COLLABORATIVE MAPPING SYSTEM

THE DESIGN OF A SET OF SOFTWARE TOOLS TO SUPPORT AND ENHANCE COLLABORATION BETWEEN STUDENTS AND INDUSTRY

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A great many thanks

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ABSTRACT

How can the *design* of a *physical/virtual space* facilitate and enhance collaboration between students and industry in an educational environment?

Currently there is a great need for student-industry collaboration to address the widening gap between design education programs and the nature of contemporary professional design practice. This gap exists because contemporary design problems rapidly change and are increasingly complex.

To address these problems, this project proposes a collaborative suite of tools, known as the "Collaborative Mapping System." The system's aim is to support and enhance student-industry collaboration by improving on the quality of virtual communication and collective intelligence through concept mapping, facilitating the separate phases of the collaborative process, and aiding group communication, memory, and thought.

In designing a tool set to support and enhance student-industry collaboration, this project looks to contemporary theories of collective intelligence, activity theory, and meeting facilitation. This project then uses that information to create collaborative spaces that facilitate communication between distant collaborators and provides a space for collaborators to act upon and share materials. The space is designed so that participants can interact with virtual materials through gestures and behaviors used to interact with physical materials. The design additionally allows for more fluid communications and collaborations among distant collaborators by projecting video feeds of the distant collaborators into the same space as the face-to-face collaborators and allowing the distant collaborators to interact with the virtual materials as if all the collaborators were in the same physical space.

INTRODUCTION

THE NEED FOR STUDENT-BUSINESS COLLABORATIONS

The increasing complexity of contemporary design problems requires collaboration among design teams and specialists from multiple disciplines. Many universities have responded by partnering with industry to enhance the educational experience of students through professional collaboration. Many design contexts and problems exceed the expertise of singular disciplines and exist at the convergence of many.

Simultaneously, industries that depend on innovation, technology, and intellectual property rely on employing qualified workers, frequently graduates of large research universities. It is becoming more common for businesses to partner with universities to better prepare students for the complexity and interdisciplinary nature of the workplace. Both industry and universities benefit through such collaborations and partnerships.

Educational researcher and theorist Dr. Joseph Novak states:

> With the accelerating globalization of business and the growing importance of creating and using knowledge to remain competitive, we shall see in the next decade exponential growth in corporate interest in educating... partnerships will be formed between businesses and educational institutions, where a new kind of sharing and seeking solutions will take place... and most importantly in how we learn better to educate people for what ever the needs may be. (Novak, 18)

Julie Klein, professor of humanities and president of the Association for Integrative Studies at Wayne State University, notes the difficulties facing traditional single-discipline teams in responding to leading business problems with innovative solutions. She states:

> Educators, researchers, and practitioners have all turned to interdisciplinary work in order to accomplish a range of objectives: to answer complex questions; to address broad issues; to explore disciplinary and professional relations; to solve problems that are beyond the scope of any one discipline; and to achieve unity of knowledge, whether on a limited or grand scale. (Klein, 11)

The discontinuity between practice and academia increases as many new segments of practice emerge and as the increasing impact of the computer on life and culture increases through the changing nature of content creation, communication, and distribution channels.

The gap between design education and practice becomes evident in traditional design models that refuse to recognize the changing role of design in new media within a networked world. Major corporate content distribution sources are now competing with ordinary people for viewership. The proliferation of social networking and user generated content software reveal many ways in which information creation and distribution is changing, and a major cultural shift, from media consumer to media creator.

Dr. Elizabeth Sanders, president and principal design researcher of Sonic Rim and Professor of Visual Communications Design at Ohio State University notes

> Communication design has moved from being a one-way transmission of the message to being an interactive scenario that unfolds rapidly over time. But we, as designers, do not yet have the knowledge, processes, or tools to deal with the unfolding of the interactive flow of information. The design education system is struggling to keep up with the demands of these new challenges. Students want to be prepared to live and work in the interactive world, but those who teach them are struggling even to learn the new tools. (Frascara, 65)

Dr. Sanders argues that a shift in our culture is occurring from designing for the consumer mindset to designing for the creative mindset (Frascara, 72). She explains there are two types of tools, industrial tools and convivial tools. "Convivial tools allow users to invest the world with their meaning, to enrich the environment with the fruits of their visions…[and] the accomplishment of a purpose they have chosen. Industrial tools deny this possibility to those who use them" (Frascara, 68).

The shift from designing for consumers to designing with co-creators is a massive change in the history of design. The education of future designers, long a locus for individual expression and presumptions of a role in controlling content and form, must now give way under a new set of values and principles for action. Further, visual designers are now playing a role within interdisciplinary teams outside of traditional graphic design contexts. Visual designers now work on interdisciplinary teams to design computer systems, communication tools, transportation systems, and robotic systems as well as many other areas. These shifts represent only a few of the many ways design practice is rapidly changing.

COLLABORATIVE CONSIDERATIONS

Collaboration can have many meanings dependent upon context. Frequently business refers to collaboration as the intellectual division of labor embodied by workflow and business processes. The purpose of workflow is not new knowledge production but rather the efficient production of business materials through an intellectual assembly line. The focus of this project is not workflow, but a collaboration that produces new knowledge to address problems whose complexity and scale is beyond the scope of any individual.

In business-education partnerships, businesses not only benefit from collaboration by employing qualified workers, but also through the fresh perspectives of the students. In design practice, deadlines, budgets, prior work, environment, and technology frequently limit the creative scope of the designers. Students are able to provide fresh ideas to industry through their willingness to push beyond creative constraints and access to university resources and expertise.

In design programs, faculty limitations determine the subject matter that can be taught and the depth to which it can be taught. Contemporary large-scale systems oriented design problems are frequently beyond the scope of faculty expertise. Student-industry collaboration can augment the educational experience by offing students the opportunity to engage with problems outside of faculty expertise, while bringing professional contemporary expertise and multiple perspectives into the classroom.

For student-industry partnerships, collaborative brainstorming is one of the more effective collaborative forms. Collaborative brainstorming provides both students and industry with a high collaborative benefit. Strategic planning expert and founding principal of Moore Iacofano Goltsman, Inc., Daniel Iacofano defines brainstorming as:

> Generat[ing] the maximum number of ideas in a non-judgmental setting. Participants are encouraged to voice all of their relevant opinions and ideas, regardless of how infeasible or disagreeable they may seem. Other participants are asked to hold all comments or disagreements until everyone has had a chance to have their input recorded (Iacofano, 7).

Iacofano goes on to define eight other collaborative forms: *exchanging information*, *visioning*, *problem solving*, *direction setting*, *evaluating alternatives*, *decision making*, *planning and action*, and *team building*. Of these nine collaborative forms, brainstorming can best serve both an educational and business purpose, while remaining appropriate to the experience and goals of each collaborative group. Asking the students to implement a large-scale system is not commensurate to the educational benefit. Asking the students to understand all the qualities affecting a complex system and create ideas and design specifications that systemically address the project criteria is far more beneficial.

Simultaneously, industry does not benefit from student implementation of design specifications. The students' work will not have the craft, understanding, and refinement needed by design practice. It is students' ability to generate fresh ideas outside of the constraints of business practice that highly benefits industry. In brainstorming, the students can be utilized as a research group and demonstrate how an external group responds to design problems.

For a business to greatly gain from collaborations with students, the ideas the students generate must have some degree of refinement and sophistication, otherwise much business time is wasted sorting through a large number of incomplete ideas. From the business perspective, the students are brainstorming, but from the students' perspective, they are engaging in a full, contemporary design problem to provide well-considered insightful ideas. To accomplish this, the students engage in a handful of collaborative forms with each other and with professionals. The collaborative forms required are: *exchanging information*, *brainstorming*, *problem solving*, *evaluating alternatives*, and *decision-making*. Any software that mediates the collaboration between students and business will need to address these five collaborative forms.

Though it is clear that student-industry collaborations are highly beneficial if conducted properly, there are many challenges that face both universities and businesses wanting to collaborate. The two largest factors are distance between collaborators and a lack of tools to support student-industry collaborations. Well designed software focusing on communication and collaborative needs and goals can begin to addresses many of the limits which exist today.

THE DESIGN OF COLLABORATIVE SOFTWARE

Software for computer-mediated communication exists, but most programs lack tools to support meaningful collaboration. Instant messaging, email, and video conferencing all fall into this category. Few software offerings exist to supporting the needs of a complex knowledge-producing collaboration. Software in this category are document repositories, shared desktops, and virtual whiteboards; these applications do little more than allow team members to archive access the same materials. The design of most computer-mediated communication and collaboration software fails to recognize that the cognitive challenges to virtual collaborators are far from the challenges of face-to-face collaboration.

Software that is specifically designed with an understanding of collective intelligence, virtual collaboration and the collaborative tools needed to address complex system oriented design problems could overcome many of these challenges and contemporary limitations. The largest problem in computer-mediated collaboration is not that the technology does not exist, but rather that the design of the software addresses the wrong set of problems. Dr. Gerry Stahl, professor of information sciences and technology at Drexel University notes:

> "It [computer support] can empower such groups to construct forms of group cognition that exceed what the group members could achieve as individuals. Software functionality can present, coordinate, and preserve group discourse that contributes to, constitutes, and represents shared understanding, new meanings, and collaborative learning that's not attributable to any one person but that is achieved in group interaction" (Stahl, 2)

As Dr. Stahl notes, the most interesting role of contemporary software is not only to enable collaboration, but rather to enhance collaboration. Many of the communication and document sharing tools mentioned above facilitate collaboration to a greater or lesser degree, but none looks to greatly enhance collaboration beyond the offerings of a face-to-face collaboration.

This project's aim is not only to enable collaboration between students and industry but to use the tremendous computational and networked abilities of the computer to enhance collaboration, leading to the question:

How can the *design* of a *physical/virtual space* facilitate and enhance collaboration between students and industry in an educational environment?

A collaborative system to fulfill the needs of both students and industry must contain features to address the unique collaborative roles and context of each party. The collaborative needs identified to fulfill the requirements of both students and industry in brainstorming collaborations are broken into two categories: features required to support collaboration and features to enhance collaboration.

Features required to support collaboration are:

- A system that allows for communication among the collaborators.
- A shared collaborative workspace that all members can access.
- Tools for rapidly externalizing and organizing thought to allow the group to understand information.

Features that would enhance collaboration are

- A communication feedback system that allows collaborators to come to a shared understanding.
- A group memory system that allows collaborators to remember why choices had been made.
- A system for generating alternatives and revealing relationships among information.
- A system to aid in negotiation and evaluating alternatives.

This proposal for a software system aims to addresses these areas to create a product that not only allows for fluid meaningful collaborations, but to enhance collaboration to create more sophisticated and thoughtful designs.

CONCEPT MAPPING

One of the core features of this project is concept mapping, articulated by the educational theorists Joseph Novak and Bob Gowin. In *Learning How to Learn* Novak and Gowin promote concept mapping as the basis for knowledge construction. They argue that human learning is a "change in the meaning of experience" (Novak and Gowin, 1). The purpose of a concept map is to allow an individual to reflect on prior experience to create new and powerful relationships and meanings. A change in the meaning of experience occurs when new relationships (prepositions) among the parts (concepts) are understood. Concept maps are visual and structural representations of the concepts connected by prepositions revealing the relationships among parts and between part and whole. Meaning is created by understanding how different concepts are linked by prepositions. The authors state, "Concept maps work to make clear to both students and teachers the small number of key ideas they must focus on for any specific learning task" (Novak and Gowin, 15).

