

Groupware for Design: an Interactive System to Facilitate Creative Processes in Team Design Work

Arjun Venkataswamy, Rajinder Sodhi, Yerkin Abdildin, Brian P. Bailey
University of Illinois at Urbana-Champaign
Urbana, IL 61802 USA
{avenkat2, rsodhi2, abdildin, bpbailey}@illinois.edu

Abstract

Creativity as modeled using the recluse genius paradigm fails to recognize the necessity and value of the collaborative aspects involved. Enhancing the creative output of teams will become more and more necessary as the complexity of problems increases; this is especially true within the design domain. This paper explores the group processes and accompanying bottlenecks related to design work. Individuals and teams with experience in collocated design settings were studied to extract principles and best practices for group design work. Based on the findings, a set of design implications were extracted and an early prototype of a collaborative system was built to implement those conclusions. The tool attempts to model the highly effective ways that design teams work in a collocated environment while also addressing some of the bottlenecks they face.

1. Introduction

In the past twenty years, groupware has become almost ubiquitous with collaborative teams, whether it is in the form of online administrative applications, electronic meeting/brainstorming systems or wiki-style project spaces. Many of these tools work to ease problems regarding scheduling or efficiency, and some even successfully tackle aspects of the wicked problems in group creativity [20, 32]. However, even after almost two decades of development, tools in this area are still grounded in limited aspects of the creative process. Groupware has great potential to foster creativity amongst teams, but the majority of this work on creativity has focused on brainstorming without adequately looking at how teams manage design artifacts and communicate with each other over a long period of time.

Our study attempts to fill the gap by drawing out the most significant bottlenecks in the team creative processes of a specific domain, namely design. Creative teams can span quite a variety of tasks which may have completely different primary needs.

For example, although there may be similarities in the general process of a research group and a web design team, the specific task and process needs of each group will be necessarily different due to their differences in output. Taking a bottom up approach by reviewing the creative needs of specific domains will allow for the creation of a comprehensive picture of group creativity by integrating puzzle pieces from many different disciplines. In this way, these examples can showcase exactly which requirements can be generalized, and which are domain specific.

We first review current literature in creativity theory, and computer-supported cooperative work along with collaboration tools that currently exist. Next we present our methodology for interviewing designers followed by our findings from that study. Based on those results, we derive a set of design implications focused on assisting creative processes and reducing the most significant bottlenecks for design teams. Finally, we operationalize these implications in an early prototype for a tool that could support creative work in a team setting. The audience for our tool includes teams of 2-5 people that would benefit from a persistent virtual workspace for managing artifacts and communications. Such teams could be collocated groups that work individually and only meet occasionally, or distributed groups that never have a chance to meet in person.

2. Related work

We begin this section with a brief foundation of creativity theory to set the stage for the types of processes our tool should support. Next we provide a brief overview of work on groups in the context of human-computer interaction followed by a survey of groupware as it exists. This section concludes with general strategies that have been proposed to address the topic of creativity in collaborative tools.

2.1. Creativity theory

It is generally accepted in the field of creativity that thought is divided into both *convergent* and *divergent* processes [11,17,26]. Divergent processes are those typically associated with creativity and entail looking at a solution in multiple frames rather than in a single, rigid context. As its name suggests, divergent thinking involves generating vast numbers of disparate ideas. However, creative solutions have been described in cognitive psychology as those that are both original *and* relevant. Convergent thinking deals with the latter by analyzing ideas for relevancy and feasibility, discarding anything impractical.

There are several existing models for how these general processes of divergent and convergent thought manifest in practice [2,10,17,26,30,31,35,38]. Our work is intended to understand and support the early stages of team problem solving, when the solution space is still ill defined and the greatest amount of divergent thinking is needed.

Creative conversation not only occurs between an individual and his or her own work, but also through collaboration and relationships between an individual and other human beings [16]. Working in groups allows individuals an opportunity to manage difficult problems by breaking them down into sub-problems [3]. Collaboration also allows team members to produce more ideas, share different perspectives and re-interpret each others ideas [21,24].

Farooq et al. [14] addresses an interesting topic of creativity in Computer Supported Cooperative Work. Researchers define three requirements for supporting creativity: support for divergent and convergent thinking, development of shared objectives, and reflexivity. A significant finding from this paper is that minority dissent stimulates divergent thinking. The authors argue that larger groups rarely achieve the level of the sum of the individuals. Creativity groupware must encourage minority dissent to make the best use of group resources.

