Lessons from ThoughtSwap-ing: Increasing Participants' Coordinative Agency in Facilitated Discussions

Margaret Dickey-Kurdziolek, Matthew Schaefer, Deborah Tatar
Virginia Tech
Department of Computer Science
{mdickey, mschaefer, tatar}@vt.edu

Ian P. Renga
University of Colorado at Boulder
School of Education
ianrenga@post.harvard.edu

ABSTRACT
A successful collaborative tool designed to aid discussion must be flexible, maintain the user's *coordinative agency*, and be appropriable in many contexts. We have developed a tool, called *ThoughtSwap*, to help widen and deepen the scope of participation in facilitated discussions while supporting, not supplanting, discussants' coordination. By driving the design of ThoughtSwap toward a simpler mechanism, we were able to create a more versatile, high-impact tool. We design for an educational setting, but see wider possible use.

Author Keywords
CSCW, CSCL, coordinative agency, collocated discussion, classroom discussion

ACM Classification Keywords
H.5.3 [Group and Organization Interfaces]: Computer-supported cooperative work

General Terms
Experimentation, Human Factors

INTRODUCTION
It goes without saying that discussion is one of the most universally used and powerful tools for shaping thought—that is, learning—and can be observed in classes and meetings of all types. Facilitators endeavor to guide and shape discussions to ensure that participants are grappling with the issues at hand and still feel safe enough to contribute their thoughts and drive discussion. Educators also do this in the context of the classroom. Providing a useful capsulization of an educator's facilitative goals, Kegan writes, "people grow best where they continuously experience an ingenious blend of support and challenge" [16, p. 42]. This conception is tied to the notion that learning is an *action* [8, 21], a concept relevant to the workplace as well as to classrooms.

CSCW 2010, February 6-10, 2010, Savannah, Georgia, USA.

However, despite facilitators' positive intentions, inspiring fruitful discussions can be difficult. In particular, fear of ridicule, self-consciousness, and time pressure can all stop participation, especially by students [8, 9, 22]. Attempts have been made to scaffold discussion through facilitative procedures such as brainstorming, through technologies, and sometimes both, stretching back to Colab [28, 31] and IBIS [25]. However, while brainstorming is widely used as a method of idea generation, there is less work on how groups can deepen ideas. In particular, technologies that facilitate this important aspect of learning have not yet become popular in the course of classroom teaching. Yet attempts continue, in part because the issue is so important. In one recent study, [12], researchers developed a system that measured participants' amount of speech and presented this information to the participants on a shared display. They found that this system did affect how students participated in the discussion, but it did so differently for the "over-participators" compared to the "under-participators." The over-participators moderated their behavior as the researchers hoped, by decreasing the amount they spoke and encouraging other students to participate more. However, the under-participators did not react to the system by contributing more. Instead, the under-participators felt that the system did not accurately assess the amount they contributed. According to the authors, this was because "under-participators are unaware of their lower level of participation, while over participators are overly aware of their higher participation" [12, p. 621]. This result is consistent with Beenen et. al's work using social psychology theories to promote participation in online communities. They found that users who were reminded of the uniqueness of their contributions and the benefits of contributing were more likely to participate than users who were asked to contribute a certain number of times [1].

Yet, arguably, the particular practices of *in-class discussion* originate from conversation, relying on the strengths and skills that people bring to coordinated activities in everyday life [7]. Although people might, in everyday life, think that one person talks too much and another too little, they do not make these judgments based on absolute number of words, but on a variety of issues, including the nature of the discussion. If people in conversation seek to understand one another *well enough for current purposes* [5, 7, 6, 27], then the goal of educating through discussion will be best met by making the perceived current purposes of the participants deeper and more inclusive.

We hypothesize that new kinds of in-class discussion genres can be created, using technology as an aid in framing expectations and providing mechanisms for deeper, more inclusive in-class discussions. One component to encouraging participation is removing obstacles, such as social intimidation and time pressure. A second component is to make the invitation to participate very strong. Of course, if these components undermine fundamental coordinative requirements of the situation, they will not work [31].

We have developed a tool, called *ThoughtSwap*, to help widen the scope of participation while maintaining coordination in in-class discussion. This is done by (1) providing sufficient time for individual reflection, (2) creating a feeling of safety through anonymity, (3) requiring at least minimal participation from each person, and (4) giving people the obligation of *re-presenting* other people's ideas. ThoughtSwap was developed using a design-based research method, in which we prototyped, evaluated, and redesigned the system while developing relationships with target users [2, 14]. Users of ThoughtSwap are pushed but not forced to contribute and encouraged to confront ideas that are not necessarily their own.

In any type of discussion, whether it is facilitated, unfacilitated, in classrooms, or in the workplace, the trajectory is negotiated between the participants. The question of "who goes next" at any point in time, arguably, structures the use of language [26]. Discussions are by nature dynamic. In successful discussions, participants have the means or instrumentality to coordinate and adjust the activity to meet their needs. In other words, discussion participants must possess *coordinative agency*. In this paper, we will discuss how users influenced ThoughtSwap evolution from more to less complexity. In particular, we moved coordinative agency along the spectrum from the system to the discussants.

In moving coordinative agency, we employ features recognizable from a variety of other commonly available tools, such as wikis, shared document editors, online forums, and instant messaging. Yet, we argue that details of precisely how and when people can make contributions play a crucial role in determining the fit of the tool to the genre and learning goal. While many of the user behaviors *can be done* with many of the tools, in the sense that there are features that support the particular functions, the *balance* between the goals of the face-to-face discussion, gleaning user contributions, incorporating them to deepen and widen on-going discussion, is particularly supported. The issue is partially one of design tensions [29], and partially one of creating foci for joint participation [13].