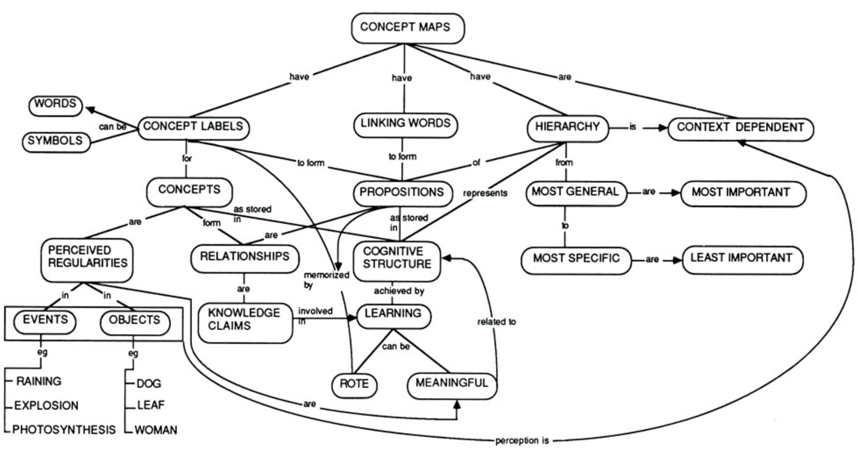


Figure II.o A concept map showing the key features and ideas that underlie concept maps.

Figure 1
A concept map by Joseph Novak mapping the underlying features of concept maps (Novak and Gowin, 14).

Novak and Gowin also note the importance and ability of concept maps to externalize thought. There are very few systems that can claim to visualize an internal understanding of a topic and the difference between two perspectives on a topic. This allows concept mapping to act as a feedback system within a group to help negotiate and understand meaning. One of the greatest challenges to overcome in group collaborations is the group's ability to understand the exact meaning of any single participant's communication. It is nearly impossible for a participant to fully communicate his or her entire mental model through language because the same terminology frequently has radically different meanings to experts from various disciplines.

It is through the visualization of thought that the concept map allows a group to create consensus. Because the map represents the group's thought on a topic, disagreement among members is represented in the map as alternate configurations. The alternative configurations reveal the often-subtle distinctions in meaning that cause disagreement and allow a group to identify and address alternative points of view.

Within group collaborations, feedback mechanisms that allow one participant to see how another participant understands the first participant's communication can greatly improve group performance.

Verbal language hides many of the connections (propositions) between concepts, and further, many people have different meanings, concepts and propositions for the same exact word or idea. This is why Allen Newell, one of the fathers of cognitive science, objects to the idea of collective intelligence. He believes that language cannot carry meaning at the rate necessary for information to be shared effectively so that a group may behave as a single distributed mind. Newell states:

> A social system, whether a small group or a large formal organization, ceases to act, even approximately, as a single rational agent. Both the other knowledge and the goals are distributed and cannot be fully brought to bear in any substantial way on any particular decision. This failure is guaranteed by the very small communication bandwidth between humans compared with the large amount of knowledge available in each human's head... Modeling groups as if they had a group mind is too far from the truth to be a useful scientific approximation very often (Newell, 490).

In *Collective Intelligence in Computer-Based Collaboration* John Smith, professor of computer science at the University of North Carolina, disagrees with Newell on the ability of groups and organizations to function with great coherence. He argues that well-designed collaborative processes and materials that aid in communication can align groups to act as a "distributed mind" and amplify the intelligence of the group. Further, "Newell is right that no group can achieve total integration of knowledge such as this. However, this may be too strong a requirement." (Smith, 101). Concept mapping is tremendously valuable in this context, both for increasing the amount of information that can be communicated; through revealing the structure and semantic network of meanings that are otherwise hidden in spoken or written language; and by decreasing the amount of information needed to be communicated through identifying information that is relevant and irrelevant to the group.

Daniel Iacofano, expert in strategic planning, agrees on the importance of visual group materials by noting the importance of the "wall graphic" in meetings. He states that it "adds a new dimension to the discussion and engages the audience," as well as being able to "focus the group and identify major themes" (Iacofano, 82). He later goes on to note the importance of the wall graphic in externalizing thought.

> Once part of the wall graphic, an idea is less likely to be connected with the person who raised it. This encourages others to build on that idea and to shape it to meet group goals. Also, putting the idea out there gives it a more tangible, concrete form" (Iacofano, 83).

Iacofano goes on to discuss other roles the wall graphic plays within meeting facilitation, such as its ability to organize and analyze ideas, creating a common focal point and, most importantly, "to clarify the meeting purpose, define the problems being solved and evaluate the proposed course of action" (Iacofano, 84). The benefit of concept mapping within group processes is that the concept map behaves as a highly sophisticated wall graphic with many qualities that aid in collaborative communication.

Novak and Gowin further explain that in the act of concept mapping, most people see new relationships they did not recognize prior to mapping; that is they recognize new meaning and learning through making (Novak and Gowin, 17). Their argument supports the principal that new and unexpected meanings are revealed by visualizing otherwise invisible relationships within a complex system. Underlying Novak's thesis is that every visualization privileges particular characteristics of information while hiding others. In concept mapping, the relationships become paramount, while the linear narrative characteristics of spoken language are hidden. Novak's later work, examines the role concept maps can play outside of an explicitly educational context and the role of learning in nearly all human tasks (Novak).

COLLECTIVE INTELLIGENCE

SMITH'S MODEL FOR COLLECTIVE INTELLIGENCE

Qualities of the concept map inherent in its design create the conditions for collective intelligence within the group. John Smith argues that the requisite condition for collective intelligence is the unimpeded flow of critical information among three vital information states: the *intangible*, *ephemeral*, and *tangible* (Smith, 24).

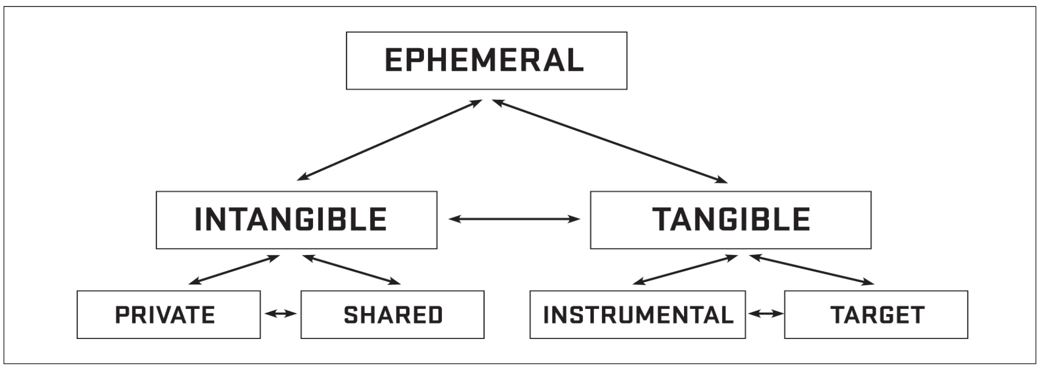


Figure 2
Smith's three information states, paraphrased (Smith, 25).

QUALITIES OF COLLECTIVE INTELLIGENCE

Intangible knowledge (Smith, 24) exists in the minds of the group members and, typically, only takes the form of spoken language. Intangible information never takes a lasting physical form. Intangible information can also be carried in the group culture. For example, a software design group may hold the value that the purpose of software is to mediate between people and their goals, and to improve upon their situation. This may never be articulated though language, but frequently will be articulated indirectly though the group's behavior, actions, and response within projects.

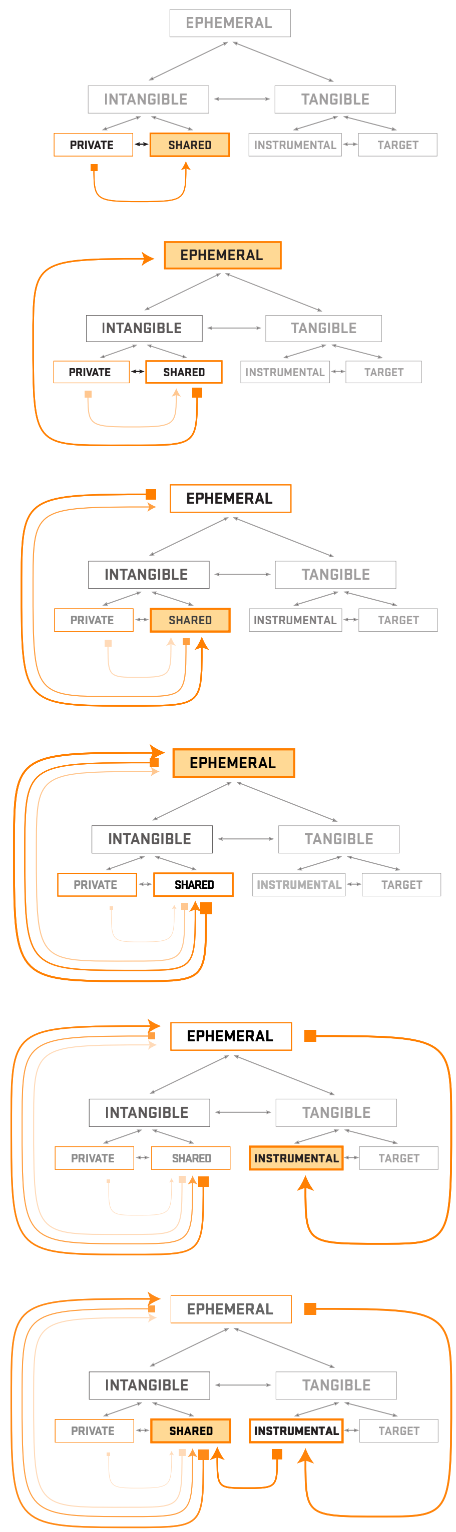
Intangible knowledge (Smith, 24) exists in two forms, *shared* and *private intangible knowledge*. *Private intangible knowledge* is information that individual members privately hold as a result of an expertise or specialization. Frequently team members will be chosen because the their *private intangible knowledge*. While *shared intangible* *knowledge* is information that is shared and distributed among members of the group, allowing the group to make decisions as a unified body.

Ephemeral knowledge (Smith, 25) is information whose physical form is short lived, and then persists in the group's memory. *Ephemeral knowledge* is information that originates as private *intangible knowledge* but moves to *ephemeral shared knowledge* through a short-lived physical form. This is information that the group must understand and negotiate to reach consensus on some factor. For example, a diagram drawn on a whiteboard for the purposes of sharing and negotiating meaning among the group would be an example of *ephemeral knowledge*. Once the group reaches consensus and a shared understanding, the diagram can be erased from the whiteboard and remain in the group's collective memory.

Finally, there is *tangible knowledge* (Smith, 25), which takes a persistent physical form. *Tangible knowledge* can be broken into two forms, *instrumental* and *target*. *Instrumental tangible knowledge* is represented by the persistent process materials that take a physical form aiding the collaboration. For example, in a collaboration using the Collaborative Mapping system, the *instrumental tangible knowledge* would be the concept maps produced by the group creating specifications for the final product. This information takes a persistent physical form that allow the group to share that information among all the collaborators and to use it for its ability to aid in group decision-making. In this way, the *tangible instrumental information* acts as a group memory to aid in decision-making. On the other hand, *target tangible knowledge* is the final collaborative product. For example, in a collaboration whose goal is to produce software, the software embodies the target tangible knowledge.

Socially collaborative concept mapping is a powerful tool that enables information to flow between the *intangible, ephemeral,* and *tangible* states. Once *private intangible knowledge* is shared, becoming *ephemeral knowledge* (figures 3–4), the group has new information for improving the map and its content to create new shared meaning (figure 4). As participants change the map, dialog occurs among the group members, in turn, generating new *intangible shared knowledge* (figure 5). As more *intangible information* emerges and is shared, the *ephemeral* in-process map is again changed until the group has shared all pertinent *private information* that affects the nature and meanings of the map. The map then becomes *instrumental tangible knowledge* (figure 7) as it persists within the Collaborative Mapping System and allows subsequent decisions to be made when examined through the collaboratively constructed map (figure 8).

Concept maps play another important communication role, which is to help collaborators identify private relevant information for sharing with the group. The map acts as an object that frames the discourse surrounding the collaboration. Through the contents and configuration of the map, the participants can identify private information that enables the collaboration versus private information that is irrelevant to the collaboration. This unique ability of the concept map reduces the large amount of irrelevant information typically shared in collaboration, addressing Newell's argument against group cognition. Newell believes that human communication doesn't allow enough information to be shared fast enough for a group to behave as a distributed mind. The concept map improves on both of these areas. It helps to create a state in which less information needs to be shared through identifying relevant information, and it acts as a secondary communication device, relieving the high demand of information transfer placed on oral communication events.



