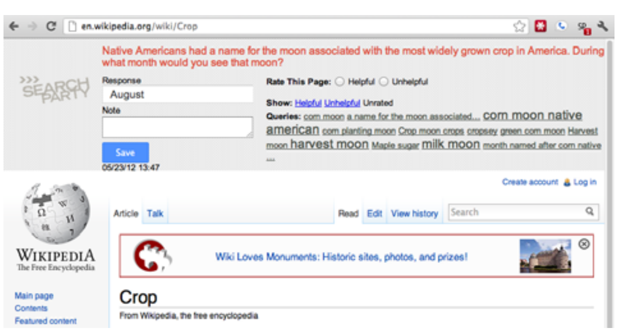

Figure 6. Student view (design #3) shows a custom "banner" UI inserted at the top of every page (in this case above a Wikipedia page).

If a teacher doesn't like what a student is doing, the teacher can simply ask the student with the pseudonym associated with the bad behavior to self-identify. If they don't, the teacher has the ability to log out the offending student. Alternatively, the teacher could require students to use their real names. Even though the technology doesn't support enforcement of this, social norms in a face-to-face setting would make this very likely to be accepted. Finally, given our ability to "push" to a client, we considered implementing an "alert" button, which would enable a teacher to positively identify a student display by, for example, flashing the entire screen and playing a sound. But throughout all of our usage, we never encountered anything beyond simple playful behavior, and so we did not implement the planned "alert" feature.

OBSERVATIONS OF USE

The following sections describe the inquiry and design research methods we adopted for our research.

Methods

We organized a series of nine classes to teach search skills (summarized in Table 1). In each class, a set of technologies was deployed to support peer awareness through activity sharing, chat, shared document, and video chat. One of the three designs of SearchParty was deployed in each class. In these classes, authors taught students Google search skills and facilitated hands-on activities using SearchParty. Students were asked to use SearchParty to apply their search skills to find answers to both assigned questions and their own questions. Search skills were specific Google search operators (e.g., "site:", "OR", and the date range operator) as well as generally-applicable search strategies (e.g., formulating a query based on anticipated common characteristics of results pages for that query). Instruction in classes was delivered using lectures, directed questioning, and hands-on tutoring. We used classrooms of varying configurations to attempt to gain a realistic picture of how people actually search in the context of a classroom environment. Examples of questions are shown in Table 2.

Each class served as an exploratory case study of different class use configurations. The goals of these case studies were to gain an understanding of how people used SearchParty and other deployed technologies to support social learning while accomplishing search tasks. At the same time, they also provided feedback to us about the design of SearchParty, which we iteratively refined for use in the later case studies [10].

We deployed SearchParty in a variety of co-located classroom and online environment configurations. Participants were adults over a broad range of backgrounds, age, geographic location, and technical experience. We employed multiple qualitative methods to attempt to triangulate and gain a broader, more realistic understanding of how technology can support social learning in a range of classroom configurations than would be possible using a single method. We chose direct and participant observation to gain insight into the way students interact with technology and each other in the flipped classroom environments in our cases studies. We chose focus groups to gather a range of perspectives and opinions about students' experiences using technology in the classroom environments in our case studies [10].

In the following sections, we summarize findings for each case study and discuss how they informed the designs of SearchParty. Case studies 1–3 were initial explorations with experts, case studies 4–7 were co-located classes with members of the public, and case studies 8–9 were online gatherings of remote participants. SearchParty design 1 was used for case study 1, design 2 for case studies 2–7, and design 3 for case studies 8–9.

DISCUSSION

Tool to Facilitate Discussions for Social Learning

SearchParty facilitated discussion among the teachers and students with participants in Hangouts. For example, in the final two case studies, teachers and students discussed the implications of using different words with similar meanings—"performance" and "festival"—in their queries. Participants noticed that these two words were being used in queries. One student said, "We found that using the word 'festival' was really helpful. We used the word 'performance' and we were getting [results for] the initial performances in the 1800s, but when we did the word 'festival', that seemed to lead us to more recent results."

The cloud visualization of helpful words used in queries reflects this student's sentiment. The only words rated helpful were variations of "Kleist", "festival", and "berlin". Notably, the word "performance" was not rated helpful.

