

The Lifecycle of a Whiteboard Photo: Post-meeting Usage of Whiteboard Content Captured with Mobile Devices

by

Danniel Varona-Marin

A thesis

presented to the University of Waterloo

in fulfillment of the

thesis requirement for the degree of

Master of Applied Science

in

Systems Design Engineering

Waterloo, Ontario, Canada, 2016

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AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

The traditional dry-erase whiteboard is a ubiquitous tool in the workplace, particularly in meeting spaces where they are a key collaboration tool. Although research on whiteboard use and the development of whiteboard systems have been a staple in the Human-Computer Interaction (HCI) literature, there is a lack of how whiteboard content is used to direct actions outside the meeting. In today's mobile-centric world, knowledge workers capture whiteboard content after a meeting by taking photos of them with mobile devices such as cellphones. This thesis empirically investigated post-meeting practices with whiteboard photos to explore how these practices might be better supported by technology. In particular, this thesis investigated the main post-meeting activities that whiteboard photos support, how people value whiteboard photos, and how they manage them. Nineteen knowledge workers from a variety of professions, companies, and industries across North America who were regular users of whiteboards were interviewed using a semi-structured protocol. A Thematic Analysis of the data revealed that whiteboard photos were primarily used to create superseding documents and were sometimes used as evidence of agreement. Whiteboard photos were used mostly in the short-term, and their value was transient. Also, an analysis of the minute detailed actions that interviewees reported taking with one or two recent whiteboard photos revealed that the typical lifecycle of those whiteboard photos involved a seven-stage lifecycle. Moreover, a memory recall task with six of the interviewees about previous meetings where a whiteboard was used revealed that general characteristics of those meetings were well remembered while characteristics about the whiteboard content were not well remembered. The findings suggested a set of unmet design needs for the development of improved mobile-centric whiteboard capture systems. The suggested design implications include the need for a mobile application that supports quick capture and the effortless transfer of whiteboard photos to productivity-oriented devices, and the need for a desktop application that supports the extraction of whiteboard content to aid users in creating superseding documents.

Acknowledgements

This thesis has been a personal learning journey into the world of qualitative research. Coming from a quantitative background, I faced many challenges, such as getting access to real people doing real things, learning how to ask good interview questions that elicited more than one word answers, not pulling my hair out by the messiness and iterative nature of qualitative analysis, and using NVivo's poorly designed interface (to the point of considering doing pro-bono UX work for them in my spare time). But thanks to my incredibly knowledgeable and supportive supervisors, Dr. Stacey Scott and Dr. Edward Tse, I was able to not only overcome these challenges, but to grow as a researcher as a result of them.

Thank you to all of those that, through some small or big way, helped me write this thesis. A special thanks to my thesis readers, Dr. Mark Hancock and Dr. Edward Lank for their thoughtful comments and suggestions, to Dr. Seçil Dağtaş for teaching me how to think like a qualitative researcher, and to Andy Cargile for helping me recruit participants and for mentoring me as a UX researcher. Thanks to Michael T. Boyle, Sheelagh Carpendale, Tony Tang, and Jagoda Walny for their input in the early stages of the research. This research was made possible thanks to funding from MITACS and SMART Technologies.

During the past two years, I had the pleasure to be accompanied by a great group of lab mates, such as Nippun Goyal, Betty Chang, Victor Cheung, Anson Ho, Damla Kerestecioglu, Umair Rehman, and Cleyton Vieira de Vargas, who made coming to the lab a delight. Also, thank you, Tess Forrester, for your love and support.

On a less serious note, I would like to thank Microsoft for the employment offer which gave me the motivation to finish this thesis a semester ahead of schedule, and to coffee, for giving me the ability to actually do so.

Finally, I would like to thank *you* for taking the time to read about what happens to whiteboard photos after a meeting in a mobile-centric world. I hope you find it useful to design better whiteboard capture systems and to inform future research efforts.

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Chapter 1

Introduction

The dry-erase traditional whiteboard—a drawing canvas not much more sophisticated than the dirt floors of caves our prehistoric ancestors first used to communicate ideas (Luzadder & Duff, 1989)—is a ubiquitous tool today in several environments such as the workplace and classrooms. In the workplace, whiteboards are particularly important for collaboration in a variety of industries. In politics, for instance, whiteboards were a key tool that helped negotiators seal the recent US-Iran nuclear deal (Biddle, 2015). Also, many modern technological ideas—like those from Apple’s Steve Jobs’ and Amazon’s Jeff Bezos’s—can be traced back to a meeting on a whiteboard (Manjoo, 2013).

Research on whiteboard use to inform the development of whiteboarding systems has been a staple in the field of Human-Computer Interaction (HCI), particularly in the Computer Supported Collaborative Work (CSCW) literature. Since early seminal work at Xerox PARC (Suchman, 1988; Stefik et al., 1987; Moran & van Melle, 2000; Pedersen et al., 1993; Moran et al., 1997; Moran et al., 1996; Mynatt et al., 1999; Myatt, 1999; Elrod et al., 1992; Saund, 1999), much of the research has concentrated on supporting remote collaboration (Ishii, & Kobayashi, 1992; Zillner et al., 2014; Cutler et al., 2002; Gumienny et al., 2011; Zhang & He, 2004), sketch recognition (Lindlbauer et al., 2013; Lee et al., 2013; Mangano et al., 2014), and integration of whiteboards with other meeting tools and systems (Haller et al., 2010; Sra et al., 2012; Brandl et al., 2008; Pao et al., 2012).

The majority of these studies, however, investigated how to support whiteboard use *during* meetings, yet little is known about how to support *post*-meeting use of whiteboard

content. Some open questions include: why do people capture whiteboard content, and what collaborative or individual post-meeting activities is the captured content used in? Use of artefacts created during meetings have been typically studied in the meeting records literature (e.g., Whittaker et al., 2006; Jaimes et al., 2004) and a plethora of multimedia meeting browsers have been developed in the ubiquitous computing literature (Chiu et al., 1999; Wellner et al., 2004; Cutler et al., 2002; Lee et al., 2002; Lee et al., 2004; Ju et al., 2004). However, the focus has been predominantly on other types of meeting records such as video and audio recordings, personal notes, but little to no attention has been paid to whiteboard content. A better understanding of the work accomplished using whiteboard content post-meeting would provide an opportunity to design better support systems.

An investigation into the post-meeting use of whiteboard content is timely given that recent studies suggest that there has been a shift in the way whiteboard content is captured. In the past, whiteboard content was typically captured by re-writing it on paper (Khan, 1993), and some workplaces outfitted meeting spaces with dedicated cameras systems to capture the whiteboard activity (e.g., FXPAL (Branham et al., 2010), Xerox PARC (Saund, 1999), and Microsoft (Zhang et al., 2004)). Recent research has shown that the norm is now to capture whiteboard content by taking a photo of the whiteboard with a mobile device, such as a smartphone, as illustrated in Figure 1 (Walny et al., 2011; Branham et al., 2010; Klokmoose & Bertelsen, 2013; Bortis, 2010). However, little is known about how people manage these captured whiteboard photos. For instance, where do people store whiteboard photos, are they managed individually or a group, what is their useful lifespan, and how do people search for them?

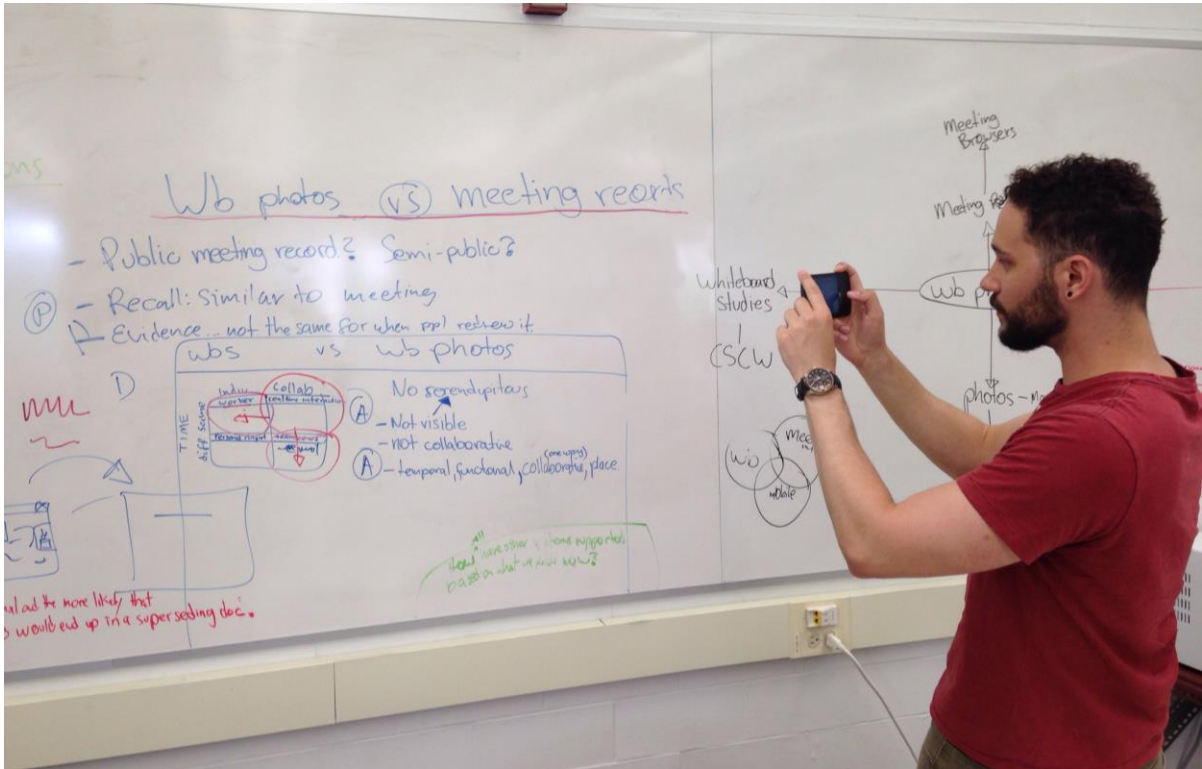


Figure 1. A photo of a whiteboard taken at the end of a meeting by an attendee using a smartphone.

Management of photos (and other types of information such as emails and web bookmarks) has been studied primarily in the Personal Information Management (PIM). The PIM literature has studied how photos are stored, organized, valued, and retrieved (see Van Den Hoven et al., (2012) for a review) and some lifecycles of personal information have been proposed (Whittaker, 2011; Bernstein et al., 2008; Lin et al., 2004). The PIM literature, however, typically studies *personal* photos (e.g., family photos). Whiteboard photos, on the other hand, are a work artefact, so it is unclear to what extent people manage them the same way they manage personal photos. By understanding how people manage their whiteboard photos, an opportunity exists to design better information management systems, and to better support relevant post-meeting activities.

This thesis investigated how whiteboard content captured through photos is used and managed post-meeting. In doing so, the findings from this thesis contribute to previous work in the CSCW literature by showing how whiteboard photos support functional, spatial, collaborative, and temporal transitions from the whiteboard. By investigating the tasks whiteboard photos support, the findings also add to the literature on meeting records which have implications for the design of future meeting browsers. Furthermore, the findings add to the PIM literature by comparing how whiteboard photos and personal photos are managed and valued by people.

1.1 Motivation

This research was motivated by the author's research internship at SMART Technologies¹, a world leader in interactive digital whiteboard technology and other collaborative support tools. SMART Technologies had recently released a product called SMART kapp² which is a traditional whiteboard that can capture whiteboard content using several small cameras embedded into the board's edges. The board records the ink strokes of a regular dry-erase marker. One of the value propositions of SMART kapp is to eliminate the need to take photos of whiteboard content. This is because SMART kapp allows users to capture a digital "snapshot" of their whiteboard canvas at any time by pressing a button on the edge of the whiteboard. This snapshot is then saved to a mobile device connected via a Bluetooth connection. Instead of storing it in the mobile device's native camera roll, it is stored in the companion mobile application (SMART kapp application) in a library of snapshots. This allows SMART

¹ <http://smarttech.com/>

² <http://smarkkapp.com/>

Technologies to develop features in the mobile application that support post-meeting activities in more powerful ways than if the whiteboard snapshot was stored as a digital photo in the mobile device's camera roll.