Figures 3, 4, 5, 6, 7, 8
Path of information through collaborative concept mapping expanded from (Smith, 26).

THE COLLABORATIVE MAPPING SYSTEM OVERVIEW

The Collaborative Mapping System is composed of three parts, two physical/semi-virtual spaces (active space) and one online virtual space (reflective space). Each of the three spaces affects the others; that is, each acts as a portal to the same information. The virtual space resides online, while one physical space exists at each collaborator's physical site.

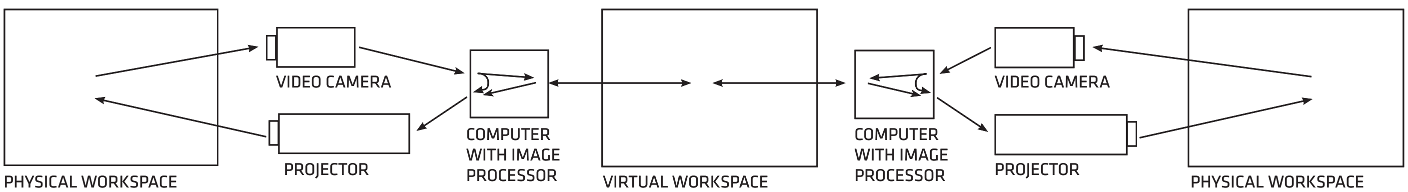


Figure 9
One of the possible technological arrangements.

The active space (figure 10) can be seen as an augmented white board with a persistent memory, mapping features, map comparison features, and features for communication between distance collaborators. Physical objects such as "sticky notes," photographs and other imagery can be placed on or in front of the workspace/screen and the high resolution camera will photograph it. The camera is in a perpetual state of recording, as the computer parses the camera's input. Once the object has been placed in front of or on the screen, a virtual representation of the object is projected onto the workspace/screen. The computer recognizes gestures and actions that allow the participants to interact with the projected virtual representations. Participants can then grab the virtual representation, move and scale it, draw on it with virtual drawing and diagramming tools, or link it to other objects or nodes within a concept map. This same

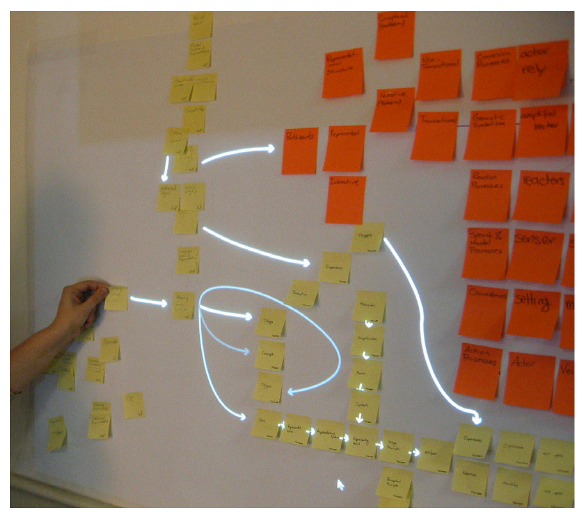
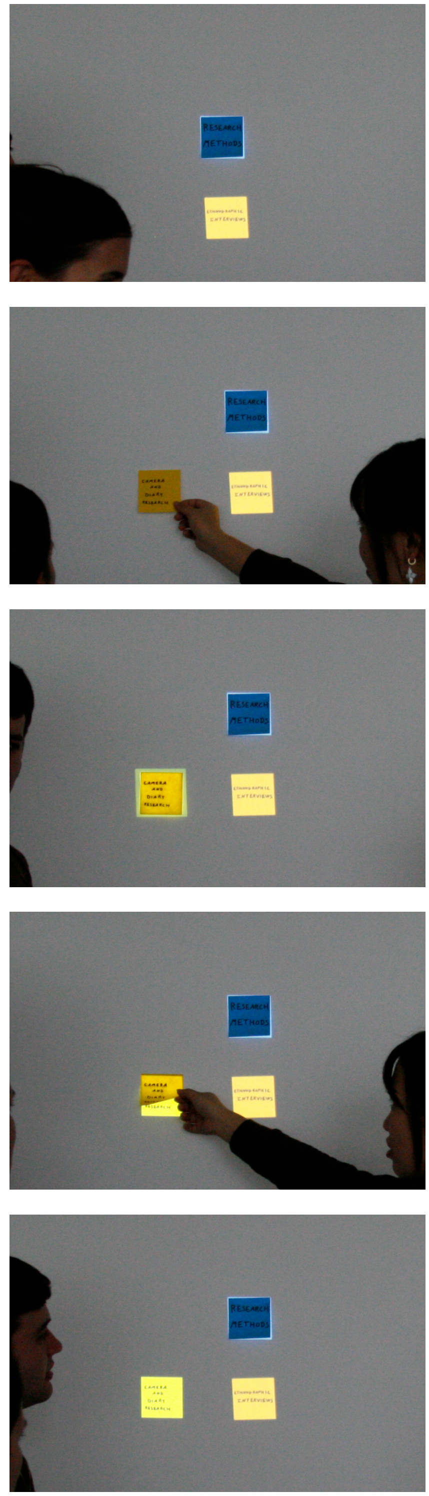


Figure 10
Example of the physical/semi-virtual (active) space.

information is simultaneously reproduced online in an alternate representation more suitable to the environment of a personal computer.

Objects such as "sticky notes" can be placed on the workspace (figures 11 – 15). A virtual sticky will not be projected until the physical sticky is removed. Collaborators in either physical space see the same representation and can modify it in any of the ways listed above. The space can also reconfigure for map comparison and video/audio conferencing (figure 16).



Figures 11, 12, 13, 14, 15
Sequence of converting a physical "sticky note" into a virtual note.

Figure 16
Virtual Communications through the active space.

THE DESIGN OF THE COLLABORATIVE MAPPING SYSTEM

As mentioned earlier, the Collaborative Mapping System is composed of two physical/semi-virtual spaces (active spaces) and one entirely virtual space (reflective space). Each of these spaces is a portal to the same information, but the representation of the information changes to address the qualities of the input and display system.

THE DESIGN OF THE ACTIVE SPACE

The decision to make the central engagement a physical/semi-virtual area (figure 17) was made after a variety of considerations, many stemming from context and participant goals. These considerations included the ability of the space to allow collaborators to engage each other; the fluidity of communication within the space; the rate collaborators would be able to map and remap information; and the ability of the space to allow for quality engagements among collaborators.

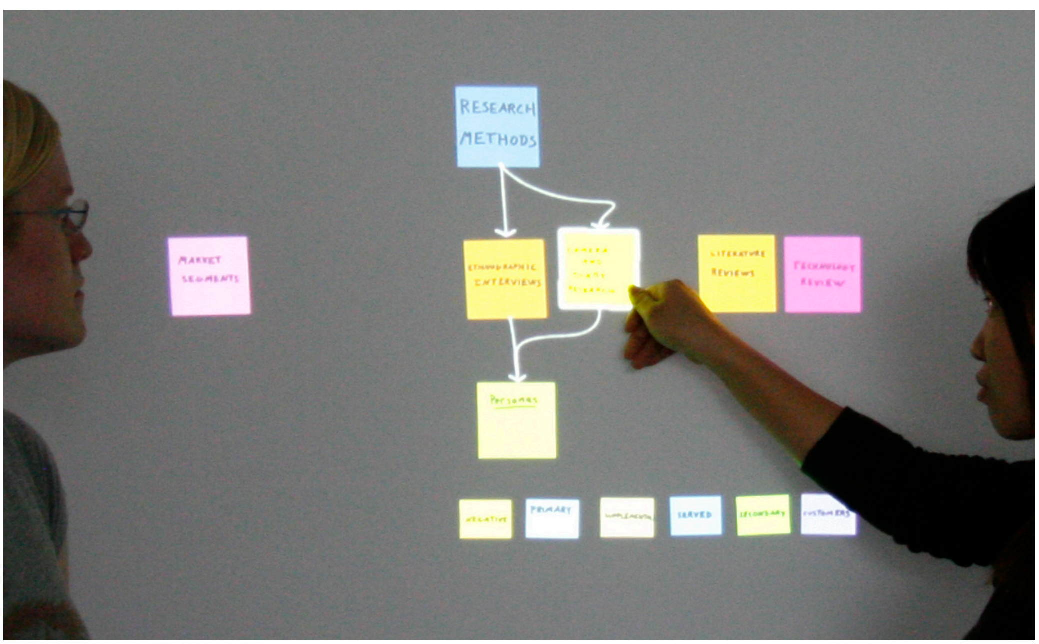


Figure 17
Active space in videoconference mode.

The active space represents information that results from the participant's use of his or her body as a means of interaction with the information. The space is designed to create a performative social space with more opportunities for the students to engage each other, the content, and the professional team. By collaboratively mapping in a social space (figure 17), the students must engage each other with spoken language and articulate their goals and understanding to the group as they add to or modify the map. The map then acts as a feedback system for the group to confirm the student's statements. An incomplete map or a map with illogical connections between nodes reveals inconsistencies in logic and/or holes in the student's understanding of a concept. These inconsistencies or holes in logic are frequently overlooked in traditional verbal discussions because the idea structure is released over time; in visual form all relationships are present simultaneously.

When trying to understand any complex system, there is only so much information that a participant can hold at a one time. Psychologist George Miller, in his famous study "The Magic Number 7 Plus or Minus Two," revealed the limitations of human short-term memory (Miller, 1956). Complex systems contain far too many components to allow for manipulation within short-term memory, exposing the need for a device that allows the system components to reside and be manipulated outside side of the participants short-term memory. The visual externalization of the system as a map acts as a group memory device and means of manipulating relationships for the entire group. At any particular moment, the map reveals the group's understanding and thoughts surrounding specific content. Through the manipulation of the concept map, the group socially co-constructs knowledge and negotiates meaning.

Other results of student engagement through concept maps include:

- The student sees new information as he or she is concept mapping.
- The other students can tag on and elaborate a peer's map in real time.
- Some students cannot fully articulate ideas through language, but can more easily represent the ideas through the concept map.

- The concept map contains valuable unintended implications and additions that are only seen and understood after a map is constructed.

Each of these advantages shows the central role the concept map plays in the group's construction of new knowledge, the contribution of private knowledge to shared group knowledge, a communication feedback mechanism for externalizing thought, and a means of negotiation and agreement of ideas.

The Collaborative Mapping System's active space privileges a face-to-face style of collaboration and discussion not present in other software models where collaborators participate through individual workstations. Having one socially active space per location allows the group to engage each other through interfacing with the concept map, allowing for the rapid externalization of thought in visual forms. By interacting with the maps in an active space, the collaborators use the maps as a thought aid to reach consensus and to construct and negotiate content, process, and outcomes socially. It is through interacting with each other that the maps are constructed and refined. New knowledge is produced through the negotiation of new relationships within the map (Novak).

THE USE OF VISUAL LANGUAGE

The decisions concerning visual language for the Collaborative Mapping System were made to accommodate and enable particular actions and behaviors appropriate to the corresponding phase of the project. The Collaborative Mapping System has two different visual languages, depending on the project's state of completion. At the beginning of the project, the students are in an idea generation mode, wanting to quickly generate as many ideas as possible. During this phase, the tools and visual language that support and allow the rapid externalization of thought further aid the students (figure 18), while tools that give the students more stylistic control over their content inhibit ideation. In the early phases, while maps are being formed, a cruder visual language composed of 'sticky notes", images, hand drawn lines, and sketches is used. The visual language and tools were chosen to encourage the students during the ideation phase to generate many ideas and to engage with the content, rather than focusing on the visual design of the content. In this phase, the tools should help the students create a lateral network of information and multiple possibilities while valuing speed and ease of use. It is also important that the students focus on a structure that addresses and negotiates the goals and motivations of the constituent parties. If the maps used a refined visual language at an early phase, it would be far easier for a student to consider the map finished than if it contained a less resolved visual language; then focusing the students on the quality and meaning of the connections.