Case Study	SearchParty Design	Participants	Instruction	Activities
1	SP1 (Google Custom Search)	4 Google interns (3 male, 1 female)	Search activities; peer instruction	(Activity 1) Answer questions collaboratively; look at Teacher Dashboard; talk together; share computers; (Activity 2) answer questions individually; look at Teacher Dashboard; no talking or sharing computers
2	SP2 (Popup)	4 Google Interns (3 male, 1 female)	Search activities; peer instruction	(Activity 1) Answer questions individually; look at Teacher Dashboard; no talking or sharing computers; (Activity 2) Answer questions collaboratively; look at Teacher Dashboard; talk together; share computers
3	SP2 (Popup)	9 Google interns (6 male, 3 female)	Lecture interspersed with search activities; peer instruction	Answer questions individually
4	SP2 (Popup), Google Talk	7 K–12 teachers (all female)	Lecture interspersed with search activities; peer instruction	Answer questions together; Teacher Dashboard; and instant messaging support (Google Talk)
5	SP2 (Popup), Google Doc	9 K–12 teachers (all female)	Search activities; collaboration in pairs	Answer questions in pairs; Teacher Dashboard; and a Google Doc for sharing immediate results
6	SP2 (Popup)	4 K–12 teachers (all female)	Search activities; shared awareness	Answer own questions as group; Teacher Dashboard (added cloud visualizations)
7	SP2 (Popup)	12 participants at public library	Lecture interspersed with search activities	Answer questions individually; Teacher Dashboard
8	SP3 (Banner), Google+ Hangouts	5 remote teachers and educators	Answer own questions as group; Teacher Dashboard; video chat support	Answer own questions as group; Teacher Dashboard; video chat support
9	SP3 (Banner), Google+ Hangouts	5 remote teachers and educators	Answer own questions as group; Teacher Dashboard; video chat support	Answer own questions as group; Teacher Dashboard; video chat support

Table 1. Summary of the 9 classes that served as case studies.

This suggests that the results for queries using "performance" were not as useful as those returned when using "festival". This consistency suggests that when students actively engage in SearchParty, specifically by rating results as helpful, the multiple modes of interaction can support discussion among teachers and students.

Tool to Student Observation and Teacher Introspection
One school librarian felt that SearchParty would be useful for observing student search activity as a basis for providing guidance to them, "As school librarians, this is incredibly helpful, because we could sit in when a class is searching and even if they weren't in the library or we weren't in their classroom, we could do this and either help them or direct them a little bit, or even get informed ourselves—like how are students searching, what would they look for? I mean to us this is really pretty exciting." Another high school librarian agreed with these comments.

One participant thought SearchParty could help gain insight into student thought processes, "… it's hard to look back and when somebody says 'I can't find something'. It's like 'Why can't you just find it?' and having this lets you glimpse into other peoples' searches and see their thinking and I can help redirect and maybe help them become better searchers. I think that being able to redirect and see inside somebody else's head as to why they're not coming up with useful results is excellent."

Tool to Encourage Students to Learn through Reflection
SearchParty allowed teachers to engage students by asking them questions about their activity. For example, in one instance, a facilitator noticed that a student used double quotes in one of their queries and asked the student to explain why they chose to use double quotes in their query. The student explained, "Well, because I wanted … 'resilience' [and] 'activities' together, but I didn't want them to be near each other or not near each other, and I wanted 'sixth' [and] 'grade' to be near each other, not just 'sixth' and then 'grade'." This allowed the student to teach others by explaining her thought process. It also allows teachers to see whether students understand material correctly.

Tool to Crowdsource Learning
In case study 7, one student enthusiastic about SearchParty noticed its potential to leverage crowdsourcing. We observed this phenomenon in case study 8 when one student used her knowledge of the domain related to a question to formulate her query. The facilitator asked her about the words in her query and she explained that it was terminology used in her domain.

For example, one participant noted that work could be distributed among people, "I can see using this in an office ... we've got multiple people looking for different aspects of a plan or a bill or something. [It would be useful] to set up so that we aren't going down ratholes and can find some useful stuff to share."

Tool to Teach Children
As one student (who was a librarian) said, "They always talk about kids being very, very social, and so the whole social aspect of this is really, really interesting, that not only could librarians give input, but could your classmates doing it as well. Sometimes it just takes a quirky kid to come up with a different viewpoint … it just takes that one person. I think that … kids would really, really like this."

