LiquidBriefing:

Augmenting briefing and decision-making in small groups

By

Douglas Frosst

A thesis submitted to the Faculty of Graduate Studies and Research

in partial fulfillment of the requirements for the degree of

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Abstract

This research presents the development and evaluation of the productivity potential of LiquidBriefing, an integrated briefing system for authors, briefers, and audience members to use for decision making. Requirements for the system are derived from a literature review and a series of role-specific interviews. Key functions include wiki-based structured document authoring, generating slides automatically from document content, generating concept maps from document structure, dynamic briefing navigation using the concept map and hyperlinks, and real-time audience feedback using the concept map. The software prototype was developed over three iterations, guided by observations and participant feedback. Productivity evaluation encompasses several dimensions, including time savings, quality of results, enhanced interaction, and information retention. Results from six experiments indicated that the system can improve productivity for: authors through increased document scope and easier collaboration; briefers through improved briefing flow and increased audience interaction; and audiences through easier interaction and improved briefing flow.

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1 Introduction

"The most important, and indeed the truly unique, contribution of management in the 20th century was the fifty-fold increase in the productivity of the manual worker in manufacturing. The most important contribution management needs to make in the 21st century is similarly to increase the productivity of knowledge work and knowledge workers." (Drucker, 1997).

Automation and networking have improved productivity and reduced operating costs for many processes and industries. One result of this is a dramatic shift in the nature of jobs; an increase in the importance of human interactions and much less on production (see Figure 1). Competitive advantage is now derived more from augmenting human creativity, judgment, and insight, and less from automating rules-based processes and

Source: U.S. Bureau of Labor Statistics, McKinsey & Company, Cisco ETL
Interactions as a % of Labor Costs

Figure 1: U.S Employment by job type

reducing costs (Johnson, Manyika, & Yee, 2005). This new model of work is more collaborative than hierarchical, and productivity-enhancing tools have to make it easier and more effective to communicate, collaborate, transfer tacit knowledge, and make decisions.

Unfortunately, many of the tools used today focus on rote learning, linear decision making, and routine tasks. PowerPoint is one of these. While some functionality exists within PowerPoint for non-linear flow and animation, most users are unaware of the features, or unable to take advantage of them due to lack of time or training. The majority of PowerPoint presentations follow a rigid, linear flow. The content is static, and does not enable a discussion of assumptions or what-if analysis. The space, PowerPoint templates, and bullet style promotes a presentation of statements that are most likely to be interpreted as conclusions. The data and on-screen format are wrapped together into a single, monolithic format, which makes it difficult to incorporate into other presentations, or extract data for analysis. The PowerPoint toolset forces authors to spend more time on mechanics than on data analysis.

1.1 Objective

The objective of this thesis is to evaluate the productivity potential of an integrated system for authors, briefers, and audience members to use for tacit knowledge transfer and decision making. While there are many attributes of knowledge transfer between humans, the specific objective is a system that makes briefings more efficient. Transferring tacit knowledge and enhancing human judgment and decision making requires interactive applications and data representations, as opposed to passive reception

of information. Appropriate visual communications techniques can significantly improve the effectiveness of a briefing, save time compared to solely verbal or textual information transfer, and allow the briefer and audience to better perceive relationships and place information within a broader context.

The research is anchored around a series of questions. Productivity in this context has multiple measurable components, including time, quality, and interactions. The quality and effectiveness of the decision-making are not directly measured as that is beyond the scope and timeframe of this work. Instead, briefing characteristics that lead to better decision-making, such as group interaction and information retention, are used as proxies.

For authors:

- Does the collaborative wiki-based tool connected to briefing slides improve author productivity?

For briefers:

- Does the dynamic briefing navigation improve briefer productivity?
- Does the audience feedback mechanism improve briefer productivity?

For audience

- Does the dynamic briefing navigation improve audience productivity?
- Does the audience feedback mechanism improve audience productivity?

1.2 Contributions

This thesis makes several contributions. First is insight into the changing role of the briefer. As knowledge work changes and technology broadens information access, the role of the briefer becomes less of a lecturer concerned with explicit knowledge transfer and more of a moderator guiding the exploration and discussion.

Second is the importance of structure and process in software integration. With a large selection of components and platforms readily available, it is relatively easy to construct software systems for specific purposes. However, the more difficult part is indentifying the appropriate structure and processes that maximize effectiveness.

Third is the different types of briefings and the relative value of a tool like LiquidBriefing. While the experiments used a discrete briefing event, the value and productivity gains will be greater from an ongoing activity, such as project management, with a growing information set and multiple briefings and decisions.

This thesis is organized into 8 chapters. Chapter 1 is the introduction. Chapter 2 briefly introduces the background to the research topic. A review of the literature and lessons learned are in Chapter 3. Chapter 4 defines the research method, problem statement, relevance, software prototype, and experiment design. Chapter 5 outlines the design and development of the prototype – LiquidBriefing – through three iterations. Chapter 6 is a discussion of the researcher’s use of the software in the development of this thesis. Chapter 7 presents the thesis experiments and results. Closing the paper is Chapter 8, the conclusions, limitations, and suggestions for future research.

2 Background

Human productivity has increased steadily for the past 150 years, initially with the automation of production activities, followed by the automation of economic transactions. For several years, the researcher has been exploring knowledge-worker productivity, from automating routine tasks to enhancing decision-making, judgment, exception processing, and pattern-recognition skills in end-users. This section provides an overview of these concepts. Improving the productivity of interactions is at the core of this research.

2.1 Production, transaction, and interaction

Organizations are experiencing a fundamental shift in the nature of work. Routine tasks are being automated at an increasing pace, in all types of organizations. People work is becoming all about knowledge, judgment, exception processing, and creativity. This shift is accompanied by an increasing specialization of tasks, resulting in frequent interactions between specialists on any given project. The knowledge involved in these interactions is less codified and more tacit, making it more difficult to transfer.

2.1.1 Production

The concepts of production, transactions and interactions are not new in the field of economics. Production has the clearest definition: activities that involve the creation of goods, such as making, building and growing. Applying technology to improve production productivity has a long history. While companies must continue to deliver world-class production productivity, the opportunity for substantial investment returns and competitive advantage from automating just production activities is greatly

diminished. Production has become a commodity – which can be seen in the increasing prevalence of outsourced manufacturing.

2.1.2 Transaction

Research on economic transactions dates back to the 1930s, with solid definitions based on research emerging in the 1970s (Economist Ronald Coase won a Nobel prize for his work on the transaction costs theory of the firm). Building on this work with people from the McKinsey Global Institute and MIT economists Frank Levy and Erik Brynjolfsson, among others, resulted in the following definition: Transaction activities are those that involve simple communication and that do not require the use of judgment and insight; these activities can involve problem-solving of a type based largely on codified rules. Simplifying this further, transactions involve basic information inquiries, stocking/inventory, shipping/transportation of goods, and payments. Many of these activities involve decision making, of the kind that can be captured with a set of rules or regulations; activities that are ripe for automation (Johnson et al., 2005). The Internet Economy made it possible to dramatically improve the productivity of transactions. The bulk of technology spending has been focused on reducing transaction costs, and companies will find it increasingly difficult to differentiate based on their transaction efficiency. As with production, being good at transactions becomes a necessary part of doing business, but a diminishing source of competitive advantage.

2.1.3 Interaction

Transactions and Interactions are more of a continuum than two separate, distinct categories. This is what provides the opportunity for differentiation, and competitive

advantage; an interaction to one company or customer segment could be a transaction to another. Research on interactions dates back to at least 1960, with Nobel-laureate Herbert Simon offering the opinion that: "In the entire occupied population, a larger fraction of members than at present will be engaged in occupations where 'personal service' involving face-to-face interaction is an important part of the job." (Simon, 1965: 45).

More recent research on this topic has been done by McKinsey, Boston Consulting Group, MIT economist Frank Levy, among others. Businesses will increasingly differentiate themselves not by how they make their product, but how they sell it. Working with these experts resulted in the following definition: Interaction activities are those that cannot function without human intervention (physical or virtual); these activities involve judgment and insight applied to complex communications and processes, creativity, exception processing. Simplifying this further, interactions involve influencing, persuading, motivating, innovating, educating and governing. These activities are complex and cannot be readily captured with a set of rules, so they resist automation. However, technology will aid interaction workers by increasing their available knowledge, automating repetitive transactions, increasing the reach, quantity and quality of interactions, and enabling them to make a more valuable contribution to their organization's growth and competitiveness.

2.2 Definitions

Audience: Individual or group that is the target of the knowledge transfer activity.

This may be a diverse group, with different objectives and interests.

Author: Individual or group responsible for creating, collecting, analyzing, and synthesizing the data and information that goes into a brief.

Briefer: Individual or group that is the primary actor or leader in the knowledge transfer activity. The briefer may or may not be one of the authors, and may change for different audiences or different components of the briefing.

Briefing: Synchronous activity of transferring knowledge to one or more audience members, in which audience members typically have a network-connected display device.

Context: Set of characteristics that define a briefing event, or the situation in which the briefing occurs. This would include factors such as the organization, audience, urgency, level of uncertainty, potential impact.

Presentation: Static set of linearly ordered slides shown on big screen

Presenter: Individual or group that is the primary manager of a presentation

3 Literature review

Given the scope of available literature and research on collaboration, presentations, and information visualization, a deep research foundation is necessary to identify the features with the greatest potential. Even in the initial review, many commonly-held beliefs about presentation effectiveness were encountered that are contradicted by empirical studies.

These persistent myths also underscore the importance of evaluating the concepts and software within typical target environments, not in hypothetical or artificial scenarios. Much of the existing research is conducted on students in a particular university course, or recruited to participate in a study. These scenarios may have very different group dynamics than a typical organizational setting. The goal is to perform the experiments in corporate organizations, with real teams that are working to solve real problems in their organization. This will provide a more accurate assessment of the validity and potential of the approach.

When investigating the impact of information technology tools on productivity, the trail leads to a series of papers written in the 1960s by Nobel-prize-winning economist Herbert A. Simon (1965). In these articles, Simon, with an interest in organizations and decision making and an educational background in operations research and economics, speculates on the future impact of computers and automation on office work and management functions.

Simon begins his analysis with a review of the factors that lead to the steady growth in labour productivity during the previous century, concluding with the familiar equation

of capital applied to automating repetitive human tasks. From this foundation, he applies the economic doctrine of comparative advantage to project the future impact of automation on the corporation. Reminding us that it is comparative advantage, not absolute advantage, which determines the substitution of capital for labour, he identifies "flexible, general-purpose problem-solving" (Simon, 1965: 38) as one of the greatest areas of comparative advantage for humans, and interacting with other humans as one of the greatest requirements for flexibility (Simon, 1965: 42).

Continuing the analysis, he equates management functions with decision making, and specifically defines decision making as "... the whole lengthy, complex process of alerting, exploring, and analyzing ..." (Simon, 1965: 53). This process is then divided into three, unequal parts: searching for decision-making opportunities, identifying potential courses of action, and choosing a particular action (Simon, 1965: 54). Realizing that advances in knowledge and computer-processing capabilities will create a shifting continuum of problems along a scale of programmable to nonprogrammable, he concludes his speculations with an assertion that a future revolution in automation will come about when we "discover how to use computers to aid humans in problem solving without first reducing the problems to mathematical or numerical form." (Simon, 1965: 77).

A later work coauthored by Simon explores the potential benefits of diagrammatic representation of problem-solving inputs. From a perspective of human computational efficiency (a component of productivity), a visual representation can not only reduce the information search time with appropriate groupings, but can augment the powerful

human abilities to detect relationships and inferences (Larkin & Simon, 1987). The scenarios envisioned for this research involve making decisions in complex situations that are exceptions to codified processes and require the use of judgment and creativity in the face of uncertainty and incomplete information. Information visualization techniques are examined to determine their potential role in the decision-making process.

To begin to address the issue of aiding human problem-solving, the literature review for this thesis covers a variety of topics (see Figure 2), listed below and discussed in subsequent sections:

Figure 2: Concept map of Literature Review section from LiquidBriefing

- How has the nature of work changed?
- What information technology is being used today to aid human decision-making?
- What information visualization techniques are advantageous?
- How can we best augment the process of creating the inputs to a problem-solving activity?
- How can we best augment the process of communicating and moderating a problem-solving discussion?
- How can we best augment the process of consuming and analyzing a problem-solving discussion?

The bodies of work that explore these topics are very large. Some have a significant degree of overlap, and it is felt that the selection used for this review is representative of the current state of research. The following subsections provide a detailed discussion of key points that have been learned from the literature and research review.

3.1 Information technology and competitive advantage

"The availability of powerful new tools for coordinating human effort will profoundly change the work of management over the next few years." Gary Hamel, as quoted in (Barsh, 2007).

3.1.1 Routine, rules-based work being automated

The invention and adoption of machines has caused, and will continue to cause, changes in the set of tasks that make up human jobs (**Error! Reference source not found.**; Autor, Levy, & Murnane, 2003; Simon, 1965). Historically, information

technology and machinery have been largely used to improve productivity by replacing human labour for repetitive and rules-based tasks. The resulting reductions in production or transaction costs, and increases in speed or flexibility, have provided companies with long periods of competitive advantage. However, analysis of economic data reveals that automating production or transaction processes is delivering diminishing returns, shrinking both the magnitude of improvement and the duration of advantage (Johnson et al., 2005). The focus is shifting as companies seek other sources of competitive advantage, not just in products, but also in processes, value chains, and business models.

Figure 3: Trends in routine and nonroutine task input, 1960 to 1998
(Autor, Levy, & Murnane, 2003)

3.1.2 Competitive advantage derived from coordination and collaboration

A review of the large set of literature on wage and skill distribution in the last half of the 20th century indicates that technology adoption has been a dominant part of a “skill-biased” change in labour demand (Katz & Autor, 1999). Technology adoption has a range of benefits, including productivity growth, quality improvements, and increased innovation, as illustrated by a recent review of the economic impact of information technology (Atkinson & McKay, 2007). As a result, the value-added output of the firm increasingly develops from jobs that require judgment and insight, exception processing, and creativity. Competitive advantage is now derived from augmenting human capabilities in these areas, not replacing them, and new tools are needed to make that possible (Autor et al., 2003; Barsh, 2007; Beardsley, Johnson, & Manyika, 2006; Johnson et al., 2005). This new model of work is more collaborative than hierarchical, and productivity-enhancing tools have to make it easier and more effective to communicate, collaborate, coordinate, and make decisions. “A power shift is underway, and a tough new business rule is emerging: harness the new collaboration or perish.” (Tapscott & Williams, 2006). As this literature review demonstrates, many concepts already exist on how to achieve these enhancements, but they haven't yet been integrated into a cohesive system (Barsh, 2007; Eppler, 2003).

3.1.3 Need for new tools to augment new work styles

In addition to the continued growth of task automation, the set of human knowledge is also growing. This increases the relative specialization of tasks, which in turn increases the volume of interactions. Outsourcing and globalization are also affecting the

volume of interactions. As a result, a greater, and increasing, percentage of the workforce is involved in complex interactions, often outside the boundaries of the firm (Johnson et al., 2005). Existing information tools have lowered costs by increasing the volume or reducing the time of human interactions, but have not made significant enhancements to the quality or effectiveness of these activities.

3.2 What information technology is used today to aid group decision-making?

According to Herbert Simon, making rational decisions requires identifying and evaluating the available options and choosing the one that best fits the goals, values, and constraints of the group or organization (Simon, 1965: 54). However, it is not feasible for any individual or group to identify and evaluate all of the potential options. There will be some missing information and uncertainty requiring the application of human judgment, which is sometimes referred to as bounded rationality. In today's organizations there are many types of decision-making; too broad a subject with many different tools to effectively cover in a single literature review. This research and literature review focuses on the exploration of choices and application of human judgment that happens in a meeting, typically accompanied by a slide presentation.

3.2.1 Human decision-making is limited by bounded rationality

As Simon identified early on, problems that consistently have a full-set of information available and follow a defined procedure can be readily programmed, and the non-programmable ones will be left for humans to deal with (Simon, 1965: 58). Traditional assumptions that humans operate as rational agents in this scenario have given way to a more nuanced model that also incorporates emotion and intuition

(Rubinstein, 1998). Making decisions with a subset of information and options requires a balance between rational and intuitive human capabilities. Some situations are better served by the intuition of experienced decision-makers, while others benefit from a greater degree of rationality, and this balance will vary among individuals (Kahneman, 2003). Humans tend to simplify problem sets, favor programmable over non-programmable tasks, and justify intuitive decisions (Rubinstein, 1998; Simon, 1965). Current briefing tools can exacerbate these issues, with an oversimplification of information but with limited support for the intuitive and pattern-matching capabilities of humans (Tufte, 2007).

3.2.2 Presentations and Microsoft PowerPoint

By far the most common slide-presentation tool used in organizations is Microsoft PowerPoint, with over 250 million copies of the software producing trillions of slides each year (Doumont, 2005). Searching the academic literature for research on PowerPoint turns up mostly studies in educational environments, such as those in Alley (2003), Alley & Neeley (2005), Amare (2006), James, Burke, & Hutchins (2006). Arguments for (Doumont, 2005) and against (Tufte, 2006) PowerPoint have been raging for some time, with adjectives like pointless, stupid, and evil often employed by the prosecution. The reality is that presentation slides have become a ubiquitous communication tool, to the point that "a lot of people in business have given up writing the documents. They just write the presentations, which are summaries without the detail, without the backup." (Gomes, 2007).

Business presentations date back long before PowerPoint, which was conceived by Robert Gaskins in 1984. As vice-president of business development at Forethought, Inc., a small software company in Sunnyvale, California, Mr. Gaskins envisioned a tool that would improve the effectiveness of presentation content, produce slides, notes, and handouts from a master file, and allow the "content-originator to control the presentation" (Gaskins, 1984). Microsoft acquired the company in 1987, their first major acquisition, and has substantially enhanced and extended the product over the past 20 years. Its creator bemoans the current state of presentation as multimedia extravaganza, commenting that "...virtually none of the extraneous entertainment had any purpose or benefit in the kinds of meetings where overheads had been used." (Gaskins, 2007).

The term presentation covers a broad range of goals, topics, and styles. In order to manage the scope of work, the focus of this literature review is on presentations that are used in a small group environment (less than or equal to 20 people in the audience versus hundreds of participants), contain substantive content, and are intended to aid a decision-making activity. This specifically excludes presentations that are primarily entertaining or persuasive in nature, as well as those that are primarily one-way communication, such as training or a lecture.

Most of the empirical studies on presentations have focused on lectures. A review of university-based studies found that outcomes of PowerPoint lectures versus other methods were inconsistent or negative, based on content recall, classroom interaction, and student behaviours (James et al., 2006). The studies indicate a neutral to negative impact on classroom participation and spontaneous discussions. There are also several

gaps between perception and reality. Students gave higher marks for PowerPoint lectures, but did not get higher marks on the tests (Amare, 2006), and the presenters tended to have a higher opinion of their effectiveness than that of the audience (James et al., 2006). Much of this gap can potentially be attributed to the challenges of creating effective presentations, and common misconceptions about slide formats, handouts, and graphical embellishments.

3.2.3 Presentation myths and challenges

There is no shortage of articles on how to create an effective presentation. Common tips cover items such as slide headings, bullet points, appropriate use of graphics, and other aspects of slide format. However, experienced commentators emphasize a greater focus on content and structure (Alley, 2003; Doumont, 2005; DuFrene, 2005; Farkas, 2005; Gaskins, 2007; Holcombe & Stein, 1996). Two enduring PowerPoint myths relate to the optimal number of items on a slide, and the value of images or video over text.

That slides should contain no more than six or seven bullet points of no more than six or seven words each is a commonly found item in PowerPoint best practices. This recommendation appears to be derived from a 1956 paper by cognitive psychologist George Miller, entitled “The magical number seven, plus or minus two: Some limits on our capacity for processing information” (Miller, 1956). Unfortunately, this metric is applied without being well understood. The paper first summarized research on people’s ability to discern different audible tones, auditory loudness, colour hues, brightness, points on a line, sizes of squares, and degrees of saltiness or sweetness; hardly related to remembering material from a slide. It then looked at short-term recall of random and

unrelated digits, letters, and monosyllabic words. This latter resulted in a range of five to nine items correctly recalled, summarized as seven. While the message is important, that the capacity of immediate memory is limited, the absolute number “as an upper limit of anything is more misleading than helpful” (Doumont, 2002).

Another frequently cited PowerPoint mantra is that people remember more of what they see, less of what they hear, and least of what they read. This is also derived from a paper from the 1950s, this time a 1954 book by Edgar Dale entitled “Audio-visual methods in teaching” (Dale, 1954). Dale presents a “Cone of Experience”, in which he summarizes “the interrelationships of the various forms of audio-visual materials”. Over the years, this original visual has been reproduced as bar graphs and pyramids with numerical values assigned to each level, attaining statistical credibility. However, this is another myth that is not supported by research. While research does make a connection between multimedia content and improved retention or learning, it is a complex area, influenced by attention and motivation, among other variables, and should not be oversimplified as a presentation rule (Cisco, 2008).

3.2.3.1 Content and structure

One of the benefits of a presentation, in contrast to written material, is the potential for timeliness of the content. By the time they are published, articles are months old and books a year or more, but a presentation is readily updated to be only days or even minutes old (Alley, 2003). This imposes upon the author and presenter some requirements for discipline and structure. When processing information, humans try to group and categorize data and identify logical relationships. In the absence of an explicit

structure communicated by the presenter, they will infer a structure based on items such as slide titles and font sizes, which can negatively affect their recall and understanding of the material if the structure is not sound (Farkas, 2005). Developing a logical structure and explicitly mapping it out for the audience (not by reading an agenda slide), places the material within the organizational context, and is a better use of preparation time than any special effects or other embellishments (Alley, 2003; Doumont, 2005; DuFrene, 2004; Farkas, 2005; Holcombe & Stein, 1996). “It’s not enough to marshal an effective argument. The essence of persuasion, communication, and self-understanding has become the ability to fashion a compelling narrative.” (Pink, 2005: 66).

Presentation challenges are compounded by the fact that people in the audience do not necessarily receive and process information in the same way. Existing research (Wagner, 2006) has identified that there are at least four different ways of connecting with and synthesizing information in a presentation: the data, the structure, the vision, and the human or organizational components. In order to effectively communicate with all members of the audience, each one of these perspectives must be included in the briefing. Even with this knowledge, PowerPoint forces the briefer to proceed one perspective at a time, often repeating information.

3.2.3.2 Presence

Another advantage of presentations over written material is the presence of the presenter to guide the discussion and answer questions (Alley, 2003). This implies a connection with the audience, an awareness of their needs and reactions, and an ability to adapt and accommodate the feedback (Alley, 2003; Doumont, 2005; DuFrene, 2004).

Unfortunately, computer-projected presentations in their current form are more likely to create a barrier between the presenter and the audience, reduce audience interaction, and restrict the ability of the presenter to adapt (Alley, 2003; DuFrene, 2004; James et al., 2006). "One disadvantage of a computer-projected presentation is that the speaker is locked into the order established at the beginning." (Alley, 2003: 100). A common practice of deferring questions to the end in order to preserve the planned slide flow can cause a loss of attention as audience members try to remember their questions, cause some to lose track because they need the answer in order to construct the necessary relationships, or even "expend their energies wondering why you won't answer questions now." (Holcombe & Stein, 1996: 207).

3.2.3.3 Graphics

Visualization on slides can have a beneficial impact on the human ability to process and retain information (Alley & Neeley, 2005). However, one of the consistent comments from empirical studies about presentation usage is the distraction of excessive or inappropriate graphics and special effects (Alley & Neeley, 2005; Amare, 2006). Instead, authors are encouraged to use visuals sparsely, in direct support of the assertions of the current topic. Basic slides are preferred by the audience over embellished ones, and when used to support and reinforce a concept can lead to improved outcomes (Alley & Neeley, 2005; DuFrene, 2004; James et al., 2006). "Audiences rarely complain about too little embellishment but are easily distracted and offended by too much." (Gaskins, 2007).