However, due to a lack of studies in the literature on how people use whiteboard content after a meeting, it was unclear what features should be provided in SMART kapp's mobile application. To address this research gap, the author investigated people's practices with whiteboard photos—the practices that SMART kapp was intending to disrupt—to better inform designers at SMART Technologies, and other researchers and practitioners working to provide better meeting and post-meeting support to whiteboard users.

1.2 Research questions

The overarching research question of this thesis is:

What do people do with whiteboard photos after a meeting?

This thesis breaks down this overarching question into the following research questions:

1. What HCI theories, concepts, frameworks, and findings are relevant to the study of post-meeting use of whiteboard photos?

A review of the HCI literature related to the whiteboard photos' content, context, and media representation was conducted to contextualize the research. Given that whiteboard photos and whiteboards share the same content (handwritten text and illustrations), the literature on whiteboard studies was surveyed. Also, because whiteboard photos are one of several types of records created during meetings, the literature on meeting records was reviewed. Lastly, given that whiteboard photos and

personal photos share the same media representation (digital photography), the PIM literature was surveyed, with a particular focus on the management of personal photos.

2. How have existing systems supported post-meeting use of whiteboard content?

The literature review also surveyed how existing technological systems, such as multimedia meeting browsers and whiteboard systems (i.e., interactive whiteboards, whiteboard capture systems, and mobile applications), currently support the capture and the post-meeting use of whiteboard content.

3. What are the main post-meeting activities that whiteboard photos support?

To answer this research question and research questions 4, 5, and 7 (below), a series of semi-structured interviews was conducted with 19 participants who regularly used whiteboards. They were recruited from various professions, companies, and industries across North America. Thematic Analysis (Braun & Clarke, 2006) was used to analyze the interview data to answer this research question and research questions 4, and 5 (below), in a two-pass analysis process. The first pass used analog tools such as post-it notes, and the second pass involved a more rigorous treatment of the data involving interview transcripts coded in a Computer-Assisted Qualitative Data Analysis Software (CAQDAS) called NVivo³.

4. How do people value whiteboard photos, and how does that perceived value change over time?

³ <http://www.qsrinternational.com/product>

5. How do people manage their whiteboard photos, particularly, where do they store whiteboard photos, how do they organize them, and how do they search for them?

6. What is the typical lifecycle of whiteboard photos?

During the interviews, participants were asked to describe in minute detail the actions they took with one or two whiteboard photos they had recently captured. During the data analysis, a diagram of the described actions was created for each whiteboard photo. A typical lifecycle of whiteboard photos was then derived from this analysis.

7. What characteristics do people remember well about whiteboard content from prior meetings that could be used as search terms to retrieve whiteboard photos?

Six of the 19 recruited interviewees had participated in a previous observational study of meetings involving whiteboard use, four months prior to this study. These six participants were asked additional questions probing what characteristics they could recall about the whiteboard content created during the prior meeting and what characteristics they could recall about that meeting itself.

1.3 Research contribution

The research contributions of this thesis are as follows:

1. Deeper understanding of the main activities that whiteboard photos support.
2. Deeper understanding of how knowledge workers value whiteboard photos, and how whiteboard photos are managed.
3. Identification of the typical lifecycle of whiteboard photos.

4. Empirical evidence related to long-term memory recall of characteristics of previous meetings where a whiteboard was used.
5. Identification of power users of whiteboards and whiteboard photos.
6. Design implications for the development of mobile-centric and whiteboard-centric capture systems.

1.4 Thesis Organization

This thesis is organized into the following chapters:

Chapter 1: Introduction contains the motivation, the main research questions, and the organization of this thesis.

Chapter 2: Literature Review contains a detailed survey of the relevant literature which reviews how previous research on similar artefacts like personal photos, meeting records, and whiteboards informed this work. This chapter also reviews how technological systems, such as multimedia meeting browsers and whiteboard systems, have supported the post-meeting use of whiteboard content.

Chapter 3: Method describes how the semi-structured interviews were conducted, including the sampling technique, participant recruitment, interview procedure, and the interview data analysis.

Chapter 4: Findings presents the insights derived from the participant interviews, highlighting the main activities supported by whiteboard photos, and how they are valued, and managed. This chapter also presents the results of the analysis of the lifecycles of whiteboard photos, and the findings of the free recall memory task.

Chapter 5: Discussion discusses the findings in the context of the literature reviewed in Chapter 2 on whiteboard studies, meeting records, and information management of personal photos. This chapter also presents design implications to aid the future development of two types of systems, 1) *mobile-centric* whiteboard capture systems, and 2) *whiteboard-centric* capture systems. The limitations of the study are also presented.

Chapter 6: Conclusion and Future Work summarizes the main findings of this thesis and describes future research direction by pointing out knowledge gaps that warrant further investigation to build upon the findings of this study.

Chapter 2

Literature Review

This chapter reviews the background literature related to this thesis research, and highlights how this thesis provides a novel contribution to the field of Human-Computer Interaction. In particular, the related literature on whiteboard studies, meeting records, and information management is discussed. Section 2.1 reviews how whiteboard and meeting records are used to gain insights into the activities whiteboard photos might support. Section 2.2 reviews related information lifecycles and how whiteboard photos might be managed by examining how personal photos are managed. Finally, section 2.3 reviews how technological systems such as multimedia meeting browsers and whiteboard systems currently support the capture and use of whiteboard photos.

2.1 Whiteboard photos as an output of the whiteboard

Given that whiteboard photos and whiteboards share the same content (handwritten text and illustrations), this section reviews the literature on whiteboard studies that are relevant to the study of how whiteboard photos are used after a collaboration on a whiteboard.

2.1.1 Types of whiteboards and whiteboard tasks

Tang et al. (2009) reported that different types of whiteboards support different types of activities. Through observational studies, they identified four kinds of whiteboards spanning the individual-collaborative spectrum: intimate, personal, shared, and public whiteboards. Intimate whiteboard were only used by the owner for personal management such as to-do's and reminders. Personal office whiteboards were also used for asynchronous activities but they

are also used synchronously for ad-hoc discussions with co-workers of the board owner. Shared whiteboards, such as those commonly found in research laboratories and war-rooms did not have a single owner but instead, were shared by a small group of known users for synchronous or asynchronous activities. Public whiteboards, such as those found in conference rooms and classrooms, typically only supported synchronous collaborative activities such as scheduled meetings.

Tang et al.'s classification of whiteboards is relevant to the present study because it suggests that the more public the whiteboard is, the more motivation there is to capture its content. Consider for instance, public whiteboards and personal whiteboards. On public whiteboards there is a high risk of losing important content due to a lack of board ownership. On personal whiteboards, however, the occupant of the office is the single owner of that whiteboard so there is little risk of someone else erasing important content. In addition, public whiteboards may be wiped clean several times during the day as different parties use it, leaving people with a small window of time to work with the content before it is erased in an upcoming meeting. In contrast, on personal office whiteboards, although the owner may invite others to collaborate, the owner is not pressured to work with the content quickly so that others may use the board. This leads some whiteboard content to stay up for years on personal office whiteboards (Branham et al., 2010).

Another strong motivator for taking pictures of collaboratively created content on public whiteboards is that they exist in locations (e.g., conference rooms) that are away from where people do their independent work (e.g., cubicles, offices, etc.). Personal office whiteboards, in contrast, are in close proximity and visible to where individual work is accomplished, suggesting that photos of personal office whiteboards may be rare. This was

confirmed by Branham et al.'s (2010) study of personal office whiteboard, in which they found that photographing a whiteboard with a cellphone was perceived as being too time consuming and only happened occasionally. These findings shaped the research question of this thesis by directing attention to whiteboard photos of content on *public whiteboards* (e.g. conference room whiteboards) taken after a meeting.

2.1.2 Transitions

Tang et al. (2009) also found that whiteboards supported three types of transitions, that is, collaborative, temporal, and functional:

- **Temporal transitions** are those that allowed people to alternate between synchronous and asynchronous work. For instance, on a team scheduling whiteboard users can review it throughout the course of a day or the week (asynchronous), or they can negotiate timetables (synchronous).
- **Collaborative transitions** allowed smooth transitions between collaborative and independent work. For instance, one might continue brainstorming on a whiteboard individually after brainstorming with a colleague.
- **Functional transitions** allowed whiteboard content to take on different functions than the ones originally intended. For instance, during brainstorming, the whiteboard functions as a creative drawing surface, but afterwards, the whiteboard might function as an information storage space for future reference.

Tang et al.'s description of transitions suggests that whiteboard photos also enable temporal, collaborative, and potentially functional transitions. Consider the scenario where a worker take

a photo of a whiteboard at the end of a group meeting in a conference room, brings it back to her desk, and continues working individually. A temporal transition occurs from synchronous group work to asynchronous individual work, as the whiteboard photo allows workers to continue working with the whiteboard content after the meeting. However, the existing literature does not detail how much time may lapse between these two phases in practice. One of the contributions of this thesis is to examine how soon people work with the whiteboard photo following a meeting, and for how long a time period they use the photos.

A collaborative transition also occurs, between the group work in the meeting and the independent work after the meeting. However, the nature of this collaborative transition is not clear. For instance, the literature currently does not detail how many people in the meeting typically take a picture of the whiteboard content (one, some, all?), to enable independent post-meeting work post-meeting. Another contribution of this thesis is that it elucidates this collaborative transition.

Finally, it is not clear whether any functional transitions occur, that is, whether the content on the whiteboard takes on a different function after it is captured through a digital photo. However, Branham et al.'s (2010) whiteboard studies suggest that functional transitional may occur. They found that sometimes people who serendipitously encountered un-erased whiteboard content "...at different times, under different circumstances, and with different outcomes than anticipated" (p. 79) derive new insights or re-use the content in unanticipated ways. This thesis explores whether any functional transitions occurs between content on the whiteboard and the content on a whiteboard *photo* and whether people also make serendipitous encounters with content on whiteboard photos.

2.1.3 The nature of whiteboards

Related to whiteboard tasks and transitions, is the disagreement in the literature on whether whiteboards are a production space or a working (pre-production) space. Mynatt (1999) found that whiteboards were a pre-production working space, where for instance, an outline or ideas for a paper are sketched on a whiteboard (the pre-production space) but the actual paper is written on a computer using a word processor (the production space). On the other hand, Klokmose et al. (2013) found instances in which whiteboards were used as a production space. That is, the whiteboard content represented the early stage of a product being designed. They add, however, that the whiteboard drawing of that product was rarely the product itself. Instead, the actual product was made outside the whiteboard, but it was a stable representation of the whiteboard drawing. Regardless of the whether whiteboard are primarily used as a working space or a production space, both papers describe the use of the whiteboards for preliminary idea formation that later becomes formalized externally from the whiteboard.

Based on their findings, Klokmose et al., argue that traditional whiteboards are a *discontinuous artefact* in that content must be remediated into and out of the whiteboard. That is, one must engage in a process of translation and de-contextualization to create whiteboard content and afterwards to extract it onto another medium. They note that the discontinuous nature of the traditional whiteboard can be a disadvantage. For instance, decontextualizing and translating content out of the whiteboard can be a laborious and error prone process. However, they note that that the discontinuous nature of the traditional whiteboard can also be a strength. For instance, adding content to the board and extracting it requires the user to engage in critical reflection.