FIRST ROUND OF THOUGHTSWAP DESIGN

ThoughtSwap originated from a face-to-face activity conducted in one of the author's middle-school English classes. In this, students would write question/answer pairs on paper, tear them apart, crumple them up and throw them into the air. Each person would then pick up two pieces of paper, and the collective job of the class was to put questions and answers together. Ideally, the questions were open-ended, thought-provoking, controversial, or involve debatable answers. The corresponding answer might represent the author's own position, or suggest an alternative viable response. Students could observe whether other people could understand the questions and answers that they had written.

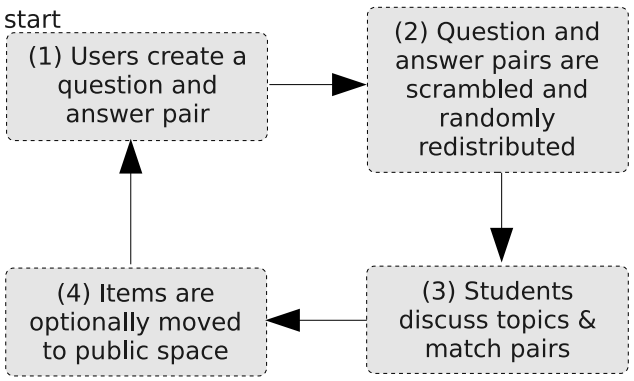

Figure 1. Cyclical model for ThoughtSwap v.1 activity

ThoughtSwap v.1 Activity

The original ThoughtSwap v.1 discussion activity was implemented in a manner consistent with this face-to-face practice. It consisted of an arbitrary number of rounds of play, subdivided into a small sequence of stages (Figure 1). In the first stage, students were asked to produce a question and answer pair about the discussion topic. Student contributions were, as in the original, anonymous. In the second stage, the participants used the software to randomly swap pair elements. In the third stage of the activity, participants received a random set of two questions, two answers, or a combination of the two, written by other members of the group. Last, the group employed the questions and answers in a discussion, one goal of which was to "match" the randomized questions with their potential answers. *The key component to contributing to the discussion was that each person had to talk about, or re-represent, the swapped items under their purview.*

ThoughtSwap v.1 Implementation

ThoughtSwap v.1 was a Java application designed to run on wirelessly connected notebook computers and utilized TSpaces [20]. ThoughtSwap v.1 operated on each group member's own system, connected to a central TSpaces server. The process for generating question/answer pairs described above was embedded into ThoughtSwap v.1's interface. The stages of the activity were established through a handful of GUI items on a single window (Figure 2) and encouraged by four design elements.

From Private to Public

Working in a private space to develop questions and answers provides users an ability to craft their contributions, without the time pressure of producing an out-loud comment or fear that others will see half-finished thoughts as they are developed and edited. The private space affords a safe place for reflection. Although Colab made this claim for the value

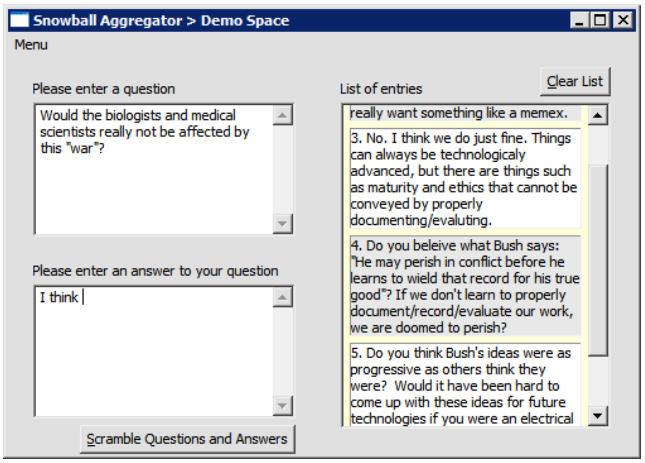

Figure 2. ThoughtSwap v.1 interface

of privacy long-ago and demonstrated problems with maintaining joint focus while users privately published to public spaces [31], recent work has suggested that private and public group activities can be successfully managed when there is a focus on bringing the group together [32].

The ThoughtSwap v.1 window can be divided down the middle into two horizontal halves—the left half of the window, which contains two text boxes, is the "private" side, and the right half, which contains a list, is the "public" side. During the first stage of the activity, participants entered their questions and corresponding answers into the text boxes on the private half. They then pressed a button to share their contributions, which were subsequently "swapped," effectively "tossing" the items into a metaphorical "hat." When the group determined that all of its members had entered their contributions, each person pressed a button which effectively "grabbed" two random anonymous contributions from the hat. The swapped items were displayed on the private half of the screen.

During the discussion, users could publicly share either or both of the contributions grabbed from the hat by adding one of the questions or answers to the public list (located on the right side of the screen). This list served as a shared resource for the group: all could add to, re-organize, or clear the list. The linear nature of the list, the explicit introduction of items as topics for discussion, and the presence of a facilitator made the movement from private to public a joint focus.

Anonymity

More recently, technology tools, including student response systems and electronic message boards, use anonymity to promote participation. However, while anonymity in collaborative systems has been problematic (or at least not clearly beneficial) in some domains of collaborative work (e.g., Group Decision Support Systems (GDSS) [23]), it has shown much promise in classrooms which utilize Student Response Systems (SRS) to increase student feedback and aide instructors in gauging students' understanding of course materials. Penuel and his colleagues argue that, by removing identifying information from expressed thoughts, individuals are relieved of social pressures involved in contributing to discussions [22]. Davis also suggests that the subtraction of identity inherent in anonymity may provide a positive benefit by adding to students' private space, giving students room to work through difficulties and "share their nascent ideas without fear of ridicule" [9, p. 162]. The correlate of private space in developmental psychology is the holding environment: a safe space in which a person can maintain the integrity of their current way of seeing and acting in the world while trying out new ways [15, p. 116] [34].