3.2.3.4 Handouts

Presenters are often faced with the question of whether to provide handouts before or after the meeting. Some think that providing handouts before the meeting is a distraction for the audience and presenter, and creates a conflict between reading and listening (Doumont, 2005; Holcombe & Stein, 1996: 85). Others see a strong benefit to handouts, especially the ability to provide supplementary details (DuFrene, 2004; Tufte, 2006). In the academic setting, professors had a higher preference to withhold handouts for fear that they would reduce attendance or participation, while students wanted the handouts to reduce duplicate note-taking and felt that attendance would be unaffected (James et al., 2006; O'Neill, 2005).

Whether provided before or after the event, handouts come in many forms, from a simple copy of the slides to a detailed briefing document. A detailed comparison of the effectiveness of various presentation summarization techniques (based on an information-recall quiz) concluded that providing just slides with bullet points resulted in the lowest comprehension, compared to more information-dense slides, a combination of basic slides and transcript, or an audio-video summary. These results "conflict with the common advice that slides should contain only the major points to retain attention of live audience", and support the creation and dissemination of more detailed documents to the audience (He, Sanocki, Gupta, & Grudin, 2000).

3.3 What information visualization techniques will be advantageous?

"Visualization has proven to be an effective strategy for supporting users in coping with complexity in knowledge- and information-rich scenarios." (Keller & Tergan, 2005).

There are many types of visualizations; they can turn data into information, information into knowledge, and knowledge into understanding (Keller & Tergan, 2005; White, 1984). In order to be effective, they must be developed with the needs of the audience in mind (Eppler & Burkhard, 2007). They can be used to support a particular topic to improve understanding and retention (Alley & Neeley, 2005), to display structure and relationships (Eppler & Burkhard, 2007), or provide overall context (Chen, 2004; Tufte, 2007). Appropriate visual communications techniques can significantly improve the effectiveness of a briefing, save time compared to solely verbal or textual information transfer (White, 1984), and allow the briefer and audience to better perceive relationships and place information within a broader context.

3.3.1 Visualizations aid human information processing

Visual communication techniques are an important part of human culture and language. Like any language, they can be classified along dimensions of formal to informal and professional (specific) to general (Kukulska-Hulme, 1999). Components of visual communication include colours and shapes, as well as icons, diagrams, tables, charts and graphs, maps, images, and text. The meaning of visuals is affected by size, location, colour, proximity to other components, and cultural norms (Horn, 1998).

The combination of eye and brain has a tremendous capacity to process complex visual information quickly. It can find subtle patterns, identify key relationships, and make comparisons more quickly and accurately than with textual data (Eppler, 2003; Eppler & Burkhard, 2007; Larkin & Simon, 1987; Tufte, 2007; White, 1984). There are distinct differences in verbal and visual processing and preferences between individuals, and they are correlated with gender and preference for science or humanities (Chabris et al., 2006). In general, the human brain processes visual information more quickly than textual information (Folds, 2005; Larkin & Simon, 1987). Visualizations provide the greatest value when they are used to supplement text, as a direct aid to organizing, interpreting, or interacting with the information. In this capacity, appropriate visualizations can reduce cognitive processing, enhance recall and comprehension, and even improve attention if they have interactive elements, such as clickable diagrams (Carney & Levin, 2002; O'Donnell, Dansereau, & Hall, 2002).

Figure 4: Visualization and knowledge management (Eppler, 2003)

However, human visual processing is not infallible. It is better at judging position than length, length than area, and area than volume (Cleveland & McGill, 1984). It can be distracted by the thickness and orientation of lines, misled by the choice of scale, and can see things that aren't really there (negative space) (Horn, 1998; Tufte, 2007). Different visualizations of the same data or information can lead to different conclusions by the same person, underscoring the importance of choosing the appropriate visualization technique for the objective (Horn, 1998).

3.3.2 External representations of structure expand capabilities of human memory

One of the primary concerns when building a briefing document with visual components is selecting and using visual elements and metaphors that are relevant to the context, objective, and audience and which can augment human productivity. In the case of decision-making, the primary processing capability to be augmented is the identification of relationships and pattern recognition (Keller & Tergan, 2005; Larkin & Simon, 1987; Simon, 1965; Wexler, 2001). Patterns and relationships involve non-linear processing by humans. Doing this with linear text requires translation of text to symbolic representations and repeated transfers between working memory and longer-term memory, or frequent searches of the document. External visual representations of information structure can be much more complex than those held in working memory, and use the much faster eye to working memory processing for rapid search and comparison (Larkin & Simon, 1987; Keller & Tergan, 2005; Ware, 2005). Colour-coding information can further reduce search time (Keller & Grimm, 2005). Problem-

solving performance can be improved with diagrams and flow charts, over verbal representations, especially for complex problems (Jonassen, 2005).

3.3.2.1 Directed graphs, knowledge maps, concept maps, semantic networks

A frequently used technique for visualizing knowledge and structure is a node-link structure or directed graph (Figure 5; Keller & Tergan, 2005; Hall & O'Donnell, 1996; Novak & Cañas, 2006). These diagrams go by many names such as knowledge maps, concept maps, and semantic networks. While definitions and uses of the terms vary throughout the literature, they share some fundamental characteristics. Each node represents an information or knowledge item, and the links represent the connections or relationships between items. Some implementations use arrows on the links to indicate the direction or causality of the relationship (Nadkarni & Shenoy, 1999). Others add text to the links to label the nature of the connection. Different node shapes, colours, and non-textual elements are also used to supplement the information. Multiple studies have shown these to be effective for reducing search time and cognitive processing, improving recall and comprehension, aiding relationship identification, and augmenting problem-solving (Eppler & Burkhard, 2007; Hall & O'Donnell, 1996; O'Donnell et al., 2002; Wexler, 2001). Maps made by an individual can impose a higher cognitive load than those created programmatically, due to partial completeness and fewer labels (Teller, 2005). These structures will be referred to as concept maps for the purposes of this research. Specific research that used concept maps as a navigation tool for presentations provides additional corroboration that this technique is worth investigating further (Holman, Stojadinovic, Karrer, & Borchers, 2006).

Figure 5: Theory underlying concept maps (Novak & Cañas, 2006)

3.4 How can tools be augmented?

There are many types of communication and interaction between humans that can be augmented by computerized tools. This research concentrates on making decision-making briefings for small groups more efficient and effective. Within this context, three main roles have been identified: author, briefer, and audience (DARPA, 2007). As stated above, *Authors* gather, analyze, synthesize and create the briefing document; *Briefers* manage and moderate the briefing activity; and the *Audience* are the people who review, comment, and interact with the document and during any meetings.

3.4.1 Augmenting the creation process

Briefing documents typically have multiple authors, according to a study by Ede & Lunsford (as referenced in Noel & Robert, 2003), so collaborative writing is the starting

point to investigate productivity issues for authors. Collaborative writing groups are still mostly working with standalone word processors, which are oriented more towards layout and production than information management. Some key opportunities to improve collaborative writing are group coordination, support for different roles within the authoring process, an explicit structure and objective, and greater feature integration (Adler, Nash, & Noel, 2006; Lowry & Nunamaker, 2003; Lowry, Nunamaker, Curtis, & Lowry, 2005; Noel & Robert, 2003).

3.4.1.1 Specialized tools can improve productivity

Recent reviews of the large and growing body of research on collaborative writing conclude that current tools are inadequate for the task, and that the productivity of writing teams can be improved with specialized tools (Lowry & Nunamaker, 2003; Noel & Robert, 2003). Potential improvements include time savings, document and decision quality, and team relationships and communication. Evaluations of current tools provide some support for these propositions, but indicate that none have yet delivered the whole solution, or even a majority of the desired feature set (Noel & Robert, 2003). As web-based applications become more functional and reliable, they start to address some of the key deficiencies, such as collocated and remote work, platform independence, open file formats, and group awareness and coordination (Adler et al., 2006).

3.4.1.2 Wikis are a starting Point

Wikis are web-based tools that are increasingly used for collaborative writing in organizations (Beardsley et al., 2006; Ding, Danis, Erickson, & Kellogg, 2007; Gao & Wong, 2008). Wikis tend to have little pre-defined structure, which can make it difficult

to locate information. Adding a visual representation of information, based on tree maps and dynamically constructed from document linkages, made it easier for the wiki users to find information. This technique also opened up new opportunities, as the users identified unexpected connections between projects, and used the maps in unanticipated ways, such as tracking the number of authors and viewers to determine the maturity of a project. The visual representation also encouraged people to keep their status up-to-date, further increasing the value of the online information repository (Ding et al., 2007).

3.4.1.3 Make the structure explicit

An explicit structure is a missing component of collaborative writing projects (Noel & Robert, 2003). The benefits of providing some structure to a group writing process include higher quality discussion and output, better communications, and enhanced teamwork and relationships (Lowry et al., 2005). Using a physical structure that allows annotation and commenting adjacent to the primary content also improves outcomes, with discussions of greater depth and focus than using a separate discussion forum (Gao & Wong, 2008).

3.4.1.4 Support integration of communication and tools

The studies in this topic have consistently identified a range of roles, tasks, and communication needs that are part of a successful and productive collaborative writing activity (Adler, et al., 2006; Gao & Wong, 2008; Lowry & Nunamaker, 2003; Lowry et al., 2005; Noel & Robert, 2003). Improving the productivity of authors, who may be collocated or distributed and working concurrently or asynchronously, requires a suitable integration of this functionality into the tools (Adler, et al., 2006; Noel & Robert, 2003).

The current model of discrete tools, such as a word processor for writing, email and instant messaging for communications, and presentation software for slide creation, results in disjointed workflow, duplication of effort, and can increase the requirement for human facilitation of the process (Lowry et al., 2005).

3.4.1.5 Research question for authors

Based on the literature review of the authoring process, the following question can be postulated:

Research Question 1: Does the collaborative wiki-based tool connected to briefing slides improve author productivity?

3.4.2 Augmenting the communication process

At various stages during the development of a briefing document it is necessary to share the information with an audience for review, feedback, and decisions. This activity is coordinated by one or more briefers for the benefit of the audience, who may have differing objectives. Reviewing the literature on human communications, presentation techniques, and PowerPoint, reveals that an explicit briefing structure and ability to understand and adapt to the needs of the audience are paramount. (Alley, 2003; Doumont, 2005; DuFrene, 2004; Farkas, 2005; Holcombe & Stein, 1996). "If people must make a decision based on your presentation, you want to be sure they understand everything as you proceed and they are listening." (Holcombe & Stein, 1996: 207). This is especially true in the context of group decision-making, which is increasingly dealing with novel situations and exceptions that are outside of the codified rules or processes of an organization that are suitable for automating.

3.4.2.1 Adapt to audience

Transferring information to, answering questions from, and moderating the discussion with the audience are the duties of the briefer. In return, the audience adds value to the decision-making process through their interactions, so it is important for the briefer to have the capability to adapt to their needs (Doumont, 2005; Trenholm, 1995). The pace and flow of most briefings is controlled by the briefer, making it important to pay close attention to the comments, reactions, and body language of the audience, and adjust accordingly (Alley, 2003; DuFrene, 2004; Holcombe & Stein, 1996). Software may not be able to analyze the audience (Holcombe & Stein, 1996: 81), but the ubiquity of portable computing devices makes it possible to gather input and feedback from the audience to give the briefer more information to work with. Functionality that enables the briefer to adapt to the feedback from the audience, quickly move off a topic that the audience is finished with, or revise the presentation due to unexpected questions are some leading suggestions for enhancing the briefer's role (Alley, 2003; DuFrene, 2004; Holcombe & Stein, 1996). Since complex decision-making, which is the focus of this study, is more of a pattern- and relationship-recognition activity for humans than one of linear information processing, moving towards a non-linear approach to navigating the briefing information may be of value (DuFrene, 2004; Harvard, 2008).

3.4.2.2 Provide supplementary details

Answering questions from the audience, clarifying points, and providing supplementary information is arguably the primary advantage of a briefing (Alley, 2003). Postponing answers to questions may hinder the audience's ability to digest the information (Holcombe & Stein, 1996). Capabilities that allow the briefer to quickly and

easily bring up the authors' supplemental information for more detailed discussions can enhance the outcome of the briefing (DuFrene, 2004; Harvard, 2008).

3.4.2.3 Make the structure explicit

"Make the implicit explicit" is the advice from the group summary of a Harvard Learning Innovations Lab event on Decision Dynamics (Harvard, 2008). Mapping out the structure of the briefing helps put the material in context for the audience, which can aid knowledge transfer (Alley, 2003; Eppler & Burkhard, 2007; Trenholm, 1995). This is typically done with an 'Agenda' slide and explicit transitions between sections (Alley, 2003; Farkas, 2005; Holcombe & Stein, 1996). Linear structures limit the opportunity for audience members to discern patterns and relationships in the briefing. Since human processing often uses visual memory, which has limited capacity, to find patterns and relationships, continuously displaying the structure during the presentation can enhance the briefer's ability to communicate, and even act as a navigation tool for the briefing (Chen, 2004; Eppler & Burkhard, 2007; Tufte, 2007).

3.4.2.4 Visualize the structure

Complex decision-making briefings likely have a complex structure and a large amount of data and information, and visualization techniques can help humans process this more quickly and effectively (Eppler & Burkhard, 2007; Tergan & Keller, 2005). As discussed above, concept maps are an effective visualization method for aiding structural processing, identifying relationships, and linking details to context. Making these an interactive tool can provide the briefer with non-linear control over the information flow,

readily adapting to the needs of the audience while keeping the material in context. (Eppler & Burkhard, 2007; Good & Bederson, 2001; Holman et al., 2006).

3.4.2.5 Research questions for briefers

Based on the literature review of the briefing process, the following questions can be postulated:

Research Question 2A: Does the dynamic briefing navigation improve briefer productivity?

Research Question 2B: Does the audience feedback mechanism improve briefer productivity?

3.4.3 Augmenting the consumption process

"... presentations are more memorable, and move more quickly toward a decision, when the audience is involved and contributes to the discussion." (Holcombe & Stein, 1996: 207). The audience is arguably the most important part of a briefing and decision-making process, since without them the briefing documents might not be created in the first place. The communications and PowerPoint literature indicates that audience members are a varied lot with different styles of processing information, but that their consumption of the briefing material can be aided by explicitly communicating the context and structure of the briefing, providing access to supplementary details, greater interaction with the briefer, and some explicit coordination of the process (Alley, 2003; Doumont, 2005; DuFrene, 2004; Farkas, 2005; Holcombe & Stein, 1996).

3.4.3.1 Display context

Edward Tufte lists four key questions for briefing audiences (Tufte, 2007):

- What's the story?
- What is this presentation relevant to?
- What do I really need to see?
- Can I believe them?

The first three of these are directly related to keeping the briefing information in context. Displaying the context or structure of the briefing topic aids knowledge transfer, human comprehension, and retention (Alley, 2003: 55; Eppler & Burkhard, 2007; Farkas, 2005; Trenholm, 1995). In complex scenarios, keeping information in context is a challenge for human information processing abilities. Continuously displaying the structure and context of the briefing can benefit the audience as well as the briefer. The display augments the limited capacity of human visual memory, enabling the rapid movement of eyes to quickly retrieve accurate information, instead of the slower and more error-prone retrieval from short-term memory (Plumlee & Ware, 2006). Using concept maps for this purpose takes advantage of the brain's capacity for visual processing, comparisons, and relationship identification, can improve the focus and attention of the audience, and improve information retention (Eppler & Burkhard, 2007; Hall & O'Donnell, 1996; Holman et al., 2006; O'Donnell et al., 2002; Wexler, 2001).

3.4.3.2 Access to supplementary details

Current projection technologies constrain the amount of information that can be displayed in front of the audience. Presentation slides only act as summaries, and complex decisions should not rely solely on the information selected for display by the authors. Audiences often need to review additional details and assumptions, or require access to specific details or visualizations related to their responsibilities (DuFrene, 2004; Hexel, Johnson, Kummerfeld, & Quigley, 2004; Tufte, 2007). There are multiple approaches to providing access to detail.

One approach is to allow the briefer and/or audience to zoom or drill-down to display the desired information. Comparisons of different techniques to display details suggest that the best performance is achieved by initially displaying as much detail as is comfortable with the display, providing the capability to zoom in when dealing with three or fewer items, enabling the simultaneous display and comparison of details across multiple windows when dealing with three or more items, and ultimately allowing the audience to drill-down to their desired level of detail (Menon, Montabert, Tungare, & North, 2007; Plumlee & Ware, 2006; Tufte, 2007).

Another method is to provide a more detailed document before, during, or after the meeting. Advance preparation and reading may be the ideal situation, but is not always possible. Since paper printouts have a higher potential information density than typical electronic displays and the audience can read faster than the briefer can speak, allowing time during the meeting for the audience to read and process details is one suggestion (Tufte, 2007). However, it is important to provide pauses to enable the audience to read,

since there is a conflict between human processing of listening and reading (Doumont, 2005). Providing handouts for consumption after the briefing is another option, enabling people to move at their own pace and examine details relevant to them, providing the information has sufficient levels of details (He et al., 2000).

3.4.3.3 Enable interaction with the briefer

Interaction between the audience and the briefer is an essential, if not the primary, component of a briefing (Alley, 2003: 3). Audience interaction can make the briefing more memorable, and improve the quality of decisions (Holcombe & Stein, 1996). Feedback helps the briefer see what the audience understands and how they are interpreting the material (O'Neill, 2005). Greater interactivity can also enhance audience attention, focus, and retention and comprehension of information (Eppler & Burkhard, 2007; Trenholm, 1995).

3.4.3.4 Explicit coordination of roles and process

The audience is not typically a homogeneous group. They have different roles within the organization, and there are also different roles during the briefing. Some may be authors who can support the briefer with additional information. One or more are the key decision-makers. Sometimes a scribe is designated to document the minutes, action items, and outcomes of the briefing. Explicit assignment of these roles may be necessary to avoid the scenario where each audience member assumes that another is taking responsibility (O'Neill, 2005).

Clear assignment of different roles is also helpful to counter issues related to poor group decision-making, often labeled 'groupthink'. Research on groupthink and team

decision-making result in similar recommendations; identify appropriate tasks and roles and support team with process definition (Esser, 1998; Hackman, 2008). The potential of groups (or powerful leaders) to discourage questions or dissent can potentially be mitigated by assigning responsibilities to explore alternatives and question assumptions (Aldag & Fuller, 1993; Esser, 1998; Fuller & Aldag, 1998; Trenholm, 1995).

3.4.3.5 Research questions for audience

Based on the literature review of the audience process, the following questions can be postulated:

Research Question 3A: Does the dynamic briefing navigation improve audience productivity?

Research Question 3B: Does the audience feedback mechanism improve audience productivity?

3.5 Lessons learned

Reviewing the literature illuminated four important lessons; the need for new tools, isolation of the presenter, lack of integration of various document types, and the challenges involved in predicting what information the audience needs. Productivity in this context has multiple measurable components, including time, quality, and interactions, which will be explored in more detail in the data acquisition.

3.5.1 Need for new tools to facilitate, instead of automate, human capabilities

The first, and perhaps most important, lesson is the need for new tools. The nature of work has changed, becoming more collaborative and increasing the emphasis on human

knowledge, judgment, and handling process exceptions and other events that don't fit into codified rules. Current tools are intended mostly for individual work, automation of repetitive tasks, and the production of documents. With many rules-based activities now automated, tools that augment human capabilities to analyze information, maintain a link between context and details, and make decisions are needed.

3.5.2 Tools lack integration between information, documents, and presentations

A decision-making presentation often encompasses a significant amount of information from a variety of different documents. However, the resulting set of slides typically has little or no connection to the source material. When used as a reference, slides alone often lack sufficient detail. Bullet points tend to be more absolute than necessary, skipping adjectives and adverbs in order to fit on the slide. Effective analysis and decision-making by the audience requires access to greater levels of detail, especially in the areas of uncertainty or those related to each individual's subject of responsibility or expertise. This is associated with Research Question 1.

3.5.3 Briefer cannot/should not predict which details are important to audience

Additional or backup slides can always be added to a presentation to provide details and supporting information. However, the challenge for the presenter is what information to include and when to present it. Providing unnecessary detail early can cause the audience to tune-out; providing the details later can be disjointed or too late if decisions have already been reached. Group decision-making can be enhanced by enabling audience members to access details on relevant subjects, when they want or

need them, not when and if the presenter decides to include them. This is associated with Research Questions 2A and 3A.

3.5.4 Briefing tools can isolate the presenter from audience feedback and constrain ability to react

The final lesson is the increasing isolation of the presenter from the audience. When presentations were done on chalkboards or handwritten on overhead transparencies, the presenter retained a significant amount of flexibility to adapt to the audience. Increasingly formal production of presentations, from pre-printed transparencies to computer projection of slides, has made presentations less and less flexible. The common practice of dimming overhead lights further exacerbates this, limiting the presenter's ability to perceive audience reactions. Since decisions are improved with greater levels of interaction among the group, briefing tools for decision-making need to enhance the connection between presenter and audience, instead of isolating them. This is associated with Research Questions 2B and 3B.

4 Research method

The research questions are evaluated in three phases. In the first phase, a series of interviews are conducted with a small number of representatives of the three roles to validate the lessons learned from the literature review and provide an initial requirements set for a software prototype. The second phase is the development of a prototype system that integrates the different features for each role. The third phase is a series of experiments to evaluate the effects of the features on the productivity of the author, briefer, and audience participants. Phase two and three overlap, with observations by the researcher and feedback from experiment participants influencing subsequent iterations of the prototype.

4.1 Problem statement

The overall objective of this research is to evaluate the questions identified above with an integrated wiki-based software system. The development of a new briefing system requires understanding, and balancing, the needs of the authors, briefers, and audience. For example, a solution which improves information analysis at the expense of author productivity would not likely be well received and adopted over existing tools. Specific objectives are to:

- Examine the characteristics of effective authoring and briefing systems for small groups (<20 people)
- Design and build a prototype briefing system, primarily through integration of existing components
- Evaluate the system in comparison to commonly used tools

Figure 6: Concept map of Research Method section from LiquidBriefing

This research was funded in part by the U.S. Defense Advanced Research Projects Agency (DARPA), following a proposal submitted to the Small Business Innovation Research (SBIR) program topic SB072-032 (DARPA, 2007), entitled “Rapid and Accurate Idea Transfer”. Their stated objective is a “presentation software or system that can be used to rapidly and accurately communicate complex ideas, plans, and high-quality analyses.” The research questions they posed are:

- Can a simple interface make briefing construction easier?
- What software abstractions will help?
- How should ideas be presented for maximum effectiveness?
- Should briefings even be presented?
- What real-time interactions should be supported?
- What makes briefing effective and easy to understand?

The research objective for this thesis is to evaluate both quantitative and qualitative results comparing the research prototype with PowerPoint. Key elements include the perceived change in efficacy and the participant's preference of the two techniques, as well as a content-specific quiz to measure information retention.

These objectives will be met with the following research deliverables:

- User requirements for authoring, briefing, and audience input
- Prototype briefing tools and audience feedback system based on a structured wiki

- Results of evaluating the system for 3 distinct roles of author, briefer, and audience

4.2 Relevance

Effective collaboration improves the rate of innovation and competitiveness. Understanding the theory and framework of knowledge worker productivity is an important part of competitive advantage, yet “little has been done to develop such frameworks theoretically and empirically” (Haas & Hansen, 2007). Common information technology tools were designed for individual work and do not meet the criteria for collaborative authoring. These criteria have been developed through literature reviews and feature comparisons, but without evaluating their impact on productivity (Adler et al., 2006).