Klokmoose et al. (2013) recommend that designers do not to merely bridge discontinuities as interactive whiteboards usually do by allowing users to prepare documents on a computer before showing them on the interactive whiteboard, and then saving the result afterward in the traditional way of file administration. Instead, they recommend that designers embrace and cultivate useful discontinuities while providing support for the undesirable discontinuities. However, they also argue that “...photographing the content of a whiteboard for later remediation may be a disservice to one self, because knowing that the content is persisted safely induces a reluctance to actually deal with it” (p. 52). This thesis examines the validity of this claim. They suggest a different capture mechanism that places an artificial expiry date such that the captured whiteboard content is stored for only a limited time, and the user is reminded to process it before it is lost forever, similar to erased content on a whiteboard.

2.1.4 Levels of effort creating drawings

In relation to discontinuities and transitions, Cherubini et al. (2007) studied how software developers used diagrams and found four levels of effort to produce them: transient, reiterated, rendered, and archival. *Transient* drawings—the most common type of drawings—were quickly drawn on whiteboards to accompany a conversation, and were found to hold no value after the conversation. Some of these transient drawings were *reiterated* from memory multiple times throughout the course of a project on different whiteboards or different meetings. Some transient or reiterated sketches were *rendered*, that is, they were important enough that developers recreated them into a more permanent form such as in digital tools like Visio, PowerPoint, or Word. Finally, some rendered drawings were made into *archival* artefacts. To do so, software developers refined them and added sufficient context and explanation so that they would be self-evident to others. However, Cherubini et al., (2007) did not specifically report on

the use of whiteboard photos. This thesis examines the role whiteboard photos play in the transition from low effort drawing (i.e., transient and reiterated) to high effort drawings (i.e., rendered, archival).

2.1.5 Activities supported by whiteboard photos

It is unclear from the literature what post-meeting activities whiteboard photos support. In a study where participants were given digital cameras as a diary tool and asked to capture useful work-related information (Brown et al., 2000) found that people photographed meeting records such as flipcharts, whiteboard, and presentation slides but for unspecific reasons; they report that it was done to add to the group's archive just in case the information was ever needed. A similar finding was reported in Klokrose et al.'s (2013) study of whiteboard use. Their interviewees reported taking photos of a whiteboard with their cellphone, but it was unclear how they were used "beyond being backups, or records for the unlikely case that the content could be used later." (p. 50).

Some recent studies have shown examples of ways in which whiteboard photos have been used post-meeting. For example, Walny et al. (2011) found two instances in which software developers in academia revisited whiteboard photos taken during a meeting. One developer realized during a meeting that he drew a particular diagram on whiteboards often, so he took a photo of it and re-created it digitally to share with others in the future. Another developer after a group brainstorming session, took a photo of the whiteboard to serve as a form of mutual agreement, and later uploaded to the group's wiki website. In a study of whiteboard photos taken with a whiteboard capture system called ReBoard, Branham et al. (2010) found instances of whiteboard photos being emailed to colleagues, printed to bring to a

meeting, and used as a reference to digitally reproduce some of the information. They noted that the primary reason for capturing the whiteboard content was “as a security net” (p. 78)—just in case people needed it in the future—yet, they found in practice that the photos were rarely ever revisited. This thesis explores in-depth the activities for which people use whiteboard photos after a meeting.

2.1.6 Types of meeting records

Whiteboard photos are one of several types of records created during meetings. The type of activities whiteboard photos support might depend on whether they are treated as personal or a public/general meeting record (Whittaker et al., 2006; Jaime et al., 2004). Personal meeting records are “those created by each individual using his or her own perspective” (Jaime et al., 2004, p. 75), while all other records are classified as general or public meeting records. Personal and public/general meeting records support different types of post-meeting activities. Public meeting records, such as meeting minutes, were found to support the following activities (Whittaker et al., 2006, p. 3):

- *To track group progress*
- *To serve as a public record of past actions and decisions*
- *To remind people about their commitments*
- *To resolve disputes about commitments*

On the other hand, personal meeting records, such as individually created notes on a laptop or a notebook, were found to support activities such as (Whittaker et al., 2006, p. 7):

- *As personal reminders*
- *To provide enough contextual information to carry out personal actions*

- *To check the accuracy of the minutes*
- *To brief others about what went on*

Jaime et al. (2004) views whiteboard photos or “prints from electronic whiteboards” as general/public meeting record. This thesis examines the validity of this claim, and specifically probes which types of activities presented above, or others, are supported by whiteboard photos.

2.1.7 Reviewing whiteboard content

The way whiteboard photos are reviewed may be similar to how other records such as audio recordings are reviewed. Moran et al. (1997) studied how meeting attendees who are not familiar with the intricacies of the meeting topic use audio recordings to create meeting minutes. They found that these meeting attendees engaged in *salvaging* behaviour, which involves “replaying [the audio recordings], extracting, organizing, and writing” (p. 22) information for future use. Moran et al. argue that information in the audio recordings are not easily consumable, which forces people to engage in this salvaging activity as an active process of sense-making that is richer and more involved than mere information consumption. Salvaging is relevant to this thesis because much like audio recordings, the content in whiteboard photos may not be easily consumable. Salvaging behaviour and consumption of whiteboard content is explored in this thesis by investigating how people use and extract whiteboard content post-meeting.

2.2 Management of photos

This section reviews the literature on information management, specifically management of digital photos, which is the media representation of whiteboard photos.

2.2.1 Lifecycle frameworks of information

One of the goals of this thesis is to shed light into the lifecycle of whiteboard photo. It is reasonable to assume, that this lifecycle may resemble the lifecycle of other, similar, information types, such as personal photos. Relevant information lifecycles are reviewed below.

2.2.1.1 Curation lifecycle

Management of personal photos, email, webpages, and other types of information have received significant attention in the Personal Information Management (PIM) literature. One area of focus within the PIM literature has been on understanding the lifecycle of certain types of information. For instance, Whittaker (2011) posited that the lifecycle of personal information goes through three distinct curation processes: 1) Keeping, which involves deciding what information is worth keeping, 2) Management, related to how the kept information is managed, and 3) Exploitation, how the information is retrieved in the future, as explained further below.

1. In the Keeping process, the decision to keep or not to keep information is difficult because it requires people to predict their future informational needs. As a result of this uncertainty, people overkeep (“just in case”) and defer evaluation of informational utility until the future. Likewise, the decision to discard information is also difficult as users fear they will delete valuable information. Thus, consistent with “overkeeping”, people show a bias towards preservation and do not tend to discard information.
2. The Management process is intertwined with the third process (exploitation) because the way that people manage information will hinder or facilitate future retrieval efforts. As a result, the decision of how to manage information is also difficult because people have to anticipate when or how the kept information will be retrieved. The difficulty of

this decision leads people to make errors in managing information. For instance, with web bookmarks, people over-manage (Whittaker, 2011) by creating complex hierarchical structures that about 47% of the time they never access again (Tauscher & Greenberg, 1997). The opposite error happens with personal photos because people often fail to create even rudimentary organization, which later leads to retrieval issues, particularly with older photos (Whittaker, 2011).

3. Finally, in the Exploitation stage, the four most common retrieval strategies are 1) searching (using text-based keyword search), 2) navigating (thorough folder structure), 3) orienteering (searching then narrowing down by navigating), and 4) tagging (using labels to categorize). However, Whittaker (2011) found that the strategy used to retrieve personal photos did not resemble any of these four strategies. Due to their lack of text, metadata, and organization, personal photos were typically retrieved using a cumbersome trial and error browsing strategy, where people jumped from folder to folder that seemed likely to contain the wanted photo.

This thesis explores whether Whittaker's curation lifecycle describes the lifecycle of whiteboard photos in the same way that it describes the lifecycle of other personal information such as personal photos, and emails.

2.2.1.2 Lifecycle of information scraps

There is evidence in the literature that suggests that the lifecycle of whiteboard photos may differ from Whittaker's curation lifecycle for personal photos, and that it may be more akin to other information lifecycles. For instance, Bernstein et al. (2008) describes the lifecycle of an *information scrap*, which is "...an information item that falls outside all PIM tools designed to manage it" (p. 3) such as scribbles on the backs of our hands or on post-it notes.

This lifecycle is relevant because Bernstein et al. found that after to-do lists, the second most common information scraps were meeting notes. They also found three “photo[s] of a whiteboard from a discussion” (p. 3) that qualified as information scraps. Their findings point to the possibility that the lifecycle of whiteboard photos may be more similar to the lifecycle of post-it notes than to the lifecycle of personal photos. If so, whiteboard photos could be described by Bernstein et al. (2008)’s information scrap lifecycle which consists of four stages: 1) Capture (similar to Whittaker’s Keeping process), 2) Transfer, 3) Organization (similar to Whittaker’s Management process), and 4) Reuse (similar to Whittaker’s Exploitation process):

1. The Capture stage involves the externalization of thought into a physical or digital form.
2. In the Transfer stage, the information of some important scraps are extracted and converted into another medium.
3. In the Organization stage, people add metadata and store the information to make it easier to re-find it in the future.
4. Finally, the Reuse stage involves the process of re-finding the information, and once found, recalling the meaning of its contents to be able to use it.

However, Bernstein et al. do not elaborate further on whiteboard photos so it is unclear whether all whiteboard photos can be classified as information scraps that follow their four-stage lifecycle. As aforementioned, a goal of this thesis is to investigate in detail the lifecycle of whiteboard photos.

2.2.2 Storage and retrieval

The later stages of both information lifecycles described above involve storing and retrieving information. Due to this emphasis on the PIM literature on management of stored information to aid future retrieval efforts, another goal of this thesis is to investigate people's storage and retrieval practices with whiteboard photos. This is also motivated by Branham et al.'s (2010) study of personal office whiteboards that found that people struggled to re-find their whiteboard photos because they forgot where they had saved them. In particular, this thesis explores whether people store whiteboard photos in personal or shared locations, and how they are organized in those locations.

Another goal of this thesis is to examine how people retrieve whiteboard photos. Jaime et al. (2004) investigated characteristics of meetings that people remembered well that could be used as retrieval cues of meeting records. They found that participants remembered well the location of the meeting room, the table layout of the room, seating positions around the table, the participants, the major topics of the meeting, who was the main speaker, and whether a whiteboard had been used. Participants could also describe the design and content of several "impressive" slides from a presentation five weeks prior. Building on Jaime et al.'s findings, this thesis investigates the characteristics of prior meetings where a whiteboard was used, that people remember well.

Jaime et al. also found that some meeting records are not reviewed often. For instance, photographs and copies of whiteboards were among the least used meeting records, along with audio and video recordings. Likewise, Khan (1993) found that 44% of people very rarely referred back to their notes, and Bothin and Clough (2014) found that "almost half of the people reviewed their notes less often than monthly. A few do this weekly, some monthly and very few

daily” (p. 131). This thesis investigates how much time typically lapses between a meeting occurs and when the whiteboard photos are retrieved.

2.2.3 Information properties

Another goal of this thesis is to investigate the information properties of whiteboard photos. Whittaker (2011) describes three types of information properties: 1) informative (e.g., web-pages), 2) action-oriented (e.g., emails, which often require the user to do something by a given date), and 3) Affective (e.g., personal photos, which people hold on to for sentimental reasons). He adds that while emails and webpages can be either actionable or informative, personal photos are unique in that they are rarely actionable or informative. This thesis explores whether whiteboard photos have similar affective properties as personal photos.

2.3 Current technology support

This section reviews technology that supports the capture and use of whiteboard photos. Multimedia meeting browsers and whiteboard systems are reviewed.