In ThoughtSwap, questions and answers are initially created in a private space, and then randomly distributed to others within the group. The author's identity is protected by the system. However, students can claim authorship out loud.

Student Questioning

Student construction of questions and answers is important because it builds on the fundamental idea that generating and providing elaborated responses to questions increases understanding and the construction of knowledge in groups [17, 18, 33]. Students tend not to ask questions in class sessions [11], but, if they create their own questions (as opposed to merely addressing those of an instructor or discussion leader), they are more likely to address their own misunderstandings or knowledge gaps in the material. Furthermore, as individuals construct their own elaborated responses to questions, they are likely to employ their own learning style and previous experiences to reconstruct their own knowledge in explanation to the others in the group, deepening their own understanding and making the knowledge more memorable [18].

Verbalizing the Ideas of Others

Perhaps the most interesting learning and social dynamic ThoughtSwap can create is that in which discussion group members propose (or at least verbalize) the ideas of others, without knowing to whom those ideas belong. For example, student A writes a question which student B receives anonymously and randomly. In discussion, student B poses student A's question to the group. Not only does this relax some of the social pressure on student A, but student B can participate in the discussion without fear of direct criticism, because the group knows that the question she is proposing is not her own. Furthermore, she can add her own commentary to the contribution. This creates an interesting interdependence between group members.

EXISTING COLLABORATIVE TOOLS

The ThoughtSwap activity is built around randomly swapping textual contributions for provocation of discussion. Thus, in designing the ThoughtSwap implementation, we worked under several coordinative requirements. First, we wanted participants to construct contributions in a private space, independent of the contributions of others. Second, participants had to exchange them randomly. Third, participants had to be able to maintain meaningful focus during the discussion, especially during the introduction of the ideas.

To accomplish these last goals, public participant contributions had to have referential integrity.

To create a reference point for understanding the coordinative properties of ThoughtSwap, this section describes the landscape of other familiar collaborative tools. ThoughtSwap does not exist in full isolation from any of these systems and benefits from many of them. However, none of these systems fill the precise niche occupied by ThoughtSwap. Table lists several systems and their properties in terms of the unit of user control, the stability of content, the content organization mechanisms, and the level of synchrony between users and the content they create.

Shared document editors and wikis

Currently, perhaps the two most relevant tools used for coordinating information exchange in group contexts are wikis and shared document editors like Google Docs. In Google Docs (docs.google.com), the object unit with which users interact is the document. The system maintains the most recent version of the document on a central server, and when users make modifications, those changes are submitted to the server, then propagated to the other collaborators [10]. The system tries to create a sense that all authors are working on the most up-to-date copy at all times. However, in fact, it is often what Clark called "nearly-synchronous" [5], with changes taking as long as ten to twenty seconds to propagate, depending on the network connection speed. To avoid conflict, the users must establish their own mechanisms of coordinating the editing process *outside of the system*. An additional drawback of Google Docs for our purposes are the document-level editing capabilities of the users. Any user can modify any portion of the document to which he has write privileges. Thus, we lose the notion of stable, focussed content for discussion.

Wikis, like shared document editors, lack content stability. While this design decision is clearly important to wiki communities, it does not provide referential integrity to discussion materials. As with Google Docs, users can "step on each others' feet," so to speak. While functionality varies between systems, in pbwiki (pbwiki.com), for example, one author can create a new section of wiki page while another also creates a new section on the same page. The author which posts the change last will overwrite the content created by the first. Unless appropriate coordination techniques are employed by the wiki authors, these conflicts may result in process loss and poor page quality [19]. This is a symptom of the unit of user control at the page or page section level and is undesirable in the context of a face-to-face discussion, where the topic can evolve quickly and participants can contribute rapidly within small time frames.

Shared document editors and wikis have been designed for the purpose of *dividing work* so users can create one lasting, shared, collection of knowledge. In contrast, ThoughtSwap is being designed to *bring users together* and focus on a collection of individual, ephemeral, contributions.

Online forums and IM

While shared document editors and wikis allow entire documents to be modified by users at once, online forums provide a much more limited unit of control for their users: the post. In an online forum, a post is somewhat analogous to a single unit of contribution in ThoughtSwap. Forums can also be configured for anonymous user submissions. However, forums are predominately hierarchical and meant to facilitate threaded discussion through explicit replies, directly supported by the system. This kind of structure is not necessarily desirable in face-to-face discussion, particularly in the context of ThoughtSwap where the tool is not meant to replace discussion or mediate it, but to *augment* it in the moment.

Swapping textual contributions in ThoughtSwap also bears resemblance to variations of instant messaging (IM) functionality. Unlike online forums, IM systems update in real-time on a "push" model. (In other words, content is *pushed* down to the users' machines instead of being *pulled* or periodically *polled* like a traditional web page or forum.) Yet, like forums, IM systems are typically strictly dialogic in nature and users' individual contributions usually only make sense in their original order; also, users cannot usually rearrange the conversation entries, even if it made sense to do so.

The most interesting coordinative process introduced by ThoughtSwap is the movement of contributions from private composition, to shared private contemplation after they are swapped and distributed, to public attention. The simple mechanism of randomly distributing anonymous textual entries with content stability would be hard to simulate using other popular collaboration tools. ThoughtSwap attempts to fit a niche unfulfilled by them.

FIRST EVALUATION OF THOUGHTSWAP V.1

Taking a design-based research approach [2, 14], we decided to evaluate ThoughtSwap v.1 in different contexts. To evaluate the system in a leaderless group, we recruited graduate students to participate in a discussion of Vannevar Bush's seminal article "As We May Think" [4]. This article was chosen because it is widely read in several fields. Participants were asked to read the paper and sign-up for one of two reading group sessions, just as they would for any other reading group. A third session with ThoughtSwap was conducted in the more formal, moderated context of a graduate-level computer science (CS) seminar. The students in this session read the normally-assigned texts for the class meeting.