PowerPoint is the dominant tool used for briefings today, generating “more than 30 million presentations per day” (James et al., 2006). Studies of its effectiveness in knowledge transfer applications have been focused on the academic environment (Alley & Neeley, 2005; Amare, 2006). “We need experimental studies that determine the impact on audiences of different deck design and differences in presenting.” (Farkas, 2005). In some situations “poorly represented information can lead to unfortunate decisions with disastrous consequences” (DARPA, 2007), which is one of the reasons why DARPA funded 10 separate proposals to research these questions in 2008.

4.3 Role interviews – 17 individuals

Interviews were conducted with 17 individuals between March and July 2008. These individuals represented 2 authors, 7 author/briefers, and 8 audience members. The

majority of interviews were structured, following the pre-briefing questionnaires (see Appendix A), and were conducted in person, via telephone, or online. A few were more conversational in nature, but still covering the full range of questions. The sample was selected from associates of the researcher. All had significant experience in their respective roles, and were in organizations with a high degree of knowledge work. The questionnaire responses are consistent and validate the lessons from the literature review, but may not be generalizable to a broader population.

4.4 Software prototype

A prototype software system for small group briefings is developed based on the lessons learned from the literature review, the role interviews described above, and iterative feedback from the experiment participants.

4.4.1 Integrated system to evaluate productivity

4.4.1.1 Author: integrated document with auto-generated concept map

To address Research Question 1, the software is based on a wiki and integrates multiple aspects of the document creation process, including the newly authored material, comments, discussions, and file attachments. Concept maps are automatically generated from the document structure. Slides can be automatically generated from the topic pages.

4.4.1.2 Briefer: dynamic briefing navigation, gather and react to audience feedback

To address Research Questions 2A and 2B, the software supports dynamic navigation through the slides by mouse clicks on hyperlinked words or nodes of the concept map. The concept map aggregates positive and negative votes on the topics by the audience to provide guidance to the briefer.

4.4.1.3 Audience: access to details, real-time feedback

To address Research Questions 3A and 3B, the software supports dynamic navigation through the slides, and the document is accessible to the audience members who have a computer and a network connection. Computer-equipped audience members can also assign positive or negative votes on the topics of the concept map to indicate their interest to the briefer.

4.4.2 Include instrumentation to gather user behaviour

The software will also record usage information to provide further insights into the behaviour of the authors, briefers, and audience. Items recorded include the topic votes and pages viewed or changed by each participant with time and date. This makes it possible to determine the actual flow of the briefing and what the audience was viewing in relation to the page being displayed by the briefer, among other things, which provides additional data points for analyzing the results.

4.5 Experiment design

The third phase is a series of experiments with small groups, using either PowerPoint or the research prototype as part of a decision-making activity. The experiment participants are then asked to complete an evaluation survey to measure the perceived benefits and a content-specific quiz to measure content retention. Between July and September 2008, six experiments were conducted with a total of 77 participants. Of these experiments, four involved comparisons between PowerPoint and the prototype, and two just used the prototype due to insufficient group size.

The unit of analysis is an individual small-group briefing, with an audience of less than 20 people. The study is meant to be illustrative of the productivity potential and provide guidance for future developments and research, and not necessarily statistically significant or representative of the general population. The sample is drawn from the associates of the researcher at organizations with a significant proportion of knowledge work.

- Time period: July to September, 2008
- Unit of analysis: Small-group briefing (audience < 20 people)
- Sample size: 6 briefings
- Sample selection: Organizations with a high proportion of knowledge work

4.5.1 Data acquisition

A two-page role-specific questionnaire was used to gather participant responses for this research, along with a 10 to 12 question content-specific quiz given to the audience. Samples of the questionnaires are included in Appendix A. The questionnaires were all supplied in English.

The first set of 5 questions (6 for the author) provides background information on the respondent. The second set of questions uses a 7-point Likert scale with responses ranging from strongly disagree (1) to strongly agree (7) to assess different components of productivity, followed by a set of questions to assess the participant's overall perception of the software prototype.

A multiple-choice content-specific quiz is also given to the audience members to evaluate their retention of the information contained in the briefing, as an additional measure of effectiveness (Alley & Neeley, 2005).

Table 1 and Table 2 summarize the proposed data acquisition. This data set was collected for the current briefing method (PowerPoint in all cases), and then iterations of the prototype.

Productivity, which is defined in economics as the value of outputs per some unit of worker input such as an hour or a day, is more difficult to measure for the increasingly non-routine and group-related tasks of the knowledge worker. The areas of improvement or importance may also be different for each role. As a result, multiple proxies are used to provide a broader picture of this complex area (Thomas & Baron, 1994). Productivity has multiple dimensions, and the participant questionnaire is designed to evaluate several dimensions for each research question. This includes time savings, improved quality of results, and enhanced interactions (Haas & Hansen, 2007; James et al., 2006; Lowry et al., 2005). Survey questionnaires and content quiz were supplied to and completed by each participant immediately following the briefing. For one experiment, the content quiz was redone one week later to measure longer-term retention.

Role	Time Savings	Quality of results	Increased scope	Improved flow	Enhanced interaction	Audience feedback
Authors “Using this software”	Reduced the time required to prepare the document	Improved the quality of the results	Increased the scope of the document		Made it easier to work with other Authors	Made it easier to incorporate feedback from reviewers prior to the meeting
Briefers “Using this software”	Reduced the time required for the briefing	Improved the quality of the results		Improved the flow of the briefing	Increased the Audience interaction	Made it easier to follow the interest of the audience during the meeting
Audience “Using this software”	Reduced the time required for the briefing	Improved the quality of the results		Improved the flow of the briefing	Made it easier for me to interact during the briefing	

Table 1: Productivity survey questions

Role	Refer to others	Effectiveness	Effectiveness
Authors	I would refer this software to others in my organization	Compared with our current tools, this software was more effective in helping me prepare the briefing materials	
Briefers	I would refer this software to others in my organization	Compared with our current tools, this software was more effective in helping me manage the briefing	
Audience	I would refer this software to others in my organization	Compared with our current tools, this software was more effective in helping me understand the briefing material	Compared with our current tools, this software was more effective in reviewing the material after the meeting

Table 2: Perception survey questions

4.5.2 Data analysis

Microsoft Excel software was used to provide descriptive statistics and graphs for the variables. Mean and standard deviation were calculated for each question and experiment group, as well as the overall mean for the entire set of experiments. The mean productivity of each role was also calculated. Regression tests were conducted between the overall productivity and participant perception of effectiveness and willingness to refer the software to others in their organization.

Information retention mean and standard deviation were calculated for all of the experiments where the content quiz was used. This quiz was intended to measure differences in retention between the PowerPoint and prototype briefing on the same topic with two similar groups. Limited group sizes for some of the experiments made it feasible to conduct this analysis for only three of the experiments.

As features in the software were introduced or enhanced during the three development iterations, trends in the mean productivity and effectiveness are also examined.

5 Prototype design and development – LiquidBriefing

The initial design of the prototype, called LiquidBriefing, was based on the areas identified in the literature review and interviews with participants who represented the different roles. This prototype was developed using an agile development approach. This implies short release iterations and feedback from the research participants. When developing programs that automate processes it is possible to develop a comprehensive requirements document, based on a clear set of codified rules. Augmenting human capabilities with computerized tools is more subjective, whether due to differences in individual preferences or the human tendency to operate somewhere between purely rational and purely intuitive. Frequent interaction, experimentation, and feedback should result in more effective tools in less development time.

A collaborative wiki was used to enable the authors to capture ideas gradually and continuously in topic pages that are hyperlinked to each other. Concept maps of the resulting document structure are generated automatically for each page. LiquidBriefing allows transformation of all collected material to “slides” for briefings, and allows audiences to interactively give feedback by voting positively and negatively on their interests during a briefing. Briefings and feedback are done via a web browser, so the solution works for geographically distributed groups without any special software. Additionally the audience feedback mechanism augments the briefer’s reading of body language. The briefings are forever linked into the collaborative system so that audience members can asynchronously drill down for more information or record comments that augment the material for future review.

5.1 New paradigms for work and software architecture

The past ten years have seen the emergence of some new paradigms in information work. Often grouped under the term “Web 2.0”, are attributes such as lightweight web-browser-based software, architecture of participation, open source, and flexible assembly of generic components into a specific application.

5.1.1 Benefits for all roles

There are three distinct (but overlapping) roles involved in a decision-making activity: (1) the people who gather, analyze, synthesize and create the briefing document (authors), (2) the people who manage and moderate the briefing activity (briefers), and (3) the people who review, comment, and interact with the document and during any meetings (audience). These roles are complementary and have areas of overlapping activity, so the software should aim to provide reasonably equally benefits to all roles. Many solutions today focus on only one role, sometimes at the expense of the others.

For example, Microsoft PowerPoint may be an effective tool for the display of slides, but it imposes a significant burden on the author who must import (often by retyping) information from another document into the slide, and who typically spends a significant portion of the creation time on mechanics of alignment, font sizes, and colour. Microsoft Word may be an effective tool for layout and production of a document, but is less suited to collaborative authoring, task coordination, or knowledge management. Interaction tools for audience members have been developed, evaluated, and deployed in many academic situations, but the computing power around the typical corporate meeting-room table is largely under-utilized in support of the meeting objective.

This thesis evaluates the impact on all three roles (authors, briefers, and audience), in an attempt to provide an equal distribution of benefits and improve the commercial potential of the prototype system.

5.1.2 Integration for all tasks

The most commonly used tools for the development of briefing documents are word processors and spreadsheets, supplemented with email for communicating among the authors. In some cases, wikis or other online collaborative writing tools are used in addition to (rarely instead of) these standalone tools in an attempt to improve coordination and reduce task duplication. For the actual briefing activity, presentation software is most common, sometimes supplemented with excerpts from the original documents. On some occasions, meeting comments and actions are collected and communicated via email, or using task-tracking tools. This makes for a disjointed development process for all roles.

A key point from the preliminary research is the necessity of an integrated solution, which encompasses the full range of tasks required for the objective. This is the only way to achieve the necessary improvements in efficiency for the authors (improving the development time and quality of the briefing document), for the briefers (aggregating audience feedback and enabling non-linear navigation through the briefing material to better respond to the needs of the audience), and for the audience (providing an opportunity for direct feedback and individual navigation of the briefing material for supplementary details).

5.2 Design iterations

There were three design iterations during this thesis (Figure 7). The features and priorities of the first iteration were identified by the literature review and requirements interviews. Successive iterations were guided by participant responses and comments and the observations of the researcher.

Role	Development focus		
Authors	Document structure	Enhanced comments	
	Page structure		
Briefers	Concept map	Slide enhancements	Navigation enhancements
	Slide rendering	Dynamic navigation	
Audience		Comments on slides	Performance improvements
			Audience feedback
	Iteration 1	Iteration 2	Iteration 3

Figure 7: Development focus and features for each prototype iteration

5.2.1 Iteration 1 – Author focus: structure, concept map, slide generation

The functionality for authors was the primary focus of the first design iteration. Starting with the available functionality of the wiki, the authoring capabilities were enhanced with an overall structure for the document, as well as a consistent structure for each page to facilitate rendering of the pages into slides.

Concept map functionality was added in this iteration, to provide visualization assistance to the authors during document development. Since the concept map is derived from the document, the authors can see at a glance what pages exist and how they are connected.

Using the page structure, slide rendering capability was started in the first iteration, to test and validate the concepts and aid the authors in developing pages that worked effectively as both written details and slides.

5.2.2 Iteration 2 – Briefer focus: slide enhancements, dynamic navigation, comments

The second iteration was focused on the functionality required for briefers, as well as accommodating initial feedback from the author participants. The basic slide rendering functionality completed in iteration 1, which required all of the ‘slides’ to be delineated on one topic page, was enhanced to render slides from any topic page.

With all pages now potential slides, briefing navigation tools were required. The concept map was augmented to enable jumps to any slide with a mouse click on the respective node. Embedded hyperlinks in the document can also be clicked on to jump to a slide.

Feedback from the authors at this stage highlighted differences in work practices, and led to the implementation of two different methods for incorporating comments into the document; below the text and inline with the text (like MS Word allows). The document structure was enhanced to enable comments to be directly added to sections included

from another page. Some authors were uncomfortable with the wiki markup language used to implement some of the features, so efforts were made to hide these artifacts.

5.2.3 Iteration 3 – Audience focus: feedback mechanism, navigation enhancements

The third iteration was focused on functionality required for the audience, as well as additional feedback from authors and briefers. Since the wiki document is online and available to multiple users simultaneously, no additional functionality was required to enable independent browsing of the document by the audience during a briefing.

An audience feedback mechanism was implemented that allows audience members to indicate their level of interest in each topic on the concept map. The positive and negative votes are aggregated and presented to the briefer using a range of colours.

The briefers, who were all very familiar with PowerPoint, found that sometimes the briefing did progress in an expected, linear fashion. Using the concept map or hyperlinks for navigation was useful when jumping to another slide, but somewhat of a distraction compared to PowerPoint's use of Page Up and Page Down. Support for these keys was added, and instrumented to follow the order of each page's table of contents.

5.3 Prototype development

The functionality required to evaluate the research questions provided the initial requirements set for the prototype. Interviews with the research participants validated and augmented the set. The prototype has also been used by the researcher and associates for the majority of the research documentation, generating a significant amount of experience and feedback. For the majority of participants, Microsoft Word is the most

commonly used tool for document development, and Microsoft PowerPoint for presentations. However, some organizations skip the document step, and produce material only in PowerPoint.

A collaborative authoring environment is a necessary foundation, and a wiki was chosen as a suitable starting point for LiquidBriefing. Wikis support multiple authors, and many have commenting and file-attachment features as well. The capability to easily modify the code or add enhancements via plug-ins is also needed.

Collaboration is poorly supported by the work model of Microsoft Office, which forces single-user-at-a-time editing in Word and PowerPoint. Email has become overburdened as people email documents and briefings back and forth to create successive revisions. Outdated file systems on laptops and servers have become museums housing years of old Word and PowerPoint documents – and the subject of scavenger hunts whenever certain “gems” of content are needed that were previously created. Many commercial collaboration tools, like Groove from Microsoft, provide an alternative to emailing documents, but knowledge workers are still left with Word and PowerPoint and their restriction of one user at a time.

5.3.1 LiquidBriefing overview

The LiquidBriefing system introduces a new workflow model, shown in Figure 8. First, knowledge workers begin with the goals and objectives of specific activity, and record their preliminary and partial ideas. The ideas can then be refined over time, reviewed by team members, and connected to others via hypertext links. Over time the ideas are organized into the reports and briefings that knowledge workers must produce.

LiquidBriefing overlays a number of items on a conventional wiki. Normally wikis are unstructured – anyone can put whatever they want in any format on a wiki topic. LiquidBriefing first adds structure in the form of topic templates, which allow the categorization of information within topics. Next it automatically generates a concept map, which is a diagram whose nodes represent topics and whose arcs represent connections between the topics. The concept map grows as information is added and associations made.

Figure 8: LiquidBriefing (1) Transforms Raw Ideas into wiki Topics for (2) Collaborative Editing, Then (3) Transforms to Reports and Briefing Slides

LiquidBriefing provides a mechanism to transform normal wiki topics into briefing slides. Briefings are no longer sequential like PowerPoint – the briefer can use the concept map to cover the topics in different order depending on the audience’s interests. Additionally the audience can interactively vote on what briefing topics they do or do not want to hear about. This is especially useful when a briefing is given to geographically distributed audience members. Meanwhile audience members can asynchronously add comments to slides or make meeting notes from their browser, or go from the slide to the underlying material in the wiki from which the slide was created to learn more. Those viewing the briefing comments later can get a more thorough picture of the audience’s opinions of the briefing than PowerPoint can provide.

5.3.2 Concept map feature

The automatic generation of a concept map built from the document structure without requiring additional user input is a key component of this research prototype. Open-source code is available to generate concept maps, and this was incorporated into the wiki. Nodes represent individual topic pages, and the arrows represent the direction of the links. Relationships between topics are based on hyperlinks included in each page. In the wiki, this information is stored in each page; there is no central database of all of the links between topics. Generating each concept map requires parsing every page in the wiki to determine what other pages link to the current one. This has an obvious performance implication as the total number of pages grows. Since new pages or page links are unlikely to be created during a briefing, previously calculated concept maps are stored and used during the briefing to improve performance. Another option is to

generate the overall map at the beginning of the presentation, and zoom or filter only during briefing navigation to improve performance.

The default format of the map, as indicated in Figure 9, surrounded each node name in an ellipse. This was considered to be unnecessary embellishment that added no additional information, but which consumed screen space, so the ellipses were removed in favour of a cleaner format with just words and arrows. The node labels are coded as hyperlinks to allow direct navigation to any page with a mouse click. Maps can be structured top-to-bottom (as in Figure 9), or left to right (as in Figure 10). For consistency, the experiments all used a top-to-bottom approach. Some of the early examples used a left-to-right format as the slide formatting possibilities were explored.

Figure 9: Example of initial concept map format, with ellipses around the nodes

5.3.3 Author-focused functions

5.3.3.1 Document structure

Most wikis, and word processors, begin with an unstructured page. For the purposes of this research, a structure to the document was developed that incorporated the goals, assumptions, and key inputs for each experiment group's project, as part of the authoring process. This acts as a guide to the authors, some of whom were using wikis for the first time. Topics pages that have not been added yet are indicated by a question mark after the topic name, providing an easy reference for authors and reviewers.

Figure 10: Example of LiquidBriefing Document Structure for a Market Research Briefing

5.3.3.2 Page structure

The page structure is intended to make it feasible to use the document for multiple purposes, including briefing 'slides', short summary, or details. Structure should also enable authors to readily incorporate and reuse topics, and to add more details at any point without a lot of mechanics. By using a consistent (but not excessive) structure for each page, it is possible to automatically generate different versions of the document. These could be handouts of varying degrees of detail, slides, document navigation, review summaries, or other, as yet unimagined purposes. Each topic page includes the following structural elements (illustrated in Figure 11):

Heading: a short sentence summarizing the main assertions or conclusions of the topic. This is used as the paragraph header, and also the slide title.

Abstract: a brief summary of the topic. This is the text displayed on the slide, and is also used for summary reports.

Image: an image or visualization to support the topic, by default a concept map of the local structure. This is displayed on the slide beside or below the abstract.

Details: Supplementary information, including links to any sub-topics. This information is used to generate the table of contents in the abstract section of the page.

Other potential structural elements are:

Contents: list of topic sub-headings and sub-topics. This is generated automatically from the detail material, if any.

Comments: feedback from reviewers.

Database fields: topic-specific sections that have a common attribute, such as updates for a specific month or answers to survey questions.

Summary sentence for this topic

Summary information for this topic

- + [Detail heading 1](#)
- + [Detail heading 2](#)

Comments - ExampleTopicPage Abstract

Add comment

Topic Concept Map

Detail heading 1

Detailed information for this topic

Detail heading 2

Detailed information for this topic

Comments - ExampleTopicPage Detail

Add comment

Figure 11: Example of LiquidBriefing page structure

5.3.3.3 Integrate comments and discussions

Most documents have multiple authors and reviewers, and they need to communicate about the documents they are working on. They also have varying responsibilities and work styles. Some write, others prefer to edit, or just add comments to the material. Sequential comments by multiple authors can become a discussion. Writing and editing was readily handled by the basic wiki functionality. All versions of a topic page are maintained for easily identifying edits between versions.

The basic wiki commenting feature was initially used for comments (illustrated in Figure 12). It allows for comments to be appended at the end of a topic page, with no requirement to learn the wiki markup language or use the editor. This feature is also useful for extended discussions, as the comments are kept in sequence and contain user and date identification information. The structure was revised to ensure that the comment area was included when an abstract or detail area was referenced on another page.

Comments

- A follow-up comment made by another user. -- [BillBurton](#) - 27 Jun 2008
- A sample comment made by the admin. -- [TWikiAdminUser](#) - 27 Jun 2008

Figure 12: Example of wiki-style comment feature

This technique worked well when topic pages were short, but it did not meet the participant needs on longer pages, where the comments could be significantly separated from the text to which they refer. To address this issue, an enhanced commenting feature was developed that supported inline comments.

The color-coding is provided for two purposes:

- To assign colors to users for visual recognition and differentiation
- To provide different background colors for questions (red) and answers (green)

Adding this functionality to the prototype involved creating a new template for use with the TWiki `%COMMENT%` variable. The template provides formatting for the rendered comments, including their appearance and location on the page.

TWikiAdminUser

BillBurton

A button has been added to the WYSIWYG editor for creating inline comments.

Figure 13: Example of in-line comment feature

Many authors preferred to make comments within the text, due to their familiarity with the Microsoft Word style, or to make the specific reference clearer. This functionality was implemented within the wiki editor. Comments are identified by the user as a query or a response, and are colour-coded accordingly (red for query, green for response, illustrated in Figure 13).

5.3.3.4 Wiki markup language and variables

Wikis typically use a markup language, similar to a simplified version of HTML, to identify formatting characteristics. This can be intimidating to many users, and has been hidden by more sophisticated editors in most wikis. The only markup language elements critical to this project are the heading-level markers, which are used to identify the table-of-content items and the slide headings for the detail section.

Wiki variables in this case are references to Perl-based software modules within the topic pages. These take the form of `%VARIABLENAME{modifier=argument}%`. Critical wiki variables to LiquidBriefing are:

COMMENT: Generates a text-entry box for comments within the wiki page, making the addition of comments quick and easy as it does not require opening the page with the editor.

INCLUDE: Add all or a specified part of another page to the current one.

LIQUIDSLIDESTART: Marker for the LiquidBriefing slide generation module, matched with LIQUIDSLIDEEND.

STARTSECTION: Marker for the start of a page section, matched with ENDSECTION.

TOC: Generates a table of contents from the text marked as headings within the page.

TOPCIMAP: Generates a concept map of the links to and from the page.

5.3.3.5 Automate and hide markup language and variables

Many participants were uncomfortable with the markup language and variables used by the wiki to implement some key features e.g. %INCLUDE{"ExampleTopicPage" section="topicabstract"}%. Two features, an automatic table of contents and the concept map, were added to the standard page template along with the other structural markups. The feature to include all or part of another page was added to the editor toolbar, and the required markup language is inserted based on the user's selection from a drop-down menu.

5.3.4 Briefer-focused functions

5.3.4.1 Basic slide rendering

The initial slide generation functionality was used to validate the assumption that an acceptable slide could be made automatically from the written material. This used the first section of the page (heading) as the slide title, formatted in a colour bar in a typical PowerPoint-like fashion (shown in Figure 14). The slide text was generated from any other headings on the page. The page's concept map was included on the right side of the slide. The menu and status bars of the web browser can be removed by pressing the F11 key (on a Windows PC), making the image fill the screen like a PowerPoint slide.

Figure 14: Example of basic slide rendering

Fitting the slide text and concept map on the screen at the same time is a challenge for anything but the most basic slides and smallest document structures. It requires the author to be very aware of the length of headings, and introduces more mechanics into the process than is desirable. Ideally, these would be in separate windows, with zoom and filter controls for the concept map. However, development of this functionality was beyond the scope and resources of this research.

This technique requires the author to write headings that contain a reasonable amount of information, almost a summary of the paragraphs they represent, a style which is supported by the empirical studies in the literature review.

5.3.4.2 Enhanced slide rendering

Feedback from the participants and the researcher's usage of the tool led to some enhancements to the slide rendering. Instead of using just the headings on the page, slides are constructed from the abstract section of the page (shown in Figure 15). A table of contents variable was added to the abstract section of the page to automatically include the headings. The font size of the text is automatically sized to fit within the display size. However, additional written material, including comments from reviewers, is now present on the slide. This gives the author more flexibility, and provides more detailed information to the audience, appropriate to a decision-making activity.

One of the limitations of this automatic rendering is that the details section of the page is inaccessible unless it is made up of included abstract sections of sub-topic pages. In this situation, the links in the bulleted list refer to HTML bookmarks, instead of other pages. This issue was addressed by identifying a bookmark link (which has a # sign

Augmenting the creation of briefing documents for authors

Briefing documents typically have multiple authors, so collaborative writing is the starting point to investigate productivity issues for authors. Groups are still working with standalone word processors, which are oriented more towards layout and production than information management. Some key opportunities to improve collaborative writing are group coordination, support for different roles within the authoring process, an explicit structure and objective, and greater feature integration (Adler, Nash, & Noel, 2006 ; Lowry & Nunamaker, 2003; Lowry, Nunamaker, Curtis, & Lowry, 2005 ; Noel & Robert, 2003).