2.3.1 Multimedia meeting browser

In 1991, Weiser described his vision of *ubiquitous computing*, the notion that computers would be embedded all around us, eventually “weav[ing] themselves into the fabric of everyday life until they are indistinguishable from it” (1991, p. 94). On one of the research themes that ubiquitous computing inspired was the *Capture and Access* theme which involved the development of computing systems that “strive[d] to automate the capture of live experiences and provide[d] flexible and universal access to those experiences later on” (Abowd & Mynatt, 2000, p. 30). In the workplace, a number of “smart meeting rooms” research projects aimed at capturing multimedia records of meetings such as audio, and video. These records could later

be accessed through a multimedia meeting browser that compiled, synchronised, and indexed the records for users to review. Some of these multimedia meeting browsers captured whiteboard content through either a video of the meeting, or photos of the whiteboard (e.g., NoteLook (Chiu et al., 1999), Ferret Media Browser (Wellner et al., 2004), Distributed Meeting (Cutler et al., 2002), MinuteAid (Lee et al., 2004), Portable Meeting Recorder (Lee et al., 2002), WorkSpace Navigator (Ju et al., 2004)). These multimedia meeting browsers allowed users to review whiteboard content with an indexed timeline, but provided little to no functionality to facilitate work with whiteboard content post-meeting.

2.3.2 Whiteboard systems

While multimedia meeting browsers and smart meeting rooms aimed to capture all aspects of a meeting, whiteboard systems aimed at supporting use of whiteboards and capturing whiteboard activity during a meeting. This section reviews the various types of post-meeting support that existing whiteboard systems provide for utilizing whiteboard content.

Whiteboard systems can be categorized as: interactive whiteboards, whiteboard capture systems, and mobile applications. Interactive whiteboards require special hardware (TV-like displays that connect to computers) and software (whiteboarding software or meetingware) to mimic the functionality of traditional whiteboards. Users can interact with them with their hands or by using a stylus. One of the first interactive whiteboards was Xerox PARC's LiveBoard (Elrod et al., 1992) running the Tivoli application (Pederson et al., 1993) which was designed to support co-located group meetings. Users could draw on the digital canvas, edit the content, save it, and restore it.

Unlike interactive whiteboards, whiteboard capture systems are traditional whiteboards which have been retrofitted with technology to capture the whiteboard content. For instance, Zombieboard (Saund, 1999) and ReBoard (Branham et al., 2010) capture content on traditional whiteboards with a digital camera installed in the room which is constantly pointing at the whiteboard. The digital camera's connection to the web allows users to access the captured whiteboard content afterward through a web interface on a computer.

With the recent surge of mobile devices, makers of some of these whiteboard capture systems have recently developed companion applications for mobile devices. Instead of uploading the captured whiteboard content to the web, they transfer it to a connected mobile device. For instance, the SMART kapp mobile application requires pairing with a SMART kapp whiteboard, a traditional whiteboard which uses small cameras on the edges and computer vision to record the dry-erase marker's annotations. Content captured with SMART kapp is transferred to the paired SMART kapp app and stored in a library.

Some other mobile applications are stand-alone so they not require any additional hardware to capture whiteboard content. For instance, Evernote⁴, Snappt⁵, YouCam Snap⁶, BoardCapture⁷, and Coletiv Snap!⁸, do not require a whiteboard capture system as they use the mobile device's camera to capture one or more snapshots of the whiteboard content.

⁴ <https://evernote.com/>

⁵ http://www.appszoom.com/iphone-developer/jolt-labs-llc_pqijt.html

⁶ www.cyberlink.com/stat/product/CyberLink_app/YouSnap/enu/YouSnap.jsp

⁷ <https://itunes.apple.com/us/app/boardcapture/id657064071?mt=8>

⁸ <https://itunes.apple.com/us/app/coletiv-snap!-streamlined/id1095660853?mt=8>

The following sections review the common post-meeting functionalities provided by existing whiteboard systems.

2.3.2.1 Reviewing whiteboard content

Whiteboard systems commonly enable users to access and review captured whiteboard content in various ways. For instance, whiteboarding software for interactive whiteboards often provide ways to save and load whiteboard content, typically implemented through common computer file saving functionality (e.g., Tivoli (Pedersen et al., 1993), Software Design Board (Wu & Graham, 2005), SMART Hawkeye⁹, SketchStory (Lee et al., 2013), TeleBoard (Gumienny et al., 2011), SMART Meeting Pro¹⁰). This usually requires the user to select “save as”, pick a location and a file name. Users can review the whiteboard content afterward by loading the file as if they were going to continue working on it. This also allows users to continue annotating after the meeting.

Much like a multimedia meeting browser, another way whiteboard systems have allowed users to review whiteboard content is by replaying the whiteboard session in a video-like fashion showing the order in which the strokes were made (Flatland et al., 1999; Brotherton et al., 1999; Gumienny et al., 2011; Zhang et al., 2004). For instance, DUMMBO (Brotherton et al., 1999) could replay whiteboard strokes along with audio, and users could navigate the timeline using a slider or with standard playback controls (e.g., play, pause, fast forward and rewind). However, whiteboarding systems have also provided functionality for reviewing whiteboard content beyond typical meeting browser systems. For instance,

⁹ http://smarttech.com/support/pdf/hawkeye_part1.pdf

¹⁰ <https://smarttech.com/en/Solutions/Business+Solutions/Products/SMART+Meeting+Pro+4+software>

DUMMBO's playback timeline could also be navigated by clicking on the annotations on the whiteboard capture itself which would take users to the point on the timeline when the annotation was made, or by clicking through thumbnails of key frames. Moreover, the Whiteboard Capture System (Zhang et al., 2004) enhanced the playback experience by displaying future whiteboard annotations in a ghost-like fashion, giving the user awareness of the strokes to come. Likewise, users of Tele-Board (Gumienny et al., 2011) could branch off and continue whiteboarding from any point on the timeline, creating a parallel alternative timeline.

A different paradigm to review whiteboard content was provided by TotalRecall (Holmquist et al., 2003). Using a mobile device, TotalRecall let users view captured whiteboard content "in-place" by holding the device up to the whiteboard. In a magic-lens (Biere et al., 1993) fashion, as users moved the device around the surface of the whiteboard, the device displayed erased annotations.

2.3.2.2 Searching and retrieving whiteboard content

Some existing systems support searching for whiteboard content from the past through timelines, calendar widgets, thumbnail browsing, keyword search, and heatmap search. These are reviewed below.

One of the most common ways whiteboard systems support searching for whiteboard content is temporally through timelines (e.g., Mynatt et al. (1999), Branham et al. (2010), Gumienny et al. (2011)). For instance, ReBoard's (Branham et al., 2010) timeline view showed a bar graph indicating days with activity of whiteboard capture. Days with tall bars indicated lots of whiteboard activity, while days with small bars or no bars indicate little to no whiteboard activity. The user could scroll through segments of the timeline spanning three days. Another temporal searching technique ReBoard used was a calendar. ReBoard's calendar view showed

all whiteboard photos taken between a range of two dates that the users selected using a calendar widget.

Thumbnail browsing is another way that previous systems have enable retrieval (e.g., Maynatt et al. (1999), Branham et al. (2010), SMART Hawkeye, SMART kapp). For instance, ReBoard's (Branham et al., 2010) thumbnail showed a small photo of the whiteboard, along with contextual metadata such as the office where that whiteboard was located, contributors, and with whom the photo has been shared. Thumbnail browsing was also the most common way to retrieve whiteboard content on mobile applications. A similar approach was used to retrieve personal photos in a smartphone's camera roll.

Keyword search is another way whiteboard systems have enabled retrieval (e.g., Maynatt et al. (1999), Brotherton et al. (1999), Evernote). In DUMMBO (Brotherton et al., 1999), for instance, users could specify contextual information such as attendees, time, and location of the meeting. Flatland (Maynatt et al., 1999) and Evernote performed hand-writing recognition to extract text from the whiteboard capture which could then be searched.

ReBoard (Branham et al., 2010) allowed another, unique, way to search for whiteboard content through a "heatmap view" which showed all whiteboard photos taken between two user-specified dates superimposed into one image. This enabled users to easily spot salient sketches that were drawn during the whiteboard session they were searching for. The user could then select the salient sketch to retrieve the whiteboard photo.

2.3.2.3 Using whiteboard content

Some whiteboarding systems provide functionality beyond retrieving and reviewing whiteboard content, such as printing and sharing. Some systems also provide hand-writing recognition, and linking to other content. These are reviewed below.

Several systems allow whiteboard content to be printed (e.g., Saund (1999), Ju et al. (2004), Branham et al. (2010), SMART Hawkeye, Zhang et al. (2004)). Some of these systems (e.g., Saund (1999) and Ju et al. (2004)) allowed printing whiteboard content during the meeting, while in other systems (e.g., Branham et al. (2010)), printing was enabled post-meeting.

Another common feature of these systems is the capability to share—in different ways—whiteboard photos after a meeting. A common way this has been supported by email (e.g., Gumienny et al. (2011)). Other whiteboard systems, like ReBoard (Branham et al., 2010), allow users to share the whiteboard image with others within the ReBoard web application. Some mobile applications, such as YouCam Snap and BoardCapture, allowed users to share the captured whiteboard image on social media sites (e.g., Facebook and Twitter). Texting a whiteboard image was also enabled by some mobile applications such as CaptureBoard¹¹. Uploading to cloud services (e.g., Google Drive and Dropbox) is also a feature in applications such as Coletiv Snap!, RocketBoard¹², and SMART kapp, but the cloud folders are not shared locations. On the other hand, some systems, such as ZombieBoard (Saund, 1999), uploaded

¹¹ <http://www.worldofappstore.org/utilities/captureboard/>

¹² <https://www.kickstarter.com/projects/rocketboard/rocketboard-superpowers-for-your-ordinary-whiteboa>

whiteboard content to a shared file directory on the web that was organized by meeting room number.

Hand-writing recognition on the whiteboard content is a feature on some whiteboard capture mobile applications. Equil Note¹³ allowed users to select a region of the captured whiteboard content and replace it with typed text (e.g., a to-do list) which could then be shared by email. In addition to replacing hand-writing with typed text, the Snappt mobile application could also replace basic hand-draw shapes (e.g., lines, circles, square, triangles, and diamonds) with digital shapes and shared them by email in a PowerPoint presentation.

The SketchLink system (Baltes et al., 2014) allowed users to link whiteboard annotations, for instance, linking sketches on a whiteboard photo to actual source code artifacts. Using the camera of a mobile device, users could take a photo of whiteboard content using the SketchLink app running on a web browser. The photo was uploaded to SketchLink's web server and later downloaded to a computer's local storage by the SketchLink IDE plugin in an IDE. Once regions of the photo were linked to parts of the source code, a user could navigate the source code by clicking the regions on the photo.

In summary, whiteboard systems provide limited technological support. In fact, most existing whiteboard capture and access systems provide little support beyond reviewing, replaying, printing, and sharing captured whiteboard content. A few have gone further by offering novel ways to search whiteboard content from the past, for example, using heatmaps and usage timelines (Branham et al., 2010, Gericke et al., 2011). The fact that none of these systems have been widely adopted and that traditional dry-erase whiteboards still remain

¹³ www.myequil.com/equilnote/

ubiquitous in the workplace, warrants investigation for how people use whiteboard photos in today's mobile-centric world.

2.4 Chapter Summary

This chapter reviewed the relevant background literature which described how similar artefacts to the whiteboard photo such as personal photos, meeting records, and whiteboards informed this work. This chapter also reviews how technological systems, such as multimedia meeting browsers and whiteboard systems, have supported the post-meeting use of whiteboard content. The next chapter elaborates on the study methodology.

Chapter 3

Method

This chapter describes the method used to investigate the main post-meeting activities that whiteboard photos support, how whiteboard photos are valued, stored, organized, retrieved, their typical lifecycle, and the characteristics that people remember well about whiteboard content from a prior meetings. To investigate these research questions, a semi-structured interview protocol was chosen as the most appropriate data collection method as they allow participants to explain at length their methods for working with whiteboard photos. The semi-structured interviews were conducted with participants who regularly used whiteboards because they would be able to shed the most light into the research questions. The sampling strategy and recruitment are first described (section 3.1), followed by a description of the interviewees (section 3.2), the interview procedure (section 3.3), and how the interview data were analysed (section 3.4).