Figure 18
Visual language for brainstorming and ideation phases.

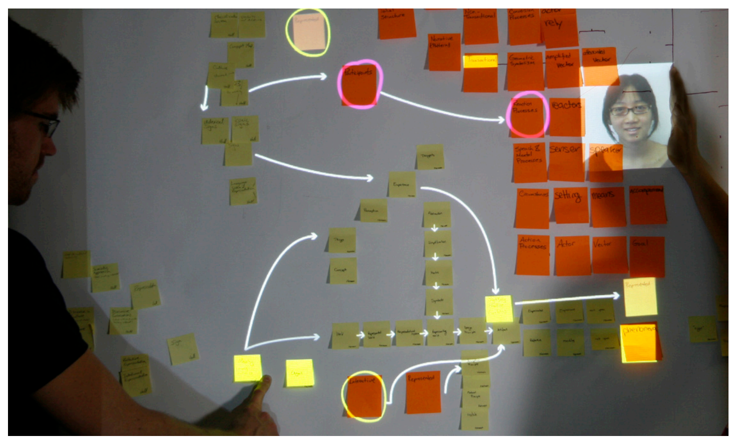
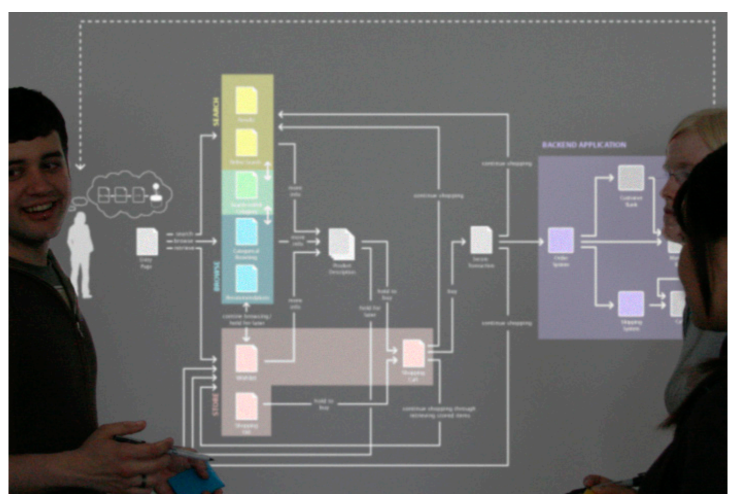


Figure 19
Visual language for refining ideas and evaluating alternatives.



Later when many ideas have been produced and maps have been negotiated and agreed upon, the focus shifts from an ideation phase to a judgment or critique phase. In this later phase, the task requires a more sophisticated visual system that allows for subtle distinctions in meaning and encourages the collaborators to assess the effectiveness of the overall structure (figure 19). At this phase, a new set of tools with a more refined visual language become available to the students, giving them more stylistic control over the imagery that can be produced. Iconic images and a set of connecting lines are part of the later tool set. The iconic images can be used within a map and styled to show subtle distinctions where necessary. The connecting lines available in the later phases have specific meanings internally to the system. These lines represent concepts such as all pathways through a system; pathways specific to personas and scenarios; and the most common pathways through a system by a persona. The goal of the changing visual language is to accommodate the challenges facing students at different project phases. By allowing the group to create their own meaning for stylistic choices, the system can accommodate a wider variety of applications than a more limited set of tools that has predefined system-level meanings. The trade-off is that by using a system that has many predefined meanings, the computer can then generate and summarize information and present alternatives for the collaborators. With the predefined tools, the computer can be used as a collaborative member generating information for the group (appendix B1 contains the functions of the ideation phase, while appendix B2 contains the full refined visual language).

NATURALISTIC ONE-TO-ONE INTERACTIONS

Another design factor in the Collaborative Mapping System's primary interface is the goal to move towards one-to-one natural interactions with the interface, rather than interactions that are based in metaphor, such as using a mouse to manipulate files and folders in windows on a virtual desktop. A desktop with windows would be a curious object in the physical world. Metaphors place a layer of interpretive meaning between the participant and the system, removing him or her from direct interaction with the system. Further, they shift thinking to the metaphorical action not to the information being acted upon. On many computer systems, tools exist as metaphors to aid in interaction with the computer system. One of the goals of this project is to design a behavior-based interactive system that bears a one-to-one relationship between the physical and virtual tasks.

In the Collaborative Mapping System, to add a sticky note to a map, the participant takes the physical sticky note and places it on the map. It is in this action that the note is captured into the system. To move the position of an object in a map, the participant grabs the object with his or her hand and moves it, just as he or she would in the physical world. The participant doesn't use a pointing device like a mouse to position icons representative of their data; instead, the participant manipulates the data as they would in the physical world. The larger purpose is to design a computer system that adapts to the participant's interaction preferences and prior experience, rather than to dictate that the participant adapt to the software and learn entirely new ways of working. P.A. Hancock, Professor of safety science, human factors, and information technology, explains that:

> "intelligent interfaces may be characterized presently as the types of interface which include tools that minimize the cognitive distance between the user's model of the task and the appearance of the task that is implied by the input and output characteristics of the computer software" (Hancock and Chingnell, v).

COMMUNICATING WITH REMOTE COLLABORATORS

One of the communication functions of the Collaborative Mapping System is video-conferencing to facilitate collaboration. The collaborators are projected into the space as if the distance team is standing on the opposite side of a glass wall. Because they are projected into the space at full size it is very easy for the two collaborators to engage each other in conversation and to work through the map as if they were in the same physical space. When dialog between the groups occur, the video image is opaque, but while mapping, the video image dims to a transparency of 60% so the video does not distract from the mapping (figures 20–21).

Figures 20, 21
Distant collaborators co-constructing a map.

The technology composing the Collaborative Mapping System comes from many technological subsystems, which can be configured in a variety of ways (for an in-depth explanation of the technology behind the system, and for the specific technology system required for this setup, look to appendix A. For a full list of all inputs, actions, behaviors and results of the system look to appendix B).

THE NEED FOR MAP COMPARISON

In a collaboration in which the participants create, discuss, and negotiate content and meaning though the manipulation of maps, it becomes important for the collaborators to understand how maps are different. Map comparison can greatly improve upon group processes in three ways: by aiding group memory, by facilitating collaborative negotiation, and by building an understanding of interrelationships within a system.

To address these three areas, the Collaborative Mapping System has three modes for map comparison: *temporal comparison*, *divergent/convergent comparison*, and *juxtaposition*. Each of these serves a different purpose through the type of information that each comparative mode reveals.

The temporal comparison acts as a group memory device. It is for comparing a map to itself at different stages of development. With time, a group frequently forgets the reasoning behind decisions. If a prior step needs to be reevaluated, access to the rationale for its decision becomes highly important. This is possible within the temporal comparison mode, which allows the collaborators to view and compare the map at all stages of its development (figures 22–24). Once any modification to a map has been made, a timeline can be displayed at the bottom of the map, allowing the participant to "scrub" through the timeline. The participant, by "scrubbing" animates the map through all stages of development, between the current state and the state corresponding to the selected position on the timeline. Once the participant begins "scrubbing" on the timeline, the current state of the map remains on the screen, but is dimmed to 75% transparency, while a duplicate of the map (the history map) animates to the different stages in the map's development (figure 23). The history map can be compared side by side with the current map (figure 25). Multiple history maps can be compared to the current map; it need not only be a two-way comparison, three, four our more maps can be compared simultaneously.

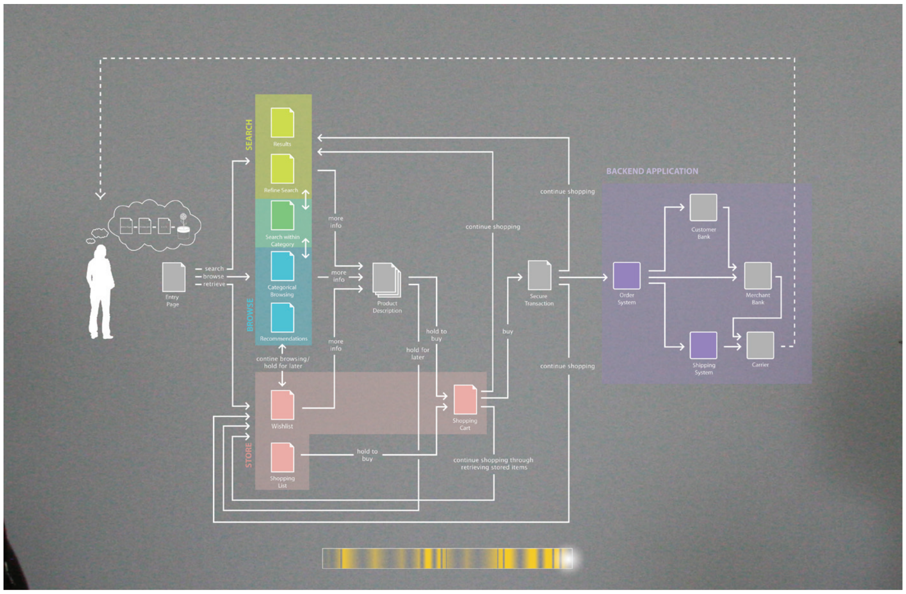


Figure 22
Map with timeline before temporal comparison. White dot represents cursor.

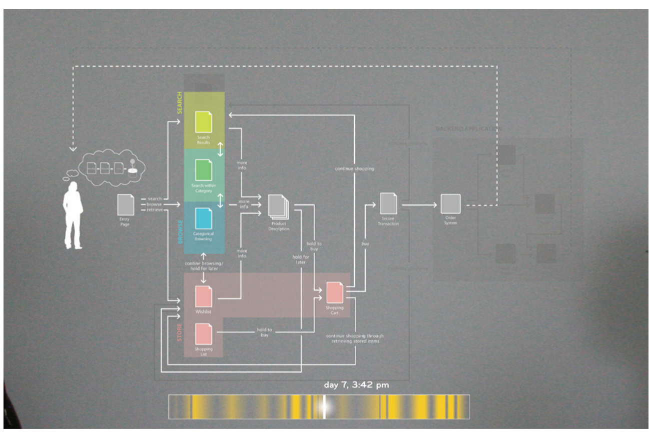


Figure 23
Temporal comparison when "scrubbing" through timeline.

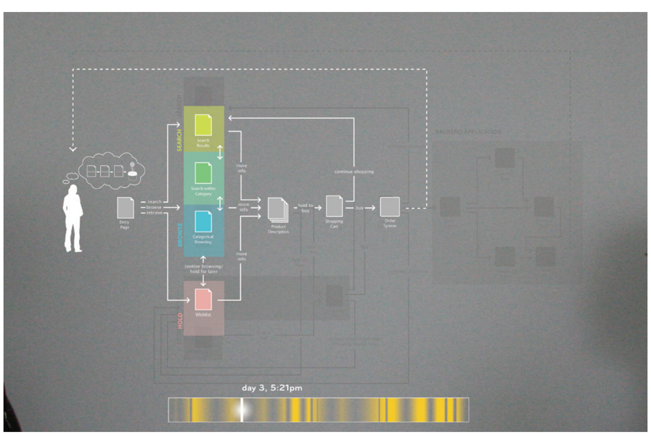


Figure 24
Temporal comparison when "scrubbing" through timeline.