- Specialized tools can improve productivity
- Wikis provide a foundation for collaborative authoring
- Make the structure explicit
- Support integration of communication and tools

Figure 15: Example of enhanced slide rendering

separating the page name from the bookmark label), and processing the selected heading as the slide heading, and any text between it and the next heading on the page as the slide text. A 'Back...' link is added to the bottom of the slide to allow a quick jump back to the abstract section of the topic (shown in Figure 16). The concept map image is left the same in this case.

Some of the topic pages in a document may be subjective and generate significant comments before or during the briefing. To facilitate this, the commenting feature can be rendered at the bottom of the slide. This enables the briefer to input audience comments directly on the slide and into the document.

Specialized tools can improve productivity

Recent reviews of the large and growing body of research on the issues of collaborative writing conclude that current tools are inadequate for the task, and that the productivity of writing teams can be improved with specialized tools (Lowry & Nunamaker, 2003; Noel & Robert, 2003). Potential improved outcomes include time savings, document and decision quality, and team relationships and communication. Evaluations of current tools provide some support for these propositions, but indicate that none have yet delivered the whole solution, or even a majority of the desired feature set (Noel & Robert, 2003). As web-based applications become more functional and reliable, they start to address some of the key deficiencies, such as colocated and remote work, platform independence, open file formats, and group awareness and coordination (Adler, Nash, & Noel, 2006).

[Back...](#)

Figure 16: Example of details section with enhanced slide

5.3.4.3 Dynamic navigation

The initial assumption was to use the concept map as a primary navigation tool for the briefing presentation. Since the concept map images already included links to the relevant pages, this was effectively accomplished by including the image on the slide. This is a powerful tool that allows the briefer to easily control the flow of the presentation, but the briefer participants identified some limitations if this was the only navigation technique. The concept-map nodes are derived from links throughout the topic page, as well as links to the current page from other pages. The current software places them in alphabetic order, which does not necessarily match the order of the headings on the slide, forcing the briefer to search for the desired link. Forward links

(pages linked from the current one), could be readily sorted in the order they are mentioned, keeping them closer to the order of headings. However, back links (pages which link to the current one) are more difficult to place in relevant order. To avoid having different sorting options for forward and back links, all of them were left in alphabetic order for the experiments.

5.3.4.4 Additional slide navigation tools

To address the navigation limitations identified, the hyperlinks in the document were also encoded to generate slide images instead of the standard wiki display. The briefer participants found this to be a more natural approach to selecting the next slide, as they tended to be pointing at the relevant text with the mouse for emphasis or in response to a question from the audience. The concept map was used more when jumping to a less-related or less-expected topic.

The briefers found that they followed their table of contents order for certain parts of the briefing. In these instances, they found having to return to the mouse and find the desired link was distracting and time consuming. In PowerPoint, moving forwards or backwards through a linear slide set can be done with the Page Up and Page Down keys. Support for these keys was implemented in LiquidBriefing, to move to the next (or previous) item in the table of contents list.

5.3.5 Audience-focused functions

Most of the audience-specific functions are enabled by using a wiki-based document for the presentation. Any audience member with a computer and network connection can

view the document in either regular or slide mode and drill-down to specific details. Enabling audience feedback during the briefing required some additional development.

5.3.5.1 Audience feedback mechanism

The audience members who were interviewed expressed a strong interest in the audience feedback mechanism. There was some discussion on how this would work and several options were explored. Further research is necessary to establish the optimal method.

Audience feedback for the experiments was implemented via the concept map. The briefer first initiates the briefing mode and specifies the number of audience members. Each audience member can then indicate their positive or negative interest in each topic with a mouse click. The votes are totaled and represented on the briefer's screen in shades of green (positive votes) and red (negative votes) as a percentage of the audience.

Figure 17: Audience feedback - briefer's view

The briefer's window is updated every 15 seconds to provide a current view of the audience's interests throughout the briefing (shown in Figure 17).

After initial testing, the feedback tool was modified to allow the briefer to select the topic pages to be included in the overall concept map. This made it possible to remove unrelated or overly detailed pages, making the concept map smaller and easier for the audience to process.

Other methods that were discussed:

- Splitting each topic node in half and separately reporting positive and negative votes
- Allowing the briefer and authors to allocate different weights to the votes of different people in the audience to better reflect the hierarchy or expertise of the group
- Using something other than colours to represent the votes, for those with difficulty perceiving colour

6 Researcher use of the software

With a view that software developers should use their own products, the researcher decided to use LiquidBriefing for all of the research, documentation, and briefing requirements of this thesis.

6.1 Gathering research material with LiquidBriefing

The initial step was reviewing the literature. Each article or book has a separate page in the wiki, with short-form reference, formal reference, notes, and a PDF copy of the article (if available). As the notes were made, tags were added to the page to indicate which topics are covered. The formal references list was generated automatically from the appropriate section of each relevant page.

6.2 Synthesizing material with LiquidBriefing

Writing the detailed sections of the literature review was much easier with the ability to quickly search and list all of the articles that related to a specific topic (e.g. author, or audience and visualization). As the concept map was implemented, it was possible to visually see how the topics and articles were related, which provided some insights on how to structure the paper. The thesis advisor and other reviewers were given access to the wiki to make their comments on the relevant pages. Reviewers could look at those pages relevant to their area of expertise, saving them time. They could also follow the progress of the work, commenting as pages matured instead of waiting for a complete document to be emailed, speeding up the review process.

6.3 Mock up of concepts in PowerPoint (DARPA briefing)

For the first presentation to DARPA, a mock-up of the concepts was built using PowerPoint. This was very painstaking, as the concept maps and hyperlinks between map-nodes and slides had to be added manually. However, the impact on the briefing productivity was significant. Only a fraction of the full document was presented, driven by questions from the key decision-maker. Using a clickable concept map to navigate the presentation, two briefers easily took turns on their areas of expertise, without concerns about slide order. The hand-crafted concept map had some benefits, as one of the briefers preferred to start with the visual relationships when developing the document, as opposed to the written material. However, it was challenging to keep the map current during the document authoring process. Hand-crafted maps might also miss some key relationships that the author is unaware of, and increases the burden on the author during the document creation process. For these reasons, the maps were generated automatically in LiquidBriefing. It would be interesting to explore this issue further in future research.

6.4 LiquidBriefing first presentation

The Gate1 milestone presentation, part of the Carleton TIM program thesis process, was scheduled for Friday, March 28, 2008. This presentation was given entirely from the wiki, and was the first presentation generated directly from LiquidBriefing. This was an effective demonstration of the author-productivity potential of the prototype, as comments and edits to the contents were processed until one hour before the presentation, yet the document and slides remained effortlessly synchronized.

To produce the slides, it was necessary to create a new topic (Gate1), which collected all of the desired items under top-level headings. The majority of these were generated directly from table of contents variables. The table summaries were more difficult, requiring some finicky table edits in wiki/HTML format. This does point to an issue where some popular slide formats may be more difficult to generate from the wiki, perhaps requiring a combination of additional functionality and the redesign of slide templates to be wiki-friendly. While the Gate1 presentation required the slides in linear order, it did support hyperlinks between slides and into the topic details. The next iteration uses the topic structure (heading, image, abstract), removing the need for a linear order. The concept maps, which are clickable in the wiki but not in slide-mode, are also enabled clickable in slide-mode.

6.5 Other presentations

Many other presentations were given with LiquidBriefing over the course of the project, to prospective experiment participants and other interested parties. The slide generation and navigation tools matured quickly with usage, and provided useful feedback for the design iterations.

6.6 Extraneous concept map links

As the contents of the thesis wiki grew to hundreds of pages, the concept map links for some pages became quite complicated. Links to status pages and pages built just for partial presentations all added extraneous links to the maps. The concept map function has the ability to exclude pages from the map, (e.g. those starting with Web*, which are used by the wiki software). Appropriately designing topic structure and page names

could extend this feature and better manage the links (e.g. all of the reference pages start with Ref). Page structure is also an issue. Additional sections on some pages to collect project status would have removed the need for separate status pages and reduced the extraneous links.

The audience feedback function was implemented with a check-box mechanism for selecting which topic pages to include in the briefing map, so that the audience was presented with the simplest map possible for the briefing.

6.7 Generating and reviewing printable documents

One of the big challenges with LiquidBriefing is the requirement to produce a complete document for review or printing. Reading online allows the reviewer to follow their own interest and path, reading abstracts and drilling-down only on selected topics. However, it does result in not being sure if all of the pages have been read. Some people also prefer a linear format, or a paper copy. Generating the contents into a linear, printable document would address this need. The ability to select pages and sections of pages, put them in order, and produce a Word or PDF formatted document is not technically challenging, and has been developed for other systems. However, it fell outside of the scope of this project. LiquidBriefing was used for writing and reviewing the monthly reports to DARPA that were a requirement of the funding. This helped with some aspects of report authoring productivity, especially working with other authors and readily reusing material. However, the mechanics of production, grabbing desired pages and converting them to Word format, was time consuming.

7 Experiments and results

7.1 Human subject research approval

In accordance with the requirements of the Carleton University Research Office, review and approval of this research thesis on human subjects was applied for and obtained from the Carleton University Research Ethics Committee. Approval was granted on March 7, 2008 for a period of one year. A copy of the approval letter is included in Appendix C.

The funding agency for this research required additional approvals beyond the Carleton University Ethics Committee. The researchers applied for and received “exempt approval” from the Virginia Polytechnic Institute and State University (VA Tech) Institutional Review Board (IRB) on March 31, 2008 for the human subject research conducted in conjunction with this thesis. A copy of the VA Tech IRB approval letter is included in Appendix C.

Subsequent to receiving IRB exempt approval from VA Tech IRB, the required review forms were submitted to second level approval with the U.S. Army’s Human Subjects Research Review Board (HSRRB). The HSRRB concurred with the VA Tech IRB and determined that the protocol is exempt under the Code of Federal Regulations Title 45 – Public Welfare, Section 46 – Protection of Human Subjects, Paragraph 101(b) (45 CFR 46.101(b)). On April 18, 2008 the approval letter was received from the U.S. Army Medical Research and Materiel Command (USAMRMC) HSRRB, which is also attached in Appendix C.

Exempt approval of the research protocol by Carleton University, VA Tech IRB and USAMRMC HSRRB was a prerequisite to recruit and engage research participants for the experiment interviews. The human subject research for this thesis involved surveying a defined group of software application users regarding their use and perception of the LiquidBriefing tools. Among other things, respondents were asked their opinions regarding ease of use, workflow and features of the software.

7.2 Experiment participants

The experiment sample was selected from associates of the researcher at organizations with a significant proportion of knowledge work. As a result, the results may not be representative of the general population. Within these organizations, participants were randomly assigned to the PowerPoint or LiquidBriefing group in an effort to reduce selection bias by the participants. Experiments were conducted on topics with which the participants had little prior knowledge. All of the participants indicated prior knowledge of PowerPoint.

There were 84 questionnaires and 82 content quizzes completed in the overall experiment, by 77 participants; 5 authors, 8 briefers, and 71 audience members. The authors were the same individuals as the briefers for all experiments, and one breifier did all experiments in set 5, while another did all of set 6, in an attempt to reduce the variability of presenter skill. Table 3 summarizes the distribution of participants by experiment and role. One group participated in two experiments (sets 3 and 4), but the PowerPoint and LiquidBriefing groups were switched so that there was no learning effect in the audience.

The survey questions ask for the participant's subjective opinion, and there is a possibility of response bias. The majority of the groups are composed exclusively of people who do not know the researcher in an attempt to counter a positive response bias. The retention quiz, which requires objective answers, provides a potential validation of some of the audience's subjective responses.

Experiments are labeled according to the following method:

- Topic group number (all experiments with the same number are on the same topic)
- Experiment type (P = PowerPoint, B = LiquidBriefing without audience feedback, F = LiquidBriefing with audience feedback)
- Quiz retest (R = retest)
- Subscript number if there is more than one experiment on the same topic with the same software features, but to different groups.

Experiment	Date	Group	Author	Briefer	Audience	Content Quiz
1B	July 24, 2008	Professional services firm	0	2	4	0
2P	July 24, 2008	Software development group 1	0	0	0	7
2B	July 24, 2008	Software development group 2	2	2	7	7
3P	Sept 8, 2008	Software development group 3	0	0	8	8
3F	Sept 8, 2008	Software development group 4	0	0	9	9
4P	Sept 18, 2008	Software development group 4	0	0	5	6
4F	Sept 19, 2008	Software development group 3	0	0	7	7
4PR ₁	Sept 26, 2008	Software development group 4	0	0	0	5
4FR ₁	Sept 26, 2008	Software development group 3	0	0	0	6
4PR ₂	Sept 26, 2008	Software development group 4	0	0	0	5
4FR ₂	Sept 26, 2008	Software development group 3	0	0	0	6
5P	Sept 28, 2008	Federal election candidate group 1	1	1	5	5
5B	Sept 28, 2008	Federal election candidate group 2	1	1	5	5
6F	Sept 28, 2008	Business professionals group	1	1	6	6
6F ₁	Sept 29, 2008	Business professionals group 1	0	1	0	0
6F ₂	Sept 29, 2008	Business professionals group 2	1	0	6	0
6F ₃	Sept 29, 2008	Business professionals group 3	0	0	4	0
5F	Sept 30, 2008	Federal election candidate group 3	0	0	5	0
Total			5	8	71	82

Table 3: Summary of experiments by date, including number of completed questionnaires by role

Descriptions of each group follow.

7.2.1 Professional services firm

This is a group of senior executives looking to start a business consulting firm. Their objective is to compare two competing business proposals that the group has developed. Two briefers from the firm and four audience members from potential clients used the earliest iteration of LiquidBriefing in this experiment.

7.2.2 Software development group

This is a group of software professionals who work on a wide range of projects within the company. Group members were subdivided into smaller groups and given either the PowerPoint or the LiquidBriefing version of the presentation.

7.2.3 Federal election candidate

This group was working to elect their candidate in the 2008 federal election. Their objective is to prepare the candidate for upcoming local debates. The group consisted of 16 volunteers from the local party association, split into three groups who were given the PowerPoint, LiquidBriefing, or LiquidBriefing with audience feedback version of the material.

7.2.4 Business professionals group

Three groups of business professionals took part in a series of experiments that used the same content material. This group was composed of 15 individuals of diverse backgrounds and from a wide range of business areas.

7.3 Experiment results

A series of experiments was conducted with different groups, different topics, and different iterations of the LiquidBriefing software, to provide a thorough evaluation of the benefits and the best opportunities for commercialization and future research. These productivity and perception results are charted for all of the experiments in Figure 18 and Figure 19, followed by detailed analysis for each group of participants.

Even though the groups were very different in nature, their responses to the questionnaires were similar, and provided support to the effectiveness of the LiquidBriefing approach compared to traditional methods of conducting presentations. In particular, all groups' responses to the questionnaire showed that the interaction

Figure 18: Chart of overall audience productivity results

between audience members and briefers was improved with LiquidBriefing over PowerPoint. Comments from individual participants indicated that the potential benefit of the research and prototype concepts was high. Their responses also indicate that they could see even more benefit after they used LiquidBriefing repeatedly and became more familiar with its use. Both productivity and perception showed a general upward trend as the prototype matured over the development iterations.

In addition to the experiment observations and user surveys, a detailed log file captures software usage metrics. This provides additional insight into participant behaviour before, during, and after the briefings. Detailed analysis of this data is included with each group.

Figure 19: Chart of overall audience perception results

One of the concerns raised about briefer-audience interaction is the impact of providing information that is beyond the control of the briefer (Case Studies; Doumont, 2005; Holcombe & Stein, 1996: 85), such as handouts or detailed notes. In the case of LiquidBriefing, audience members who have a computer during the briefing have far more than a copy of the slides, with access to the full information set prepared by the authors. However, evidence from the briefing logs indicates that rather than being a distraction, the access to information is a significant aid to interaction and comprehension.

In all of the experiments that included audience members with computer access, there were only a very small number of times when a participant skipped ahead of the briefer, and even then it was most likely just one slide. One of the most frequent comments from audience members of these experiments is requesting a feature to easily get the same slide the briefer has displayed.

The business professionals group had three experiments with the identical content and objectives but with different audiences. Even though they had the same content, the logs show that they all followed slightly different paths through the briefing material. This is a good demonstration of the flexibility of this solution, enabling the briefer to dynamically adapt to the knowledge level and context of the audience.

7.3.1 PowerPoint experiments

The PowerPoint experiments demonstrated a neutral to slightly negative overall productivity and perception for the audience (illustrated in Figure 20 and Figure 21, and summarized in Table 4). Only one author and briefer survey was done for PowerPoint, which were also neutral. Information retention was generally poor, with the overall mean a failing grade. One group achieved a 'C' average, one a 'D', and the remaining two 'F'. After one week, information retention dropped by 25%, and even after reviewing the material this group remained at an "F".

Note: due to a miscommunication, the content quiz was administered to the audience in experiment 2P but not the participant survey.

Figure 20: Chart of PowerPoint audience productivity results

Figure 21: Chart of PowerPoint audience perception results

PowerPoint Experiments	2P	3P	4P	5P	Mean
Audience – “Using this software...”					
a. Reduced the time required for the briefing	N/A	4.0	2.6	3.8	3.6
b. Improved the quality of the results	N/A	3.6	3.4	3.4	3.5
c. Improved the flow of the briefing	N/A	4.1	3.6	3.6	3.8
d. Made it easier for me to interact during the briefing	N/A	3.6	3.0	4.6	3.7
Audience productivity	N/A	3.8	3.2	3.9	3.7
a. I would refer this software to others in my organization	N/A	4.4	3.6	5.4	4.5
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	N/A	3.7	3.2	4.8	3.9
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	N/A	3.6	3.8	N/A	3.7
Audience perception	N/A	3.9	3.5	5.1	4.1
Information retention	46%	77%	49%	63%	59%
Information retention grade	F	C	F	D	D
Retest without review (4PR₁)			37%		
Retest with review (4PR₂)			45%		

Table 4: PowerPoint experiment results

7.3.2 LiquidBriefing authors

The LiquidBriefing experiments with the authoring aspect of the tool identified productivity gains for authors. in increased scope of the document, strong gains in ease of working with other authors, quality of results, and incorporating reviewer feedback, and loss of productivity on time (shown in Figure 22 and Figure 23 and Table 5). The sample was small (3 experiments with 4 authors completing questionnaires), and responses quite varied, especially for ease of working with other authors and quality of results. These findings answer Research Question 1: collaborative wiki-based tool connected to briefing slides improved author productivity, primarily through increased scope of the document and ease of working with other authors.

Figure 22: Chart of LiquidBriefing author productivity results

Figure 23: Chart of LiquidBriefing author perception results

LiquidBriefing authoring Experiments	2B	5B	6F	Mean	Difference from PPT
Author– “Using this software ...”					
a. Reduced the time required to prepare the document	3.0	3.0	4.0	3.3	(3.7)
b. Improved the quality of the results	5.0	7.0	5.0	5.5	1.5
c. Increased the scope of the document	6.5	7.0	7.0	6.8	2.8
d. Made it easier to work with other authors	7.0	5.0	6.0	5.8	1.8
e. Made it easier to incorporate feedback from reviewers prior to the meeting	5.0	6.0	6.0	5.5	1.5
Author productivity	5.3	5.6	5.2	5.4	0.8
a. I would refer this software to others in my organization	5.0	6.0	7.0	5.8	1.8
b. Compared with our current tools, this software was more effective in helping me prepare the briefing materials	5.0	7.0	6.0	5.8	1.8
Author perception	5.0	6.5	6.5	5.8	1.8

Table 5: LiquidBriefing author participant results

7.3.3 LiquidBriefing for briefers

The LiquidBriefing experiments with the briefing aspect of the tool identified productivity gains for briefers in increased audience interaction and ease of following the interest of the audience, slight gains in other areas, except time savings which had a slightly negative mean response. The overall trend was positive over the successive iterations of the software. The most significant variances were in time savings and improved flow (shown in Figure 24 and Figure 25).

Figure 24: Chart of LiquidBriefing briefer productivity results

Figure 25: Chart of LiquidBriefing briefer perception results

7.3.4 LiquidBriefing without audience feedback mechanism

The LiquidBriefing experiments without the audience feedback mechanism enabled or audience access to the briefing details, identified productivity gains for briefers and audience members, summarized in Table 6 and Table 7.

The briefer participants identified productivity gains in audience interaction and ability to follow the interest of the audience, slight gains in quality of results, neutral on improved flow, and slightly negative on time. These findings answer Research Question 2A: dynamic briefing navigation improved briefer productivity, primarily through ease of following the interest of the audience and increased audience interaction.

LiquidBriefing w/o audience feedback Experiments	1B	2B	5B	Mean	Difference from PPT
Briefer – “Using this software...”					
a. Reduced the time required for the briefing	4.0	2.0	4.0	3.2	(0.8)
b. Improved the quality of the results	5.0	5.5	5.0	5.2	1.2
c. Improved the flow of the briefing	4.5	3.5	6.0	4.4	0.4
d. Increased the audience interaction	5.0	7.0	5.0	5.8	1.8
e. Made it easier to follow the interest of the audience during the meeting	5.5	6.0	6.0	5.8	2.8
Briefer productivity	4.8	4.8	5.2	5.9	2.1
a. I would refer this software to others in my organization	5.0	5.5	6.0	5.4	1.4
b. Compared with our current tools, this software was more effective in helping me manage the briefing	5.0	5.5	6.0	5.4	1.4
Briefer perception	5.0	5.5	6.0	5.4	1.4

Table 6: Briefer participant results without audience feedback mechanism

The audience participants identified slight productivity gains in easier interaction and improved quality of results. They were neutral on gains from reduced time or improved flow; however their responses were higher in all categories than the PowerPoint experiments. The difference was especially notable in the effectiveness of reviewing material after the briefing. Information retention was higher, with an overall ‘D’ average.

These findings answer Research Question 3A: dynamic briefing navigation improved audience productivity, primarily through easier interaction and improved quality.

LiquidBriefing w/o audience feedback Experiments	1B	2B	5B	Mean	Difference from PPT
Audience – “Using this software...”					
a. Reduced the time required for the briefing	3.0	4.0	5.0	4.1	0.5
b. Improved the quality of the results	4.5	4.6	5.2	4.8	1.3
c. Improved the flow of the briefing	5.0	3.0	5.2	4.2	0.4
d. Made it easier for me to interact during the briefing	5.0	6.0	5.0	5.4	1.7
Audience productivity	4.4	4.4	5.1	4.6	0.9
a. I would refer this software to others in my organization	4.5	4.4	5.4	4.7	0.2
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	4.0	4.3	5.6	4.6	0.8
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	N/A	6.9	N/A	6.9	3.2
Audience perception	4.3	5.2	5.5	5.1	1.0
Information retention	60%	64%	78%	67%	7%
Information retention grade	D	D	C	D	

Table 7: Audience participant results without audience feedback mechanism

7.3.5 LiquidBriefing with audience feedback mechanism

The LiquidBriefing experiments with the audience feedback mechanism enabled, and with the audience able to access briefing details, identified further productivity gains for briefers and audience members, shown in Table 8 and Table 9.

The breifier participant identified significant productivity gains in improved flow of the briefing, gains in audience interaction and quality of results, slight gains in following the interest of the audience and time savings. These findings answer Question 2B: audience feedback mechanism helped improve breifier productivity, primarily through improved flow and increased audience interaction.