Procedure and Data Collected

Participants in both the reading groups and seminar used the ThoughtSwap v.1 software either on their own laptops, or on machines provided by the researchers. The researchers demonstrated the software functionality and made sure that everyone had a working version. Participants were asked to create question and answer pairs, enter them into ThoughtSwap, and discuss the paper in the manner of their choosing. In the informal reading groups, the discussion was stopped

System	Unit of User Actions	Stability of Content	Content Organization	Synchrony and Data Delivery
ThoughtSwap	generate and share thought items	all thought item content stable; list can be sorted by any user	items are independent; can be combined linearly in public list	nearly-synchronous, push (grab from hat similar to pull)
Google Docs	compose and edit document text	all content unstable; editable by collaborators	linear text in single document	nearly-synchronous, push
Wikis	compose and edit pages, sections, elements of page	most content unstable; admin. can lock	pages, linear text, sections, hypertext	asynchronous, pull
Online Forums	compose and share post, create and apply tags	most content stable; some content editable by author, admin. can filter/remove	linear hierarchy of posts	asynchronous, pull
Instant Messaging (IM)	compose and send statements	all content stable	fixed, linear list of comments	nearly-synchronous, push
Email	compose and send message	all content stable	messages, linear text, can be organized by properties in clients	asynchronous, push/pull

Table 1. Conventional collaborative systems and their content and coordination properties

after 45 minutes. The seminar class lasted roughly $1\frac{1}{2}$ hours. Participants completed a demographic questionnaire before the discussion and an evaluation questionnaire afterwards. Video and audio of the discussion were recorded, and logs from their use of ThoughtSwap were kept.

Participant Demographics

A total of 21 participants were split between three discussion groups (Table 2). Graduate student participants were from CS (12), science and technology studies (2), sociology (1), and philosophy (1). The remaining 5 participants were faculty members who regularly attended the graduate seminar. All participants from the two reading groups indicated that they had read the paper as had 8 out of 10 participants in the seminar session. Two of the participants in Group 3 had also participated in a previous session (one in Group 1, and the other in Group 2), so this group had more collective experience.

Table 2. Number of participants in each discussion group (N=21)

Group	Type	# of participants	minutes
1	leaderless group	4	45
2	leaderless group	7	45
3	seminar class	10	90

Results of First Evaluation

Participant Responses

In the post-discussion questionnaire we asked our participants to elaborate about what they thought went well and went poorly during their discussion, as well as what they thought about the ThoughtSwap software.

Many participants (13/21) had suggestions for improving ThoughtSwap. All of the comments suggested features to be *added* to the software, such as allowing the user to edit the questions once they have been added to the list, allowing the user to delete or "check-off" individual questions or answers in the list that have been discussed, and providing a visualization that could help participants assess when it is okay to "grab" questions and answers from the "hat."

Six participants spontaneously mentioned the anonymity of the ThoughtSwap activity. Four said that anonymous submission of questions and answers was the best part of using ThoughtSwap. As one participant put it, "[ThoughtSwap] gave us a way to give our questions and opinions without having to own them—like taking them for a test drive before admitting that they were yours." However, one participant thought there was room in the ThoughtSwap software to add even more anonymous submission of ideas: "I didn't like that I couldn't write anything in the dialogue box to contribute anonymously. That was annoying because there were times I wanted to say something (or did and it got ignored) and think it might have been better received if I could anonymously post."

Also, 15/21 participants commented on the Q/A swapping activity itself, mostly positively. One participant felt that the activity "let questions get put out there that would normally not be asked" and another participant felt that the structure of the activity "helped to refocus the conversation when it got off track or when we ran out of content." However, there were a few participants (5/21) who did not like all aspects of the activity. One of these enjoyed generating questions about the material, but said, "I didn't think that having answers was valuable. I don't feel like we actually discussed the answers." Another participant said, "it was frustrating if I had an idea I wanted to talk about that didn't fit into a question/answer form easily."

Observations

Group 1 played 2 rounds of the Q/A activity during their 45 minute discussion session. They started by entering Q/A pairs into ThoughtSwap, and once they had retrieved two questions or answers from the system, they had a brief dis-

cussion on how to best match the questions with their answers. They then decided to bypass the second phase and move all questions and answers into the public list so they could read them all at once. As the group was reading over the accumulated list of questions and answers, one participant posed a question that was not on the list: "do you think he really predicted the internet? or just hyperlinks?" The group then began to discuss the nature of Bush's predictions and how they were reflected in Internet technology. They did not return to the ThoughtSwap system again until 30 minutes into the session. At that point, one group member said, "you want to try to come up with more provocative questions to discuss?" In their second round, this group again decided to move all of their Q/A pairs to the public list. One of the participants read a question on the list aloud, and then asked a clarifying question to the group, "Do you know if they had scientific calculators back then?" The group finished the discussion period while conversing about when scientific calculators were first developed and whether Vannevar Bush would have known about scientific calculators when he wrote the article.

Group 2 also played two rounds of the Q/A activity; however, their conversation was more heavily guided by the questions and answers submitted to ThoughtSwap. After Group 2 swapped Q/A pairs, they decided to take turns reading a question aloud and putting the question into the public list. At that point, other group members would discuss a possible answer match they had on the private side of their ThoughtSwap screen. Once the Q/A pair had been briefly discussed, they would move on to another question. Occasionally, (in 3 out of 7 questions) a participant would suggest alternative answers that were not previously submitted into ThoughtSwap. This process continued until they had discussed each Q/A pair, roughly 30 minutes into the discussion session. At that point, one of the group members had a suggestion, "how about this time, instead of putting in questions we put in our own predictions for the future and swap those?" The group discussed the possible alternative activity, but decided to return to the previous Q/A activity because they could not determine exactly how to make the proposed activity work in the ThoughtSwap v.1 system.