Everyone Wants to Be a Teacher, Tech-savvy People Want to Use SearchParty Remotely
In case study 1, participants said that they wanted to be able to explore the Teacher Dashboard on their own computers. They felt that the fact that technology wasn't controlled by them was limiting their ability to leverage the activity of their peers. This seems to be supported by the explicit information requests from the non-native English speaker in case study 2.

Engagement with the Shared Display, Teachers Must Direct Attention to The Display, Teaching Style Matters
In our case studies, we found that most co-located students did not pay attention to the shared display unless their attention was explicitly directed to it, even though it was demonstrated to them and they were engaged with SearchParty on their individual computers.

Students in co-located classes (case studies 1–7) paid virtually no attention to the shared display when not being directed to it—i.e., during a lecture, or during hands-on activities. The single exception was a non-native English speaker who asked for specific information on several occasions (case study 2).

In contrast, participants in online sessions using Hangouts seemed attentive to the Teacher View on the shared display (case studies 8–9). This observation is supported by the numerous comments cited previously.

Example Activity Questions
I want to find activities that kids can do (by themselves) to build "resilience"? – From a student in the second RAFT class.
Locate three American Indian language groups (the Algonquian, the Siouan, and the Iroquoian) on a map. – From one of the participants in the first Hangout case study.
Have there been any recent performances or adaptations of Kleist's plays? Say, in the last 10 years? – From one of the participants in the first Hangout case study.

Table 2. Examples search questions from case study 8. These are authentic questions fielded from participants.

In both co-located and online classes, when features of shared activity were pointed out, students generally took them to be useful—but seemingly only if the student understood why the disclosure was relevant and timely.

The SearchParty Teacher Dashboard helped teachers and students achieve this correct timing. For example, teachers can intervene when a query is formulated with unique words that may be helpful to other students. But students seem to need shared context to understand when and why to share search knowledge. This was especially apparent when we encountered technical problems transmitting audio in our classes using Hangouts.

The most sharing of work happened between pairs of people working together closely (side-by-side)—such as during the collaborative activities in case studies 1–2, 5, and for the two librarians working on a single computer in case study 8.

Differences Between Classes can be Substantial

These findings differ from those found by Moraveji et al. in their research on ClassSearch [15]. ClassSearch is similar to SearchParty in many ways (e.g., both aggregate student activity and show query and site clouds). Moraveji et al. found that the eighth grade students in their field study actively engaged ClassSearch. In our co-located deployments of SearchParty, we consistently encountered difficulty actively engaging students in the shared display. Unless students were explicitly directed to SearchParty on the shared display, they seemed to largely ignore it.

The students that used SearchParty differ from those that used ClassSearch. We taught adults using SearchParty, but ClassSearch was used to teach 6–8 grade students. Moraveji et al. reported that the eighth grade students in their study were actively engaged in ClassSearch.

This may be due to the demographic differences between the participants of SearchParty and ClassSearch. ClassSearch was deployed to middle school students spanning grades 6–8 (ages 11–14) in a suburb of Seattle that were both tech-savvy and regular users of computers. In contrast, our co-located deployments of SearchParty were to Google Interns in conference rooms on the Google Mountain View campus, to K–12 teachers in classrooms at the Resource Area for Teaching (RAFT), and to self-selected adults from the general public in a classroom at the Milbrae Public Library. Our participants were adults spanning a range of diverse backgrounds, a wide age range, and a wide range of tech savviness and regularity of computer use. The environments most similar to a traditional classroom where SearchParty was deployed were public libraries.

Most of the adults in the RAFT and Milbrae Public Library classes did not seem to be tech-savvy. For example, one participant in the RAFT class was confused about the difference between a browser and a search engine. One other participant asked, “Is a browser an app?” In the Milbrae Public Library class, one older adult entered questions directly into Google search and expressed dissatisfaction when a direct answer to the question was not returned by the search engine and did not seem to understand that finding an answer required manual inspection of results on the results pages. This suggests that the adults in our classes may simply be less tech-savvy than the students in the classes studied by Morajevi et al. The lack of attention to the shared display from adults may be because attention was focused on operating the technology rather than the content delivered by the technology. The tech-savvy middle schoolers studied by Moraveji et al. may have had a cognitive surplus that granted them attention to focus on the content delivered by the technology (i.e., ClassSearch) rather than the technology itself.