3.1 Sampling and Recruitment

A *purposive sampling* strategy was used (Patton, 2002). The goal of this sampling strategy is to quickly generate insights by “selecting information-rich cases strategically and purposefully” (p. 243). This is the preferred sampling strategy when the aim is to learn a great deal about the topic being studied, rather than to generalize from sample to population (Patton, 2002). Thus, frequent users of whiteboards were sought after, rather than a probabilistic representative sample of whiteboard users. The criteria used to identify them were, people who:

- a) had access to whiteboards in their work environment, and
- b) used whiteboards regularly (at least once a month)

In addition, a *maximum variation sampling* strategy (Patton, 2005) was used with respect to the professional background of the whiteboard users sought after. The goal of this sampling technique is to broaden the range of insights by examining a wide range of cases. Thus, participants were recruited from various professions, companies, and industries across North America.

Nineteen potential participants who met the criteria (above) were identified in the following three ways:

1. Seven of the participants (P1 through P6, and P18) were customers of SMART Technologies who had recently purchased a newly launched dry-erase whiteboard capture board (SMART kapp). These participants were pursued under the presumption that people who spend money on whiteboarding solutions are likely to be regular users of whiteboards.
2. A second group of six participants (P7, P8, P11, P12, P13, and P15) that had been part of a previous observational study of whiteboard use during meetings, four months prior to this study¹⁴, were recruited. The researchers of that previous study shared the recordings of those meetings, so that the participants' recall accuracy could be assessed. Due to the focus in the Personal Information Management (PIM) literature on search and retrieval, the findings from the memory task with these participants informed the design of better search mechanisms to retrieve whiteboard photos by uncovering what

¹⁴ This study was conducted by a different team of researchers from SMART Technologies and the University of Washington who were interested in how traditional whiteboard are used during meetings. The meetings they observed were audio and video recorded.

people remember well from whiteboard meetings. These participants regularly used whiteboards so they also participated in the semi-structured interviews, in addition to the memory task.

3. In a quasi-snowball sampling fashion (Singh et al., 2010), the remaining six participants (P9, P10, P14, P16, P17, P19) were recruited by recommendation of other participants.

The sample size of 19 was not predetermined but guided by the concept of saturation (Glaser & Strauss, 1967), that is to say, “as the study goes on more data does not necessarily lead to more information” (Mason, 2010, p. 1) and the researcher’s time is better spent on other aspects of the research.

3.2 Participants

Nineteen whiteboard users participated in the interviews. Thirteen were male participants, and six were female participants. Nine of the participants were between 36-45 years old, three between 26-35 years old, three between 46-55 years old, and one between 18-25 years old). They had diverse job titles such as Product Manager, Software Developer, Chartered Accountant, User Experience Researcher, and CEO. They varied widely in seniority (1 to 16 years at their organization) and worked in organizations of varying sizes, from start-ups to large companies (see Table 1). These companies were distributed across North America spanning several sectors such as Software and Product Development, Consulting, Biotechnology, and Construction. Thus, a diverse set of people were interviewed to generate a diversity of insight.

Interview number	Participant number	Profession	Company type & Size
1	P1, P2	Software Developers	Small software development company
2	P3, P4	Chartered Accountant (P3), Systems Analyst (P4)	Medium size software & technology company
3	P5	CEO	Oil and gas software start-up
4	P6	CAD Technologist	Large size university engineering laboratory
5	P7	Director of Marketing	Small size UX consultancy
6	P8	Principal UX Researcher	Small size UX consultancy
7	P9	Design Manager	Medium size engineering and design consultancy
8	P10	CEO	Small size UX consultancy
9	P11	Chief Product Officer	Mobile software startup
10	P12	Program Manager	Medium size Business management consultancy
11	P13	VP of Operations	Medium size business management consultancy
12	P14	Software Architect	Medium size Business management consultancy
13	P15	Product Manager	Medium size biotechnology company
14	P16, P17	UX Director (P16) User Researcher (P17)	Small size UX consultancy
15	P18	IT	Large size commercial real-estate development firm
16	P19	Software Engineer	Large size internet computer software company

Table 1. Participants' professions and the company type and size they worked in.

3.3 Interview Procedure

The interviews were conducted in person at the participants' workplace in a meeting room (with the exception of P18, who was interviewed over the phone, and P19 who was interviewed in the lab of the author of this thesis). P1 & P2, P3 & P4, and P16 & P17 were interviewed in pairs as working colleagues. The interviews lasted between 20 and 60 minutes and were audio and video recorded. The interviews were conducted between July 2015 and February 2016.

3.3.1 Interview Questions

Using a semi-structured interview protocol, participants were asked several questions related to the methods they used for working with whiteboard photos. The questions spanned topics such as capture, share, store, archive, search, revisit, and re-use of whiteboard photos (see Appendix 2 for a full list of seed questions). To illustrate their practices, participants were asked to describe in detail the actions they took with one or two recently taken whiteboard photos. These descriptions were used to create lifecycle diagrams during the data analysis phase (described in section 3.4.2.1). Interviewees were also asked questions related to the utility they derived from their whiteboard photos, and if and how that utility changed over time.

In addition, participants with access to their phone, laptop, or desktop computer during the interview were asked to retrieve a sample whiteboard photo and to think aloud while doing so. This allowed the interviewer to observe how the participants approached the retrieval of whiteboard photos, the locations where they kept them, and how those locations were organized (if at all).

The six participants who had also been participants in the previous observational study of meetings involving whiteboard use (Recruitment Group 2), were asked additional questions

probing what they could recall about that previous meeting. These questions were included because well-remembered characteristics of whiteboard meetings have the potential to become effective search terms to retrieve whiteboard photos. Without looking at the whiteboard photo (or any materials) from the prior meeting, which occurred four months before the interviews, they were asked to describe what the meeting had been about in as much detail as possible.

Then they were also asked:

- a) who drew on the whiteboard
- b) what colours were used
- c) what percentage of the whiteboard was used
- d) what parts/quadrants of the whiteboard were used
- e) whether any complete erasures of the whiteboard occurred
- f) whether paper artefacts (such as post-it notes) were posted on the whiteboard
- g) the location of the meeting
- h) whether they remembered any diagrammatic content (non-text) that had been drawn on the board during this meeting, and if so, whether they could try to redraw it on a blank piece of paper the interviewer provided
- i) with whom the whiteboard photos were shared after the meeting

After the interview phase, all participants were asked to complete a background questionnaire (see Appendix 2 for details). The questionnaire asked how often they used whiteboards and whiteboard photos, and basic demographic information such as age group, gender, profession, current employer, and tenure at current employer.

The need to uphold confidentiality prevented the researcher from obtaining copies of the whiteboard photos and other documents described during the interviews.

3.4 Data Analysis

Using Thematic Analysis (Braun et al., 2006), the interview data were analysed twice by the author. This section discusses the basic method of conducting a Thematic Analysis, then describes the two thematic analyses of the interviews, followed by a description of how the responses to the memory recall task were analysed.

3.4.1 Thematic analysis

According to Braun et al. (2006, p. 87), Thematic Analysis involves a six-step process:

- 1. **Familiarizing yourself with your data:** Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas.*
- 2. **Generating initial codes:** Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.*
- 3. **Searching for themes:** Collating codes into potential themes, gathering all data relevant to each potential theme.*
- 4. **Reviewing themes:** Checking if the themes work in relation to the coded extracts (Level 1) and the entire data set (Level 2), generating a thematic ‘map’ of the analysis.*
- 5. **Defining and naming themes:** Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.*
- 6. **Producing the report:** The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.*

These six steps were roughly followed throughout the two thematic analyses that were conducted. The first thematic analysis was conducted in October 2015 using analog tools such as post-it notes based on reviews of the video and audio data. Four months later (February

2016), a second more rigorous analysis was conducted using interview transcripts on a Computer-Assisted Qualitative Data Analysis Software (CAQDAS) tool called NVivo. These two analyses are described in the following sections.

3.4.2 Thematic analysis using analog tools

The aim of the first thematic analysis was to present preliminary findings from the interviews to stakeholders at SMART Technologies. Analog tools (paper, post-it notes, whiteboard) were used due to a limited timeframe (five days) to analyse and prepare a presentation of the preliminary findings. The focus of the analysis and the presentation was on findings that related to features and the overall product development of SMART kapp.

The author of this thesis watched all the interview recordings, and made notes on a piece of paper of what the interviewees were saying and the themes that were emerging (as shown in Figure 2, left). Interviewees' answers, especially the feature-oriented ones, were written down on post-it notes and posted on a large whiteboard. An affinity diagram (Beyer & Holtzblatt, 1999) was used to categorize the data (as depicted in Figure 2, right). In this round of analysis, the "report" was a PowerPoint presentation which was presented five times towards the end of the author's internship at SMART Technologies to various internal company stakeholders, and then once to a Human-Computer Interaction research group at the University of Waterloo to obtain general feedback on the project.



Figure 2. Sample paper notes for Participant 11 (left), and a partially completed affinity diagram of the post-it notes (right).

3.4.2.1 Lifecycle analysis

Lifecycle diagrams were created to analyse the detailed actions interviewees reported taking with one (or two) whiteboard photos. Inspiration for the lifecycle diagrams was drawn from Walny et al. (2011), who used a similar approach to illustrate the lifecycle of sketches drawn on paper, whiteboards, and notebooks by software developers in an academic research setting.

Figure 3 shows one such diagram and Appendix 4 shows the complete list of diagrams.



Figure 3. This diagram depicts the actions taken by P8 with one whiteboard photo. After a brainstorming session with co-workers, P8 took a photo of the whiteboard with his cellphone and used Apple’s AirDrop to transfer it to a personal project folder in his laptop. He then used the photo as a reference when creating a proposal in Microsoft Word, but he did not import the photo itself into the document (as the black arrow shows).

The lifecycles diagrams were created illustrating the capture and use process described by each participant during the interviews. These lifecycles were analyzed for common patterns.

The lifecycle diagrams were presented to stakeholders at SMART Technologies with the preliminary findings. In this thesis, the diagrams were used to aid the thematic analysis, to illustrate some of the findings, and to develop a general lifecycle framework of whiteboard photos (Section 4.7).

3.4.3 Thematic analysis using transcript coding in NVivo

For the purpose of this thesis, a more thorough thematic analysis of the interview data was conducted four months after the first analysis.

To facilitate this in-depth analysis, transcription of the interviews was outsourced to Rev.com, an online transcription service. The transcripts were later reviewed and a few were corrected for accuracy by the author. The thematic analysis initially involved a line-by-line coding of transcripts where the codes were derived from the data during the coding process. Figure 4 shows the codes applied to the data.

(5) it may simply create the “worst of all worlds”: not enough of a sample for a statistical test, and too anemic a representation to adequately represent rich data

Beyond these reasons, quantifying responses is particularly difficult to do with data derived from semi-structured interviews. To obtain rich data and insightful narratives during semi-structured interviews, the same questions are not always asked, and when they are, they are not always asked the same way, or in the same order. Often participants indirectly answer a question by way of answering a different question or while giving a narrative. Semi-structured interviews analysed thematically shed light into “what”, “how”, and “why” questions through identification of emergent *categories* and *themes*. This is in contrast to structured interviews and surveys, in which the data lends itself to quantification to answer “how much”, “how many”, and “how often” questions in the form of “15 out of the 20 participants (75%) agreed, while the rest (25%) disagreed”. Nevertheless, where appropriate, some of the findings presented in the next chapter (Chapter 4) give the reader a sense of how rare or common the reported phenomena were by adopting the conventions used by other qualitative researchers such as ‘a number of participants’, ‘the majority of participants’, and ‘many participants’ (Braun et al., 2006).