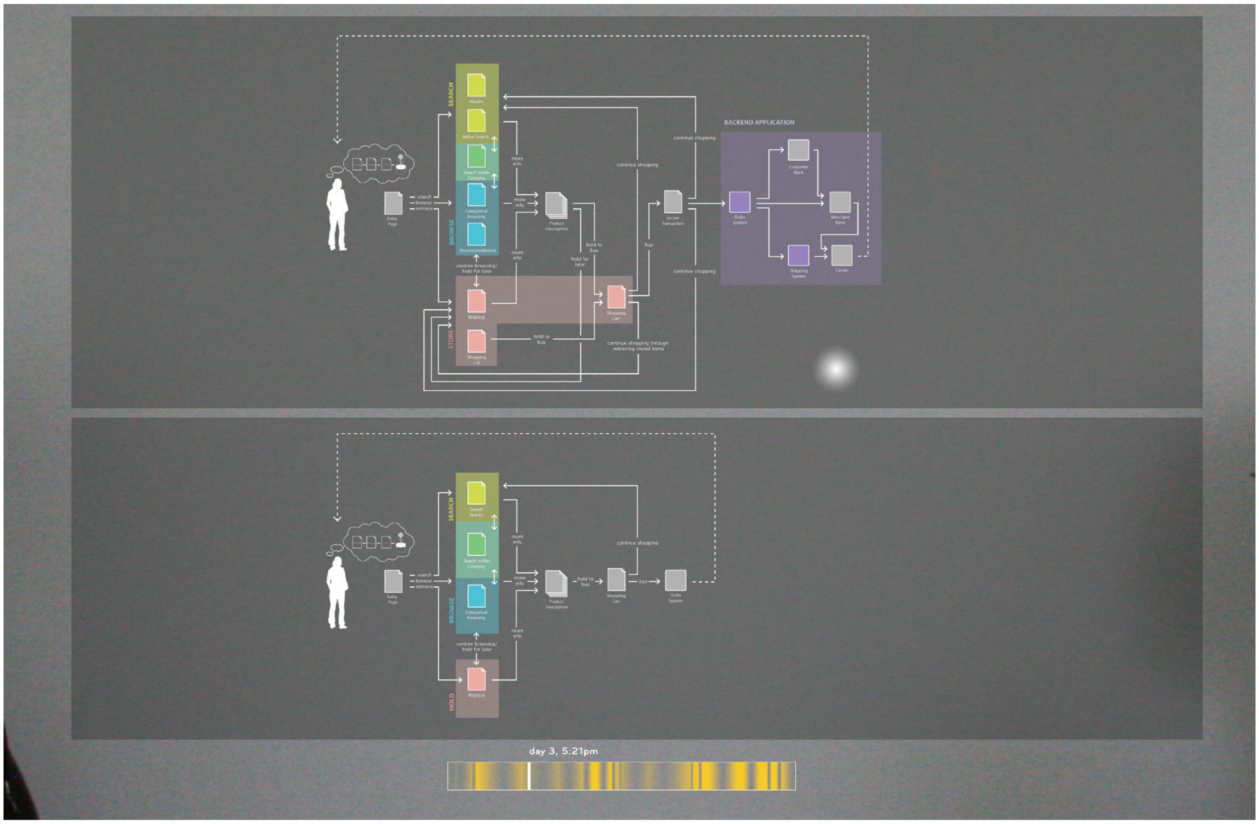
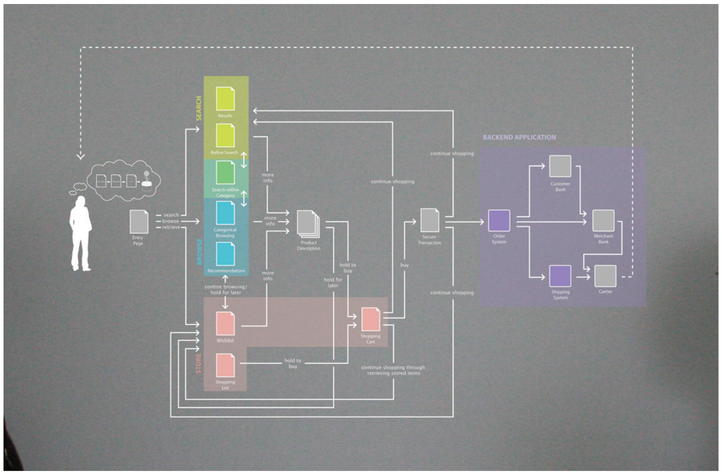
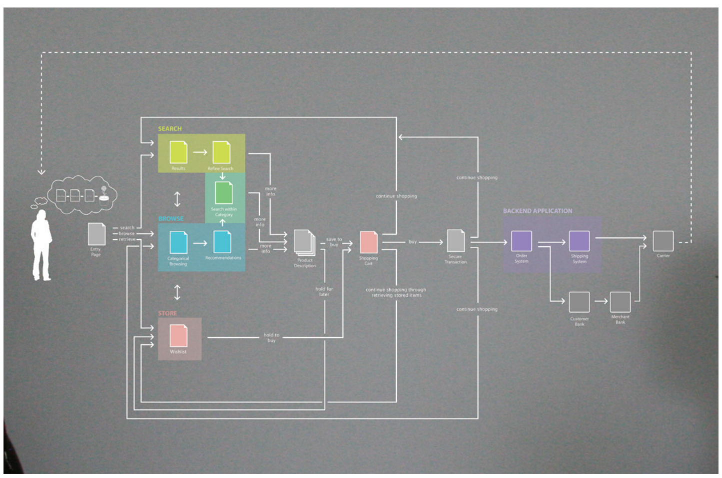


Figure 25
Temporal comparison in juxtaposition mode.

Frequently, collaborators create multiple alternatives to a design problem leading to much disagreement and debate. The divergent/convergent map comparison function addresses this collaborative dynamic by allowing the collaborators to create alternative maps and then providing comparative features for evaluating them through group negotiations (figures 26–28).

The final comparison addresses the difficulty in understanding the interrelationships among the parts of a complex system. This feature allows participants to take two or more maps, each representative of different information, and to juxtapose or overlay them to understand the interrelationships among maps. For example, by examining a data model map for a website juxtaposed with persona pathways through the same website, it might be revealed that the data model inadequately addresses persona goals, or forces participants to traverse a path unrelated to his or her goal. This information would have been very difficult to identify without comparing the two maps.

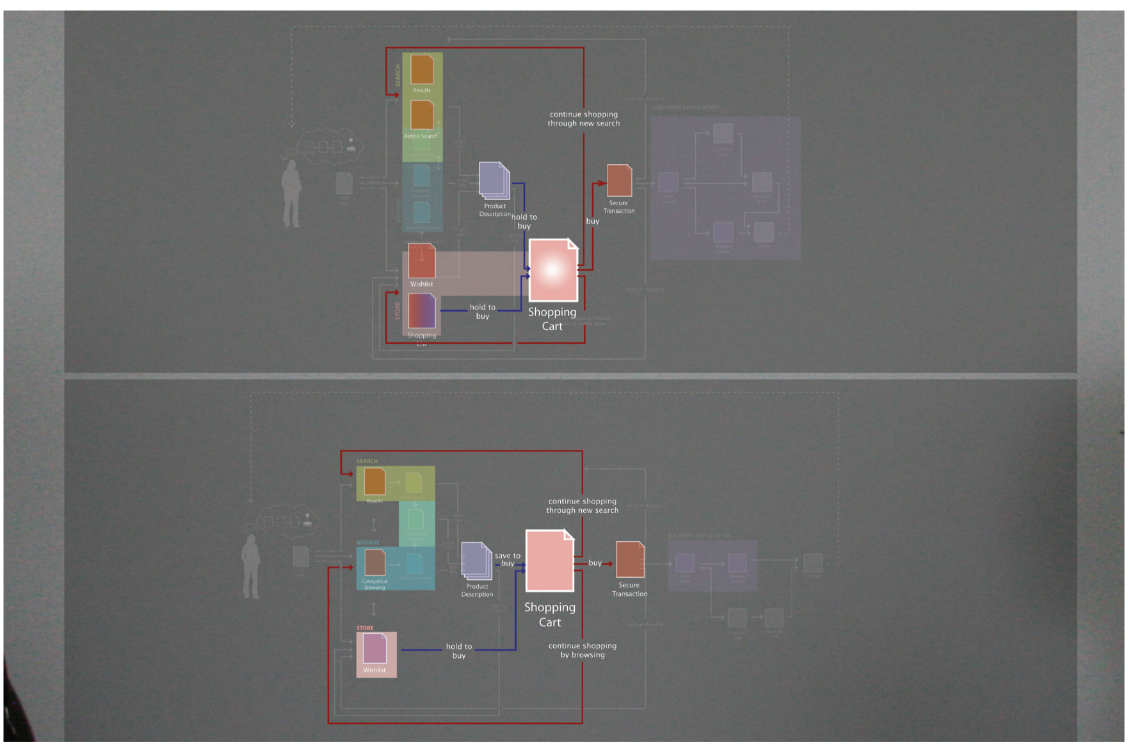




Figures 26, 27, 28
Divergent/Convergent juxtaposition comparison.

The Collaborative Mapping System further provides comparative features once maps are either juxtaposed or overlaid. The interface contains a corresponding highlight feature (figure 30) that can identify similarities and differences among multiple maps. The feature has two modes: one can visually draw attention to similar aspects of different maps while the other draws attention to different aspects of similar maps. Visual distinctions are made though changing the transparency of map sections, by changing the size of map sections, and by highlighting and color-coding map areas (figure 30).

Figures 29, 30
Map corresponding highlight feature.



The locking feature of the Collaborative Mapping System allows educators and professionals to lock areas of a map they feel have reached completion, preventing students from modify those section. An image of a staple in the node visually indicates that it is locked (figure 31). Frequently in large projects, students have a difficult time ranking competing priorities, which leads to time management problems. By allowing the educators and professionals to lock areas of the map, it forces the students to move on to other project components that deserve more time. This allows the educators to divide the time for the project among its components so that each component's allotted time is equal to its educational value.

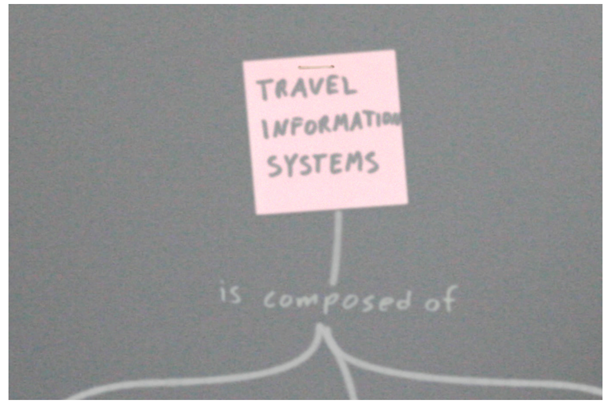


Figure 31
Locked Section of map represented by image of staple in node.

EXTENDING COMMUNICATIONS

One of the factors in designing the primary interaction space is the space's ability to benefit the students by extending a rich social collaboration space to a group of professionals .

This project was informed by an existing collaboration between the Lotus User Experience Design Team at IBM in Research Triangle Park NC and the junior graphic design students at NC State University. Chris Paul, the head of the Lotus Design Team came to NC State and worked with the juniors on an interaction design problem over the course of a few weeks. The students interacted primarily with Chris except on three occasions, when they interacted with multiple members of the Lotus Design Team. Both the students and the Lotus Design Team would have benefited from more interaction, which was limited because of the time and travel distance between IBM and NC State University.

The proposed interface would have extended the benefits of the collaboration in two ways; all Lotus Design Team members who wished to participate could have been involved, and the frequency of interaction between the students and the Lotus Design Team could have been greater. These two changes would increase the expert knowledge among the collaborators and provide the students with a wider variety of perspectives. Simultaneously it would extend the collaborative benefits to a greater portion of the Lotus Design Team. With more interaction, the collaborative product would have been more sophisticated and refined, further benefiting both teams.

DISCIPLINE-SPECIFIC COMMUNICATIONS

Another factor that affects the design of the central interface is the importance of discipline-specific language development skills. Educational Researcher Dr. Deanna Dannels, notes the importance of strong discipline-specific oral communication abilities. She explains that in professional practice, specifically in engineering and design, much new knowledge is produced and communicated orally. Dr. Dannels states "Design teams note the centrality of oral events as a means of knowledge construction, even suggesting that many of the decisions that are most closely tied to claims about knowledge in the disciplines are made in oral discussion" (Dannels, 2005). University-wide English and humanities courses cannot adequately prepare students for discipline-specific communication abilities. It is only through the practice of discipline-specific communications that students acquire these abilities.