Competition for Attention Between Displays

Interestingly, the lack of attention to the shared display extended to Google Interns who are highly tech-savvy. Therefore, the shared display was not actively engaging to any of the adults in our co-located classes. In the three classes taught to Google Interns, the lack of engagement with SearchParty may be because they feel confident in their own searching ability. Indeed, in two of these classes, one student engaged the challenges competitively in an attempt to find answers before the other students.

Based on these observations, one hypothesis to explain our observations is that SearchParty is most useful to co-located students who are comfortable enough using the technology platform that it doesn’t demand all of their attention but not so proficient in the content delivered on the platform that they do not find benefit in social learning by observing their peers. In other words, students who are comfortable with the technology platform but unfamiliar with the content delivered by it may benefit from observing their peers. If this is the case, then technology platforms that support peer learning should be designed such that minimal effort is required to understand the platform itself.

Our difficulty actively engaging students may also be due to differences in the affordances of a shared display for teaching the participant matter. ClassSearch was used by a sixth grade teacher and an eighth grade American History teacher. Moraveji et al. stated that the eighth grade teacher did not focus on search expertise during instruction, but do not state whether or not the sixth grade teacher focused on search instruction [15].

In the final two case studies, multiple technologies were used with the online classroom. This added complexity that was not present in prior studies. This additional complexity was needed to establish communication between participants allowing them to broadcast audio and video to one another. Audio consisted primarily of participants speaking to one another. Video was used to both stream themselves speaking and to share screens.

In our online classes, students seemed more engaged in the shared display. One hypothesis is that geographically distributed students engage more because the shared display is part of the technology platform that supports their communication.

The presence and distribution of lectures and activities may also affect student engagement in social learning. Co-located classes that included a lecture to communicate search skills to students interspersed with search challenges designed to test specific search skills presented in the lecture. Classes that included a lecture were carefully designed to provide students scaffolding for specific search skills that search activities were designed to demonstrate. This scaffolding provided guidance unavailable to students in classes without a lecture. Students in lecture-based classes may have had less time to freely think about search challenges and formulate queries through a trial-and-error process than those in classes without a lecture. These students were guided to formulate queries using search skills taught to them immediately prior to the search activity. In contrast, classes without a lecture can allow students more time to freely consider search challenges and try different queries. opportunities to benefit from social learning by observing their peers.

The difference in attention to the shared displays of SearchParty and ClassSearch may also be due to the design of each. While the shared display are conceptually similar, the actual designs are entirely different.

Teaching style also no doubt varied, and could have affected attention to the shared display. We do not know exactly how the teachers of the ClassSearch research introduced the system or how they directed student attention to the shared display. For example, classes that rely heavily on lecture may afford fewer opportunities for students to focus on a shared display and apply their knowledge.

Finally, an additional difference is that ClassSearch was used in a pre-existing cohort while all nine SearchParty classes were with groups that were formed just for the purpose of the class. It is possible that students were more interested in their peer's activities when they had a prior personal relationship with those peers.

FUTURE WORK

This research explored social learning in deployments of SearchParty in classrooms of co-located students as well as geographically distributed students working synchronously. There are numerous trajectories to follow, some of which we outline here.

Support Topics Beyond Search

To date, SearchParty has been used exclusively to aggregate and display student search activity to support the learning of search skills. However, we believe that technologies that support shared awareness of student and classroom activity offer unexplored potential for enabling teachers and students to leverage social learning for a wide variety of domains and activities. We are currently starting to generalize the technology, and look forward to developing student activities and aggregated views to support them.

Integration with MOOCs

We posit that shared awareness of activity can supplement existing tools that support online education. One specific option for future work is to integrate SearchParty with online course delivery systems. While there has been a log of visibility and interest in these massive open online courses (or MOOCs), most systems remain closed. However, Course Builder, the technology built by Google for its Power Searching with Google massive open online course [17] was recently released as open source code, and we are considering integration with it. This would add a new option for students to learn from one another (in addition to technologies such as Google Groups for discussions, Hangout on Air for office hours, and Moderator for fielding questions from students).

Google+ Hangouts

Google+ Hangouts offer a way for students to video and text chat while sharing screens with one another synchronously. This allows geographically distributed students to virtualy form dynamic study groups. In our own studies, we found that the Hangout feature that lets students share their screens, quickly became a rapid way to facilitate collaboration. However, this feature only allows students to show their present activity, does not aggregate the cumulative activity of all students into a single presentation, and requires students to manually select (and deselect) the student activity of interest. We anticipate that something like SearchParty could supplement Hangouts to provide that missing functionality.