3.4.3.2 Analysis of deviant cases

Also, as is typical with in-depth qualitative analysis (Pope et al., 2000; Madill et al., 2000; Miles & Huberman, 1994), special attention was devoted to the deviant cases (also called outlier, rare, negative, or extreme cases) because they can offer significant insight into the phenomena of interest. Two types of deviant cases were analysed, artefacts (whiteboard photos that were valued or used uniquely) and users (power whiteboard users that used whiteboard and whiteboard photos unlike most of the other participants interviewed).

3.4.4 Analysis of memory recall task

In addition to the thematic analysis, the interview data from the six participants who had also been part of the previous study were analyzed to assess the long-term memory recall of the free-recall memory task these participants performed. To verify the recall accuracy, their answers to each of the questions were recorded and compared to the correct answers. The correct answers were derived from the video and audio recordings of the meetings the participants were being asked to recall, which had been shared by the researchers who conducted the previous study. Participants' answers were coded in one of three ways:

- 1) *correct* (e.g., correctly recalled all meeting attendees who drew on the whiteboard)
- 2) *partially correct* (e.g., recalled some of the meeting attendees who drew on the whiteboard)
- 3) *incorrect or did not remember* (e.g., misidentified all who drew on the whiteboard or could not recall who drew on the whiteboard)

In a more qualitative fashion, how confident participants appeared to be in their answers was also taken into account. The latter assessment was done to get a sense of whether they actually remembered, or whether they were guessing, or inferring the answer. Due to the small sample size ($n=6$), the findings were grouped into only two groups: 1) correctly and confidently reported characteristics, and 2) the rest (reported characteristics that were partially correct, incorrect, or could not be remembered, and reported characteristics that appeared to be guesses, or inferences).

3.5 Chapter Summary

Nineteen whiteboard users from 11 companies participated in semi-structured interviews where they were asked about their practices with whiteboard photos. The interview data were

analyzed using two rounds of thematic analysis. The findings are presented in the following chapter.

Chapter 4

Findings

The previous chapter described how the interviews were conducted to uncover what people do with whiteboard content after a meeting. This chapter presents the findings.

4.1 Key findings

The key findings were:

- Whiteboard photos were primarily used in the creation of a more permanent document (*superseding* document) such as a project report (or similar), presentation slides, or an email to the meeting attendees. They also served as evidence of shared agreement and were used to settle disputes.
- Participants perceived whiteboard photos to be most valuable in the short-term. They lost most of their utility after their information was extracted into a *superseding* document.
 - A few “special” whiteboard photos were particularly important and people reported that they would be devastated if they lost them while a project was active.
- Short-term actions such as transcribing the information out of the photo were reported as pain points; long-term actions such as retrieval of whiteboard photos were not reported as pain points.
 - Well-remembered characteristics of a prior meeting that occurred months before in which a whiteboard was used were: meeting room, topic of meeting, meeting attendees, and who drew on the whiteboard. Whiteboard-specific characteristics,

such as the colour of dry-erase markers used, or the specific whiteboard content (text or drawing) were not well remembered.

- Whiteboard photos generally went through a seven-stage lifecycle: Capture, Transfer, Extract for attendees, Share, Store, Extract for self, and Forget.
- A small number of participants stood out from the rest as “power users” due to how frequently and uniquely they used whiteboards and whiteboard photos.

These and other findings are contextualized and expanded in the sections below. Section 4.2 describes participants’ practices around capturing whiteboard content. Section 4.3 describes how participants transferred the whiteboard photo from their cellphones to a location accessible by a laptop or desktop computer before they worked with them. Section 4.4 describes the tasks that whiteboard photos are used in. Section 4.5 describes how whiteboard photos were valued and how that value changed over time. Section 4.6 describes people’s practices around storing and retrieving whiteboard photos, and presents the findings from the memory test about what whiteboard content from a prior meeting people remembered. Section 4.7 summarizes the findings by presenting a general lifecycle model of whiteboard photos. Section 4.8 describes power users and the unique ways in which they used whiteboard photos. The chapter is summarized in Section 4.9.

4.2 Capturing whiteboard content

This section expands more on reported practices around capturing whiteboard content.

4.2.1 Uncaptured whiteboard content

Participants described meetings in which the content written on the whiteboard was not captured. For instance, when the whiteboard content was on a project-related whiteboard such as those in “...a war room, or core team working room” (P12) dedicated to a team project, the content “...just gets left up, because it's the work room, and it's a working session” (P12). Also, sometimes the whiteboard content is deemed not important enough to be captured, such as when “...you're quickly writing something down on the whiteboard, usually it's just to convey a concept to someone so as soon as you are finished with it, it just gets erased or forgotten.” (P1).

4.2.2 Captured whiteboard content

In other meetings whiteboard content is deemed worthy of capture. Commonly, these meetings have produced whiteboard content “... that's specific, and has tasks that you want to go forward with, or decisions that you want to move forward” (P5), and thus important enough to be photographed.

Participants were asked how they capture whiteboard content after (or during) the meeting and all participants reported using their cellphone's camera. They reported typically only taking one photo, but “...sometimes, if [the whiteboard content is] really detailed, of course, you end up taking multiple pictures [of the whiteboard]” (P14). Moreover, typically the person responsible for working with the whiteboard content after the meeting is the only person who takes a photo of the whiteboard. However, sometimes more than one person will take a photo of the whiteboard, such as in a meeting P8 had in which his client also took a photo of the whiteboard content for her records. Also, to mitigate issues with poor resolution, lighting, and

blurriness, in some cases “*whoever had the best [camera] phone*” (P1) captured the content and then sent it to the person who was responsible for working with the whiteboard photo.

4.2.3 Uncertainty around when to capture

The analysis revealed that participants struggled with determining whether whiteboard content was important enough to merit capture. Participants coped with this uncertainty by overcapturing whiteboard content “just in case” it turned out to be useful later. As P11 and P15 explained:

“In some cases, it's almost like a security blanket to take a photo of what happened... I think the 'why' of it is just, again, more for the general security that comes from having that data preserved in some place in case we want to get back to it for whatever reason.” (P11)

“A lot of the time I'll take [a photo of the whiteboard] just to know that I have it, but I don't really need to distill the information, we were all there, we had all kind of knew what we needed to do.” (P15)

Overcapturing, although tedious, appeared to be effective in avoiding a situation where important content was lost due to failure to capture. Evidence for the success of this strategy comes from the fact that no participant reported regretting not capturing whiteboard content that they later realized was actually important.

Some participants were more inclined to overcapture whiteboard content than others. For instance, one participant who reported overcapturing frequently commented that “*Since having this conversation, I'm realizing that I'm not referencing back to them very often [...] You're probably going to teach me here not to bother taking a picture [again]*” (P18). In contrast, other participants overcaptured less, such as P10 who said “*I try to not take pictures if I know I don't need to do something with it*”, and P1 who expressed that “*...we only take pictures of what we*

consider important whiteboards, we don't keep around the other [unimportant content], they just get [left on the board, and eventually] erased".

A consequence of this overcapturing behaviour was that some (sometimes many) whiteboard photos were never used. As P18 expressed *"I'll tell you the truth, I probably use my phone to take a picture of a lot of whiteboards, and I've never looked back on [them]."*

4.3 Transferring whiteboard photos

Before working with whiteboard photos, all participants reported first transferring the whiteboard photos from their cellphones to a location accessible by a productivity-oriented device such as a desktop or a laptop computer. Participants transferred whiteboard photos off of their phones in one of three ways: 1) email to self (most common), 2) auto-synchronize to a personal cloud-based folder, or 3) AirDrop¹⁵ for Mac OSX users. Transferring the whiteboard photo was found to be a significant pain point for participants, as illustrated by the following comments:

"I will love if I could just save [whiteboard content directly] to OneDrive¹⁶. Today I have to send a copy by mail, and from there I have to forward it to the team, as we are big user of OneDrive, if I could just put it there." (P13)

"It would be nice if it was more seamless, because right now I have to remember to take the photo on my phone and post it to Slack¹⁷. Even though that's pretty easy, it's still a non-trivial amount of effort. If this whiteboard has a control that was always signed into Slack, and once you're done with whatever you're

¹⁵ Apple AirDrop is a user-initiated file transfer method between Macintosh computers and iOS devices

¹⁶ <http://onedrive.live.com>

¹⁷ <https://slack.com>

working on, if that's actually what it's saving, I think that would be a step-up. That would be likely to be used.” (P11)

“We might write the JIRA¹⁸ task number on the board [during the meeting] and then that would be perfect if you could make [the photo] attach itself automatically to that JIRA [task], that would be sweet.” (P1)

“It would work great if you could upload your [whiteboard content directly] to the Asana¹⁹ network.” (P5)

In fact, two participants, P5 and P6, used the analogy of the scan-to-email feature on modern photocopiers to describe how captured content should be captured, transferred, and stored:

“If you could hit a button [on the whiteboard to] say, ‘I’m done”, and it captured that...like when you scan to PDF on a multi-function copier [...] That would be pretty cool.” (P6)

“If I were designing [a better whiteboarding solution] I would take today’s functionality that’s on my fax machine or scanner.” (P5)

4.4 Using whiteboard photos

After transferring the whiteboard photo, the primary way in which participants used whiteboard photos was as a reference when creating another document. In addition, a secondary and less frequent way in which whiteboard photos were used was as evidence in case of disagreements. These practices are described in more detail below.

4.4.1 Creating the superseding document

The most common way in which the participants used whiteboard photos was as references when creating another more formal document such as a PowerPoint presentation, a Word/OneNote document, or an email to the meeting attendees. This thesis refers to it as

¹⁸ <https://www.atlassian.com/software/jira>

¹⁹ <https://asana.com>

superseding document, because whiteboard photos lose most of their utility after this document was created (as described in section 4.5).

Whiteboard photos were useful in creating these documents because they served as a memory aid about a discussion participants had during a meeting, and they also provided many details that were difficult to remember, as P10 and P18 explain:

“I can't remember what we decided [during the design meeting last week], so I rely on that drawing to tell me 'these are the requirements'.” (P10)

“I used [the whiteboard photo] mostly to jog my memory...” (P8)

4.4.1.1 How superseding documents were created

Participants reported that they rarely imported the whiteboard photo into the superseding document as they were creating it. Instead, they would typically “...*have the image open on my one monitor, and then [the document] open on the other*” (P7). Two participants also mentioned using a printed version of the whiteboard photo, as illustrated by the comment “*[I] cropped it, framed it, contrast adjustment, printed it as a reference for myself while I was writing the grant application [in Microsoft Word]*” (P6). With both documents open, people then extracted the important content from the whiteboard photo into the superseding document.

The extraction process was more complex than just duplicating the words (and diagrams) found in the photo verbatim in the superseding document, as illustrated by the comment “*I would try to put [the brainstorming ideas] into meaningful categories in Word, because in the raw form [whiteboard photo], they were all over the place, and couldn't really group them. [In the Word document] is where I was able to make meaning of them*” (P7).

Participants reported extracting some or all of the content on a whiteboard photo “...*and then*

build[ing] out more detail [in the document]" (P8) using their memory of the conversations during the meeting.