LiquidBriefing with audience feedback Experiments	5F	6F	Mean	Difference from PPT
Briefer – “Using this software...”				
a. Reduced the time required for the briefing	6.0	3.0	4.5	0.5
b. Improved the quality of the results	6.0	6.0	6.0	2.0
c. Improved the flow of the briefing	7.0	6.0	6.5	2.5
d. Increased the audience interaction	5.0	7.0	6.0	2.0
e. Made it easier to follow the interest of the audience during the meeting	6.0	4.0	5.0	2.0
Briefer productivity	6.0	5.2	5.6	1.8
a. I would refer this software to others in my organization	7.0	7.0	7.0	3.0
b. Compared with our current tools, this software was more effective in helping me manage the briefing	7.0	5.0	6.0	2.0
Briefer perception	7.0	6.0	6.5	2.5

Table 8: Briefer participant results with audience feedback mechanism

The audience identified further productivity gains in all areas, but most notably in easier interaction and improved quality of results. Perception also improved, although it dropped in effectiveness of reviewing material after the meeting. This latter could be an artifact of the small sample size. Information retention did not improve from the previous experiment, still a 'C' average overall, but nearly 12% better than the PowerPoint scores. After one retest without review, the group still maintained a 'C' average, and after reviewing the material improved to an 'A'. These findings answer Research Question 3B: audience feedback mechanism improved audience productivity, primarily through easier interaction and improved quality.

LiquidBriefing with audience feedback Experiments	3F	4F	5F	6F₁	6F₂	6F₃	Mean	Diff. from PPT	Diff. from w/o audience feedback
Audience – “Using this software...”									
a. Reduced the time required for the briefing	4.2	3.4	6.5	5.0	5.8	4.4	4.7	1.1	0.6
b. Improved the quality of the results	5.0	4.9	6.7	6.0	6.0	5.0	5.5	2.0	.07
c. Improved the flow of the briefing	4.6	4.3	6.8	6.0	6.8	6.0	5.5	1.7	1.3
d. Made it easier for me to interact during the briefing	5.8	5.6	6.3	6.2	6.5	6.2	6.0	2.3	0.6
Audience productivity	4.9	4.5	6.6	5.8	6.3	5.4	5.4	1.7	0.8
a. I would refer this software to others in my organization	5.1	5.0	6.8	6.2	5.5	5.6	5.7	1.2	1.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	4.0	4.7	6.7	5.7	6.0	5.4	5.2	1.3	0.7
c. Compared with our current tools, this software was more effective in reviewing the material after the meeting	5.3	6.1	N/A	6.3	N/A	N/A	5.8	2.1	(1.1)
Audience perception	4.8	5.3	6.8	6.1	5.8	5.5	5.6	1.5	0.6
Information retention	67%	69%	79%	N/A	N/A	N/A	71%	11%	4%
Information retention grade	D	D	C				C		
Retest without review (4FR₁)		66%						29%	
Retest with review (4FR₁)		92%						47%	

Table 9: Audience participant results with audience feedback mechanism

7.3.6 Professional services firm

This group is a recent startup looking to develop a competitive combination of technology and staffing to deliver professional services to underserved small- and medium-sized businesses. They reached a point in the development of their business plan where there are two competing views of the business model and potential opportunity. In an effort to resolve this, they scheduled a briefing to compare the two proposals using the LiquidBriefing prototype. This was the earliest experiment with the prototype, so it was unavailable for use as an authoring tool, and had the minimum navigation functionality, and no audience feedback tool.

One of the proposals was written as a Microsoft Word document, and the other as a series of Web pages. The contents of both were reviewed for similarities in structure, and were slightly modified to make them easier to compare. The resulting structure was:

- Introduction
- Core problems and beliefs
- Identified business opportunity
- Specific business proposal

The contents were then added to the prototype (cut and paste to the appropriate pages), and edited to turn common elements and references into links that could be processed by the software. The top levels of the two proposals were built as separate hierarchies, but lower-level elements were not, to enable the briefers and audience to readily identify the common and disparate elements of the proposals.

7.3.6.1 LiquidBriefing without audience feedback (experiment 1B)

This group consisted of two briefers and four audience members. The experiment took place on July 24, 2008, and consisted of one briefing done with the LiquidBriefing prototype without audience feedback tool. Each of the two briefers had 30 minutes to present their version of the business model in an interactive fashion, encouraging questions and discussion along the way.

After the briefing, the two briefers and four audience members completed the questionnaires, summarized in Table 10 and Table 11. One breifier gave neutral responses, and commented that he was trying to persuade instead of describe, which negatively affected his results (in the preliminary research and assumptions it was identified that briefings with an objective of persuading were not covered by the approach of this thesis). The other breifier strongly agreed that the software increased the audience interaction, and made it easier to follow the interest of the audience. This agrees with the strongest responses from the audience, that the flow was improved and that it was easier to interact.

In this group, none of the participants perceived any time savings, with the briefers giving a neutral response, and the audience a slightly disagree. The group did perceive an improvement in quality using the software (no scores less than a neutral 4).

In the comments, one breifier and two audience members identified inexperience with the software as having an impact on their scores. They all concurred that the concept and implementation had significant potential, but that more training or experience would have improved the results.

Experiment 1B	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Briefer – “Using this software ...”					
a. Reduced the time required for the briefing	4.0	2	0.000	4.0	4.0
b. Improved the quality of the results	5.0	2	1.414	4.0	6.0
c. Improved the flow of the briefing	4.5	2	0.707	4.0	5.0
d. Increased the audience interaction	5.0	2	2.828	3.0	7.0
e. Made it easier to follow the interest of the audience during the meeting	5.5	2	2.121	4.0	7.0
Briefer productivity	4.8	2	1.414	3.8	5.8
a. I would refer this software to others in my organization	5.0	2	1.414	4.0	6.0
b. Compared with our current tools, this software was more effective in helping me manage the briefing	5.0	2	1.414	4.0	6.0
Briefer perception	5.0	2	1.414	4.0	6.0

Table 10: Experiment 1B briefer participant results, LiquidBriefing without audience feedback mechanism

Comments from the briefers included:

“I can see the application of this software in working meetings where the goal is to process information and derive an outcome.”

“Very interesting approach to manage and drive a meeting. I did really like the way you could jump around between topic areas and move the discussion around. I would like to work more with this.”

Experiment 1B	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	3.0	4	1.414	1.0	4.0
b. Improved the quality of the results	4.5	4	0.577	4.0	5.0
c. Improved the flow of the briefing	5.0	4	0.816	4.0	6.0
d. Made it easier for me to interact during the briefing	5.0	4	1.155	4.0	6.0
Audience productivity	4.4	4	0.161	4.0	4.8
a. I would refer this software to others in my organization	4.5	4	0.577	4.0	5.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	4.0	4	0.816	3.0	5.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	N/A	N/A	N/A	N/A	N/A
Audience perception	4.3	4	0.645	3.5	5.0

Table 11: Experiment 1B audience participant results, LiquidBriefing without audience feedback mechanism

Comments from the audience participants included:

“I liked the concept but the execution seemed flawed. The ‘presentation’ aspect did not really keep up with or reflect the discussion most of the time. It did not help focus or support the presenter’s discussion. This could be my own PowerPoint bias. I do see value in it though, if there is a tighter linkage.”

“I believe that inexperience with the toolset diminished its effective use.”

“Very interesting way of presenting - could understand the flow of material much easier than a typical presentation. Useful dialogue kept conversation fresh and interesting as well as keeping all audience members on their toes.”

7.3.6.2 Log file analysis

In the Professional Services experiment, none of the participants brought laptops, so there was only one active wiki session. The first briefer largely followed the original table of contents order, although he did take advantage of the ability to easily switch between topics during the latter part of the presentation, when there was more discussion and questions from the audience.

The second briefer started off in the intended order, but jumped around a lot more, using the document for supporting points and reacting more to the interests and questions of the audience. His key comment:

“Now that I have been through it once, I would have prepared somewhat differently and probably had a suggested navigation of the material planned out.”

7.3.6.3 Summary

This was the first experiment with LiquidBriefing, and demonstrated some of the prototype's potential. In this group the audience did not have access to the supplementary details and the audience feedback mechanism was not yet implemented. The two briefer's reported a higher productivity gain and perception of the software than the audience did. However, the variability between the two briefers was quite high, with one responding consistently positive and the other consistently neutral to negative. Some of this could be attributed to personal presentation style, or to a need for more training and familiarity with the software.

7.3.7 Software development group

The largest series of experiments was conducted with a Software Development Group. This began with a PowerPoint baseline, followed by iterative experiments of additional functionality. Retention quizzes were given after each round, and also again one week after the last experiment, to evaluate the 'stickiness' of the knowledge. The experiments conducted with the two groups consisted of the following steps:

- Administer a survey questionnaire to authors, briefers and audience members regarding their background and process currently used for presentations and briefings.
- Conduct an initial briefing to half the group in a traditional manner using PowerPoint to provide a baseline.
- Administer a knowledge retention quiz to audience participants on content from the briefing within one hour of the completion of the briefing.

- Conduct a briefing using LiquidBriefing to the other half of the group.
- Administer a knowledge retention quiz on the second briefing content within one hour of the completion of the briefing
- Administer post-briefing surveys to author, briefer, and audience participants.

7.3.7.1 LiquidBriefing without audience feedback (experiments 2P & B)

The Software Development Group held a baseline briefing experiment with seven audience members using PowerPoint, on July 24, 2008. For the retention quiz, the PowerPoint group had a mean score of 45.7%. Due to a miscommunication, the content quiz was administered to the audience in this experiment but not the participant survey.

The next experiment used LiquidBriefing without audience feedback, but with the same content material as the above briefing. Audience members for the Software Development Group's briefings were encouraged to bring a computer to the LiquidBriefing presentation. This permitted some early feedback on the effectiveness of permitting audience members to drill down into the wiki during the presentation to learn more about the topic being presented, and to make comments. Participants saw a strong case for significant productivity gains in the authoring, briefing and understanding of material presented using LiquidBriefing.

Experiment 2B	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Author– “Using this software ...”					
a. Reduced the time required to prepare the document	3.0	2	1.414	2.0	4.0
b. Improved the quality of the results	5.0	2	1.414	4.0	6.0
c. Increased the scope of the document	6.5	2	0.707	6.0	7.0
d. Made it easier to work with other authors	7.0	2	0.000	7.0	7.0
e. Made it easier to incorporate feedback from reviewers prior to the meeting	5.0	2	0.000	5.0	5.0
Author productivity	5.3	2	0.707	4.8	5.8
a. I would refer this software to others in my organization	5.0	2	0.000	5.0	5.0
b. Compared with our current tools, this software was more effective in helping me prepare the briefing materials	5.0	2	0.000	5.0	5.0
Author perception	5.0	2	0.000	5.0	5.0

Table 12: Experiment 2B author participant results, LiquidBriefing without audience feedback mechanism

The biggest gains in authoring were an increased scope to the document and ease of working with other authors, shown in Table 12. The biggest (and only) reduction in productivity was the time required to prepare the document, which may be attributed to the prototype nature and learning curve of new software, which was reflected in the comments:

“The software still has kinks to be worked out but it is going in the right direction.”

“This would solve a majority of my problems. The editor has to be done well though, that is what makes PowerPoint nice since it is so easy and intuitive to use.”

Experiment 2B	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Briefer – “Using this software ...”					
a. Reduced the time required for the briefing	2.0	2	0.000	2.0	2.0
b. Improved the quality of the results	5.5	2	2.121	4.0	7.0
c. Improved the flow of the briefing	3.5	2	0.707	3.0	4.0
d. Increased the audience interaction	7.0	2	0.000	7.0	7.0
e. Made it easier to follow the interest of the audience during the meeting	6.0	2	1.414	5.0	7.0
Briefer productivity	4.8	2	0.849	4.2	5.4
c. I would refer this software to others in my organization	5.5	2	0.707	5.0	6.0
d. Compared with our current tools, this software was more effective in helping me manage the briefing	5.5	2	0.707	5.0	6.0
Briefer perception	5.5	2	0.707	5.0	6.0

Table 13: Experiment 2B briefer participant results, LiquidBriefing without audience feedback mechanism

The biggest gains for the briefers were increasing the audience interaction and ease of following the interest of the audience, shown in Table 13. Comments from the briefers expand on the benefits and challenges of this approach:

“The interface seems to lend itself to a presentation in which the speaker is solicited by audience members to speak about specific topics; while still other audience members might browse entirely different parts of the map, waiting for their chance to ask questions.”

“Live commenting on topics is good, less I have to remember, also allows the audience to better guide the briefing to fit their needs. Since everything is electronic I can send out links to the documents and presentation ahead of time in a consistent fashion.”

“The ability to turn topics into slides automatically is great, no need to format manually, although more control of layout and content would be good. Topic maps that show related information in the briefing give the audience a chance to drive the direction of the briefing to suit their needs.”

Once again, the biggest drop in productivity was the time required for the briefing, with a slight drop in the flow of the briefing. Comments from the briefers indicate an awareness of this:

“The briefer must take more control of the flow in order to keep on point and avoid going on tangents that draw out the briefing. The briefing took longer but I think the audience got more out of it.”

“Ultimately the tool probably requires too much overhead to be useful for small-scale presentations; but this same initial investment may generate increasingly greater returns for progressively larger briefings and audiences.”

Experiment 2B	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	4.0	7	1.528	2.0	7.0
b. Improved the quality of the results	4.6	7	1.272	3.0	6.0
c. Improved the flow of the briefing	3.0	7	0.816	2.0	4.0
d. Made it easier for me to interact during the briefing	6.0	7	1.000	4.0	7.0
Audience productivity	4.4	7	0.537	3.8	5.3
a. I would refer this software to others in my organization	4.4	7	1.397	3.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	4.3	7	1.704	2.0	7.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	6.9	7	0.378	6.0	7.0
Audience perception	5.2	7	1.034	4.0	7.0

Table 14: Experiment 2B audience participant results, LiquidBriefing without audience feedback mechanism

The biggest gain for the audience was making it easier to interact during the briefing, shown in Table 14. The biggest drop in productivity was the flow of the briefing. This

could have been caused by the different skills of the briefer, as well as the complex structure of the document, according to audience comments:

“One of the problems could be that the presenters were different. The speaker giving a presentation through PowerPoint was much more organized and used to giving oral presentations. The speaker giving the presentation using the software is not as practiced a speaker and tends to give convoluted presentations anyway.”

“The actual organization of the topic map needs to be clearer. In this instance, it was near impossible to separate the proposed solution from the current solution.”

Several participants also felt that the software was better suited to repetitive presentations to larger audiences:

“The software feels much more slated toward presentations that will be given to a large audience where the material will be presented many, many times. It seems less appropriate for one off presentations.”

“The alternate software would be useful in large open ended presentations as opposed to very narrow focus controlled briefings.”

The perceived benefit of being able to review material after the briefing was very high, possibly due to the significant amount of material that is readily available compared to a PowerPoint slide deck:

“I really liked the idea of being able to venture off on a different topic if the current topic is not of interest to me. I definitely think that this tool can be more informative

given the vast amounts of information available to you, if you don't want to rely on the slides alone.”

“Potentially, very powerful. The drawback is that the current presentation does not allow the presenter to filter the data displayed in any way, so the audience is flooded with large amounts of data. If you were to make the presentation a limited view on the data, then I think you would have a much more powerful product. For example, a presenter creates a presentation that is a few topics with a few bulletins from each topic. He then presents that to a group. If the group has questions that go beyond the scope of the presentation, the more complete topic is still connected and available. Additionally, if a factual error is corrected in the knowledge base, it will be corrected in the presentation automatically.”

Additional experience with LiquidBriefing by both authors and briefers, along with exposure to this novel technology by audience participants, should improve the benefits realized. This group scored a mean of 64% on the retention quiz, almost 40% higher than the PowerPoint group, summarized in Table 15.

Content retention quiz (5 questions)	Mean	n	Standard deviation	Minimum	Maximum
Experiment 2P	46%	7	9.8%	40%	60%
Experiment 2B	64%	7	14.0%	40%	80%

Table 15: Experiment 2P & 2B information retention results

7.3.7.2 LiquidBriefing audience feedback trial (experiments 3P & 3F)

Based on feedback to the prototype and the experimental methods from the first experiment with the Software Development Group, adjustments were made in preparation for the experiments with the audience feedback tool. In experiment 2P & 2B, the two styles of presentation (PowerPoint and LiquidBriefing) were authored and briefed separately by two individuals. Although some collaboration occurred and the subject matter was the same, the difference in author and briefing styles was an undesirable variable for further experiments. Additionally, refinements were made to the prototype to enhance audience and briefer interaction. A trial of the modified method and the audience feedback mechanism was conducted prior to moving ahead with additional experiments.

The trial consisted of two briefings on the same material, one using PowerPoint and one using the LiquidBriefing prototype. The subject of the briefings was a current project in development at the company. Each briefing was authored and presented by the same person, the lead developer on the project. The audience, made up of employees in various positions at the company, was split into two different groups, one for each briefing. Upon completion of the briefings, each group took identical retention quizzes prepared by the presenter, followed by the research questionnaire.

Experiment 3P	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	4.0	8	0.756	3.0	5.0
b. Improved the quality of the results	3.6	8	1.188	1.0	5.0
c. Improved the flow of the briefing	4.1	8	0.641	3.0	5.0
d. Made it easier for me to interact during the briefing	3.6	8	1.506	1.0	5.0
Audience productivity	3.8	8	0.855	2.0	4.5
a. I would refer this software to others in my organization	4.4	8	1.408	3.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	3.7	8	0.781	2.0	5.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	3.6	8	0.744	2.0	4.0
Audience perception	3.9	8	0.801	2.7	5.0

Table 16: Experiment 3P audience participant results, PowerPoint

The PowerPoint group indicated generally neutral productivity and perception, as would be expected since PowerPoint is their typical briefing tool, shown in Table 16.

The audience feedback mechanism recently added to the prototype was first used in this trial. The mechanism presented audience members with a concept map of the

presentation where each node represented a topic that would be covered. Audience members were able to indicate whether they had more or less interest in a topic by clicking on the nodes. The presenter saw a similar map that changed colours as audience members used the feedback mechanism. More interest in a topic caused that node to fade into deeper shades of green, while less interest caused it to fade into deeper shades of red. The audience feedback mechanism was made available a few minutes before the prototype briefing began, and was left open for the duration.

This trial highlighted some of the challenges involved with moving to a dynamic briefing environment. Participants rated the prototype higher than PowerPoint in every question on the survey. In particular, audience members rated the prototype 50% higher in effectiveness for post-briefing review, and 60% higher in ease of interaction. Participants also rated the prototype significantly higher in overall quality of the results. By contrast, the overall retention scores were slightly lower for LiquidBriefing than PowerPoint. Both the higher ratings and the retention scores are explained in part by the introduction of the audience feedback mechanism. The increased ability to interact during the briefing and to review the material afterwards was seen as a notable improvement. However, it also provided the audience members with a new feature that could distract them from the presenter. One participant even noted,

"It might be interesting to see the effects of locking out slides. Or something along the lines of only being able to stray so far from the presenter's current slide. That way members won't be off on a completely different topic."

Another challenge with this briefing software involves controlling the flow of the briefing. Traditionally, presentation slide shows have been created and presented in a linear way. There is a start slide, an end slide, and slides 2, 3, 4, and so on in between. The briefer's only notion of flow has to do with when to advance the slides; no decision needs to be made on where to go. With this new environment, slide show presentations are no longer linear. The presenter may move from one slide to any other slide, particularly in response to feedback from the audience. While this adds a great deal of potential to the effectiveness of briefings, it also provides presenters with more decisions to make. Prior to starting a briefing, presenters need to consider the overall flow in order to give focused, cohesive presentations.

The results from this trial, summarized in Table 17, emphasize that the potential of this technology is closely tied to how accustomed the participants are with collaborative environments and dynamic presentations, summed up well by this audience member,

"Also, more time was needed for both the briefer and the audience members to get used to using the feedback map. In short, both briefer and audience member would benefit from more use and/or training with the [prototype]."

Experiment 3F	Mean scale 1- 7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	4.2	9	1.641	2.0	6.0
b. Improved the quality of the results	5.0	9	1.118	4.0	7.0
c. Improved the flow of the briefing	4.6	9	1.667	2.0	7.0
d. Made it easier for me to interact during the briefing	5.8	9	1.302	3.0	7.0
Audience productivity	4.9	9	1.112	3.0	6.8
a. I would refer this software to others in my organization	5.1	9	1.453	3.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	4.0	9	1.500	2.0	7.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	5.3	9	1.500	3.0	7.0
Audience perception	4.8	9	1.056	3.7	7.0

Table 17: Experiment 3F audience participant results, LiquidBriefing with audience feedback mechanism

Again, the biggest gain for the audience was making it easier to interact during the briefing.

"I believe that this software has the potential to revolutionize the way that presentations and lectures are handled. This method allows the presentation to move with the thought processes of the people in attendance. I think that it is also a remarkable idea to allow feedback from the audience during the presentation without interrupting the presentation."

In this case, there was no overall drop in productivity, but that view was not shared by all participants. Some participants found it difficult to find the current slide, which may have been the primary cause:

"It might be nice to have a 'go to presenter's location' link to allow an audience member to navigate directly to the slide being viewed by the presenter."

"The biggest problem I had was keeping track of which slide the presenter was on. If I wasn't watching when he clicked on the item in the map, I often had trouble finding the correct slide."

"I believe it would also be helpful to see what slides the viewers are currently on. This would provide some useful feedback in real time. With the presenter being able to see how many of the viewers are on the current slide, he can gauge that actual attention that the audience has on the current topic."

The risk of audience members being distracted was also raised:

"I definitely see benefits using [LiquidBriefing] such as allowing the audience control the flow of the presentation, but one negative I see is that an audience member can shoot themselves in the foot by browsing through the topics on their own during the

presentation. The audience member can easily miss most of the important points of the presentation because their attention is elsewhere."

In this experiment, the PowerPoint participants outscored the LiquidBriefing participants on the information retention quiz, as shown in Table 18. This could be a result of the novelty of the audience feedback mechanism distracting the audience from the content. For future briefings, some 'playtime' will be allocated before the start of the briefing in an effort to reduce this effect.

Content retention quiz (13 questions)	Mean	n	Standard deviation	Minimum	Maximum
Experiment 3P	76%	8	4.0%	75%	81%
Experiment 3F	67%	9	16.7%	50%	94%

Table 18: Experiment 3P & 3F information retention results

7.3.7.3 LiquidBriefing with audience feedback (experiment 4P & 4F)

This experiment consisted of another series of two briefings on the same material, one using PowerPoint and one using the LiquidBriefing prototype. The subject of the briefings was another project in development, with distinctly different content than that from the briefing earlier in the month (experiment 3). Each briefing was authored and presented by the lead developer for the subject project. The audience, again made up of the internal Software Development Group, was split into two different groups, one for each briefing. Upon completion of the briefings, each group took identical retention quizzes prepared by the presenter, followed by a brief participation survey.

Experiment 4P	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	2.6	5	1.517	1.0	4.0
b. Improved the quality of the results	3.4	5	2.191	1.0	5.0
c. Improved the flow of the briefing	3.6	5	2.074	1.0	6.0
d. Made it easier for me to interact during the briefing	3.0	5	1.581	1.0	5.0
Audience productivity	3.2	5	1.664	1.0	4.8
a. I would refer this software to others in my organization	3.6	5	1.673	1.0	5.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	3.2	5	1.483	1.0	5.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	3.8	5	1.643	1.0	5.0
Audience perception	3.5	5	1.502	1.0	5.0

Table 19: Experiment 4P audience participant results, LiquidBriefing with audience feedback mechanism

The PowerPoint group, summarized in Table 19, again indicated generally neutral to even slightly negative productivity and perception, as would be expected since PowerPoint is their typical briefing tool. Their information retention was a mean of 49%

The audience feedback mechanism was used in this experiment. The mechanism presented audience members with a concept map of the presentation where each node represented a topic that would be covered. Audience members were able to indicate

whether they had more or less interest in a topic by clicking on the nodes. The presenter saw a similar map that became colourized as audience members used the feedback mechanism. More interest in a topic caused it to fade into green, while less interest caused it to fade into red. The audience feedback mechanism was made available a few minutes before the prototype briefing began, and was left open for the duration.