The active space for the Collaborative Mapping System is designed to foster discipline-specific communications by creating, using and negotiating knowledge through oral events. The space is designed to be a brainstorming and critique space, which places a heavy emphasis on verbal exchange. In the critique space, the concept maps are representations of thought, and it is through the oral discussion and negotiation of meanings that new information is produced. Communication through both the maps and spoken language are at the very center of this collaboration. The goal is for the group to work as a distributed mind in socially constructing knowledge to create an end result. The complexity of the project requires participation from each group member, and it is through communication that the members participate. This project models and requires discipline-specific communications through the emphasis the primary interface places on oral communication.

THE COLLABORATIVE MAPPING SYSTEM AS A GENERATIVE COLLABORATOR

As previously mentioned, when objects have predefined system level meanings, the computer can computationally affect and generate information. As previously mentioned, maps are composed of nodes and connections among the nodes. The nodes represent objects and ideas while the connections represent relationships among the objects. The Collaborative Mapping System contains two functions that can computationally affect maps through the manipulation of nodes and connections. These two functions are based on metadata associated with the map elements.

Node-based metadata can come from two sources; the first is the virtual space, which allows participants to tag the node with a variety of information and keywords; and the second is information the Collaborative Mapping System generates, based on contextual information from when the node is created and later used. This contextual information includes: map of origination, location on originating map, time of creation, hierarchical information (if the node is map-based) and value information (if the node is matrix-based).

The two main operations the Collaborative Mapping System can perform to generate new information are animated map restructuring, and the animated repositioning of nodes within a Cartesian coordinate system by changing axis criteria (figure 32).

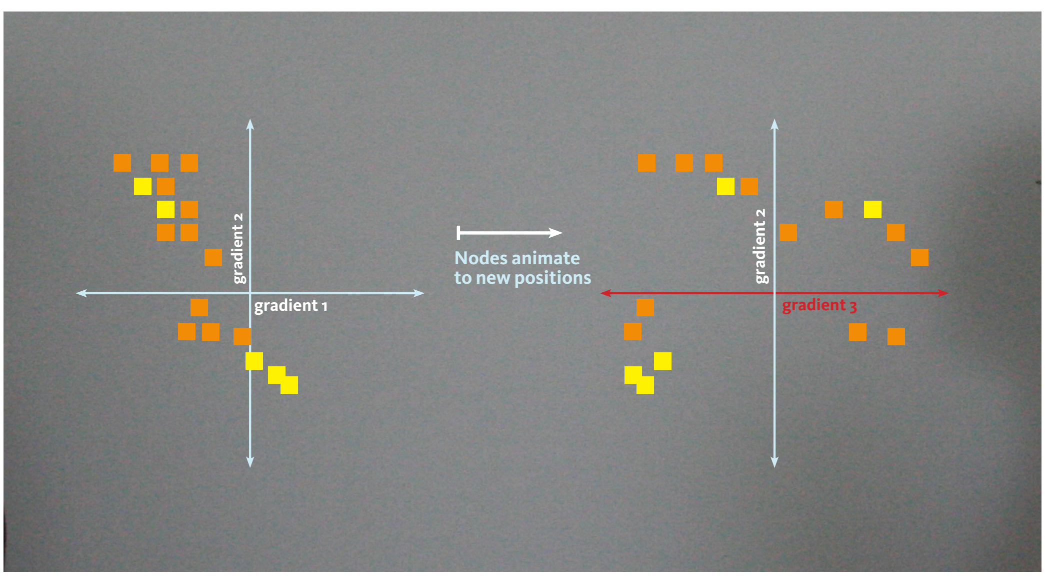


Figure 32
The animated repositioning of nodes.

Within the Collaborative Mapping System, objects can be plotted within a coordinate system. The plotting of the objects can reveal patterns among the objects. Once the objects have metadata assigned to them, the participants can change the criteria for one of the axes and the objects will animate to their new positions. The animated repositioning within the coordinate system displays the positions and values of nodes along a continuum. The participant can control the rate of the animation because significant meaning can be revealed by patterns within the motion. For example, objects can be plotted within a two dimensional coordinate system where the axes could represent quantity, and specificity. This would plot all the objects in two-dimensional space within the coordinate system. The participant then could change the value of an axis from quantity to a continuum of service-oriented vs price-oriented. As the axis' value changes the objects would animate to their new positions. Seeing the pattern of motion would reveal information about the types of objects that exist and how the objects as a group address different criteria.

Another example is the plotting of an application's features where the first axis is *amount of functionality* and the second axis is *amount of customizability*. The application features are represented as nodes in the 2D matrix, and distributed within the matrix according to their metadata values. The axis value *amount of functionality* could then be changed to *amount of processing power required* re-plotting all the nodes within the matrix. The animation of the nodes as the axis changes would reveal if a correlation existed between processing power and functionality while the nodes' new positions represent amount of processing power cross-referenced with customizability.

More importantly, the new positioning of the objects may not have been plotted before; that is, the system would generate graphs that did not exist until asked to plot against those two specific criteria. With this feature the computer is computationally generating information for the collaborators. The collaborators only specified the criteria while the system generates the graph and plot structure. The Collaborative Mapping System would generate new information that the collaborators may not have known or understood prior to the graph.

This is also a factor consistent with Smith's theory of collective intelligence. In this example, the computer generates new ephemeral information for the collaborators. If the new information is meaningful it can become the basis for new group dialog, allowing knowledge to move among the three information states, ultimately generating new tangible instrumental knowledge. In this instance the Collaborative Mapping System behaves as a collaborator by generating ordered configurations of information that contain meaning through position and motion.

The map restructuring function is similar to the re-plotting of nodes. Map restructuring hierarchically reorders nodes (figure 33) through their metadata while retaining the structural connections, or restructures the map along different criteria. For example, a

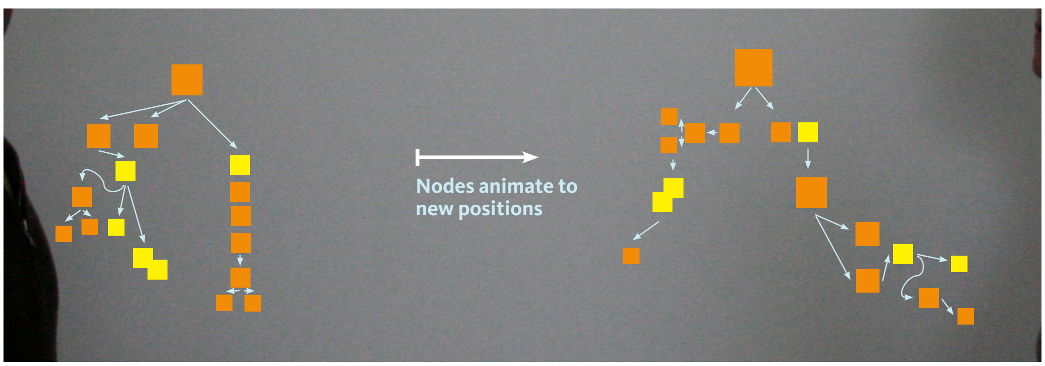


Figure 33
The animated reordering of maps.

map could be reordered hierarchically in layers by "goal type" while keeping the integrity of the connections among nodes. The map would reorder the nodes in layers from most significant goal type to least significant goal type, while keeping the preexisting connections among nodes (figure 33).

THE ONLINE SPACE

The synchronous qualities of the Collaborative Mapping System was the focus of this project, hence, not much research or design work has been invested in the actual asynchronous online space, other than defining the elements and functions of the online space.

The purpose of the online space is to complement the active space. While the active space is designed to be a group space for social collaboration, the online space is a private reflective space for an individual to analyze, reflect, and come to individual understandings of the collaboration. The online space is a portal to the same information as the active space, but provides an alternate representation of the information that is more appropriate to the computer monitor, keyboard, and mouse. When a modification is made through the online space, the modification is made to a duplicate copy, so the collaborators can collectively evaluate that change as an alternative. In the online space, participants can add or subtract metadata from any node or map, making a duplicate copy for negotiations when the collaboration reconvenes. Additionally, annotations can be attached to nodes, and maps, which then are displayed in the active space. Any action that requires a great deal of text input or data manipulation occurs in the online space.

The online space also holds the archive and is repository of all the design decisions and ideas. Finally, the online space hosts forums where the students, educators, and professionals can engage each other in a, more considered dialog as opposed to the action of the active space. In the online forum, lengthy, thoughtful texts and discussions can exist. In the forum, arguments can be constructed and reacted to over time, as opposed to task specific conversations that occur in the real-time active space. The forums would serve as a different form of archive or record of the collaboration than the maps. The forum captures the discourse and issues surrounding the maps.

The online space is also able to extend the collaboration to a wider audience through online forums. The educators and professionals can invite others to participate in the forums regardless of their locations, allowing experts from other locations to participate. By involving other experts, new perspectives and insights are available to the students.

It further allows students to engage others in the material they are working with and understand how the design principles can extend beyond the current project.

The features of the online space for accessing, organizing, and editing the digital recording of collaborative events further compliment the active space. There is a great opportunity for the online space to act as a group memory and give participants the ability to review all factors leading to prior decisions. This would allow collaborators access to the spoken conversation surrounding decisions affecting maps.

The reviewing of collaborative events also allows both professionals and educators to examine group dynamics, and evaluate both group and student performance. The resulting information could be used to improve upon the group performance and for educational purposes to critique and address student collaborative behavior through the student's collaborative contribution.

Addressing student collaborative behavior can increase group performance through two factors: by preventing highly extroverted personalities from inhibiting participation from more introverted collaborators, and to encourage highly introverted students to participate. Degree of extroversion is a factor in all group dynamics and presents a difficulty in all collaborations. The digital recording allows the professionals and educators to view student dynamics when the professionals and educators are absent, providing an opportunity for the educators and professionals to intervene and address the situation.

Additionally, the asynchronous quality of the online space offers opportunities for participation better suited to highly introverted members. Introverted students are more likely to feel comfortable engaging others online because the student can interact with others in the privacy of their own space and can take as much time as desired to write and respond.

Finally, the online space offers features that allow collaborators to collect relevant information from external sources and store them in a central shared location. It would create a space for materials relevant to the project, but are not part of the student work. Information in this category could be items used to frame the project, information and articles to provide background information, examples, project descriptions, learning objectives, detailed information, and readings. By centralizing the content, the students, professionals, and educators can continually bring in found materials and share new relevant information with them at different stages of the project.

The online space compliments the active space by providing an environment for activities better suited to a computer monitor, mouse and keyboard. By dividing the activities among the two spaces, participants can focus on tasks best suited for each space. The active space is optimal for synchronous collaborations while the online space compliments the active space by providing features that facilitate and enhance asynchronous collaborations between students and industry. It is through these two complimenting spaces that the Collaborative Mapping System can provide a socially rich information space to address student-industry collaborations.

CONCLUSION

Currently there is a great need for student-industry collaboration. A widening gap exists between design education programs and the nature of contemporary professional practice. This gap is caused by problems that are increasingly complex and sit at the intersection among many professions. Because schools are not adequately preparing students for the problems of contemporary practice, industry is not receiving qualified workers. To exacerbate the situation, the very nature of contemporary problems change rapidly, partially due to the massive effects of networked culture on everyday life.

A lack of tools and software exists to enable substantive collaborative processes. Most collaborative software exists in one of two categories, communication or information sharing. These two categories reveal the software manufacturers' perspective of collaboration, which is workflow, the intellectual assembly line. Workflow is only one of many perspectives on collaboration. There is little or no software that is designed to facilitate other forms of collaboration and the many needs of participants at different phases in the collaborative process.

Most collaborative software contains functions for communication, but leaves the facilitation of all other collaborative aspects up to the participants. In video conferencing software, the software allows distant groups to communicate, but the group members must create processes for note taking, negotiating, evaluating alternatives, etc. Other software packages create team spaces where the collaborators can share documents and leave notes for each other, but again, shared content and communication are only parts of the collaborative process.