Since design problems can become very complex, the attention of multiple individuals can be beneficial in addressing the problem. Still, collaborators are limited by spatial (across distance), temporal (across time), conceptual (across different communities of practice), and technological barriers (between persons and artifacts) [16]. Our study attempts to identify some of the most significant instances of these bottlenecks as they relate to design.

2.3. Group Support Systems

Nunamaker et al. [28] defines a group support system (GSS) as a computer based environment to support concerted and coordinated effort for joint problem solving and task completion. Fjermestad et al. [15] showed in their experiments that GSS can be used to improve idea generation among group members. Santanen et al. [34] introduced a GSS technique called directed brainstorming and looked at the effects of external stimuli on creative solution generation. GroupSystems is a commercial [20] tool that helps team members exchange ideas through formal meeting procedures. Other systems make less of an effort to constrain the process, however they are limited in the types of media supported and fall only within the same-time category of group work [9,19,32]

It is important to have tools that support brainstorming sessions. However, our work is trying to take a broader perspective and seeks to find the common bottlenecks and processes in team design practice as they occur over a longer period of time.

2.4. Current state of asynchronous (different-time) groupware

Groupware as it exists is referred to by Yardi et al. [39] as ‘multi-user software that is designed to help team members coordinate and track joint projects.’ Currently, asynchronous methods involve email, database or document sharing, group calendaring/scheduling and threaded discussions, which solve many spatial and temporal communication barriers. Still, unlike many GSS, these tools do little to improve the *creativity* of group ideas, only the speed at which ideas are communicated. A vast number of tools designed to asynchronously support collaborative work exist, so we will briefly go over a sample of available software.

One example of an asynchronous groupware system has been developed by Li et al [23]. This tool shows the continuous supply of performance metrics such as individual time spent, individual action items completed, and team time spent in meetings. While these performance metrics are useful for group assessment, they do little to aid in the idea generation process.

Commercial editing tools such as Microsoft Word and many wiki systems [6] support the tracking of various changes to a shared document, which can be very useful in overcoming Fischer’s temporal boundary by creating a team memory of a project. However, their very linear system based on sequence

only supports narrowing, convergent thinking while completely neglecting the branching, divergent processes that make up a very important aspect of creativity, especially during the early stages. Divergent thought does not follow the progress of one path, but instead creates new paths to explore. Creativity groupware should take this factor into account when creating team memories.

Basecamp [4] is a popular system that addresses many of the issues in other types of collaborative groupware. It creates a centralized space where team members can communicate and share project related files. However, with core functions like to-do-lists and message boards, Basecamp functions more as a project management tool than a collaborative creativity tool. While the two domains overlap on many requirements such as ease of use and smoothness of communication, the Basecamp approach is still very linear and forum-based. It does not visualize divergent paths or offer a loose system of idea organization that is essential for restructuring elements of a problem [11].

Churchill et al. [5] mentioned that virtual communication in groups was often focused on the actual task related objects, such as documents or media files. For example, individuals communicating through instant messaging or videoconferencing are often discussing a word file that is open in front of them. This conclusion suggests the use of cognitive externalizations as a creativity support tool, effectively embedding communication within the externalization itself. Our tool allows for collective production and organization of these cognitive externalizations.

2.5. Addressing creativity in groupware

The technological barriers put forth earlier by Fischer et al [16] can possibly be dealt with through the proper use of externalizations. “External representations are in the world, as physical symbols (e.g., written symbols, beads of abacuses etc.) or as external rules, constraints, or relations embedded in physical configurations (e.g., spatial relations of written digits, visual and spatial layouts of diagrams, physical constraints in abacuses etc.)” [40]. Zhang and Norman emphasized the effects that external representations can have on task performance. In addition, they claim that external representations provide memory aids, directly perceivable information, structured cognitive behavior, and change the task. Team members use visual expression as a means to externalize their thoughts and ideas through unique representations. In groupware using external representations, designers

should be able to integrate and coordinate several representations to aid in the creative process.

Larkin and Simon [22] showed that diagrammatic representations require less search, comprehension, and inference than sentential representations. For example, a graph showing the return on an investment is processed quicker than a table or paragraph containing the same information. By providing multiple external representations to creative groups, members should be able to create a collective and easily searchable group memory to continually reference as problems and sub-problems are refined through solution development.