4.4.1.2 Creating superseding documents was a source of frustration

Two main sources of frustration for people in creating the superseding document from the whiteboard photo were: 1) recreating textual and drawn content into digital form into the document, and 2) knowing when they had extracted all the useful information from the whiteboard photo. Transcribing and redrawing the whiteboard content in the superseding document was a commonly reported pain point *"because it's kind of tedious..." (P19)*

Participants were quick to suggest solutions:

- *"...some kind of quick 'translate to text' maybe that helps, real text ...some kind of recognition on the handwriting. That would be helpful.... you can just copy and paste so they don't have to retype everything" (P9)*
- *"...if instead of typing it all in [the document], maybe if I had interface that said 'okay, that, that, that, that, and that sentence [that was on the board], turn those into [typed] sentences..." (P15)*
- *"[A] pain point I sometimes feel is, for example, if I have to sometimes reproduce that exact same diagram I drew on the whiteboard onto my design document... So I feel like if there was a way where I could just draw a picture somewhere [on the whiteboard], and it can stop and load it into a Visio type of diagram, instead of me going and doing that same thing again on the computer." (P19)*

The second pain point was a lack of confidence that they had extracted all the useful information from the whiteboard photo, as illustrated by the comment *"how do you know when you're done with the picture?...It's a gut feel and a guess that I... yeah, that I think that I've got it all and nobody has complained. By default, I must have gotten it all. It doesn't mean I did. That means somebody hasn't spoken up yet."* (P14). Knowing what has and has not been extracted seemed to be especially challenging when participants were extracting the whiteboard

information over time. For instance, P8 expressed: *"I think the act of synthesizing research data is something that it's an iterative process...I'll look back several times at the [whiteboard] notes and say, "Am I capturing things accurately from our [whiteboarding] session? Am I representing [in the document] what we were talking about and thinking about well?..."* This may be one of the reasons why some participants mentioned that shortly after creating the superseding document, they *"...still want to be able to go back to that photo where I can see if I've missed something..."* (P19). The need for a useful mapping solution was articulated by P14 and P15:

"I would like to have the traceability to say this section [on the whiteboard photo] became this [in the superseding document], this section became that, this section became that." (P14)

"[Let's] say this one [sketch] is covered [in the document]. Okay, when I come back [to the photo], I need to get this one, so star that one [because] I don't want to forget that. I got all of [the whiteboard content extracted] except for this little piece right here. And so being able to sort of annotate and make sure that you have captured it all when you go to do your transcription, it's helpful." (P15)

4.4.1.3 The whiteboard photo as evidence of agreement among meeting attendees

The most commonly reported superseding document created using a whiteboard photo was an email to send to the meeting attendees. The extracted information often took the form of meeting summaries, next steps, or action items. Some participants mentioned that the extracted actions items were usually easy to recognize on a whiteboard photo because they were usually underlined, numbered, starred, dated, or were people's name or initials.

Although some participants reported instances in which they did not attach the whiteboard photo to the email, most participants reported that they did attach the whiteboard photo to the email. This was not because the other meeting attendees needed to work with the whiteboard photo, but because *"...the whiteboard photo is the thing we've all walked away*

saying, 'We're in agreement'" (P14). Thus, the other meeting attendees could use the whiteboard photo to point out inconsistencies between the whiteboard photo and the information transcribed in the superseding document. As an addressee, P8 explained that: "*[if] I'm reading somebody else's analysis or piece of writing that came out of this [whiteboarding] session that I was part of, I want to say like, 'Oh wait, is there anything missing in this piece of writing that my colleague has done that existed in our [whiteboard] note session that needs to be in there or vice versa, like, 'where did this thing come from? I don't remember talking about that.' I might go back [to the whiteboard photo].*" But he (P8) adds that "*I don't think it's as strict as [an] agreement or contract, but having notes on a whiteboard is part of some type of system of shared understanding amongst people.*" Also, it was not typically considered an agreement people could formally agree on, as illustrated by the comment, "*people can't sign off on a whiteboard [photo]*" (P6). This may be because participants typically understood the marks on the whiteboards to be highly contextual, as illustrated by the following comments:

"What you put on the board is a very condensed version of the conversation and many times there are lots of different reasons for why you put something on the board." (P17)

"You speak ten things and you only draw one of them on the board, and you capture only the most important thing, but it's sometimes kind of hard to realize that that one thing that you drew may not represent the entire conversation you had about it." (P19)

"What you have on the board has some context around it, a discussion that's situated in a particular time and you kind of lost that time and all you have left is one word that you thought to take a picture of." (P16)

The contextual nature of whiteboard content is also the reason why participants believed that "*...the whiteboard [photo] on its own would have been of no value to anybody, unless they were in that meeting*" (P10). As a result, whiteboard photos were rarely shared with non-attendees.

4.5 The ephemeral value of whiteboard photos

One of the research goals of this thesis was to determine how people valued whiteboard photos, and how that perceived value changed over time. Participants were asked questions probing the value of their whiteboard photos, such as which whiteboard photos they would want to save if they were about to lose most of their whiteboard photos, and what factors they would consider if they had to go back to every single one of their whiteboard photos and rate them as important, not important, or somewhat important. Many participants said that they would not be interested in saving any of their whiteboard photos, as illustrated by the comments, *“I’d have to go look at what’s in there, but I could probably lose them all”* (P18), and *“I wouldn’t lose sleep over losing my whiteboard stuff, especially if it is older than a week”* (P15). P15’s emphasis on *“...especially if it is older than week”* highlights the strong relationship the data revealed between how recent whiteboard photos were and how valuable participants perceived them to be. By far, the most common criterion participants reported that they would use to determine which whiteboard photos were important and worth keeping was how recent a whiteboard photo was, as illustrated by the following comments:

“I’d just [keep the] most recent [whiteboard photos]... let the other ones die. Just like a PVR, they tend to write over old stuff.” (P5)

“The more recent stuff is more important [...] I guess [a way to organize them] would be maybe chronologically.” (P8)

“I would save the most recent [...] If I go to a whiteboard photo that’s one year old, probably the project that we were discussing, the project about which that photo was, that is probably over by now, so I don’t really care about it. It’s already long gone.” (P19)

“I’d say eight weeks out and [the whiteboard photo] probably isn’t relevant anymore.” (P11)

4.5.1 The superseding document and the value of whiteboard photos

The data revealed that one of the reasons that recent whiteboard photos were the most important was because whiteboard photos were primarily valued on their ability to inform a superseding document, which was created recently after a meeting. Participant comments illustrated this finding, *"Rarely do I find the image itself useful other than transcribing the data. If I haven't done anything with [the whiteboard photo] then it probably didn't have all that much value"* (P15), and *"If [the whiteboard photo] hasn't been carried forward into a future document, [then] it probably wasn't important"* (P4).

The data also revealed that after the *"...information's been lifted..."* (P12) from the whiteboard photo and transferred to the document, the photo loses most of its value, as evidenced by the following comments:

- *"Actual whiteboard notes? Because we translate them into other documents, I guess I could stand to lose them."* (P4)
- *"So once that document is finalized, I can throw away this photo."* (P19)
- *"...as soon as I have transcribed from the picture to the notes, it's gone. The pictures for me was one time, one shot memory."* (P13)
- *"I think most of my whiteboard photos that I have, or have access to, are very low in importance because I'm translating them into a document that has then lived on beyond that. It was just a thing to inform another thing. It doesn't live on its own."* (P7)

Although the latter participant (P7) expressed not caring if she lost all her whiteboard photos, she added, *"I'd be crushed if my [superseding] documents were gone"*. These comments demonstrate that the utility of whiteboard photos decreased significantly after the *"...superior document..."* (P4) had been created.

4.5.2 Ongoing projects and the value of whiteboard photos

Despite the fact that superseding documents often rendered whiteboard photos obsolete, for some people, whiteboard photos were still worth keeping if they were part of an ongoing project, as illustrated by the following comments:

- *“But if there's any photo and the project with which that photo is associated is still in progress, I would definitely want those to still be accessible at least until the project is over.”* (P19)
- *“[I would keep] the ones we're currently engaging with a client on a project and it's not finished...”* (P16)
- *“The 5% [that I would keep] would be [the whiteboard photos] that I am working on right now, something cooking for something in the future. But the [other] 95% would be [photos] from a project in the past which I don't think I would use again...If the project's completed, most likely I won't touch [the whiteboard photos] again.”* (P9)
- *“If we already shipped [the product], the whiteboard [photo] matters a lot less.”* (P11)

Moreover, the completion of a project marked the end of the useful life of whiteboard photos.

However, for a few participants, the terminal value of whiteboard photos after the end of a project consisted of the rare possibility that external parties, such as auditors, might want to *“...look at our notes to say ‘Okay, they are meeting regularly, they identify issues and things like that’”* (P3), or lawyers in the case of intellectual property disputes *“If we're on a software and somebody were just saying, ‘You stole my invention, this is my intellectual property, I patented that idea’ ‘Really? Okay, no, here, I can show you our whiteboard picture’”* (P14). Nevertheless, both P3 and P14 reported that these situations had yet to happen.

4.5.3 Some whiteboard photos were special

Some participants described a whiteboard photo that was particularly important to them and they would be devastated if they lost it while a project was active. These highly valued photos tended to be the result of extensive group work not documented anywhere else, as evidenced by the following comments:

“What we come up with in the meeting is a result of a really in-depth hour long conversation about this particular element of the interface. In a week from now, I've forgotten that conversation, but the interface shows the thinking. I really need to make sure that in that meeting a week later, I've got that drawing, because I can't remember a word we said, but the drawing is what we need to be building. I need to make sure that what got built is what's in that drawing.” (P10)

“Well, I'm just thinking of a particular project but where it's just like so much content and it's basically like the report on like five different whiteboards we did a series of interviews and there were sticky notes everywhere and we took photos of the sticky notes, and you know the whole team effort thing, I wanted to capture all the notes and also capture the essence of what was happening because it was a big deal at that time within the company.” (P17)

“It's the amount of effort and detail that went into creating them. The ones that I would say that is three pictures concatenated together to make one whiteboard that's a classroom-sized whiteboard. We spent probably four hours brainstorming...if I lost that, because we have not completed that, that's another point, we're not finished with that, if I lose it, I would be very remorseful.” (P14)

“...we were working on [product name], the one you saw with like the 20 versions... or this [other photo with a] really complicated UI that took an hour or more to draw, if we had lost that in the middle [of the project]...that would have been catastrophic.” (P1)

An analysis of the quotes above revealed that these “special” whiteboard photos had the following common characteristics:

- They were dense with ink (lots of detail)

- They contained graphical elements (i.e., sketches and illustrations, not just hand-written words)

These special whiteboard photos also tended to come from meetings which had the following common characteristics:

- They were lengthy, often lasting several hours
- Several people wrote on the whiteboard
- For the purpose of creation or ideation (as opposed to explanation or note-taking)

These special whiteboard photos were consulted regularly and retained significant value throughout the life of the project, as P8 explained: *“When notes on a whiteboard are created as part of some type of analysis or synthesis of a research study, for instance, then I tend to go back to it many more times than just once”*.

4.6 Management of whiteboard photos

This section details the findings on how participants reported that they managed whiteboard photos, such as the locations where they stored, and how they were retrieved and eventually discarded. The findings from the recall memory task are also presented.

4.6.1 Personal and shared storage locations

The interview data revealed that participants owned several duplicate copies of the same whiteboard photos across several storage locations. These storage locations were more commonly personal than shared. The top three personal storage locations reported by participants were the camera roll in a cellphone, email, and cloud-based folders. The camera roll became a storage location as a result of capturing whiteboard content. Email became a

storage location as it was the most common way participants transferred the photo off of their cellphones (email to self), and the most common way whiteboard photos were shared with attendees. Most personal cloud-based folders became a storage location automatically, as participants reported that their cellphone's camera roll automatically uploaded all their photos to the cloud. Additionally, a few participants, such as P6, P10, and P14, also mentioned printing some whiteboard photos and placing them on their desks or pinning them up on their desks. Only one participant, P17, would sometimes add whiteboard photos to his Evernote.

In addition to personal storage locations, whiteboard photos were sometimes stored in shared locations. Storing to a shared location typically occurred after an email had been sent to the attendees. The most commonly reported shared storage location was a folder, either on a network drive or a cloud service such as OneDrive. Less commonly, important whiteboard photos were sometimes stored in collaboration tools such as JIRA (P1, P2, P15)—where they were attached to tasks—and Slack (P11)—where whiteboard photos were uploaded to a dedicated whiteboard photo channel such as “#design_whiteboards”.