Because there is a need for an investigation into the design of collaborative tools that extend beyond communication and workflow, this project proposes a tool set that enables collaborators to perform in ways traditionally achievable only though face-to-face interaction. At the same time, it examines how the computer can augment this collaborative paradigm with sophisticated communication and collaborative functions.

The Collaborative Mapping System improves upon virtual communications, and collective intelligence, as well as facilitates the separate phases of the collaborative process, and aids group communication, memory, and thought.

The Collaborative Mapping System addresses the needs of collective intelligence between students and industry through concept maps. Concept maps support group processes by acting as a feedback mechanism among the students and between the students and professionals. The maps reveal complex relationships among ideas and allow information to be presented in multiple forms, both orally as spoken language and visually through concept maps.

Collective intelligence is further addressed by the active space. The space is designed to allow both students and professionals to engage socially with each other in naturalistic interactions, creating a rich information-sharing environment. Through the naturalistic interactions that allow for information sharing, the space encourages the students and professionals to co-construct knowledge socially, one of the key tenets of a knowledge-producing collaboration.

To further benefit student-industry collaboration, the system proposes tools that aren't only for communication and information sharing, but tools for specific phases in the collaborative process, including brainstorming, evaluating alternatives and problem solving.

Brainstorming is supported through a specific tool set and visual language appropriate for rapid ideation and map construction. Divergent thinking, negotiation and evaluating alternatives are actions supported through the three separate map comparison functions. Problem solving is addressed through tools that use a more sophisticated visual language and allow the collaborators to encode more specific and appropriate information for solving problems.

The Collaborative Mapping System further enhances student-industry collaboration by providing general collaborative tools that generate alternative presentations of information and act as group memory.

The purpose of these tools is to provide a rich information environment that allows students and industry to have meaningful engagements with each other. In doing so, tools and features support the social co-construction of knowledge and realize meaningful relationships and patterns within the information so that the collaborators can better address complex problems and reach solutions only achievable through collaboration.

There are areas of this project that could have been improved upon but that were limited by time constraints. Left unexplored were the roles that text, audio and video annotations could play within the system; the role of video recording; the integration of the online and active space, computer support for other stages of collaboration; and information not suited for representation in concept maps, such as narratives and linear information.

An annotation system is important because insight can occur at any time, not only at times when the group is fully assembled. Text, audio and video annotation can play a powerful asynchronous communication role within the Collaborative Mapping System and greatly add to its usefulness.

To enable many of the other collaborative features the entire collaborative sessions are video recorded. Further investigation is needed on how the video recording is accessed, and further integrated into other features within the system.

The online space can further addressed methods to aid the non-synchronous qualities of collaboration and additional investigation into the design of tools for aiding individual cognition. Investigating designs for integrating the online space with the active space can also benefited the project's future development.

This project proposed methods of computer support for various stages of collaboration. Further investigation should be conduced on computer support for other stages of student-industry collaboration.

Additionally, concept maps are not the only suitable representational form for all information. Opportunities existed for using the online space to integrate alternate representations of information along with the concept maps, such as lists, charts, graphs, narratives, scenarios, and communications.

Tools that address collective intelligence and group processes are seriously needed. Interdisciplinary teams of people will be the innovation centers of the 21st. century. Many problems are too complex for the individual and require highly specialized knowledge. Without tools and processes to overcome complex challenges, innovation will be stunted and the potential of collaboration will not be fully realized. If done properly, the computer can tremendously augment the collaborative process by enhancing group memory, thought and communication. When this is fully realized we will see great innovation far beyond what exists today.

FUTURE AREAS FOR RESEARCH

This project proposes two separate types of technology. The first organizes a set of tools into an integrated suite that better enables collaborations for designing complex systems, while the second proposes how a participant can interact with virtual data though the same gestures and behaviors one would use with objects in the physical world.

Both of these areas are rich for research. In the area of non-traditional interaction with computer systems, much research would be needed to determine which gestures from the physical world should correspond to data transformation. This is tricky, because many people will do the same task but in different ways. For example, people reach and grab objects in a variety of ways, so the research questions become: Whose version of reaching and grabbing is modeled into the system or can the system accommodate a range of methods for accomplishing the same task? This leads to the more difficult question; can all data transformations be represented through gestures originating in the physical world and how does one perform a data transformation that has no equivalent in the physical world? The data transformation itself could be brought into question and a new method could be found to accomplish the same task. Much more research needs to be conducted on the types of gestures a participant should perform to manipulate virtual objects and control computer systems.

Another area of further research comes from examining tools for the design of complex systems. Simulations and simulation software play a large role in many of the engineering disciplines. For example, very sophisticated software exists for modeling transportation systems. These simulations can account for factors of human cognition, human perceptual range, failures in technology, along with many other factors. The simulation takes a variety of inputs and runs that information through a very sophisticated algorithm. These simulations run for a period of time and return statistics and data resulting from the simulation. In a transportation simulation, the simulation may output that during the simulated six weeks, three accidents occurred, two occurred through insufficient braking distance, while one occurred because of technical failure. There were 23 incidents because of lack of visibility and 19 vehicles ran a stop sign.

Simulations generally have two purposes. The first purpose is to confirm the validity of a design decision, and the second is to reveal unintended consequences and tangential affects of a design decision. An entire subspecialty in transportation research exists solely to compare simulation performance to real world performance. The results of the simulation should not be interpreted as indisputable truth, but rather as likely occurring result within a particular statistical significance interval.

In large-scale software systems, it would greatly improve the software development cycle if simulation software existed to reveal the effects of design and structural decisions. Navigating complex information is very different from navigating a transportation system, so it is unclear whether or not simulations with personas could be run on large-scale software systems prior to development. If they could, the simulations could generate scenarios that the design and development team could have never imagined. The simulations could also drive the construction of scenarios.

Another area within the design of large-scale systems for future research would be the development of simulated "live personas." These would be personas to whom the design teams would attribute values, prior experience, life goals, experience goals, end goals, information processing characteristics, navigation biases, etc. Once this information is within the computer system, the personas could come to life.

Once alive, the personas could respond to a variety of design decisions by revealing tradeoffs and consequences of a decision to the larger system. When the designer changes an aspect of the system, one live persona may respond "I can get to this information more quickly now, and it allows my address book to integrate it." While another live persona may respond to the same decisions "I can no longer find the phone number for help."

The live personas could also be the basis for simulations. Once defined, they could move through a website 40 times with a variety of goals. Places where the persona was lost within the system and navigation that took the persona to unexpected places could then be visualized as map overlays, and placed onto the corresponding map.

More research needs to be done on the types of tools that will aid designers in creating large-scale systems. For all tools constrain thought, privilege outcomes, and limit the quality of a product in ways that are not obvious to those who use the tools. Further, one can only produce outcomes that are commensurate with the sophistication of the tools, thought processes and language for the task. Research must be done on how the design decisions facilitated by complex system modeling tools affect the product.

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APPENDICES

APPENDIX A: Technological setup

There are many technologies that could support the Collaborative Mapping System. The proposed system would use a rear projection screen with small video cameras embedded into the screen and inferred lights to rear illuminate the participants. With this setup, the camera could read the inferred light while blob detection and gesture recognition software would identify participants and their gestures for interacting with the interface. At the same time, a high-resolution camera mounted to face the screen would photograph media that collaborators place on the screen. Image processing software and optical character recognition would create virtual objects and scan the text into the system. The video cameras embedded within the screen would allow the participants to communicate with distant collaborators.

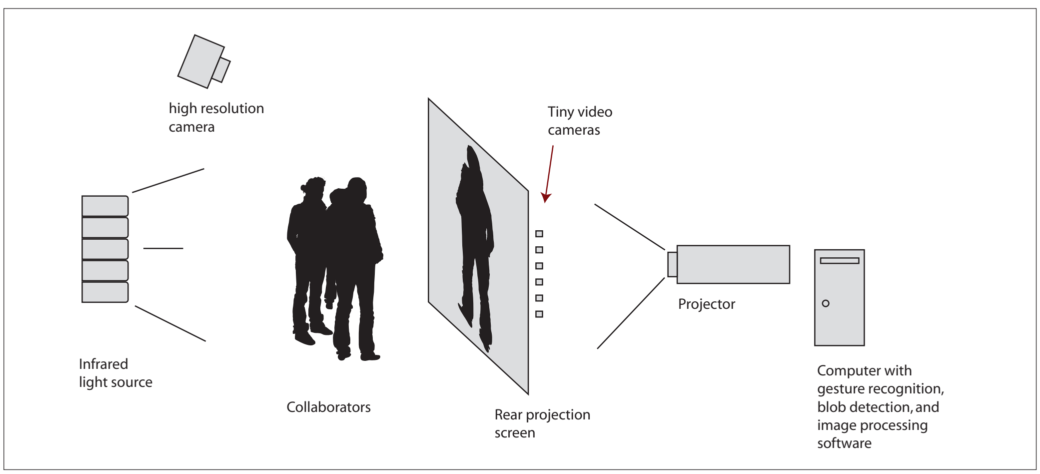
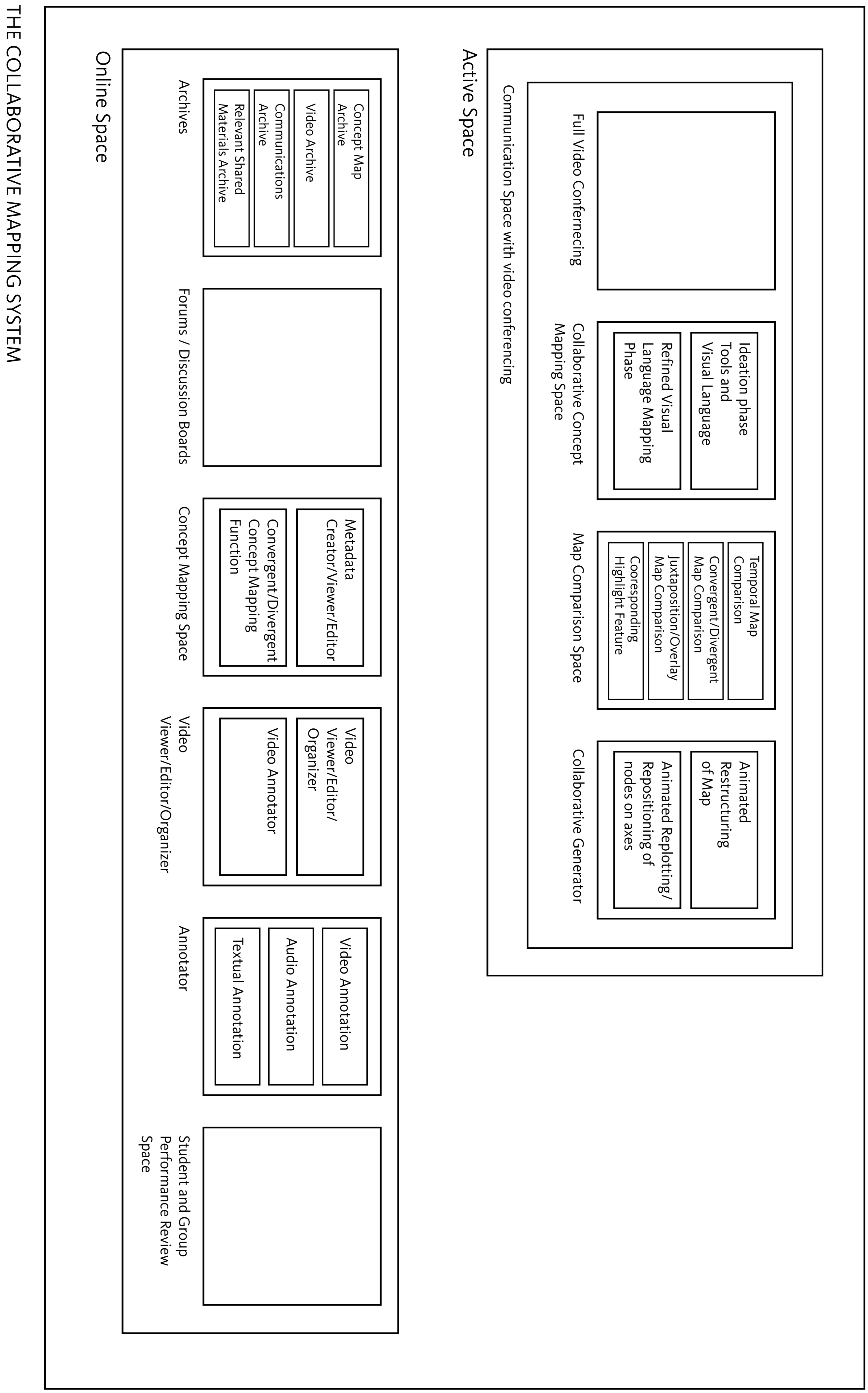


Figure 33
One of the many technological configurations for the Collaborative Mapping System

Many other technologies exist that could support the same functionality. For example, Multi-sense touch screens would allow the same physical interaction with virtual information. Apple Inc. holds a patent for embedding micro cameras in-between every pixel of a lcd display. This would allow for communication between distance collaborators. It would also allow for the recording of the collaborative sessions.