Similar to the ways in which Schön [36] showed how designers externalize their ideas through sketches, manipulations of external representations can aid in both the perception and judgment of a solution. The involvement of several users in this process will multiply input to the design and add levels of material with which to have a reflective conversation that are normally unavailable to the individual working alone. Our proposed tool supports user-based reorganization of representations so that various problem frames and associations will be visible. This re-interpretation and reorganization can be performed to set in motion a team based reflective process that extends Schön’s work from the individual to the group [36].

In addition to providing a method for overcoming person-artifact barriers, externalizations will also attend to conceptual barriers across different communities of practice. Resnick et al. [33] recommend that knowledge systems for teams should be constructed to resolve the meanings of ideas and concepts between individuals through shared understanding. Since input to a given externalization is coming from multiple individuals, reflective conversations occur not only between an individual designer and an artifact, but also between designers through shared artifacts. With effective communication avenues, these modifications should lead to a more complete understanding of collective team knowledge as well as offering stimulus for divergent thinking similar to the method of collaborative sketching [37].

Finally, any creativity groupware tool should have support for overcoming temporal barriers that arise through extended group projects. Collaboration can occur over many years and thus there exists a need to establish awareness of rationale behind the choice of artifacts and alternative implementations considered [27]. In the same vein, Farooq et al. [14] state that clarity of group objectives and reflexivity leads to a higher level of creativity. Groups should have a shared awareness of the end goal in addition

to an awareness of current and past work. Ubiquitous virtual spaces that communicate the state and decision bases of all team members at any given point in time would contribute both to workspace awareness as well as shared understanding of the current problem or sub-problem. Ideas and relationships can easily be lost in face-to-face design meetings as meeting spaces are used for other purposes. Our tool is ubiquitous and always accessible to team members, ensuring that important artifacts and processes are always accessible.

Literature to date suggests that groupware specifically aimed at augmenting group creativity should focus on the creation/manipulation of externalizations and awareness tools in order to both maximize the use of group creative resources and minimize barriers that exist for groups in general. Much of the work done is conceptual and provides directions to pursue. This paper will extend that work by verifying this knowledge through a study of groups in the field and by actually developing a tool that combines and applies existing theory to create a practical interface for improving the creative output of groups.

3. Methods and procedure

In order to gain a better understanding of the mechanics and issues of team-based design processes, interviews were conducted with several design teams and individuals with experience in this area. A semi-structured interview methodology was used to guide discussion in interviews that lasted 30-50 minutes. We asked designers to describe a current or past project, and viewed artifacts of the process if they were available. This process involved asking questions from a script that allowed tangential paths to be followed. A sample of the questionnaire can be found in Table 1. A total of 14 people were interviewed, ranging from undergraduate students to professionals, all of whom have had at least one year of experience working in design groups. The subjects surveyed were recruited from three design domains:

- industrial design (8)
- game design (4)
- art and design (2)

A variety of experience-levels and domains allowed us to explore a diverse subset of the problems that designers face. The questionnaire covered topics including creative practice (stimulus for creativity, specific process), group dynamics (idea sharing, levels of contribution), and bottlenecks

(frustrations, lost ideas). A combination of written notes and audio recordings of the sessions were taken after obtaining permission from the subjects.

Table 1: Sample of Interview Questions

Q1	How do you share ideas within your team? Do you have any frustrations with this process?
Q2	Do you often build off of each others' ideas? How does this happen?
Q3	What sorts of artifacts are created at your meetings? How do you use them?
Q4	What creative bottlenecks do you have as a team? How have you tried to address them?
Q5	Are more ideas generated in meetings or outside of them? Why do you think this is?
Q6	How do you communicate outside of meetings? What are the strengths and weaknesses of your approach?
Q7	What electronic tools do you currently use? What are the strengths and weaknesses of the tool? How do you address these problems?

4. Results of Study

Responses to our questionnaire were informative and relevant to a wide range of topics, from the general creative process to the effect of group dynamics on creative productivity. Subjects provided especially interesting insight into design-specific communication. Information gathered was categorized into three sections: process, communication and creative bottlenecks.