Similar to Experiment 2B and 3B, the participants rated the LiquidBriefing prototype higher than PowerPoint in every question on the survey, summarized in Table 20. The ratings were significantly higher again for interactivity (mean 5.6 versus 3.0) and effectiveness of reviewing material after the briefing (mean 6.1 versus 3.8). Participants also perceived a considerable increase in the quality of the results, rating the prototype over 40% higher. The group tended to agree that the prototype was more effective in helping them understand the material (mean 4.7 versus 3.2). Audience members were generally neutral on improved flow and slightly negative on time savings. The scores from the retention quizzes were notably higher using the prototype (69% vs. 49%, an increase of 41%), as shown in Table 21.

Experiment 4F	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	3.4	7	0.976	2.0	5.0
b. Improved the quality of the results	4.9	7	1.215	4.0	7.0
c. Improved the flow of the briefing	4.3	7	1.799	2.0	7.0
d. Made it easier for me to interact during the briefing	5.6	7	1.272	4.0	7.0
Audience productivity	4.5	7	0.859	3.5	5.5
a. I would refer this software to others in my organization	5.0	7	1.528	3.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	4.7	7	1.496	3.0	7.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	6.1	7	1.864	2.0	7.0
Audience perception	5.3	7	1.297	3.3	7.0

Table 20: Experiment 4F audience participant results, LiquidBriefing with audience feedback mechanism

Again, the biggest gain for the audience was making it easier to interact during the briefing. In this case, there was a small overall drop in productivity in the time required for the briefing. The perceived benefit of being able to review material after the briefing was high.

Content retention quiz (15 questions)	Mean	n	Standard deviation	Minimum	Maximum
Experiment 4P	49%	6	9.8%	35%	63%
Experiment 4F	69%	7	17.5%	37%	92%

Table 21: Experiment 4P & 4F information retention results

7.3.7.4 Log file analysis

This last experiment with the Software Development Group was the largest experiment with computer access, and it clearly illustrates the potential benefits. The presentation appears to have four distinct stages: setting up the problem, exploring the key issues, additional points, and recommending a solution.

The audience members consistently follow the briefer for the early part of the briefing (first 6 of 14 'slides', Figure 26). In a small number of cases there is a brief jump to a related topic, sometimes followed by a vote for additional information. This stage of the briefing, which is setting up the problem and foundation, takes one or two minutes per slide (mean of 1.5). In this stage, if the audience is not on the same slide as the briefer, the most common activity is to be looking at supplementary information (four of seven audience members, one occasion each). Next most likely is to be looking at an earlier page, just one or two slides back from current (one of seven audience members during this stage, three occasions). This allows different audience members to review material or finish reading a slide, without slowing down or disrupting the briefer.

Briefer Page	Slide #	Minutes	User	Audience Page
Stakeholders	1	1	0141	Stakeholders
			3347	Stakeholders
			3746	Stakeholders
			4072	Stakeholders
			5690	Stakeholders
			6819	Stakeholders
			9943	Stakeholders
ProblemABC	2	2	0141	ProblemABC
			3347	ProblemABC
			3746	GuidanceXYZ
			3746	ProblemABC
			4072	ProblemABC
			5690	ProblemABC
			6819	ProblemABC
			9943	ProblemABC
			3746	
			9943	
ProblemXYZ	3	2	5690	
			0141	ProblemABC
			0141	ProblemXYZ
			3347	ProblemXYZ
			3746	ProblemXYZ
			4072	ProblemXYZ
			5690	ProblemXYZ
			6819	ProblemXYZ
			9943	GovernanceXYZ
			9943	ProblemXYZ
			3746	GuidanceXYZ
			4072	GovernanceXYZ
			4072	GuidanceXYZ
Architecture	4	2	0141	GovernanceXYZ
			3746	GovernanceXYZ
			5690	Architecture
			0141	
			0141	ProblemXYZ
			0141	Architecture
			3347	Architecture
			3746	Architecture
			4072	Architecture
			6819	Architecture
			9943	Architecture
Plugins	5	1	9943	
			0141	Architecture
			0141	Plugins
			3347	Plugins
			3746	PluginComponents
			3746	Plugins
			4072	Plugins
			5690	Plugins
			6819	Plugins
			9943	Plugins
WebServices	6	1	3746	
			3746	
			0141	WebServices
			3347	WebServices
			4072	WebServices
			5690	WebServices
			6819	WebServices
			9943	PluginComponents
			9943	WebServices

Legend
Same slide as briefer
Supplementary information
Positive Vote
Negative Vote
One slide before current
Two slides before current
Three slides before current
Four slides before current
Five or more slides before current
One slide ahead of current
Two slides ahead of current
Three slides ahead of current
Four slides ahead of current
Five or more slides ahead of current

Figure 26: Log file analysis, slides 1 to 6

During the second stage of the briefing ('slides' 7-9, Figure 27) the behaviour changes significantly as the group explored the key issues. While audience members are still consistently following along with the briefer, they are also much more active. The incidence of quick jumps to previous slides increases (four of seven audience members, one to three occasions each, mean of 1.75), almost always back just one slide. The higher level of activity at this stage is jumps to supplementary materials (six of seven audience members, two to six occasions each, mean of 3.8). Sometimes this results in votes for more information about the topic, enabling the briefer to quickly provide the necessary information to maintain attention and comprehension. In other cases the supplementary details are sufficient for the inquiring audience member, allowing them to get the information they want without disrupting the briefer. Slide duration extends during this stage, ranging from two to four minutes (mean of 2.7). The one slide at four minutes also has the most supplementary activity by the audience.

Briefer Page	Slide #	Minutes	User	Audience Page
TranslationService	7	2	0141	Automate
			0141	TranslationService
			0141	WebServices
			3746	Automate
			3746	TranslationService
			3746	WebServices
			4072	TranslationService
			6819	TranslationService
			9943	Automate
			9943	TranslationService
			3347	TranslationService
Artifact	8	2	9943	
			9943	
			0141	Artifact
			5690	Artifact
			5690	TranslationService
			6819	Artifact
			9943	Artifact
			0141	TLA
			3347	Artifact
			3746	Artifact
			3746	TLA
			4072	Artifact
			9943	TLA
Processes	9	4	0141	Artifact
			0141	TLA
			0141	Processes
			3347	Processes
			3746	TLA
			3746	Processes
			4072	TLA
			4072	Processes
			5690	Artifact
			5690	Processes
			6819	Processes
			9943	Artifact
			9943	Processes
			3746	
			6819	TLA
			6819	
			9943	Apache
			6819	Processes
			9943	CoreUtilities
			9943	TrackingServices
			0141	CoreUtilities
			0141	TrackingServices
			0141	Processes
			3347	Apache
			3347	CoreUtilities
			3746	CoreUtilities
			4072	CoreUtilities
			6819	Apache
			6819	CoreUtilities
			6819	TrackingServices
			9943	CoreUtilities

Legend
Same slide as briefer
Supplementary information
Positive Vote
Negative Vote
One slide before current
Two slides before current
Three slides before current
Four slides before current
Five or more slides before current
One slide ahead of current
Two slides ahead of current
Three slides ahead of current
Four slides ahead of current
Five or more slides ahead of current

Figure 27: Log file analysis, slides 7 to 9

In the third stage ('slides' 10-12, Figure 28), behaviour is most similar to the first stage, as the briefer covers a few additional points. Two audience members look at a previous slide, and three look at one or two pages of supplementary information.

Briefer Page	Slide #	Minutes	User	Audience Page
ProductA	10	2	0141	Processes
			3347	ProductA
			3746	ProductA
			4072	ProductA
			5690	ProductA
			5690	
			6819	ProductA
			9943	ProductA
			0141	ProductA
			3746	DesignerDashboard
Dashboard	11	1	3746	
			9943	DesignerDashboard
			9943	
			0141	Dashboard
			3347	Dashboard
			4072	Dashboard
			5690	Dashboard
			6819	DesignerDashboard
			6819	Dashboard
			9943	Dashboard
OpenStandards	12	1	0141	OpenStandards
			3347	OpenStandards
			3746	DesignerDashboard
			3746	OpenStandards
			3746	Dashboard
			4072	OpenStandards
			5690	OpenStandards
			6819	OpenStandards
			9943	OpenStandards

Legend

Same slide as briefer

Supplementary information

Positive Vote

Negative Vote

One slide before current

Two slides before current

Three slides before current

Four slides before current

Five or more slides before current

One slide ahead of current

Two slides ahead of current

Three slides ahead of current

Four slides ahead of current

Five or more slides ahead of current

Figure 28: Log file analysis, slides 10 to 12

In the fourth and final stage ('slides' 13-14, Figure 29), the behaviour changes again, as the group examines the recommend solution. All seven audience members review previous slides, sometimes going back four or more steps in the briefing. The majority of participants (five of seven) review only one page, but one audience member reviews seven pages. This type of quick review, unique to each audience member, would not be possible with a centrally-controlled solution like PowerPoint.

Briefer Page	Slide #	Minutes	User	Audience Page
SolutionABC	13	0		
SolutionXYZ	14	3	0141	SolutionABC
			0141	SolutionXYZ
			3347	SolutionABC
			4072	SolutionABC
			4072	SolutionXYZ
			5690	
			5690	SolutionABC
			6819	SolutionABC
			9943	SolutionABC
			9943	SolutionXYZ
			3347	SolutionXYZ
			3746	SolutionABC
			3746	SolutionXYZ
			5690	SolutionXYZ
			6819	SolutionXYZ
			9943	
			9943	
			9943	OpenStandards
			9943	PresentationRoadMap
			9943	
			9943	
			9943	

Legend

Same slide as briefer

Supplementary information

Positive Vote

Negative Vote

One slide before current

Two slides before current

Three slides before current

Four slides before current

Five or more slides before current

One slide ahead of current

Two slides ahead of current

Three slides ahead of current

Four slides ahead of current

Five or more slides ahead of current

Figure 29: Log file analysis, slides 13 to 14

7.3.7.5 Repeat retention quiz (experiments 4PR₁, 4PR₂, 4FR₁, & 4FR₂)

For all of the experiments, the information retention quiz was given to the participants within one hour of completing the briefing. To provide further validation of the benefits of LiquidBriefing, the quizzes for the last two experiments in this group were repeated one week later.

The first retake was given with no opportunity to prepare or review the material (experiments 4PR₁ & 4FR₁). The PowerPoint group's score dropped significantly from 49% to 37% (experiment 4PR₁). The LiquidBriefing group's score dropped only slightly, from 69% to 66% (experiment 4FR₁). Even after one week, this group had a significantly higher retention than the PowerPoint group after less than one hour (shown in Figure 30).

For the next test, the audience members were allowed to review the original material presented, whether PowerPoint slides or LiquidBriefing wiki. The thinner details and summarization typical of PowerPoint slides increased their retention to just 45% (experiment 4PR₂), lower than their original score. Even with the review materials, one participant's score dropped and only one out of six achieved a passing grade. The LiquidBriefing group's score increased to 92%, over twice the retention of the PowerPoint group (experiment 4FR₂); every participant's score increased significantly with the review. The quiz results are summarized in Table 22.

Content retention quiz (15 questions)	Mean	n	Standard deviation	Minimum	Maximum
Experiment 4P	49%	6	9.8%	35%	63%
Experiment 4F	69%	7	17.5%	37%	92%
Experiment 4PR ₁	37%	6	9.7%	23%	45%
Experiment 4FR ₁	66%	6	8.1%	55%	77%
Experiment 4PR ₂	45%	6	15.6%	22%	65%
Experiment 4FR ₂	92%	6	7.8%	80%	100%

Table 22: Experiment 4P & 4F retest information retention results

Figure 30: Chart of experiment 4 information retention results

7.3.7.6 Summary

This was the largest set of experiments with LiquidBriefing, and continued to support the productivity potential. The authors reported productivity gains for increased document scope and ease of working with other authors, but loss of productivity in time to prepare the document. The briefers reported gains in audience interaction and ease of following the audience, but losses in briefing time and flow.

Over all three sets, the audience was consistently positive on easier interaction during the briefing, slightly positive on improved quality of results. The introduction of the audience feedback mechanism improved the gains on briefing flow from negative to slightly positive, but may have reduced the neutral impact on briefing time to negative.

7.3.8 Federal election candidate

The electoral district association of a political party took part in an experiment on Sept 28, 2008. This group was working to elect their candidate in the 2008 federal election. Their objective was to prepare the candidate for upcoming all-candidates debates. The group consisted of 17 volunteers from the local party association, randomly distributed into three groups.

7.3.8.1 LiquidBriefing without /with audience feedback (experiments 5P, 5B, & 5F)

This experiment set consisted of three briefings on the same material; one using PowerPoint, one using LiquidBriefing without audience feedback, and one with the audience feedback mechanism. For each briefing, the candidate presented a quick overview of 11 topics from the party's platform (about 20 minutes total), followed by 10 to 15 minutes of questions. The participants completed questionnaires after the briefings, as well as identical content quizzes to evaluate information retention.

Experiment 5P	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Author– “Using this software ...”					
a. Reduced the time required to prepare the document	7.0	1	N/A	N/A	N/A
b. Improved the quality of the results	4.0	1	N/A	N/A	N/A
c. Increased the scope of the document	4.0	1	N/A	N/A	N/A
d. Made it easier to work with other authors	4.0	1	N/A	N/A	N/A
e. Made it easier to incorporate feedback from reviewers prior to the meeting	4.0	1	N/A	N/A	N/A
Author productivity	4.6	1	N/A	N/A	N/A
a. I would refer this software to others in my organization	4.0	1	N/A	N/A	N/A
b. Compared with our current tools, this software was more effective in helping me prepare the briefing materials	4.0	1	N/A	N/A	N/A
Author perception	4.0	1	N/A	N/A	N/A

Table 23: Experiment 5P author participant results, PowerPoint

The PowerPoint authoring productivity gains were produced entirely from the fact that the central party had produced a PowerPoint slide set that could be used to present the party’s platform. Otherwise the responses were entirely neutral, shown in Table 23, as was expected.

Experiment 5P	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Briefer – “Using this software ...”					
a. Reduced the time required for the briefing	4.0	1	N/A	N/A	N/A
b. Improved the quality of the results	4.0	1	N/A	N/A	N/A
c. Improved the flow of the briefing	4.0	1	N/A	N/A	N/A
d. Increased the audience interaction	4.0	1	N/A	N/A	N/A
e. Made it easier to follow the interest of the audience during the meeting	3.0	1	N/A	N/A	N/A
Briefer productivity	3.8	1	N/A	N/A	N/A
a. I would refer this software to others in my organization	4.0	1	N/A	N/A	N/A
b. Compared with our current tools, this software was more effective in helping me manage the briefing	4.0	1	N/A	N/A	N/A
Briefer perception	4.0	1	N/A	N/A	N/A

Table 24: Experiment 5P briefer participant results, PowerPoint

The PowerPoint briefer’s responses were neutral, as shown in Table 24, as expected.

Experiment 5P	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	3.8	5	1.643	1.0	5.0
b. Improved the quality of the results	3.4	5	1.342	2.0	5.0
c. Improved the flow of the briefing	3.6	5	1.517	2.0	5.0
d. Made it easier for me to interact during the briefing	4.6	5	1.517	3.0	7.0
Audience productivity	3.85	5	0.859	3.0	5.0
a. I would refer this software to others in my organization	5.4	5	1.517	4.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	4.8	5	1.304	4.0	7.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	N/A	N/A	N/A	N/A	N/A
Audience perception	5.1	5	1.194	4.0	7.0

Table 25: Experiment 5P audience participant results, PowerPoint

The PowerPoint audience group again indicated generally neutral to slightly negative productivity, shown in Table 25, although this group had an overall slightly positive perception. For the PowerPoint briefing retention quiz, this group scored a mean of 62.7% correct (out of 11 questions), with the highest score 9 and the lowest 5, out of 11.

Experiment 5B	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Author– “Using this software ...”					
a. Reduced the time required to prepare the document	3.0	1	N/A	N/A	N/A
b. Improved the quality of the results	7.0	1	N/A	N/A	N/A
c. Increased the scope of the document	7.0	1	N/A	N/A	N/A
d. Made it easier to work with other authors	5.0	1	N/A	N/A	N/A
e. Made it easier to incorporate feedback from reviewers prior to the meeting	6.0	1	N/A	N/A	N/A
Author productivity	5.6	1	N/A	N/A	N/A
a. I would refer this software to others in my organization	6.0	1	N/A	N/A	N/A
b. Compared with our current tools, this software was more effective in helping me prepare the briefing materials	7.0	1	N/A	N/A	N/A
Author perception	6.5	1	N/A	N/A	N/A

Table 26: Experiment 5B author participant results, LiquidBriefing without audience feedback mechanism

For the LiquidBriefing segment, the biggest gains in productivity for the author were an increased scope to the document and improved quality of results, shown in Table 26. The biggest (and only) reduction in productivity was the time required to prepare the document, which may be attributed to the learning curve of new software or the increased scope. There were no additional comments made by the author.

Experiment 5B	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Briefer – “Using this software ...”					
a. Reduced the time required for the briefing	4.0	1	N/A	N/A	N/A
b. Improved the quality of the results	5.0	1	N/A	N/A	N/A
c. Improved the flow of the briefing	6.0	1	N/A	N/A	N/A
d. Increased the audience interaction	5.0	1	N/A	N/A	N/A
e. Made it easier to follow the interest of the audience during the meeting	6.0	1	N/A	N/A	N/A
Briefer productivity	5.2	1	N/A	N/A	N/A
a. I would refer this software to others in my organization	6.0	1	N/A	N/A	N/A
b. Compared with our current tools, this software was more effective in helping me manage the briefing	6.0	1	N/A	N/A	N/A
Briefer perception	6.0	1	N/A	N/A	N/A

Table 27: Experiment 5B briefer participant results, LiquidBriefing without audience feedback mechanism

The biggest gain in productivity for this briefer, shown in Table 27, was an improved flow to the briefing and ease of following the audience interest. This briefer was neutral on any time savings, but did not report any reductions in productivity. Perceived value was higher than the productivity gains. There were no additional comments made by the briefer.

Experiment 5B	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	5.0	5	1.000	4.0	6.0
b. Improved the quality of the results	5.2	5	1.304	4.0	7.0
c. Improved the flow of the briefing	5.2	5	1.095	4.0	7.0
d. Made it easier for me to interact during the briefing	5.0	5	2.000	2.0	7.0
Audience productivity	5.1	5	1.154	4.0	6.8
a. I would refer this software to others in my organization	5.4	5	1.140	4.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	5.6	5	1.140	4.0	7.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	N/A	N/A	N/A	N/A	N/A
Audience perception	5.5	5	1.118	4.0	7.0

Table 28: Experiment 5B audience participant results, LiquidBriefing without audience feedback mechanism

For LiquidBriefing without audience feedback tool, the audience gave slightly positive responses on average to all questions, shown in Table 28, indicating a slight reduction in perceived briefing time, improved quality and flow, and easier interaction. This group also agreed that the LiquidBriefing software made it easier to understand the

material, which is reflected in their retention scores. This group scored a mean of 78.2% on the 11 question retention quiz, with the lowest score 6 and the highest score 11. No additional comments were made by this group.

Since the same content was used for the experiments with and without the audience feedback tool, no author survey was completed for the audience feedback experiment, 5F.

Experiment 5F	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Briefer – “Using this software ...”					
a. Reduced the time required for the briefing	6.0	1	N/A	N/A	N/A
b. Improved the quality of the results	6.0	1	N/A	N/A	N/A
c. Improved the flow of the briefing	7.0	1	N/A	N/A	N/A
d. Increased the audience interaction	5.0	1	N/A	N/A	N/A
e. Made it easier to follow the interest of the audience during the meeting	6.0	1	N/A	N/A	N/A
Briefer productivity	6.0	1	N/A	N/A	N/A
a. I would refer this software to others in my organization	7.0	1	N/A	N/A	N/A
b. Compared with our current tools, this software was more effective in helping me manage the briefing	7.0	1	N/A	N/A	N/A
Briefer perception	7.0	1	N/A	N/A	N/A

Table 29: Experiment 5F briefer participant results, LiquidBriefing with audience feedback mechanism

Using the audience feedback mechanism, the briefer experienced the largest gain in productivity for improved flow to the briefing. Other large increases in productivity came from reduced briefing time, improved quality of results, and ease of following the audience interest. Perceived value was again higher than the productivity gains. There were no additional comments made by the briefer.

Experiment 5F	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	6.5	6	0.548	6.0	7.0
b. Improved the quality of the results	6.7	6	0.516	6.0	7.0
c. Improved the flow of the briefing	6.8	6	0.408	6.0	7.0
d. Made it easier for me to interact during the briefing	6.3	6	1.211	4.0	7.0
Audience productivity	6.6	6	0.585	5.5	7.0
a. I would refer this software to others in my organization	6.8	6	0.408	6.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	6.7	6	0.516	6.0	7.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	N/A	N/A	N/A	N/A	N/A
Audience perception	6.8	6	0.274	6.5	7.0

Table 30: Experiment 5F audience participant results, LiquidBriefing with audience feedback mechanism

For the LiquidBriefing segment with audience feedback tool, summarized in Table 30, the audience gave slightly positive to strongly positive responses on average to all questions, indicating a reduction in perceived briefing time, significantly improved quality and flow, and easier interaction. This group also agreed that the LiquidBriefing software made it easier to understand the material. This group scored a mean of 79% on the 11 question retention quiz, with the lowest score 7.5 and the highest score 10.

While the overall score did not change significantly from the briefing with no audience feedback tool, the consistency did improve, with more even distribution of knowledge. In the PowerPoint retention quiz 3 of 11 questions were answered correctly by less than 50% of the group. In the LiquidBriefing without feedback tool quiz 2 of 11 questions were answered correctly by less than 50% of the group. In the quiz with audience feedback, only 1 of 11 questions was answered correctly by less than 50% of the group. The biggest productivity gains for this audience were improved flow and quality of results, although their results were generally equal in all areas, and higher than the audience without the feedback mechanism. Comments from this group reflect an appreciation for the improved flow:

“See huge value in using this tool with audience where [you] don’t know varied knowledge/interest and only have one ‘kick at cat’. Brings huge credibility to presenter’s respect for audience time and interest.”

“I liked the visible flow dimension [and] chance to tailor presentation based on interest.”

“After finishing 4 years of university – looking over 100s and 100s of slides from profs ... (in comparison to your presentation) I found this system to be much more effective in learning about the information and seeing how it all connects and links together. If my profs did that in their lectures I think I would have understood a lot more, instead of the information being all scattered all over the place.”

Mean information retention scores improved significantly over the PowerPoint version, shown in Table 31, but were virtually unchanged between the two LiquidBriefing experiments. However, the variance of the scores dropped for the audience feedback group.

Content retention quiz (11 questions)	Mean	n	Standard deviation	Minimum	Maximum
Experiment 5P	63%	5	15.2%	46%	82%
Experiment 5B	78%	5	16.5%	55%	100%
Experiment 5F	79%	6	8.9%	68%	91%

Table 31: Experiment 5P, 5B, & 5F information retention results

7.3.8.2 Log file analysis

The election experiment with audience feedback had three audience members with active wiki sessions. They had 10 minutes to prepare before the start of the briefing. Each used the time to look at 4 or 5 pages of material (out of 11 major topics), and then cast their votes for topics that they had more or less interest in. Once the briefing started, this group paid attention to the briefer without changing the page viewed on their own computer. Even though they had the opportunity to read ahead, they did not appear to

lose interest in the briefing, asked specific and detailed questions, and rated highly their perceived level of interaction (mean 6.3 out of 7).