Group 3 only played one round of the Q/A activity. The class started with one graduate student giving a presentation summarizing the literature the class had jointly read. The presenter had her laptop connected to an overhead projector, which she turned off while she entered her Q/A pair into ThoughtSwap, and turned back on again once she was finished. Unfortunately, some of the participants had difficulty connecting to the wireless internet after everyone had entered their Q/A pairs. The instructor therefore suggested that everyone who could access ThoughtSwap move their questions to the public list so that they could be viewed on the overhead projector. The remaining time was spent discussing the questions placed in the public list, while the answers were moved to the bottom of the list and not discussed.

Reflections from first evaluation

The goal of classroom discussions may be to reach an understanding or to share and evaluate a set of ideas. Teachers will often have their own goals for discussion and methods for meeting those goals. Yet students may steer the discussion in unanticipated directions. Similar to "playground games" and "mock games," these different forces driving "what happens next" are negotiated [3, 30]. Classroom discussions, like playground games, may start with some set of "rules" or a plan, but ultimately the plan may be altered and negotiated during the course of the activity. The discussion participants determine what questions to pose, which points to debate, and when the discussion should move on to another point.

Participants in ThoughtSwap v.1 study sought to discuss and deepen their understanding of literature they had jointly read, and the plan for the discussion was encapsulated within ThoughtSwap v.1's design. While ThoughtSwap v.1 was largely well-received by our participants, there were a few situations in which users wanted to participate in ways that the system did not allow. For example, there were moments when participants wanted to contribute anonymously to the system, but at that moment starting a new round of the question/answer activity would steer the discussion astray.

We concluded that ThoughtSwap v.1 encapsulated too much of the coordinative process and limited the participants' capacity to steer the discussion. While the system was designed to deepen discussion engagement and learning, it in fact limited the possibilities. As Dwyer and Suthers point out, when collaborative systems are designed with the "single tool = single meaning" paradigm, they limit the possible activities that participants can engage in [13, p.143]. In our terms, systems that rigidly encapsulate a process or plan limit the participants' coordinative agency.

SYSTEM REDESIGN

In ThoughSwap v.2, we sought to make a more simple and flexible mechanism that supported the sharing of ideas during face-to-face discussions. Following Dwyer and Suther's [13, p.143] call to develop more "flexible tools that support creative combination and repurposing," instead of adding more elements to the system we took a *zensign* approach, eliminating and omitting elements that would limit participant involvement [30]. We removed the stages of the question and answer activity embedded into the first version. The resulting ThoughtSwap v.2 kept the elements of the process but jettisoned the controls on stages. In ThoughtSwap v.2, users can enter thoughts and throw them into the "hat" at any time. Likewise, at any time, users can "grab" thoughts from the hat, optionally adding them to the shared list. The software became more lightweight; instead of structuring a discussion activity, it served as a simple (yet potentially powerful) tool for anonymously distributing ideas to different individuals.

Design Changes

In ThoughtSwap v.2, the first interaction students have is when they enter a thought into the text box on the private half of the window. Once finished, they then press the "Throw

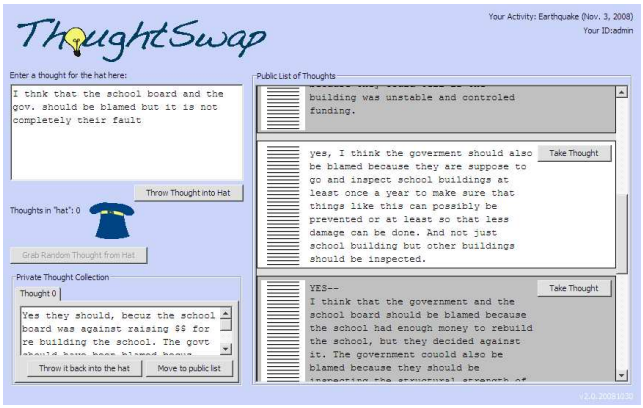

Figure 3. ThoughtSwap v.2 applet interface

Thought into Hat" button, which tosses their thought in the metaphorical "hat." When the group determines that all of its members have entered a contribution, each user presses the "Grab Random Thought from Hat" button, which effectively "grabs" one random, anonymous contribution from the hat. The swapped thought is then displayed to the participant on the private half of the screen in their "Private Thought Collection." Depending on the activity, students can throw any number of thoughts into the hat, and can equally hold any number in their private thought collection.

At any point during the discussion, users can publicly share thoughts from their collection by moving them to the public list on the right side of the screen. As in the first version, this list serves as a shared resource for the group—all can add to, re-organize, or clear the list. It is intended to be a resource for referencing and organizing ideas during discussion.

The new interface is relatively simple, and merely provides a few mechanisms—namely, idea aggregation, swapping, and a shared display. However, these mechanisms still promote the four design elements that were essential to ThoughtSwap v.1: private composition, anonymous contribution, requirement of minimal participation, and the obligation of re-presenting another's ideas. ThoughtSwap v.2 was implemented as a Java applet, eliminating the need for installation and setup, and facilitating instructors who need to move quickly between different activities with as little disruption as possible.