4.1. Process

Our subjects indicated four main stages in a design project: definition, generation, evaluation and finalization. These stages are roughly consistent with the models of the creative process proposed by earlier work [2,10,17,26,30,35,38]. The definition stage sets constraints and end goals for what exactly the project is aiming to accomplish. This often takes place with the consideration of high-level qualitative concepts such as mood and style that set the direction for the project. A physical artifact frequently created at this stage is a *mood board*, which is a collage of images and words that describe the feel of a project that is ubiquitous in the design space. This process is fairly common in design [18,25]. In addition, research is done to acquire the appropriate domain-specific knowledge and frame the problem by setting the appropriate constraints.

The generation and evaluation stages are analogous to the divergent and convergent thought processes discussed earlier [11,17,30]. In the generation stage, members ask 'what if' questions

and build off each others' ideas. In industry, generation sessions are fairly short, usually lasting not longer than one hour. Subjects indicated that the most critical aspect of the generation phase, especially in a group setting, is the suspension of evaluation for the duration of the period. This importance has been corroborated by previous work [2,11]. In many situations, there is a moderator present to keep group members in check and ensure they are following the rules of each phase. The evaluation phase is where ideas are criticized and either discarded or developed further. The generation and evaluation phases are cycled until a single idea is selected for finalization. This phase is simply an extended development of the final idea, which is fleshed out and polished up. It is acceptable to cycle between all of the stages; however it is critical that each stage is kept separate.

4.2. Communication

The vast majority of communication occurs in collocated spaces with a portion also taking place through electronic media such as email or wikis. One of the most significant benefits of collocation for our respondents was the ease with which communication takes place, falling within the results of Tom Allen's seminal study [1]. As one interviewee put it, you get 'instant feedback' on everything. Group members often build off each other's ideas, so this process is accelerated when communication occurs quickly.

Other functions of communication for our subjects included the clarification of one's own ideas and the use of external input to determine the feasibility of an idea. Simply working in a collocated space often helps keep the entire team on the same page. The richness of this communication is often lost while groups converse in other mediums such as wikis or email. However, regardless of method, the *tone of communication* was said to be integral in determining the quality of ideas produced.

Specific methods of communicating ideas or feedback varied widely. Almost every subject mentioned extensive gesturing towards the contents of design artifacts to give context to their feedback. The industrial design teams would even communicate their thoughts on a given artifact by actually drawing over each other's sketches on the same piece of paper. In addition, most of our interviewees would put sketches or artifacts up on a wall to discuss them as a group. These are also sometimes rearranged or grouped into categories through manipulation of spatial layout.

4.3. Creative Bottlenecks

Several bottlenecks occur within team-based creative processes, the most important of which deal with the control of criticism and communication. Much of our results mirror those found by Diehl and Strobe [13]. It is imperative in any idea generation session that group members leave their egos at the door and stay positive throughout the session, until the evaluation phase begins. Poor attitudes often manifest themselves through inappropriate criticism or feedback that is often intended to display knowledge instead of actually improving an idea. As a result, ideas are dismissed prematurely when team members decide not to share an idea that they believe will not face group approval. This may seem to run contrary to work done by Connolly on evaluative tone, however it is not criticism itself that is undesirable, but criticism during divergent thinking [7]. A positive tone is also not mutually exclusive with effective criticism. A portion of our subjects insisted that a good moderator is essential to keep stages separated and evaluation positive when it does occur. Another strategy used by some subjects to combat this bottleneck is to set aside a time to specifically ask for "stupid" or infeasible ideas. This way, judgment has already been placed and often ideas that are ludicrous to one individual are of value to another.

Communication outside of meetings also causes problems. Ideas generated immediately following a formal idea generation session are not available to the group for inspiration and development and are often lost. In addition, one group mentioned that the 'time gap of emails makes things difficult,' referring to the discouraging effect of delays in response. The slowdown in communication and a lack of awareness on what other group members are doing can cause long delays in progress.

Finally, there is always a danger of 'having ideas implanted into you.' This situation occurs when a designer becomes fixated on an external solution that is either given with the problem definition or passed from other group members. It is generally solved by allowing time for individual ideation before any ideas are put forth to the group.