CONCLUSION

Our goal is to develop SearchParty into a lightweight tool to support collaboration and social learning in a variety of environments—in particular flipped classrooms and other environments that encourage hands-on participation and collaboration. Our case studies of SearchParty and Google+ Hangouts suggest that SearchParty can be an effective way to support shared awareness and social learning in online environments. In particular, our cases suggest that video chat and screen sharing can supplement activity sharing as a way to establish a shared awareness of activity. These technologies are mutually beneficial. One consideration for future work is a tool for supporting formation of dynamic study groups to support social learning in MOOCs. Such a tool would enable geographically distributed students to help each other learn by discussing and collaboratively resolving their own questions.

REFERENCES

1. Bederson, B. B., Quinn, A. J. and Rose, A. SearchParty: Learning to Search in a Web-Based Classroom (Short Paper) at Educational Interfaces, Software, and Technology (EIST) 2012. https://sites.google.com/site/eist2012/home/program.

2. Brown, J. S., Duguid, P. 1989. Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.
3. Course Builder. https://code.google.com/p/course-builder/.
4. Gerald C. Gannod, Janet E. Burge, and Michael T. Helmick. 2008. Using the inverted classroom to teach software engineering. In Proceedings of the 30th international conference on Software engineering (ICSE '08). ACM, New York, NY, USA, 777-786. DOI=10.1145/1368088.1368198 http://doi.acm.org/10.1145/1368088.1368198
5. A Google a Day. http://www.agoogleaday.com/.
6. Google App Engine. https://appengine.google.com/.
7. Introduction to Artificial Intelligence. https://www.ai-class.com/.
8. Johnson, M., Teaching the World to Search. http://googleresearch.blogspot.com/2012/08/teaching-world-to-search.html.
9. Lage, M. J., Platt, G. J., Treglia, M. Inverting the Classroom: A Gateway to Creating an Inclusive Learning Environment. Journal of Economic Education, 31(1):30–43, Winter 2000.
10. Lazar, J., Feng, J. H., Hochheiser, H. 2010. Research Methods in Human-Computer Interaction. John Wiley and Sons, Ltd., Chichester, West Sussex, UK.
11. Medlock, M. C., Wixon, D., Terrano, M., Romero, R., and Fulton, B. (2002). Using the RITE Method to improve products: a definition and a case study. In Usability Professionals Association (Citeseer), 1-23.
12. MITx. http://mitx.mit.edu/.
13. Moravec, M., Williams, A., Aguilar-Roca, N., O'Dowd, D. K. (2010). Learn before lecture: a strategy that improves learning outcomes in a large introductory biology class. CBE Life Science Education 9, 473–481. doi:10.1187/cbe.10.
14. Morris, M. and Horvitz, E. (2007) SearchTogether: an interface for collaborative web search, in Proceedings of Conference on User Interface Science and Technology (UIST 2007) , ACM Press, New York, 3–12.
15. Moraveji, N., Morris, M., Morris, D., Czerwinski, M., and Riche, N. H. 2011. ClassSearch: facilitating the development of web search skills through social learning. In Proceedings of the 2011 annual conference on Human factors in computing systems (CHI '11). ACM, New York, NY, USA, 1797-1806. DOI=10.1145/1978942.1979203 http://doi.acm.org/10.1145/1978942.1979203
16. Piazza. http://www.piazza.com/.
17. Power Search with Google. http://www.powersearchingwithgoogle.com/.
18. SearchReSearch. http://searchresearch1.blogspot.com/.
19. Shneiderman, B., Borkowski, E., Alavi, M., Norman, K. (1998) Emergent Patterns of Teaching/Learning in Electronic Classrooms Educational Technology Research and Development 46, 4, pp. 23-42.
20. Socrative. http://socrative.com/.
21. U.S. Children's Online Privacy Protection Act of 1998. 1998. http://www.ftc.gov/ogc/coppa1.htm.
22. Wagner, E. D. 1997. Interactivity: From agents to outcomes. In T. E. Cyrs (Ed.), *Teaching and learning at a distance: What it takes to effectively design, deliver, and evaluate programs* (pp. 19-32). San Francisco: Jossey-Bass Publishers.
23. Wood, W. B., Tanner, K. D. 2012. The role of the lecturer as tutor: doing what effective tutors do in a large lecture class. In CBE Life Science Educaton, 11(1):3–9, March 20, 2012.