7.3.8.3 Summary

This was the second-last set of experiments with LiquidBriefing, and the results show much higher productivity gains and user perception than the first experiment. The author's responses were similar to the Software Development Group, but reported highest productivity in document scope and quality. The briefer reported gains in all areas, except briefing time without the audience feedback mechanism. The briefer and audience reported higher productivity gains and perception of the software with the audience feedback mechanism than without. Variability of the responses also decreased.

7.3.9 Business professionals group

A group of business people took part in a series of experiments on September 29, 2008. There were three separate experiments in this group, using the same content material (a review of the LiquidBriefing business problem and proposed solution). These groups, totaling 15 people, were: a prime contractor, a government department, and some local interested business people. The experiment consisted of one local and two remote briefings using the LiquidBriefing software with the audience feedback tools. For each briefing, one of the researchers presented the LiquidBriefing details for 20-30 minutes, followed by 10-15 minutes of questions or discussion. The participants completed surveys after the briefings, but not retention quizzes.

7.3.9.1 LiquidBriefing with audience feedback (experiments 6F₁, 6F₂, & 6F₃)

The author and briefer for this experiment only completed one survey based on the overall experience.

Experiment 6F	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Author– “Using this software ...”					
a. Reduced the time required to prepare the document	4.0	1	N/A	N/A	N/A
b. Improved the quality of the results	5.0	1	N/A	N/A	N/A
c. Increased the scope of the document	7.0	1	N/A	N/A	N/A
d. Made it easier to work with other authors	4.0	1	N/A	N/A	N/A
e. Made it easier to incorporate feedback from reviewers prior to the meeting	6.0	1	N/A	N/A	N/A
Author productivity	5.2	1	N/A	N/A	N/A
a. I would refer this software to others in my organization	7.0	1	N/A	N/A	N/A
b. Compared with our current tools, this software was more effective in helping me prepare the briefing materials	6.0	1	N/A	N/A	N/A
Author perception	6.5	1	N/A	N/A	N/A

Table 32: Experiment 6F author participant results, LiquidBriefing with audience feedback mechanism

The biggest gains in productivity for this author were an increased scope to the document and feedback incorporated from reviewers, shown in Table 32. There were no drops in productivity, possibly because this participant was an experienced wiki user. Comments included:

“The potential for this software is impressive. In its current prototype state, some of the functionality is a bit inconsistent and slow, and there are numerous improvements that should be made. However, enough of the functionality is there to see that, in a more mature state, this could drastically change the way collaborative documents are built.”

Experiment 6F	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Briefer – “Using this software ...”					
a. Reduced the time required for the briefing	3.0	1	N/A	N/A	N/A
b. Improved the quality of the results	6.0	1	N/A	N/A	N/A
c. Improved the flow of the briefing	6.0	1	N/A	N/A	N/A
d. Increased the audience interaction	7.0	1	N/A	N/A	N/A
e. Made it easier to follow the interest of the audience during the meeting	4.0	1	N/A	N/A	N/A
Briefer productivity	5.1	1	N/A	N/A	N/A
a. I would refer this software to others in my organization	7.0	1	N/A	N/A	N/A
b. Compared with our current tools, this software was more effective in helping me manage the briefing	5.0	1	N/A	N/A	N/A
Briefer perception	6.0	1	N/A	N/A	N/A

Table 33: Experiment 6F briefer participant results, LiquidBriefing with audience feedback mechanism

The biggest gain in productivity for this briefer was increased audience interaction, followed by improved flow and quality of results, shown in Table 33. The only drop in

productivity was time. Perceived value was higher than the productivity gains. Additional comments include.

“The main point that I would make is that this is a completely new way to give presentations. As such, it will require some time for users to gain some familiarity with it. For example, the audience feedback mechanism is a great way for presenters to follow where the audience is and what they are interested in, but it adds another aspect that the presenter has to think about. People accustomed to PowerPoint will need some training and practice to get used to this new interface. Given that, the capabilities of this software far exceed anything offered by PowerPoint or Impress.”

Experiment 6F₁	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	5.0	6	1.095	4.0	6.0
b. Improved the quality of the results	6.0	6	0.894	5.0	7.0
c. Improved the flow of the briefing	6.0	6	1.265	4.0	7.0
d. Made it easier for me to interact during the briefing	6.2	6	0.983	5.0	7.0
Audience productivity	5.8	6	0.732	4.8	6.5
a. I would refer this software to others in my organization	6.2	6	0.983	5.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	5.7	6	1.033	4.0	7.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	6.3	6	1.211	4.0	7.0
Audience perception	6.1	6	0.800	5.3	7.0

Table 34: Experiment 6F₁ audience participant results, LiquidBriefing with audience feedback mechanism

The group of local interested business people (experiment 6F₁, summarized in Table 34) agreed that they would refer the software in the organization and that it made it easier to interact. They also agreed that it improved the flow and quality of results, and was more effective than current tools. There was moderate agreement that it reduced the time required.

Experiment 6F₂	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	5.8	4	0.957	5.0	7.0
b. Improved the quality of the results	6.0	4	0.816	5.0	7.0
c. Improved the flow of the briefing	6.8	4	0.500	6.0	7.0
d. Made it easier for me to interact during the briefing	6.5	4	0.577	6.0	7.0
Audience productivity	6.3	4	0.540	5.8	7.0
a. I would refer this software to others in my organization	5.5	4	1.291	4.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	6.0	4	0.816	5.0	7.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	N/A	N/A	N/A	N/A	N/A
Audience perception	5.8	4	0.957	5.0	7.0

Table 35: Experiment 6F₂ audience participant results, LiquidBriefing with audience feedback mechanism

The government department participants (experiment 6F₂, summarized in Table 35) agreed strongly that the software improved the flow of the briefing and made it easier to interact. They also agreed that it improved the results and was more effective than current tools, reduced the time, and would refer it to others in their organization.

Experiment 6F₃	Mean scale 1-7	n	Standard deviation	Minimum	Maximum
Audience – “Using this software...”					
a. Reduced the time required for the briefing	4.4	5	0.957	5.0	7.0
b. Improved the quality of the results	5.0	5	0.816	5.0	7.0
c. Improved the flow of the briefing	6.0	5	0.500	6.0	7.0
d. Made it easier for me to interact during the briefing	6.2	5	0.577	6.0	6.0
Audience productivity	5.4	5	0.540	5.8	7.0
a. I would refer this software to others in my organization	5.6	5	1.291	4.0	7.0
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	5.4	5	0.816	5.0	7.0
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	N/A	N/A	N/A	N/A	N/A
Audience perception	5.5	5	0.957	5.0	7.0

Table 36: Experiment 6F₃ audience participant results, LiquidBriefing with audience feedback mechanism

The participants from the prime contractor (experiment 6F₃, summarized in Table 36) agreed that LiquidBriefing made it easier to interact and improved the flow of the briefing. They slightly agreed that it improved the quality of results, but were neutral on

time savings. The also agreed that it was more effective than their current tools at helping them understand the material, and would refer it to others in the organization.

7.3.9.2 Log file analysis

The experiment with local interested business people was an in-person briefing with six audience members. This group did not have advance preparation time to review the material before the briefing. During the briefing, all of the members of this group consistently followed the briefer's activity, viewing the same page on their computer that was projected. This group was experienced and knowledgeable about wiki technology, so they were not constrained by technical issues or unfamiliar user interface.

The government department experiment was a remote briefing to an organization that is interested in the commercial application of LiquidBriefing within its operations. The four audience members for this briefing were connected to the briefer via a conference call, and were in front of computers in their individual offices. During this briefing the audience generally kept pace with the briefer. During four of the topics (out of 15), one audience member viewed slides that were supplementary or more than two slides ahead of the briefer. In all occasions, this participant quickly returned to the current slide.

The prime contractor experiment was also a remote briefing to a company that is interested in the commercial use of LiquidBriefing. The five audience members for this briefing were connected via a conference call to the briefer, and were in front of computers in their individual offices. During the briefing the entire group consistently kept pace with the briefer. There were a very small number of occasions when an audience member jumped back one or two slides from the current one. At the end of the

briefing two audience members spent several minutes reviewing earlier parts of the material. One participant reviewed a significant portion of the presentation, something that would not be possible if this had been a typical remote presentation of PowerPoint slides using a web conferencing tool.

7.3.9.3 Summary

This was the final set of experiments, and the results show consistent gains in productivity and user perception of the software compared to PowerPoint. In this set, experiment 6F₁ was local but the other two were remote, yet there were no significant differences in productivity gains between them. Even the area of audience interaction, which would be expected to drop during a remote presentation, remained high.

8 Conclusions

The objective of this thesis was to build and evaluate the productivity potential of an integrated briefing system for authors, briefers, and audience members in a decision-making scenario. At the outset, it was believed that new tools were necessary to augment, instead of automate, human capabilities. Current tools can be isolating. They keep discussions, reports, presentations, and meeting minutes in separate files and applications. They act more as an electronic barrier between the author, briever, and audience than a connector. And they impose a heavy burden on the production process, consuming significant amounts of time in formatting and layout instead of content analysis. Many of the expectations about how to improve the productivity of these roles were met by the LiquidBriefing experiments.

The increased scope of information is a result of the ease with which any author can add new material and immediately visualize the connections and gaps in the document. This benefits all participants in the decision-making process, although the productivity gain is attributed to the author.

The combination of dynamic navigation and audience feedback gives briefers real-time feedback on audience interests and the ability to act on the information. The result is a greater understanding of the needs of the audience and improved flow of the briefing, guiding the briever without the need to interrupt.

For the audience, visibility of the depth of material and ability to drill down into the details supports greater and more informed interaction. The concept map and wiki links provide a quick grasp of what is available and what is missing.

This thesis shows that it is possible to improve productivity for the authors, briefers, and audience of a decision-making process over existing tools (illustrated in Figure 31 and Figure 32Error! Reference source not found.). Authors increased the scope of their work and enhanced their collaboration. Briefers found it easier to follow the interests of the audience. Both briefers and audience agreed that they increased the level of interaction and improved the flow. Audience members achieved 25-50% higher information retention immediately after the briefing and 50-80% higher with later review of the document. Information retention or time savings are a useful proxy, but the real goal is better quality results. All roles agreed that they improved the overall quality of the results, and was more effective for their respective role.

Figure 31: Chart of productivity results related to each Research Question

Figure 32: Chart of perception results related to each Research Question

8.1 For authors

Research Question 1: Does the collaborative wiki-based tool connected to briefing slides improve author productivity?

Overall, the authors slightly agreed that LiquidBriefing improved their productivity. The input assumptions covered decision-making in situations of uncertainty, where the application of human judgment and insight are critical. These situations benefit from greater scope, or breadth and depth in the document. The author participants strongly agreed that LiquidBriefing increased the scope of the documents they produced.

In this knowledge-driven economy, authoring of documents is usually a collaborative process. The author participants in the experiments agreed that LiquidBriefing improved

their collaboration productivity, making it easier to work with other authors, as well as incorporating feedback from reviewers. With increased scope and better collaboration, the participants also agreed that LiquidBriefing improved the quality of their results. Whether because of lack of familiarity with the software, working with a different authoring process, or other issues, these productivity gains came at an apparent cost of time. Research Question 1 results are summarized in Table 37 and Table 38.

Author productivity	Overall author productivity	Time Savings	Quality of results	Increased scope	Enhanced collaboration	Easier for reviewer feedback
Question 1 Experiments 2B + 5B	5.4	3.0	5.7	6.7	6.3	5.3

Table 37: Mean productivity responses for Research Question 1

Author perception	Overall author perception	Refer to others	Effectiveness creating briefing
Question 1 Experiments 2B+5B	5.8	5.8	5.8

Table 38: Mean perception responses for Research Question 1

8.2 For briefers

Research Question 2A: Does the dynamic briefing navigation improve briefer productivity?

Research Question 2B: Does the audience feedback mechanism improve briefer productivity?

Overall, the briefers slightly agreed that LiquidBriefing improved their productivity. Getting to an effective decision is more likely with a high level of interaction among the group, not a lecture from the briefer to the audience. With just the dynamic briefing navigation, the briefer participants agreed that LiquidBriefing increased the audience interaction, and made it easier to follow the interests of the audience. They also agreed that the software was more effective in helping manage the briefing than their current tools.

With the audience feedback functionality enabled, productivity increased significantly in time savings and improved flow of the briefing. Slight gains were reported in improved quality and audience interaction. However, there was a slight drop in following the interest of the audience. This may be an artifact of the small sample size. The audience responses indicate flow improvements with the audience feedback, so it could be briefer perception that they were not taking advantage of the information.

The audience feedback functionality provides some powerful opportunities for the briefer with greater insight into the needs and interests of the audience. As this functionality matures, it may help to reduce the briefing time, as only the necessary topics are covered. Some interesting possibilities for this functionality were proposed by the participants. With the detailed logging capabilities in LiquidBriefing, it is possible to let the briefer know what pages are being viewed by the audience, or provide a summary of how many in the audience are ahead of or behind the current slide. Research Question 2A and 2B results are summarized in Table 39 and Table 40.

Briefer productivity	Overall briefer productivity	Time savings	Quality of results	Improved flow	Enhanced interaction	Audience interest
Question 2A Experiments 1B+2B+5B	4.9	3.2	5.2	4.4	5.8	5.8
Question 2B Experiment 5F+6F	5.6	4.5	6.0	6.5	6.0	5.0
All experiments	5.1	3.6	5.4	5.0	5.9	5.6

Table 39: Mean productivity responses for Research Question 2A & 2B

Briefer Perception	Overall briefer perception	Refer to others	Effectiveness managing briefing
Question 2A Experiments 1B+2B+5B	5.4	5.4	5.4
Question 2B Experiment 5F+6F	6.0	6.5	6.3
All experiments	5.6	5.7	5.6

Table 40: Mean perception responses for Research Question 2A & 2B

8.3 For audience

Research Question 3A: Does the dynamic briefing navigation improve audience productivity?

Research Question 3B: Does the audience feedback mechanism improve audience productivity?

Overall, the audience participants slightly agreed that LiquidBriefing improved their productivity. As mentioned above, interaction is an important aspect of improved decision making. There would be little value if one group believed the interactivity of a briefing was improved but another group did not. With just the dynamic briefing navigation, the audience participants in the experiments agreed with the briefers that LiquidBriefing made it easier to interact, and slightly improved the quality of the results.

With the audience feedback mechanism enabled, and with full access to the briefing document, the productivity gains for the audience increased in all areas, especially quality of results and improved flow. Individual access to the full briefing document, not just the summaries presented, enabled the audience to evaluate the quality and scope of information and explore details as needed. In the wiki, missing links have a '?' at the end, turning an assertion into a question and underscoring the uncertainty.

Greater interaction is of little benefit if the information isn't being accurately received and processed. Content-specific information quizzes to measure the level of retention are a useful proxy to measure this. The results of the experiments are consistent – the combination of access to full briefing details and information visualization techniques that augment human memory and processing increased information retention immediately following the briefing for audiences using LiquidBriefing over those using PowerPoint. Research Question 3A and 3B results are summarized in Table 41 and Table 42.

Audience productivity	Overall audience productivity	Time savings	Quality of results	Improved flow	Enhanced interaction
Question 3A Experiments 1B+2B+5B	4.6	4.1	4.8	4.2	5.4
Question 3B Experiments 3F+4F+5F+6F	5.4	4.7	5.5	5.5	6.0
All	5.2	4.5	5.3	5.1	5.8

Table 41: Mean productivity responses for Research Question 3A & 3B

Audience perception	Overall audience perception	Refer to others	Effectiveness understanding briefing	Information retention
Question 3A Experiments 1B+2B+5B	5.1	4.7	4.6	67%
Question 3B Experiments 3F+4F+5F+6F	5.6	5.2	5.8	71%
All experiments	5.4	5.7	5.6	

Table 42: Mean perception responses for Research Question 3A & 3B

8.4 Building the software – structure was harder than software

LiquidBriefing was surprisingly easy to construct. The key building blocks, a structured wiki and concept-map software, were readily available. Generating basic slides from the page structure was not difficult. Determining the appropriate page and document structure was a more difficult, and more important, activity. Learning and

adopting the necessary discipline to follow the structure, and teaching it to others, was also a significant component.

Ease of use was frequently cited issue by the participants. Broad familiarity with PowerPoint and other applications would make it necessary to mimic some of the expected user interface functions for broad and rapid adoption of LiquidBriefing.

The concept maps were readily understood and used by a majority of the participants. However, not everyone responds the same way to visualization techniques, so alternatives may be a desirable avenue to explore. Training in the best way to use the concept map for navigation was frequently cited (and observed). Better functions to filter, zoom, and navigate the concept maps were also requested. These techniques have been explored by others, and lessons from their research could be readily adopted for LiquidBriefing.

8.5 Implications for management

The trio of email/Word/PowerPoint defines the lives of many knowledge workers today. Knowledge workers creatively solve problems as only humans can. Then the ideas are transformed into a neat linear order of elaboration based on assumptions about the audience, and a Word document or PowerPoint presentation is created. These documents are then emailed around, reviewed and revised, generating an avalanche of email. Multiple document versions must be juggled and merged. When a briefing is made in an organization, the audience assumptions made earlier may or may not fit. After a briefing, with 10-30 million PowerPoint briefings created a day, it is difficult to

locate old briefings or slides, and even then people are left trying to guess at the meaning of phrases in slide bullets with no effective link to text that can explain them further.

New tools can improve on this practice. Collaborative authoring, information visualization, and structured documents can result in better, broader, and deeper input documents. Dynamic navigation can increase the interactions during a briefing. Managers who explore these techniques may be rewarded with increased productivity.

Briefing events are just one stop on the workflow cycle in organizations. What may be more important is what was learned about the opportunity to significantly change the workflow of knowledge workers. Briefings and presentations are not a discrete event, but part of a continual process that begins with a problem or opportunity, and continues through brainstorming, gathering data, analyzing and synthesizing into information, reviewing with colleagues, giving multiple briefings with a range of objectives and audiences, making one or more decisions, executing the plan, and the next problem or opportunity. The core functions of the LiquidBriefing prototype fit well into this larger scenario.

Often a decision is not reached during the meeting, but with some amount of review after the meeting. When quizzed one week after the meeting, with no opportunity for review, the retention difference was over 50% in favor of LiquidBriefing. After reviewing the respective material, this difference increased to over 80%, with a score of 92% for the LiquidBriefing participants. The availability of the full information set, as opposed to a slide-based summary, is definitely beneficial. Incentives to share and

distribute background documents, not just PowerPoint slides, should be considered by managers who want to improve the quality of their decision making.

There is a significant opportunity for tools like LiquidBriefing to transform workflow. Using a comprehensive information set, the software could generate a wide variety of reports and briefings. Comments, discussions, and meeting minutes are all stored concurrently, enabling ready review of earlier decisions as personnel and market conditions change. Wikis are being used to address some of these issues in organizations today, and managers are encouraged to increase the adoption of these collaborative tools.

8.6 Implications for academics

Knowledge workers use a range of skills in a complex environment. This thesis combines several research areas, including collaborative writing, information visualization, presentations, and human cognition in order to better understand how to augment these skills. Further exploration of the relationships between these (and other) research areas would provide greater understanding of the productivity potential for information technology.

PowerPoint slides are commonly used in many educational settings. This research adds to the body of work that suggests there are limitations to this tool as a teaching aid, and demonstrates some potential alternatives. Most notably, providing real-time feedback on the students' interests and understanding to guide the lecture and detailed information to the students to facilitate their understanding and interaction. Courses which have a significant discussion component stand to benefit the most. In this situation, the role of the professor becomes more of a facilitator and less of a lecturer.

The requirements of the students also change, to do more preparatory work in advance of class time, and the number of formal classroom hours may be reduced.

Since collaboration is an essential part of many organizations roles, it may also be necessary to change the nature of student assessment. The same workspace that is used for classes becomes the home of assignments, with students expanding and modifying the knowledge set through their assignments, and learning from the work of their classmates. Students may need to be taught and evaluated on the different collaboration roles, such as primary contributor, editor, reviewer, and briefer. Expecting all students to be equal in all areas is probably unrealistic. Even in the Facebook generation, a very small percentage of users are responsible for a very large percentage of contributions. The other roles also provide value, challenging facts and assumptions and improving the overall work, and a method of assessing and acknowledging the value of these participants should be incorporated into the assignments. Collaborative workspaces also benefit from clear incentives and motivations to participate, and the “build it and they will come” approach typically leads to unsatisfactory participation levels.

8.7 Limitations and future research

There are several limitations to this research. The sample selection was not necessarily representative of any particular population. The size of the sample, especially the author and briefer roles, was statistically very small. Considering the number of PowerPoint presentations created every day, a larger study that would be statistically representative of one or more discrete groups of decision-makers would be beneficial.

Decision-making involves more than just presentations. This research looked at a discrete set of events with different groups that are really part of a continuum of activities. Group decision-making has many variables, including the personal stakes of the participants and adjustments for the diversity of individuals involved. Time and sequence are factors, as later decisions depend on previous ones. As noted by several participants in their comments, some of the most valuable productivity gains from LiquidBriefing are only realized with cumulative and repetitive use. A longer-term study that covered more of this continuum, such as a project-management or sales life-cycle, would provide a useful perspective on the best opportunities for productivity improvements.

The literature of empirical studies of PowerPoint almost exclusively deals with an educational setting. More research on the productivity of tools for knowledge workers in different types of organizations is important to better understand the possibilities and limitations of augmenting human capabilities.

The productivity and effectiveness metrics for this thesis were derived from the subjective perspective of the participants. It would be desirable to augment this with some objective and quantifiable metrics. Proxies for organizational productivity, such as growth rates, competitiveness, or revenue or profit per employee, may provide additional insight into difficult-to-measure aspects such as quality or effectiveness.

8.8 LiquidBriefing 2.0

From the experiment results and personal use, some key features for the next iteration of LiquidBriefing can be identified. Importing and exporting material to existing legacy

software is critical. A lot of knowledge in an organization already exists in word processing and presentation files, and the ability to easily import this into the wiki, preserve key formatting, and identify some basic linkages for the concept map is critical. Other research by the author has illustrated the importance of achieving a critical mass of material in a collaborative workspace, and importing existing material is a good way to speed this up. Exporting material back to legacy systems makes it possible to work with a larger group of collaborators with a lower retraining impact.

As mentioned earlier, greater control of the concept map, including the ability to zoom and filter the map and nodes is necessary to manage the large maps that result from cumulative use. Multiple or larger displays, so that the map and topic-page can be visible at the same time is also important.

In PowerPoint it is easy to adjust the format of slides, such as putting images or graphics beside the text. Improved slide generation would do this automatically, choosing the best format for the desired content and producing better slides than the current version.

More information on the briefing can be summarized and presented to the briefer and audience. Briefers wanted to know what percentage of the audience was ahead or behind the current slide, to guide their briefing speed. Audience members requested a “jump to current slide” button to make it easier to follow along. Breadcrumbs on the concept map would allow both briefer and audience to see at a glance what information has already been covered and what hasn’t.

8.9 10 years from now

Ten years from now, the volume of available information will be much larger, and software like LiquidBriefing will have transformed and augmented our ability to deal with it.

A LiquidBriefing workspace means each team member can create, review, edit, and augment the report as befits their skills. Semantic markup makes it feasible for automated routines to scour the Internet for relevant information and assemble it into a useful structure, much more than lists of search results. Information visualization techniques help the team manage the vast amount of information, identifying important patterns, relationships between key elements, areas of uncertainty, and holes that remain to be filled. Since the human brain tends to favor intuitive decision-making and pattern recognition, these tools augment their capabilities without creating analysis paralysis.

The decision makers can review the material as it develops in LiquidBriefing, providing direction and guidance to the team. Each can quickly focus on their primary area of concerns and expertise. Open interfaces enable them to use personalized and role-specific tools for their analysis. In many cases a formal review meeting is not required, as the group reaches a decision and the project proceeds directly to execution. As the team grows and changes, the workspace functions change. But the original work, discussions, and decision process are always available for review to guide the project.