5. Design Implications

Major themes from the qualitative results of our study were extracted to form the following design implications. The most significant findings which relate to creative collaboration in *design* teams are as follows:

Allow for anytime, anywhere, lightweight additions to the design space. Since ideas often arise outside of pre-defined meetings, easing the capture of these thoughts, which are often lost, will utilize the team's potential to a fuller extent. For example, if a designer is searching the web and encounters an item of interest, she should be able to quickly add it into the design space

Do not impose excessive structure on the design space and allow for spatial grouping of ideas and objects. An effort should be made to model the spatial grouping and categorization already used by design teams. Imposing too much structure would inhibit some designers from working in their natural style. Interestingly, this implication from our interviews is in direct contrast to an earlier study finding structure to be necessary for general creativity support tools [32]. Perhaps the best approach is to allow user-specified transitions between unstructured and structured interactions.

Simulate location-specific gestures and comments. Collocated communications occurs so quickly partially because design teams are able to physically point to locations on sketches as they voice comments. This behavior should be supported as much as possible in an electronic tool

Enable knowledgeable parties to comment on designs. Several designers expressed the desire to get feedback from other colleagues or professors on design projects. There should be the option to provide limited access to individuals outside of a project team.

Some of the results from the study are similar to those already put forth for supporting creativity in generic groups. **Encouraging the suspension of judgment during idea generation, mediating evaluation apprehension, and creating a team memory** are conclusions that have been discussed previously, so we will not evaluate them further [2, 13, 29].

6. Ideaspaces: an Early Prototype for Supporting Team Design Work

IdeaSpaces is a new system that allows a group of designers (e.g., 2-8) to create workspaces, share, and interact with design artifacts that mirror environments seen in practice (see Figure 1). Benefits of the system include fostering creativity through collaboration over distributed spaces,

gathering and storing ideas or research data, maintaining awareness of each group member's work through a flagging system, and sharing ideas generally lost in traditional group collaborative sessions. The system is comprised of the user interface, different views and representations of design artifacts and support for the separate phases of the design process. Based on our field study and literature review, a tool built to support team design processes should meet the criteria argued above in section 5.

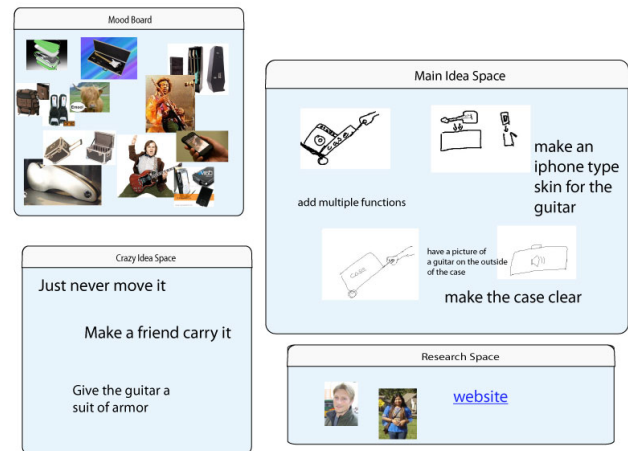


Figure 1. The main view of IdeaSpaces allows a design team to share ideas, inspiration and research for a project involving the redesign of a guitar case. Generic workspaces can be instantiated to contain different parts of a given project.

6.1. User Interface

The system allows users to dynamically generate and manipulate several windowed themes that are based on practiced techniques found in our study. For example, users may choose to create four windows, a mood board window, the main idea space, the user research space, and a "crazy" idea space to represent their organization of ideas. A user can mimic mood boards found in group environments by storing "pre-ideas" normally composed of images and text for the purposes of inspiration. With a research space, designers can store background information and all interviews conducted for a particular project. Ideas that fall out of the scope of a project's objective or considered out of the norm are often not shared in group meetings. A "crazy" idea space gives the user an opportunity to pose solutions to design problems and draw out ideas that would otherwise be internally dismissed due to evaluation apprehension [2, 13]. Finally, the main idea space can be used to submit solutions that users feel are well developed and are possible choices for the next

iteration of the design process. Based on our study, these design solutions are normally sketched by hand or generated using an electronic tool such as Photoshop, and then presented to group members before entering the evaluation phase. All of the spaces simulate the spatial grouping of ideas and objects designers almost always use to share information in a collocated environment, also supporting Schön's reflective thinking [36].

6.2. Multiple Representations

Several different representations of ideas will be available for selection to help users reorganize associations between ideas and stimulate creativity [40]. A temporal slider gives users the ability to access ideas and objects generated at a particular instance. For example, if several users stored ideas in the main idea space on a particular day, then a slider whose value corresponds to that day should only show ideas and objects that were created at that instance. This way, users have a view of how their ideas are progressing, where their ideas began, and the steps the team has taken throughout the design process, partially addressing temporal barriers [16, 27].