EVALUATION OF THOUGHTSWAP V.2

For our evaluation of ThoughtSwap v.2 we recruited a local middle school science teacher named "Mr. R." About once a month, he gives his 6th and 7th grade students articles about current events that relate to science, and assigns them a reading response. This assignment is always accompanied by an in-class discussion regarding the article and students' reactions to it. After seeing a demo of ThoughtSwap, Mr. R brainstormed a list of ways he could incorporate the tool into his monthly class discussions. In the following sections we will briefly outline Mr. R's plans and learning goals for his students, our observations of his classroom, and a subsequent interview with Mr. R. (After we conducted our observations and interviewed him, Mr. R was invited to join the ThoughtSwap design team and contributed to this paper.)

One of the many goals for teachers of early-adolescents, such as Mr. R, is to encourage their students to take perspectives, or make bridges between their ideas and those of their peers, parents, and the various media they are exposed to. Mr. R noted that this struggle is evident when listening to a typical discussion between his students. "When someone expresses a viewpoint that they can relate to," he noted, "each student tends to share his or her experience with the topic rather than directly acknowledging the person who expressed the viewpoint." We (a) envisioned ThoughtSwap facilitating this bridging and (b) could not rule out the relevance of bridging to all adult discussions.

First Session—6th Grade Science Class

Activity Plan—Cooling the Lava

During the first of our two pilot sessions, Mr. R's 6th grade science class was asked to discuss a previously completed homework assignment. Their task was to consider the decision of a harbor town in Iceland to stop a lava flow from demolishing the town by spraying it with water. After reading an article about the decision, they were to generate and write down two reasons why it was wise to stop the lava, two reasons why it was unwise, and then choose one position with two supporting points.

The plan was to use ThoughtSwap in three rounds, all led by Mr. R. First, students were to create a thought item in the software, indicating their best reason in favor of cooling the lava. These items were to be thrown into the hat, swapped amongst the students, and compiled on the public list. Then, the students were to go around the room and one-by-one, move a single thought item so it was close to a similar thought on the list. This would create aggregated groupings and topics for discussion about the arguments, comparing and contrasting them. This process was to be repeated; only the second time students were to enter their best argument against cooling the lava. We called these activities, "aggregating activities."

The aggregating activities were to be followed by a round in which students were to enter a thought into the software in which they adopted a position and provided their best supporting reason for that position. They would then swap thoughts and explain and comment on the random thought item they received—re-presenting the ideas of others. Mr. R termed these activities, "individual focus activities," since the students would focus on whatever single thought was in their private space.

Observation

All 11 6th grade students were present in class during the Cooling the Lava session (5 females, 6 males). They, along with Mr. R and two of the authors were in the school's computer lab—a small room with nine desktop computers on tables located along three walls. Two students used laptops on a table against the fourth wall.

During the first aggregation activity, the students entered their "pro" arguments as planned. After everyone was done, they pulled the thoughts out of the hat and moved them into the public list. Mr. R then asked students, one at a time, to move one of the thoughts so it was close to another with a similar theme. This was repeated for a short while until Mr. R felt they were using too much time, and improvised, asking all of the students to simultaneously sort the list according to similarity. He added a game-like quality to the activity by telling the students that they were not able to talk to accomplish the task. Many students let out exasperated sighs, giggles, and one student even expressed her frustration by saying, "Stop moving those ones! I was moving mine to be in that group." After less than a minute of the sorting activity, one student said, "I think we have them pretty much sorted." Mr. R then redirected the class to talk about some of the common themes they found and moved to the white board so he could note the categories and the number of responses in each. The students said that 6 of the responses that were entered in to ThoughtSwap fell into an "economic reasons" category, while the remaining 5 responses fell into the "cooling lava strategy actually worked" category.

This aggregation activity was repeated, but this time the students entered their "con" reasons. Unfortunately, as the last students were submitting their thought items, the software locked up due to a server issue. While the researchers worked to remedy the problem, Mr. R improvised and continued the activity by asking students to predict the categories of reasons to not cool the lava. Each of the 11 students raised their hand during the activity, and Mr. R called on them individually to contributed a possible "con" argument category aloud to the class. Mr. R then paraphrased and recorded the categories on the whiteboard. The students brainstormed four different categories of "con" reasons, including the cost of materials, the amount of time citizens had to spend spraying the lava, the danger in getting close to the lava, and the possibility that this natural disaster may happen again. He then asked the students to individually share their positions on the topic, and to consider if their position was the same or different from those already presented.

While the technology problem was unfortunate, it provided a way for the observers and Mr. R to compare how the class discussion proceeded with ThoughtSwap and without. While the students were organizing the "pro" arguments with the ThoughtSwap software, each student read the other students' responses and considered how the "pro" reasons were related and could be categorized more generally. When the students were asked to predict what categories they would have for the "con" arguments, each student raised their hand and when called on expressed their own con argument. Mr. R then had to categorize the responses as they were said aloud, and indicate this on the white board.

Second Session—7th Grade Science Class

Activity Plan: the Earthquake Activity

During the second of our sessions, Mr. R's 7th grade science class was asked to discuss a reading assignment regarding the then recent earthquakes in Sichuan Province, China. The students were asked to read two articles regarding the earthquakes, on focusing on the collapse of school with questionable building integrity. In the article, a parent is quoted as saying, "this was 20% natural disaster and 80% man-made disaster" [24]. The students were asked to interpret the quote, and take a position on who, if anyone, should be blamed for the school's collapse.

Mr. R planned to start the session by calling on volunteers to briefly discuss some facts about the earthquakes, such as their location, their magnitude, and what fault line they followed. Then Mr. R would ask students to put their interpretations of the parent's quote into ThoughtSwap and aggregate them into the public space. Finally, Mr. R planned to have students enter their position on who should be blamed for the school's collapse into ThoughtSwap, and draw one peer's position from the hat. He would ask the students to read their peer's thought, consider it in relationship to their own position, and report back to the class what they felt, again, re-presenting the ideas of others.