If a formal meeting is required, the detailed information and analysis in the workspace becomes the briefing. Each audience member can drill down into details as desired. Instead of following a fixed slide order (“hold that thought, we cover that issue

on slide 37”), the discussion can flow naturally, focusing on the key issues and areas of uncertainty that benefit from human judgment and insight. Work is now less about the artifacts of production and more about analyzing the information and interacting with the group.

9 References

- Adler, A., Nash, J.C, & Noel, S. 2006. Challenges in collaborative authoring software. *Interacting with Computers*, 18 (4): 665-682.
- Aldag, R.J. & Fuller, S.R. 1993. Beyond fiasco: A reappraisal of the groupthink phenomenon and a new model of group decision processes. *Psychological Bulletin*, 113: 533-552.
- Alley, M. 2003. *The craft of scientific presentations: Critical steps to succeed and critical errors to avoid*. New York: Springer.
- Alley, M. & Neeley, K.A. 2005. Rethinking the design of presentation slides: A case for sentence headlines and visual evidence. *Technical Communication*, 52 (4): 417-426.
- Amare, N. 2006. To slideware or not to slideware: Students' experiences with PowerPoint vs. lecture. *Journal of Technical Writing and Communication*, 36 (3): 297-308.
- Atkinson, R. D. & McKay, A.S. 2007. *Digital prosperity: Understanding the economic benefits of the information technology revolution*. Washington, D.C.: The Information Technology & Innovation Foundation.
- Autor, D., Levy, F. & Murnane, R. 2003. The skill content of recent technological change: an empirical exploration. *Quarterly Journal of Economics*, 118:4, 1279-1333.
- Barsh, J. 2007. *Innovative management: a conversation with Gary Hamel and Lowell Bryan*. *The McKinsey Quarterly*, 2008 (1).

- Beardsley, S. C., Johnson, B. C., Manyika, J. M. 2006. Competitive advantage from better interactions. *The McKinsey Quarterly*, 2006 (2): 52-63.
- Cao, X., Ofek, E. & Vronay, D. 2005. Evaluation of alternative presentation control techniques. *CHI 2005 Extended abstracts on human factors in computing systems*: 1248-1251. New York: ACM.
- Carney, R.N. & Levin, J.R. 2002. Pictorial illustrations still improve students' learning from text. *Education Psychology Review*, 14 (1): 5-26.
- Chabris C.F. et al. 2006. Spatial and object visualization cognitive styles: Validation studies in 3800 individuals. Harvard University 'Group Brain' project.
- Chen, C. 2004. *Information Visualization*. Springer-Verlag.
- Cisco. 2008. *Multimodal learning through media: what the research says*. Cisco Systems, Inc.
- Cleveland, W.S., and McGill, R. 1984. Graphical Perception: Theory, Experimentation, and Applications to the Development of Graphical Methods. *Journal of the American Statistical Association*. 79 (387): 531-554.
- Dale, E. 1954. *Audio-visual methods in teaching*. New York: Dryden.
- DARPA (Defense Advanced Research Projects Agency). 2007. SB072-032. Rapid and accurate idea transfer.

- Ding, X., Danis, C., Erickson, T., and Kellogg, W. A. 2007. Visualizing an enterprise Wiki. In CHI '07 Extended Abstracts on Human Factors in Computing Systems, ACM.
- Doumont, J-L. 2002. Magical numbers: the seven-plus-or-minus-two myth. IEEE Transactions on Professional Communications, 45 (2): 123-127.
- Doumont, J-L. 2005. The cognitive style of PowerPoint: Slides are not all evil. Technical Communication, 52 (1): 64-70.
- Drucker, P.F. 1997. Knowledge-worker productivity: The biggest challenge. California Management Review, 41 (2): 79-94.
- DuFrene, D.D. 2004. Concept, content, construction, and contingencies: Getting the horse before the PowerPoint cart. Business Communication Quarterly, 67 (1): 84-88.
- Eppler, M.J. 2003. Making knowledge visible through knowledge maps: Concepts, elements, cases. In Handbook of knowledge management 1: Knowledge matters: 189-206. Berlin: Springer.
- Eppler, M.J & Burkhard, R.A. 2007. Visual representations in management: framework and cases. Journal of Knowledge Management, 11 (4): 112-122.
- Esser, J.K. 1998. Alive and well after 25 years: A review of groupthink research. Organizational Behavior and Human Decision Processes, 73 (2/3): 116-141.
- Farkas, D. 2005. Understanding and using PowerPoint. In Proceedings of the STC annual conference: 313-320. Arlington, VA: STC Publications.

- Folds, D.J. 2005. Quantification of rapid decision making. In McBride, D.K, and Schmorrow, D. (Eds.) Quantifying Human Information Processing: 233-243. Lanham, MD: Rowman & Littlefield.
- Fuller, S.R. & Aldag, R.J. 1998. Organizational Tonypandy: Lessons from a quarter century of the groupthink phenomenon. *Organizational Behavior and Human Decision Processes*, 73 (2/3): 163-184.
- Gao, F. & Wong, D. 2008. Student engagement in distance learning environments: A comparison of threaded discussion forums and text-focused wikis. *First Monday*. 13 (1).
- Gaskins, R. 1984. Sample product proposal: Presentation graphics for overhead projection. Forethought Inc., Sunnyvale, CA.
- Gaskins, R. 2007. PowerPoint at 20: Back to basics. *Communications of the ACM*, 50 (12): 15-17.
- Gomes, L. 2007. PowerPoint turns 20, as its creators ponder a dark side to success. *Wall Street Journal*, June 20, 2007.
- Good, L. & Bederson, B. 2001 CounterPoint: Creating Jazzy Interactive Presentations. HCIL Tech Report #2001-03, University of Maryland, College Park, MD.
- Guy, E.S. 2005. "...real, concrete facts about what works ...": Integrating evaluation and design through patterns. In *Proceedings of the 2005 international ACM SIGGROUP Conference on Supporting Group Work*: 99-108. GROUP '05. ACM, New York.

Haas, M.R. & Hansen, M.T. 2007. Different knowledge, different benefits: Toward a productivity perspective on knowledge sharing in organizations. *Strategic Management Journal* 28: 1133-1153.

Hackman, R. 2008. What makes for a great decision-making team? Presentation at Harvard LILA event, Feb 26-27, 2008, Cambridge, MA.

Harvard, 2008. Decision dynamics: Exploring the interpersonal forces in decision-making. Notes from Harvard Learning Innovations Laboratories (LILA) event. Cambridge, MA: Harvard University, February 27-28, 2008.

Hall, R.H. & O'Donnell, A. 1996. Cognitive and affective outcomes of learning from knowledge maps. *Contemporary Education Psychology*, 21: 94-101.

He, L., Sanocki, E., Gupta, A., & Grudin, J. 2000. Comparing presentation summaries: slides vs. reading vs. listening. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*: 177-184. CHI '00. ACM, New York, NY, 177-184.

Hexel, R., Johnson, C., Kummerfeld, B., & Quigley, A. 2004. "PowerPoint to the people": suiting the word to the audience. In *Proceedings of the Fifth Conference on Australasian User interface - Volume 2*: 49-56. ACM International Conference Proceeding Series, vol. 53. Australian Computer Society, Darlinghurst, Australia.

Highsmith, J. 2004. *Agile project management*. Boston, MA: Addison-Wesley.

- Holcombe, M.W. & Stein, J.K. 1996. Presentations for decision makers (3rd edition). New York: Van Nostrand Rheinhold.
- Holman, D., Stojadinovic, P., Karrer, T., & Borchers, J. 2006. Fly: an organic presentation tool. In CHI '06: CHI '06 extended abstracts on Human factors in computing systems: 863-868. New York.
- Horn, R.E. 1998. Visual language: Global communications for the 21st century. Bainbridge Island, WA: MacroVU, Inc.
- James, K.E., Burke, L.A. & Hutchins, H.M. 2006. Powerful or pointless? Faculty versus student perceptions of PowerPoint use in business education. *Business Communication Quarterly*, 69 (4): 374-396.
- Johnson, B., Manyika, J.M., and Yee, L.A. 2005. The next revolution in interactions. *McKinsey Quarterly*. 4: 21-33.
- Jonassen, D.H. 2005. Tools for representing problems and the knowledge required to solve them. In Tergan, S-O., and Keller, T. (eds), *Knowledge and Information Visualization*: 82-94. Berlin: Springer.
- Kahneman, D. 2003. Maps of bounded rationality: Psychology for behavioral economics. *American Economic Review* 93(5): 1449-1475.
- Katz, L.F. & Autor, D. H. 1999. Changes in the wage structure and earnings inequality. *Handbook of Labor Economics*, volume 3. Amsterdam: El Sevier.

Keller, T. & Grimm, M. 2005. The impact of dimensionality and color coding of information visualizations on knowledge acquisition. In Tergan, S-O., and Keller, T. (eds), *Knowledge and Information Visualization*: 167-182. Berlin: Springer.

Keller, T. & Tergan, S-O. 2005. Visualizing knowledge and information: an introduction. In Tergan, S-O., and Keller, T. (eds), *Knowledge and Information Visualization*: 1-23. Berlin: Springer.

Kukulska-Hulme, A. 1999. *Language and Communication: Essential concepts for user interface and documentation design*. Oxford University Press.

Larkin, J.H. & Simon, H.A. 1987. Why a diagram is (sometimes) worth ten thousand words. *Cognitive Science*, (11): 65-99.

Lowry, P.B. & Nunamaker, J.F. 2003. Using internet-based, distributed, collaborative writing tools to improve coordination and group awareness in writing teams. *IEEE Transactions on Professional Communications*, 46 (4): 277-297.

Lowry, P.B., Nunamaker, J.F., Curtis, A., & Lowry, M.R. 2005. The impact of process structure on novice, virtual collaborative writing teams. *IEEE Transactions on Professional Communication*, 48 (4): 341-364.

Malone, T.W. 2004. *The Future of Work*. Cambridge, MA: Harvard Business School Press.

- McBride, D.K, and Schmorrow, D. 2005. Quantifying Human Information Processing. Rowman & Littlefield.
- Menon, S., Montabert, C., Tungare, M., & North, C. 2007. Performance Evaluation of Navigation Approaches on High-resolution Displays. Technical Report TR-07-22, Virginia Polytechnic Institute and State University, Department of Computer Science, Blacksburg, VA.
- Miller, G.A. 1956. The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review*: 63: 81-97.
- Nadkarni, S. & Shenoy, P.P. 1999. A Bayesian network approach to making inferences in causal maps. *European Journal of Operational Research*, 128: 479-498.
- Noel, S. & Robert, J-M. 2003. How the web is used to support collaborative writing. *Behavior and Information Technology*, 22 (4): 245-262.
- Novak, J.D. & Cañas, A.J. 2006. The theory underlying concept maps and how to construct them. Technical report IHMC CmapTools 2006-01, Florida Institute for Human and Machine Cognition.
- O'Donnell, A.M., Dansereau, D.F., & Hall, R.H. 2002. Knowledge maps as scaffolds for cognitive processing. *Education Psychology Review*, 14 (1): 71-86.
- O'Neill, M. E. 2005. Automated use of a Wiki for collaborative lecture notes. *SIGCSE Bulletin*, 37 (1): 267-271.

Pink, D.H. 2005. A whole new mind: Moving from the information age to the conceptual age. New York: Riverhead Books.

Plumlee, M.D. & Ware, C. 2006. Zooming versus multiple window interfaces: Cognitive costs of visual comparisons. *ACM Transactions on Computer-Human Interaction*, 13 (2): 179-209.

Rubinstein, A. 1998. Modeling bounded rationality. Cambridge, MA: MIT Press.

Simon, H.A. 1965. The shape of automation for men and management. New York: Harper & Row.

Surowiecki, J. 2004. The wisdom of crowds: Why the many are smarter than the few and how collective wisdom shapes business. Doubleday.

Tapscott, D. & Williams, A.D. 2006. Wikinomics: How mass collaboration changes everything. Toronto, Canada: Portfolio.

Tergan, S-O., and Keller, T. (editors). 2005. Knowledge and Information Visualization. Berlin: Springer.

Tergan, S-O. 2005. Digital concept maps for managing knowledge and information. In Tergan, S-O., and Keller, T. (eds), Knowledge and Information Visualization: 185-204. Berlin: Springer.

Thomas, B.E. & Baron, J.P. 1994. Evaluating knowledge worker productivity: literature review. Interim Report, No. FF-94/27, USACERL Available at: <http://www.cecer.army.mil/kws/tltoc.htm>

Trenholm, S. 1995. Thinking through communication: An introduction to the study of human communications. Needham Heights, MA: Allyn and Bacon.

Tufte, E. 2006. Beautiful Evidence. Cheshire, CT: Graphics Press.

Tufte, E. 2007. Notes from Presenting data and information: a one-day course. Washington, DC. October 15, 2007.

Wagner, D. 2006. Speaking in Tongues. MIT Sloan Management Review. Summer, 2006.

Ware, C. 2005. Visual queries. In Tergan, S-O., and Keller, T. (eds), Knowledge and Information Visualization: 27-35. Berlin: Springer.

Wexler, M.N. 2001. The who, what and why of knowledge mapping. Journal of knowledge management, 5 (3): 249-263.

White, J.V. 1984. Using Charts and Graphs. R.R. Bowker Company.

Wildbur, P. & Burke, M. 1998. Information Graphics: Innovative Solutions in Contemporary Design. Thames & Hudson.

Appendix A – Research questionnaires

Participant	Interview	Role	Duration
Software Company Project Manager	Conversational, telephone	Author	60 minutes
Community Association board member 2	Conversational, in person	Author	60 minutes
Market Research VP	Structured, in person	Author, Briefer	60 minutes
Professional services firm founder	Structured, in person	Author, Briefer	60 minutes
InfoTech Department Director	Conversational, in person	Author, Briefer	60 minutes
Community Association board member 1	Conversational, in person	Author, Briefer	60 minutes
Software Company CTO	Conversational, telephone	Author, Briefer	60 minutes
Team leader	Structured, online	Author, Briefer	
Programmer	Structured, online	Author, Briefer	
InfoTech Department VP 1	Conversational, in person	Audience	60 minutes
InfoTech Department VP 2	Conversational, in person	Audience	60 minutes
Software Developer	Structured, online	Audience	
Software Developer	Structured, online	Audience	
Lead Developer	Structured, online	Audience	
Software Developer	Structured, online	Audience	
Java developer	Structured, online	Audience	
Junior Software Engineer	Structured, online	Audience	

Table 43: Summary of role interviews

LiquidBriefing – Author questionnaire ID# _____

1. What is your title? _____

2. What are the objectives of this document? _____

3. What is the expected number of contributors? _____

4. What is the expected number of reviewers? _____

5. What software do you typically use for this type of objective? _____

6. How long do you have to prepare the document before the briefing? _____

7. Using this software (please circle one response for each question):

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately Agree	Strongly agree
a. Reduced the time required to prepare the document	1	2	3	4	5	6	7
b. Improved the quality of the results	1	2	3	4	5	6	7
c. Increased the scope of the document	1	2	3	4	5	6	7
d. Made it easier to work with other authors	1	2	3	4	5	6	7
e. Made it easier to incorporate feedback from reviewers (prior to the meeting)	1	2	3	4	5	6	7

8. Your overall perception of this software (please circle one response for each question):

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately Agree	Strongly agree
a. I would refer this software to others in my organization	1	2	3	4	5	6	7
b. Compared with our current tools, this software was more effective in helping me prepare the briefing material	1	2	3	4	5	6	7

Please add any additional comments on the authoring experience and the software: _____

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Thank you for your participation.

LiquidBriefing – Briefer questionnaire ID# _____

1. What is the objective of this briefing? _____

2. How many briefers were involved? _____

3. How many audience members? _____

4. What software do you typically use for this type of objective? _____

5. How much time did you have to prepare before this briefing? _____

6. Using this software (please circle one response for each question):

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately Agree	Strongly agree
a. Reduced the time required for the briefing	1	2	3	4	5	6	7
b. Improved the quality of the results	1	2	3	4	5	6	7
c. Improved the flow of the briefing	1	2	3	4	5	6	7
d. Increased the audience interaction	1	2	3	4	5	6	7
e. Made it easier to follow the interest of the audience during the meeting	1	2	3	4	5	6	7

7. Your overall perception of this software (please circle one response for each question):

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately Agree	Strongly agree
a. I would refer this software to others in my organization	1	2	3	4	5	6	7
b. Compared with our current tools, this software was more effective in helping me manage the briefing	1	2	3	4	5	6	7

Please add any additional comments on the briefing experience and the software: _____

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Thank you for your participation.

LiquidBriefing – Audience questionnaire ID# _____

1.What is your title? _____

2.What is the objective of this briefing? _____

3.How many audience members were involved? _____

4.What software do you typically use for this type of objective? _____

5.How much time did you have to prepare before this briefing? _____

6.Using this software (please circle one response for each question):

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately Agree	Strongly agree
a. Reduced the time required for the briefing	1	2	3	4	5	6	7
b. Improved the quality of the results	1	2	3	4	5	6	7
c. Improved the flow of the briefing	1	2	3	4	5	6	7
d. Made it easier for me to interact during the briefing	1	2	3	4	5	6	7

7.Your overall perception of this software (please circle one response):

	Strongly disagree	Moderately disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Moderately Agree	Strongly agree
a. I would refer this software to others in my organization	1	2	3	4	5	6	7
b. Compared with our current tools, this software was more effective in helping me understand the briefing material	1	2	3	4	5	6	7
c. Compare with our current tools, this software was more effective in reviewing the material after the meeting	1	2	3	4	5	6	7

Please add any additional comments on the briefing experience and the software: _____

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Thank you for your participation.

Appendix B – Software specifications

LiquidBriefing prototype software specifications

Requirement	Details
Wiki Software	TWiki version 4.2
Concept Maps	GraphViz version 2.20
Operating System	Linux
Languages	Perl, Javascript, HTML cascading style sheets (CSS)
Browser	Internet Explorer 7 and above or Firefox 2 and above

To implement the prototype, the TWiki open source enterprise collaboration platform and knowledge management wiki system was selected (<http://twiki.org/>). TWiki was selected due to its open architecture, speed of prototyping, and the ability to develop extensions tailored for the LiquidBriefing prototype. TWiki is mostly written in the Perl language, with some Javascript extensions, and extensive use of HTML cascading style sheets (CSS).

Appendix C – Ethics approvals

Carleton University Research Office
5th Floor Tory Building
1125 Colonel By Drive
Ottawa, ON K1S 5S6 Canada
Tel: (613) 520-2516
Fax: (613) 520-2521
www.carleton.ca/cu/research/curo/

Ethics Approval Form

This is to certify that the Carleton University Research Ethics Committee has examined the application for ethical approval. The committee found the research project to meet appropriate ethical standards as outlined in the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* and, the *Carleton University Policies and Procedures for the Ethical Conduct of Research*.

X New approval

☐ **Renewal of original approval**

Original date of approval:

Date of approval	7 March 2008
Researcher	Douglas Frosst
Status	M.Sc. candidate
Department	Department of Systems and Computer Engineering
Supervisor	Prof. Michael Weiss
Title of project	Augmenting briefing and decision making in small groups

Ethics approval expires on: **7 March 2009**

All researchers are governed by the following conditions:

Annual Status Report: Ethics clearance is valid for one year from date of approval unless otherwise indicated. You are required to submit an Annual Status Report to either renewal approval or close the file. Failure to submit the Annual Status Report will result in the immediate suspension of the project. Funded projects will have accounts suspended until the report is submitted and approved.

Changes to the project: Any changes to the project must be submitted to the Carleton University Research Ethics Committee for approval. All changes must be approved prior to the continuance of the research.

Adverse events: Should any participant suffer adversely from their participation in the project you are required to report the matter to the Carleton University Research Ethics Committee. You must submit a written record of the event and indicate what steps you have taken to resolve the situation.

Suspension or termination of approval: Failure to conduct the research in accordance with the principles of the *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans* and the *Carleton University Policies and Procedures for the Ethical Conduct of Research* may result in the suspension or termination of the research project.

Leslie J. MacDonald-Hicks
Research Ethics Committee Coordinator
For the Chair of the Carleton University Research Ethics Committee
Prof. Antonio Gualtieri

Office of Research Compliance
Institutional Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24061
540/231-4991 Fax 540/231-0959
e-mail moored@vt.edu
www.irb.vt.edu

FWA00000572 (expires 1/20/2010)
IRB # is IRB00000667

DATE: March 31, 2008

MEMORANDUM

TO: Marc Abrams
Douglas Frosst

FROM: David M. Moore

SUBJECT: IRB Exempt Approval: "Rapid and Accurate Idea Transfer", IRB # 08-191

I have reviewed your request to the IRB for exemption for the above referenced project. The research falls within the exempt status. Approval is granted effective as of March 31, 2008.

As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in the research protocol. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

cc: File

Invent the Future

VIRGINIA POLYTECHNIC INSTITUTE UNIVERSITY AND STATE UNIVERSITY
An equal opportunity, affirmative action institution

DEPARTMENT OF THE ARMY
US ARMY MEDICAL RESEARCH AND MATERIEL COMMAND
504 SCOTT STREET
FORT DETRICK, MD 21702-5012

REPLY TO
ATTENTION OF

MCMR-RPS

18 April 2008

MEMORANDUM FOR THE RECORD

SUBJECT: Determination for Protocol, "Rapid and Accurate Idea Transfer," Submitted by Marc Abrams, PhD, Harmonia, Inc., Blacksburg, VA, Proposal Number D072-032-0648, Award Number W31P4Q-08-C-0210, HRPO Log Number A-14877

1. The subject protocol and supporting documents received on 9 April 2008 in the U.S. Army Medical Research and Materiel Command (USAMRMC) Office of Research Protections (ORP), Human Research Protections Office (HRPO) have been reviewed for applicability of human subjects protection regulations.
2. The research involves the exploration of emerging knowledge management techniques, such as mind-maps, tag clouds, and network visualizations that may provide a more powerful development and navigation technique for briefing or visual essay than a linear set of slides.
3. The Virginia Polytechnic Institute University (VA Tech) Institutional Review Board (IRB) determined that the protocol is exempt under 45 CFR 46.101(b), as it involves research on the effectiveness of or the comparison among instructional techniques, and the use of survey or interview procedures with adult subjects.
4. The HRPO concurs with the determination made by the VA Tech IRB. The project may proceed with no further requirement for review by the HRPO. The HRPO protocol file will be closed.
5. In the event that there is a change to the subject research or statement of work (SOW), the Principal Investigator must notify the Contracting Officer's Representative (COR) and send a description of the change to the HRPO at hsrb@us.army.mil referencing both the Proposal Number and the HRPO Number listed in the "Subject" line above. The HRPO will re-open the protocol file if necessary.

Any changes to the SOW that the COR determines could affect the exemption status of the project, must be reviewed by the HRPO prior to approval by the Contracting Officer.

MCMR-RPS

SUBJECT: Determination for Protocol, "Rapid and Accurate Idea Transfer," Submitted by Marc Abrams, PhD, Harmonia, Inc., Blacksburg, VA, Proposal Number D072-032-0648, Award Number W31P4Q-08-C-0210, HRPO Log Number A-14877

6. Do not construe this correspondence as approval for any contract funding. Only the Contracting Officer can authorize expenditure of funds. It is recommended that you contact the appropriate contract specialist or contracting officer regarding the expenditure of funds for your project.

7. Further information regarding the contract agreement can be obtained by contacting the assigned Contract Specialist, Ms. Karen Jones, at 256-876-1716.

8. Further information regarding technical oversight can be obtained by contacting the assigned COR, Jeffrey Wright, at 256-842-9189.

9. Further information regarding this review may be obtained by contacting Debra DePaul, RN, MSN, Human Subjects Protection Scientist, at 301-619-2620.

E-Signed by Andrea J Kline
VERIFY authenticity with Approva

ANDREA J. KLINE, MS, CIP
Chief, Research Administrative Support
Human Research Protection Office
Office of Research Protections