A network view allows users to see a big-picture overview of how early ideas progressed and evolved into the current idea set, effectively providing a less structured team memory than the timeline representation (see Figure 3). As users create new ideas, they have the option of indicating the parent ideas or objects by shift+clicking on parents before clicking on a blank space to signify a new idea. As the new idea is created, the tool has already embedded these parent relationships. The third view is created by darkening all objects not related by one degree of separation to the current set of objects (see Figure 4). This feature allows users to view the immediate parents of any particular idea, either in terms of existing ideas, research or mood board elements. These relationships are all user-defined; however the low cost of this definition will allow the process to become seamlessly integrated into the normal set of actions that create an idea within the space.

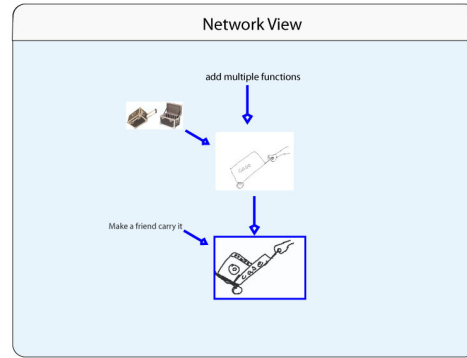


Figure 3. The network view allows a user to view all of the parent ideas that contributed to the development of the sketch highlighted with the blue rectangle. In order to simplify the representation, only network objects that are connected in some fashion to the selected idea will be displayed.

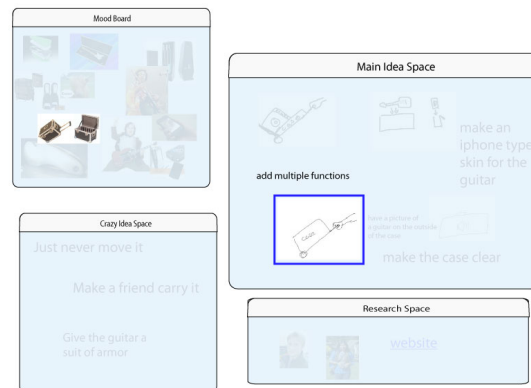


Figure 4. This modal view can be used if a team member would like to see all of the immediate contributors to an idea (selected here in blue). Only contributing ideas, mood board or research items are shown in full opacity, in this case being one mood board picture and the "add multiple functions" idea. This view allows the user to either see what a team member was thinking when he or she created an idea.

6.3. Phases

The definition, idea generation, and evaluation phases will also be moderated by the system to control criticism (see Figure 5). This process of moderation was observed in our study and is set according to user preferences. The group as a whole or a project manager can decide the length of each phase at the beginning of the entire process. A cycle of a generation and an evaluation phase represents one collocated idea generation session [30]. Once this has been decided, users then begin the definition phase by engaging in a process of collecting "stock" ideas, research items, and sketches. By default, the definition phase is always left open so that the mood

board and research spaces can be added to at any point in time.

In this tool, an ‘idea’ is defined as a sketch or phrase that embodies a concept relevant to the design of a given project. The generation phase will allow users to add sketches or phrases to the idea space that can be viewed by other group members and serve as stimulus for further ideas. At this stage the ability for users to leave comments is disabled to encourage the suspension of judgment [2,13]. This is done by ensuring that no criticism can be given for specific ideas and other team members’ ideas are only used for divergent thought purposes (see Figure 6).

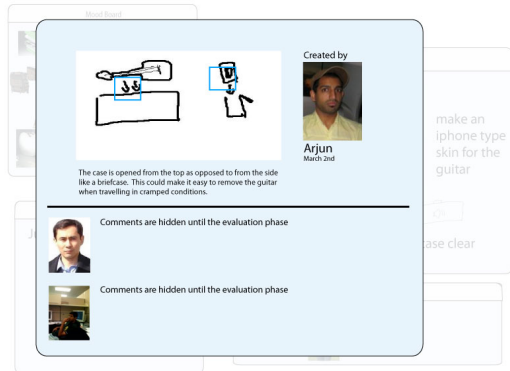


Figure 6. When an idea is clicked, it zooms into a detail screen, which displays a larger version of the idea with an optional description, along with information on who created it as well as when it was created. In this case, a team member created the idea of having a guitar case opened from the top, as opposed to the side. The rest of the team has already made comments on the idea; however, comments are only visible during the evaluation phase. Comments can be added in a general format or a location specific Flickr-style format, as shown by the two blue rectangles.