Observation

Similarly to the 6th grade class, there were 11 students in the 7th grade class (5 female and 6 male); they were situated in the same computer lab. Mr. R started the class by reviewing the assignment questions and asking students to volunteer facts about the earthquakes.

As planned, Mr. R then asked his students to enter their interpretations of the parent's quote into ThoughtSwap, grab another thought from the hat, and try to organize the interpretations into categories in the public space. The students were surprised to find that nearly all of them entered the same answer: that the parent's quote implied the school was not built well. However, the students noted that there was one thought in the list that was slightly different from the majority. One interpretation in the public list implied the parent was blaming the builders for the school's collapse.

At this point, Mr. R decided to move on to the individual focus activity, but adapted his plan to fit the situation. He asked the students to enter a thought into ThoughtSwap describing how they felt about blaming the builders specifically for the collapse. If the students agreed with blaming the builders they were to provide reasoning, and if they disagreed they were instructed to provide an alternative with reasoning. The class did not use the public half of ThoughtSwap to aggregate answers, but rather kept the retrieved thoughts in their private space. One student volunteered to discuss the thought he drew from the hat, and said, "I agree with them, I think the builders should be blamed, but I don't agree with how extreme they are about it." Mr. R asked this student to explain further, and the student replied, "builders have to get their plans approved, don't they?" At this point, Mr. R led the class in a discussion about the amount of limited information they were provided with in the articles, and asked his students to offer other sources of information they would need if they were a committee charged with determining who was at fault for the school collapse.

Teacher Interview

Two days following the activities in the classroom, we conducted a semi-structured interview with Mr. R. Because of his integral involvement with the activity, and his position as the students' instructor and evaluator, we believe his feedback is extremely important. Mr. R was asked to describe his overall reactions to using ThoughtSwap, what went well, what went poorly, and how his learning goals were or were not met.

Overall Impressions

Mr. R felt that ThoughtSwap was a tool for centering students. After the software failed part-way through the first session, the class continued the discussion without ThoughtSwap. Mr. R observed that during this time, the students seemed drawn into the discussion and engaged as a group; it had a feeling of naturalness, as if they stepped out from behind the safety of the software. He noted that in usual class discussions it would take considerable time and effort to get all students engaged. However, using the software seemed to draw them in to the point where they no longer needed it to get everyone's participation.

Individual Focus Activity

According to Mr. R, the best moment in the two classes took place during the earthquake session. Towards the end of the class, the students used the software to argue who was to blame for the tragedy, and why. Students reacted to the thoughts they pulled from the hat; this gave them an opportunity to comment on, possibly disagree with, and point-out the need for more thoughts with more nuanced stances on the issue. Mr. R believed that the provocative nature of the question allowed the software to bear more fruit than in the earlier portions of the activities, and by using ThoughtSwap they were able to see their ideas in relation to others.

Change from usual class discussions

Mr. R noticed that the talkative students, who tend to dominate classroom discussion, were discouraged from doing so by the activity. He credited this to the quiet moments during discussion in which students took time to stop, turn towards their computers, collect their thoughts, and write. The activity offered the time needed for the non-vocal students to digest their thoughts without having to do so out loud.

Thoughts for future uses of ThoughtSwap

While the thought-aggregation activity was a quick way for students to see how their responses related to other responses in the class, Mr. R felt the activity could be improved by adding a more game-like quality to it. In the future Mr. R plans to select pairs of students to simultaneously attempt organize the list without talking to each other. Such an activity may be frustrating at first, but might eventually prove to be eye-opening as they observe differences of opinion as well as engage with the grouping process. This kind of aggregating activity also suggested a possible new feature, which would allow students to mark each thought in the public list from a set of colors. This may aid in visually noticing groups and their respective sizes, as well as offer a different means of organizing other than moving items.

Reflections from second evaluation

What was the most remarkable about the second evaluation of ThoughtSwap was the variety of ways ThoughtSwap was used in the context of classroom discussions. Mr. R was able to anticipate many ways to use ThoughtSwap before he taught with it, such as the aggregating and individual focus activities. Then, throughout the course of our observations we saw instances in which Mr. R needed to and could modify his teaching plan. One example of this was when the first group ran out of time while organizing the "pro" arguments during the "Cooling the Lava" activity and Mr. R opted to create a new activity in which each student simultaneously organized the list into categories without talking to their peers. Mr. R also modified his teaching plan in the Earthquake activity when a student made a comment that brought up the need for more information and he turned the discussion to what kinds of information they needed.

CONCLUSION

In classroom discussions educators endeavor to keep discussion going, encourage students to participate, maintain appropriate levels of participation, touch on key points of interest, and let students wrestle with certain difficulties while not letting the discussion get too difficult. Balancing these goals is a challenging task. It requires the teacher to react and adjust as need arises, and as such, any collaborative tool designed to aid discussion must also be flexible, maintain the users coordinative agency, and allow for many possible appropriations. We designed ThoughtSwap to help facilitators scaffold discussion difficulties in three key ways: private-to-public expression, anonymous contribution of thoughts, and re-distribution of ideas. By driving the design of ThoughtSwap to a simpler mechanism we were able to increase the coordinative agency of the tool. Although, as a society, we currently have many tools to support group action, the precise details of how coordination is supported are crucial in influencing the potential of highly coordinated group activity.

REFERENCES

1. BEENEN, G., LING, K., WANG, X., CHANG, K., FRANKOWSKI, D., RESNICK, P., AND KRAUT, R. E. Using social psychology to motivate contributions to online communities. In *Proc. CSCW 2004* (New York, NY, USA, 2004), ACM, pp. 212–221.

2. BELL, P. On the theoretical breadth of design-based research in education. *Educational Psychologist 39*, 4 (2004), 243–253.