THE COLLABORATIVE MAPPING SYSTEM
Active Space
Communication Space with video conferencing
Full Video Confernecing
Collaborative Concept Mapping Space
Ideation phase Tools and Visual Language
Refined Visual Language Mapping Phase
Map Comparison Space
Temporal Map Comparison
Convergent/Divergent Map Comparison
Juxtaposition/Overlay Map Comparison
Cooresponding Highlight Feature
Collaborative Generator
Animated Restructuring of Map
Animated Replotting/ Repositioning of nodes on axes
Online Space
Archives
Concept Map Archive
Video Archive
Communications Archive
Relevant Shared Materials Archive
Forums / Discussion Boards
Concept Mapping Space
Metadata Creator/Viewer/Editor
Convergent/Divergent Concept Mapping Function
Video Viewer/Editor/Organizer
Video Viewer/Editor/ Organizer
Video Annotator
Annotator
Video Annotation
Audio Annotation
Textual Annotation
Student and Group Performance Review Space

INTERACTIONS WITH THE IDEATION INTERFACE

The interface will recognize all of the following actions:

Place 2-D materials or images onto the screen/workspace (materials are recognized as node within a concept map)

Reposition a node on the screen

Draw connections between nodes

Remove physical 2-D material from the screen to reveal a virtual representation of the same material

Delete nodes

Draw nodes by hand

Basic Drawing Tool

Title propositions connecting nodes

Title nodes

Rearrange clusters of nodes

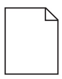
Highlight node(s) to draw attention

VISUAL LANGUAGE, TOOLS AND ICONS FOR THE REFINED MAPPING PHASE

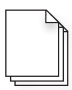
These are the icons, tools, and stylistic features available in the later mapping phase

Icons exist for:

A Single Page



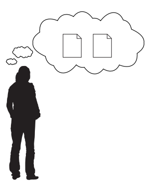
Multiple Pages



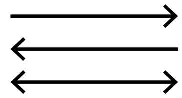
A Software Participant

A group of software participants

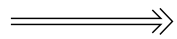
Software Participant's Mental Model



Connections between pages



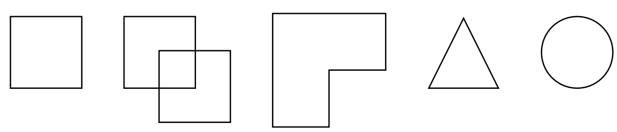
Pathway of a persona through pages



Alternate pathway of persona

Electronic System moving through pages

Shapes that group pages together



Tools also exist to:

- Create and draw shapes and lines
- Stylize lines, shapes and icons with color and stroke characteristics
- Modify: shapes, lines, icons, color, type color, type face, and other type specifications
- Photographs, "sticky notes," digital images, and other materials can be used in addition to the icons and stylistic features.

NARRATIVE SCENARIO

To help understand some of the more complex and subtle features of the Collaborative Mapping System a brief scenario is provided here.

Josh, Becca, Sharon, Kelly, and Kalesia are undergraduate students at North Carolina State University while *Jason*, *Jon*, and *Chris* are members of the Lotus Design Team at IBM in Research Triangle Park, NC. Both the student team and the Lotus Team are standing in front of their respective screens. Both groups see the other group projected onto the corresponding screen.

Collaborator		Dialog	Action(s)
Jason	IBM	**How have you guys been doing since we last met?**	
Josh	NCState	Okay, we were a little confused on, um, how to reconcile how the difference in goals between Frank Raddas (a fictitious persona) and Nick Sobotica (another fictitious persona constructed from participant research) affects the organization of the pages for finding a product. Frank wants to browse through the system while Nick wants to hierarchically find the product quickly. Right now we have created a pretty flat system hierarchically that is, one that doesn't allow for much browsing. What should we do?	
Jason	IBM	**Lets look at the personas and a map of the underlying data model with the site structure overlaid.**	**The screen quickly dims the video stream of the collaborators**

Becca NCState

Brings up the maps of the data model, with her hands she reaches to the side of the screen and gestures like she is grabbing the map. The program responds by highlighting the data-model map, and correspondingly moves it along with her hand, as if she is holding it, as she lets go of the map, it expands to take over most of the screen. Each team can still be seen behind the data-model map but their images are heavily ghosted. The corresponding teams can still see the members on the other side and what they are doing but the image is soft enough as to not distract from the maps.

She then reaches back to the side of the screen and pulls out the site-structure map. As she drags the map across the screen, different regions of the data-model map light up. As she positions the map over the left side, the left side of the data-model map lights up, as she centers the site structure map, the center of the data model map lights up. She finally releases the map as it is positioned over the right side of the data model. As Becca releases the map, the data model map shrinks in size and slides over to the left hand section of the screen while the site structure map grows in size and slides over to the right section of the screen. The maps are now in the juxtaposition mode.

Jason	IBM	Lets overlay them to see the intersections for a moment. I want to see if the structure was a limitation of the data model or whether it was an participant-based decision	Grabs the map and centers it over the data model map. The center of the data model map lights up to indicate that if the site structure map is released, it will become an overlay on top of the data model map. As Jason releases the map, the site structure map overlays the data model map as both maps grow in size and take over the screen while sliding into place.
Josh	NCState	It's not a data model limitation; we decided to do that so Nick could quickly find products, which is his main goal, he is an expert and knows the products. His end goal is to purchase the product while his experience goal is to find the item quickly, and not get lost in the site. He doesn't like using the computer and is used to the organization at the physical store. We didn't create Frank until recently and that is when this problem occurred.	
Chris	IBM	Because this isn't a limitation of the data model, you can change the system structure here to add another tier. By adding this tier, it only separates Nick one level further from his experience goal, but it opens up the system to Frank, who is far more representative of a typical participant.	He highlights the pages he is referring to. He grabs the data-model map and pushes it back into the library. He then grabs the participant-experience map to look at the pathways personas take through the system. Chris overlays the participant-experience map and selects Nick's path. He then pulls apart the map, which represents different pages within the website the students are designing. With his

Chris cont. IBM		finger he draws boxes onto the site structure map to represent new pages. As he draws, the system recognizes the boxes as pages due to their location on the map and the context of being on the site structure map.
Chris IBM	What should be on these pages to allow Nick to still get to his product quickly while allowing Frank to move around, and what types of connections should the new pages have between each other and to the preexisting pages?	
Becca, Kelly, Sharon NCState		Come up to the map
Becca NCState	At this level we can have a larger categorical hierarchy, while at the same time, the system can show all the related products by category. So if Frank has a broken sink, he can start browsing through all the different parts that have to do with sinks, it will put him in the sink section, which is part of the plumbing section. He will be able see the common interactive diagram of the sink and try to find his part within it. At the same time, we can have a discussion board here where site participants can recommend parts, or how to diagnose problems. If they mention a product within the discussion board, the system can link the product to its page. At the same time, Nick just picks his part from the categorical based list, which is moved from the earlier tier of pages.	Touches one of the new pages that Chris made and it lights up. Draws the connections between the pages with her fingers and fixes both Nick's and Frank's path through the site structure.

Josh & Kelly
NCState

Objecting to how Becca mapped out her explanation. Josh goes over and grabs one of the pages. As he grabs it, the page lights up, he drags it to a new position and the connections between the pages fluidly move along with page, keeping the integrity of the connections. Kelly grabs some of the connections and begins to change the connections, changing how the pages within the site link together and the pathways the different personas use. They talk some more and rearrange pages and links until they are satisfied with how the **participants** embodied in Frank and Nick would both be able to accomplish their experience goals and end goals.

Jon IBM **How does your new configuration affects the corporate goals of the store and the technology goals for the project?**

This scenario was provided to aid in understanding how a collaboration may occur using the Collaborative Mapping System and how it can support and augment collaboration.

ANNOTATED BIBLIOGRAPHY

CHALLENGES IN VIRTUAL COLLABORATION *Wainfan, Lynee & Davis, Paul*

Wainfan and Davis examine many of the behavioral and cognitive factors which exist when using various forms of computer mediated communication tools for virtual collaboration. It summarizes a large amount of literature and research and is very good for understanding the diverse challenges that are contingent upon the pairings of collaborative goals and computer mediated communication tools.

COLLECTIVE INTELLIGENCE IN COMPUTER-BASED COLLABORATION *Smith, John*

This book is relatively old for the type of content I am interested in. Smith looks at different computer models as supporting various forms of collective intelligence, from information processing activity to cognitive models and architectures to collective awareness and control. Has a great ground work for many of these ideas but it would be nice to see more contemporary examples.

GROUP COGNITION: COMPUTER SUPPORT FOR BUILDING COLLABORATIVE KNOWLEDGE *Stahl, Gerry*

In this text Dr. Stahl reviews his research of computer systems to aid in collective knowledge building and problems solving. He believes the computer can augment group memory and thought, allowing groups to behave as a distributed mind accomplishing tasks far beyond the abilities of an individual. He looks at the theory and history of Computer Support for Cooperative Work (CSCW) and reviews how computer support has enabled large collaborations to address complex problems.

INTERDISCIPLINARITY: HISTORY, THEORY, AND PRACTICE *Klein, Julie*

In this text Julie Klein takes an in-depth look into Interdisciplinarity, including where it came from, why it is important, how it is being used, who is using it, and where it is being taught. It presents a strong argument that the contemporary problems are becoming far too complex for single disciplines and individuals to overcome and that the traditional divisions of knowledge represented in the academic disciplines need to work together to address the complexity of today.

LEARNING, CREATING, AND USING KNOWLEDGE: CONCEPT MAPS AS FACILITATIVE TOOLS IN SCHOOLS AND CORPORATIONS *Novak, Joseph*

In his text, Novak examines how people can learn in meaningful ways through concept mapping. Novak argues that concept mapping allows people to learn in ways that empower them in work and life. He explains that concept mapping creates meaningful learning as opposed to rote learning. In meaningful learning, people understand how many different concepts come together, allowing them to see how an idea integrates into and affects their lives.

LEARNING HOW TO LEARN *Novak, Joseph & Gowin, Bob*

This book discusses meaningful learning and visual aids and structures that facilitate meaningful learning. I am interested in the use of concept mapping Novak and Gowin propose. It is a means of externalizing thought and representing complex relationships among parts, and the relationships of part to whole.

MEETING OF THE MINDS *Iacofano, Daniel*

Iacofano looks at the strategies for successful meeting facilitation. It examines how to structure meetings, develop an agenda, manage teams with roles in addition it discusses the different roles of a facilitator, group dynamics, and the use of wall graphics. It's a good overview of how to run meetings from start to finish. It's an introductory text written for a general audience.

SCAFFOLDS FOR BUILDING EVERYDAY CREATIVITY *Sanders, Elizabeth*

Dr. Sanders argues that over the past 50 years, man made tools have removed the act of creativity from everyday life, resulting in people who no longer wish to be consumers but to be creators as well. She calls on designers to respond by involving everyday people in the design process by making tools that allow people to express their creativity rather than only using products. She refers to this as a shift from designing industrial tools to designing tools for conviviality, and as the shift from designing for people to co-creating with people.