Only after the idea generation phase has ended and the evaluation phase has begun will the users be allowed to actively comment and criticize each others ideas, which may then be decreased in size or moved away from the focal point of the space as they are discarded. Anonymity can be turned on or off at this phase to possibly encourage minority dissent [14]. These two stages may cycle as many times as users wish. Thus, the system itself then acts as a facilitator, moving between phases based on initial input given by the group.

6.4. Interaction Techniques

IdeaSpaces supports the following interaction techniques for storing and viewing ideas:

Drag and Resize. Objects can be resized and dragged to various parts of the workspace. This allows users to cluster related items and give precedence to the object in focus.

Linking. The user can also link two related objects together. For example, in the main idea space, if a sketch was created based on reading text inserted previously into the space, then a link can be created going from the text to the sketch. This acts as the basis of the network view which allows users to see all of the contributions made from the parent ideas.

Flagging. Objects can be flagged for greater salience in the space. If a sketch is added to the main idea space, a user can flag the sketch and a notification will be sent out to all group members that a flagged object is available. That object will be highlighted as group members enter the space.

Commenting. During the evaluation phase, users can click on an object and add general comments with the use of a comment form or add comments directly to areas of the object itself.

Saving. Users can save the state of the space by clicking on the save button. This will allow group members to view changes or flagged items and store information for access at a later point in time.

6.5. Implementation

IdeaSpaces currently exists in prototype form. The system was written in JavaScript using Ajax. Several unobtrusive JavaScript libraries were included for the purposes of creating a rich interactive environment. In addition, the Facebook JavaScript client library is being used so that users in a Facebook design group can be notified of certain objects that have been flagged.

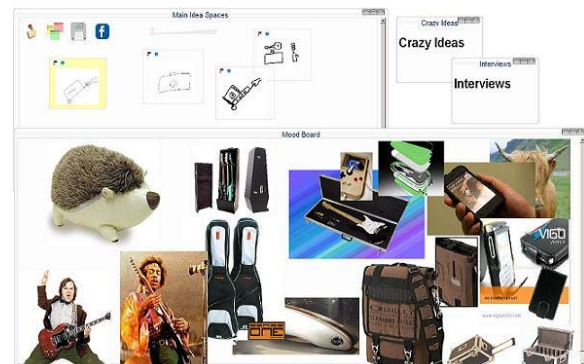


Figure 7. When a flag icon is clicked, the image is highlighted so that group members know where their attention should be directed

While constructing the system, it was clear that each space would be best utilized through the use of a windowing system. Each window links to an external html file that includes its own separate set of

JavaScript libraries for its theme. Although a window separates each workspace, the entire environment can be viewed as a single complete workspace where each set of windows represents a project.

When IdeaSpaces is completed, a management server will be implemented using an SQL Database Server that stores all flagged items, sketches, images, and text in the different spaces. In addition, user profiles and settings for projects will be stored for access at any remote location over the Web. Everything stored on the management server will be managed using a server side scripting language such as PHP. Our system currently works with Firefox, Opera, and Internet Explorer 6.0 and is generally compliant with most browsers.

7. Future Work and Limitations

We have just scratched the surface of the problems that arise in creating a tool for design collaboration. As our study consisted entirely of interviews, information gathered was qualitative, not quantitative and was used mainly to inform big-picture design decisions. The effectiveness of these decisions will need to be tested with actual users before any tentative conclusions about the usefulness of our tool can be drawn. In addition, it is possible that a focus on asynchronous interaction may detract from the tool's potential value for communication [12].

8. Conclusions

After a review of literature and field study of designers, we built a tool to support creative processes within design groups. Our study identified processes and major bottlenecks faced by design teams and we attempted to operationalize these implications in an early prototype. Major departures from current creativity and groupware systems include the use of multiple representations of group externalizations to emphasize different associations between objects and the use of spatial instead of linear organization. Future work utilizing user studies is necessary to verify the usefulness of these main features and confirm the appropriate directions to take in augmenting group creativity with computer tools.

8. Acknowledgements

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