3. BRYNSKOV, M., AND LUDVIGSEN, M. Mock games: A new genre of pervasive play. In *Proc. DIS 2006* (2006), pp. 26–28.

4. BUSH, V. As we may think. *The Atlantic Monthly* (July 1945).

5. CLARK, H. H., AND BRENNAN, S. E. Grounding in communication. In *Perspectives on Socially Shared Cognition*, L. B. Resnick, J. Levine, and S. D. Behrens, Eds. APA, Washington, D.C., 1991, pp. 127–149.

6. CLARK, H. H., AND SCHAEFER, E. F. Contributing to discourse. *Cognitive Science 13*, 2 (1989), 259–294.

7. CLARK, H. H., AND WILKES-GIBBS, D. Referring as a collaborative process. *Cognition 22* (1986), 1–39.

8. COUNCIL, T. N. R. *How People Learn : Brain, Mind, Experience, and School*, expanded ed. National Academy Press, Washington, D.C., 2000.

9. DAVIS, S. M. Impact of anonymity of input in next-generation classroom networks. In *Proc. CSCL 2007* (2007), International Society of the Learning Sciences.

10. DEKEYSER, S., AND WATSON, R. Extending google docs to collaborate on research papers. Tech. rep., The University of Southern Queensland, Australia, 2006.

11. DILLON, J. T. The remedial status of student questioning. *Journal of Curriculum Studies 20*, 3 (1988), 197–210.

12. DIMICCO, J. M., PANDOLFO, A., AND BENDER, W. Influencing group participation with a shared display. In *Proc. CSCW 2004* (New York, NY, USA, 2004), ACM, pp. 614–623.

13. DWYER, N., AND SUTHERS, D. D. A study of the foundations of artifact-mediated collaboration. In *CSCL 2005* (2005), International Society of the Learning Sciences, Lawrence Erlbaum Associates, pp. 135–144.

14. HOADLEY, C. M. Methodological alignment in design-based research. *Educational Psychologist 39*, 4 (2004), 203–212.

15. KEGAN, R. *The Evolving Self: Problem and Process in Human Development*. Harvard University Press, Cambridge, Massachusetts, 1982.

16. KEGAN, R. *In over out heads: The mental demands of modern life*. Harvard University Press, Cambridge, Massachusetts, 1994.

17. KING, A. Facilitating elaborative learning through guided student-generated questioning. *Educational Psychologist 27*, 1 (1992), 111–126.

18. KING, A. Guiding knowledge construction in the classroom: Effects of teaching children how to question and how to explain. *American Education Research Journal 31*, 2 (1994), 338–368.

19. KITTUR, A., AND KRAUT, R. E. Harnessing the wisdom of crowds in wikipedia: quality through coordination. In *Proc. CSCW 2008* (New York, NY, USA, 2008), ACM, pp. 37–46.

20. LEHMAN, T. J., COZZI, A., YUHONG, X., GOTTSCHALK, J., VASUDEVAN, V., LANDIS, S., DAVIS, P., KHAVAR, B., AND BOWMAN, P. Hitting the distributed computing sweet spot with tspaces. *Computer Networks 35*, 4 (2001), 457–72.

21. PAPERT, S. A. *Mindstorms : Children, Computers, and Powerful Ideas*. Basic Books, Inc., New York, NY, 1981.

22. PENUEL, W. R., ABRAHAMSON, L., AND ROSCHELLE, J. Theorizing the networked classroom: A sociocultural interpretation of the effects of audience response systems in higher education. In *Audience response systems in higher education: Applications and cases*, D. Banks, Ed. Information Science Publishing, Hershey, PA, 2006.

23. POSTMES, T., AND LEA, M. Social processes and group decision making: anonymity in group decision support sytems. *Ergonomics 43*, 8 (2000), 1252–1274.

24. REYNOLDS, J. Grief and anger at quake school memorial. *BBC News* (Sept. 9, 2008).

25. RITTEL, H. On the planning crisis: Systems analysis of the ‘first and second generations’. In *Bedriftsokönomen* (1972), vol. 8, pp. 390–396.

26. SACKS, H., SCHEGLOFF, E., AND JEFFERSON, G. A simplest systematics for the organization of turn-taking for conversation. *Language 50* (1974), 696–735.

27. SCHOBER, M. F., AND CLARK, H. H. Understanding by addressees and overhearers. *Cognitive Psychology 21*, 2 (1989), 211–232.

28. STEFIK, M., BOBROW, D., FOSTER, G., LANNING, S., AND TATAR, D. WYSIWIS revised: early experiences with multiuser interfaces. In *ACM Transactions on Information Systems (TOIS)* (1987), vol. 5 (2), ACM Press (New York, NY), pp. 147–167.

29. TATAR, D. The design tensions framework. *Human-Computer Interaction 22*, 4 (2007), 413–451.

30. TATAR, D., LEE, J.-S., AND ALALOULA, N. Playground games: a design strategy for supporting and understanding coordinated activity. In *Proc. DIS 2008* (New York, NY, USA, 2008), ACM, pp. 68–77.

31. TATAR, D. G., FOSTER, G., AND BOBROW, D. G. Design for conversation: lessons from cognoter. In *Computer-supported cooperative work and groupware*. Academic Press Ltd., London, UK, 1991, pp. 55–80.

32. VAHEY, P., TATAR, D., AND ROSCHELLE, J. Using handheld technology to move between the private and public in the classroom. In *Ubiquitous computing in education: Invisible technology, visible impact*, M. van ’t Hooft and K. Swan, Eds. Lawrence Erlbaum Associates, Mahwah, NJ, 2006.

33. WEBB, N. M. Peer interaciton and learning in small groups. *International Journal of Educational Research 13*, 1 (1989), 21–39.

34. WINNICOT, D. *The maturational process and the facilitating environment*. International Universities Press, New York, 1965.