Shared and personal folders were usually “project” folders, but it varied depending on the nature of the business. For instance, participants who worked in consultancies used “client folders”.

4.6.1.1 Naming conventions

The interviewer was able to observe the folders of a few participants where whiteboard photos were kept. This revealed that when whiteboard photos were added to folders, people sometimes renamed the file from the arbitrary filename created by the cellphone image software, to a name with meaningful metadata. As P7 stated, “*It can't just be 'Image 07196'.*”

Some participants also described their naming process, as illustrated in the following comments:

"I find that for me I try to name them more carefully...so maybe the name of the file starts with the date, include briefly what the feature [being designed] was for, and something else like "01" or something [if there's more than one photo]." (P2)

"I'll date them the day they were created. I may have some notation in the title about the subject matter but that's as best as it can get." (P8)

The typical naming convention included the meeting date and a few words describing what the whiteboard content or the meeting was about. A third less common metadata was a suffixed number to differentiate whiteboard photos from the same meeting.

A reason why people invested time in renaming whiteboard photos in folders was because browsing through them was difficult, even when there were few photos. The few project folders the interviewer was able to observe were set to the default "list" view, and the thumbnails were not visible. Getting the thumbnails to show was problematic in some cases, such as for co-workers P2, who said *"That's another problem with trying to get the tiles view...this shared drive is actually in Toronto, so it's a little bit slower... it's basically downloading all the picture to generate [a thumbnail]"*, and for P3, *"I never even thought to use that. I'm curious though. How do you even get to the thumbnail [view]?"*

A few participants suggested solutions to aid the renaming of the filename of whiteboard photos, such as P9 who said, *"Just the ability at the moment when it exports out as a photo, that you must name it something. It can't just be image 07196....and then the date is automatically attached ...That would be much more helpful."* Some participants had even more elaborate suggestions such as automatically naming the file by extracting the title from the *"the*

subject of the [meeting] invite" (P10), or from the whiteboard content itself if there was a title and it was "*double underlined*" (P6).

Nevertheless, consistent with the short-term way in which people used and valued whiteboard photos, people did not expect to retrieve whiteboard photos from these storage locations in the long-term, as P12 explained, "*the whiteboard capture isn't something that I go [to]. That's not my long-term repository for information. That's the rough idea generation that inputs into something else*" (P12). The short-term nature of whiteboard photo retrieval is discussed in the following section.

4.6.2 Retrieval

Consistent with the previous finding that whiteboard photos were primarily used in the short-term after a meeting to create a document, long-term retrieval of whiteboard photos was not reported to be a pain point for most of the participants. This was not because people kept great archives, but because whiteboard photos were rarely retrieved in the long-term, as illustrated by the following quotes:

"I don't really use a photo I took two months ago or something, usually it's just within a week" (P19)

"I really go back [to the whiteboard photo] only 1 or 2 days [after the meeting]". (P13)

"If you were to ask me 'where's the whiteboard from three months ago?' That would be a little more challenging [than finding a recent photo]. That's not usually a scenario that I would do." (P12)

"I would say it's not likely that I'm going to go back and look at something that's much more, for this kind of reference, more than three to four weeks old." (P11)

Retrieval of whiteboard photos was mainly in the short-term. This made whiteboard photo retrieval a trivial task given that “...it would be a recent photo...” (P12) in people’s cellphone’s camera roll, or an attachment to a recent email in people’s inbox. Another reason is that people do not have a great number of whiteboard photos, as reported below:

“We haven’t generated that many [whiteboard photos] yet. We’ve done eight or nine [whiteboard photos] this year, so even if we kept working at a tortoise pace, I don’t feel like that’s a particularly huge scale challenge.... [Problems with retrieval are] going to happen eventually, but right now we just don’t have enough of those [photos] that I’ve had an issue” (P11)

“I went back and tried to look at how many [whiteboard] pictures I actually have and surprisingly I have very few...” (P15)

“I may take a picture of the board, maybe 10 [per] month? It’s not like I have a huge quantity of pictures.” (P13)

Long-term retrieval of whiteboard photos was not common also because more typically participants would go back to the associated superseding document, as reported by the following comments:

“If I have sent my notes, I will go back to the notes. If I haven’t sent [them], I will go to the picture...Once I send my notes, done! I don’t go back [to the whiteboard photo].” (P13)

“[The whiteboard photo is] the rough idea generation that inputs into something else, [and] once the information’s pulled, you wouldn’t go back to the whiteboard [photo].” (P12)

Retrieving the whiteboard photo in the long-term, as P15 described it, was “... the last resort because then you get this thing that you have to go back to, and [once you find it] it’s hard to piece it together”. While the majority of the participants did not report that long-term storage and retrieval of whiteboard photos were pain points, a small number of users (power users) reported the contrary, as described in section 4.8.

Consistent with the findings that retrieval was predominantly short-term, recalling the meaning of content in a whiteboard photo was not a reported pain point. However, participants reported that occasionally there would be content on the whiteboard photo they could not understand its meaning. This typically occurred with one or more illegibly hand-written words by another meeting attendee.

4.6.3 Whiteboards photos are forgotten, not deleted

Despite the fact that most whiteboard photos that people have are not recent and thus no longer valued, people did not actively delete them. Instead, after their useful lifespan had expired, whiteboard photos were passively discarded by being forgotten about in the locations where they were originally stored, as illustrated by the following comments:

"I guess, [it's] mostly just sitting there [in an email]...Once my design document is finalized, I just forget about the [whiteboard photo]..." (P19)

"I will say okay, you know 'I might want that [whiteboard content] later' and so it just sits up there in my personal One Drive." (P15)

"It will probably just stay in a folder." (P6)

"You just kind of forget about [the whiteboard photo], or have misplaced it..." (P5)

One of the reasons people did not delete whiteboard photos was because, as P6 explained, "...we have lots of computer memory so I don't feel the need to delete it." The data also suggested that digital clutter was less bothersome than paper clutter because it was less visible, as evidenced by the way in which printed copies of whiteboard photos were discarded even when whiteboard photos were not. As P14 explained, "*It's printed out. Eventually, it depends on if you're a hoarder or not, most people will [throw it out], I'm trying not to [be a hoarder]. I'm trying*

to throw it away. I don't need it. I've gone to that next level." However, P14's corresponding digital whiteboard photos were kept.

The only digital storage location from where participants routinely deleted whiteboard photos was the camera roll on their cellphones. Participants explained that it was inconvenient to keep whiteboard photos from work on their *personal* phone, as illustrated by the following comments:

"[the whiteboard photo] just sits there until you purge the whole photo archive, and work [photos] is the first stuff to get ripped off because it's your personal stuff on your personal phone." (P6)

"I clean out my phone constantly, and we [at our consultancy] have a pretty strict security policy of doing that, so I can't keep [client-related information] on my phone." (P7)

"Once it's in Slack I know it's safe, and my phone is not my work phone, it's my personal phone, so I don't like having a ton of work data on it...My phone is not a better archive than Slack." (P11)

Other than deleting whiteboard photos from their cellphones, no participant ever mentioned engaging in periodic clean-ups, archiving for easy long-term retrieval, or maintenance of their whiteboard photos in the other storage locations.

4.6.4 What do people remember well about whiteboard meetings?

As part of the study's original aim to understand usage practices around whiteboard photos, it is also useful to understand what people recall about their stored whiteboard photos, to help inform the design of potential retrieval aids.

To retrieve a document, one typically has to remember some content or context to guide the retrieval. But what is it that people easily remember about whiteboard photos or the

meetings in which they were created? This question was investigated with the six interviewees who had previously participated in a meeting four months prior. Participants were asked about several characteristics of the whiteboard content and the associated meeting. The accuracy of their recall memory was verified using video and data from the prior meeting (as described in the previous chapter). Table 2 shows the characteristics that were well remembered while Table 3 shows the characteristics that were not well remembered.

Easily recalled characteristics
Meeting room
Topic of meeting
Meeting attendees, although people struggled to recall all the attendees when the meeting had over 8 people
Attendees who drew on the whiteboard

Table 2. Easily recalled characteristics.

Characteristics difficult to correctly recall
What colours markers were used on the whiteboard
Parts or quadrants of the whiteboard used
Major or complete erasures of the board during the meeting
Density/percentage of the whiteboard used
Who the photos were shared with after the meeting (if shared at all)
People remembered fairly confidently whether or not diagrammatic content (non-text sketches) had been written on the whiteboard, but could not remember what these sketches were about or what they looked like

Table 3. Characteristics difficult to correctly recall.

These data show that participants easily remembered most characteristics of the four-month old *meeting*, but not characteristics of the *whiteboard content*. The characteristics that participants easily remembered about the meeting were not specific to the whiteboard (e.g.,

meeting room and attendees). The only whiteboard-specific characteristic that was well remembered was who had drawn on the whiteboard during the meeting.

The above recall was typical among all but one of the six participants, P8, a Principal UX Researcher who had been trained as a designer and self-described as a very visual thinker. P8 could recall a significant amount of characteristics of the whiteboard content from a meeting four months prior. He was, in fact, able to ‘wireframe’ the rough spatial layout of the whiteboard content, as shown in Figure 5.

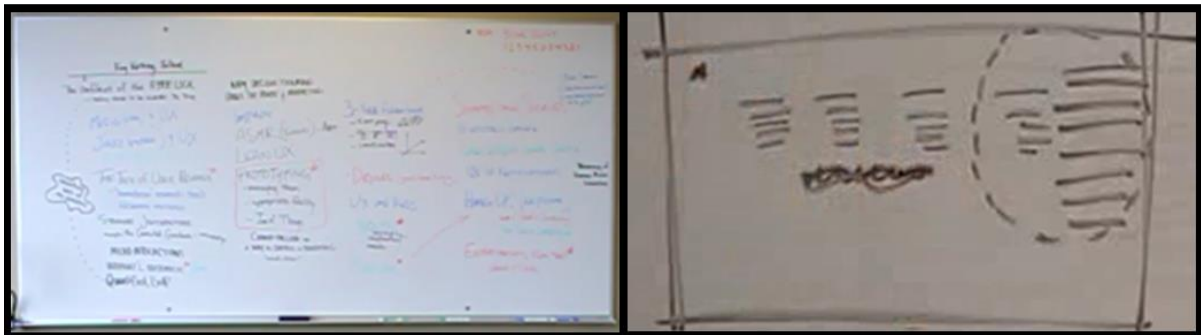


Figure 5. Whiteboard content from the meeting (left), and P8’s recall of the spatial layout of that content drawn during the interview (right).

P8 explained that “...it’s frequent that I’ll have an idea in my mind about what the whiteboard looked like from a 10,000-foot level like, ‘Oh, I remember there were three columns here, then there was an illustration here, then there was a bunch of sideways writing down here.’” He added that, “having a picture-like search would be helpful for me... If I had to describe it in any more detail than that [wireframe], then the [picture-like] search would not be productive” (P8).

4.7 Lifecycle of whiteboard photos

One goal of this thesis was to better understand the lifecycle of whiteboard photos. As described in Section 3.4.2.1, lifecycles diagrams were created illustrating the capture and use process

described by each participant during the interviews. These lifecycles were analyzed for common patterns. This analysis revealed that whiteboard photos generally go through a seven-stage lifecycle, as shown in Figure 6, and described below:

Capture: All interviewees reported capturing whiteboard content with a photo using a cellphone, as described in section 4.2.

Transfer: After capturing, all interviewees reported transferring the whiteboard photo out of the cellphone to a location accessible via a desktop computer or laptop, as described in section 4.3. The most common practice was to email oneself. Participants rarely shared the whiteboard photos from their cellphones with others. In fact, cellphones were used primarily to capture whiteboard content and to transfer it to another location. The remaining four stages occurred on a productivity-oriented device such as a desktop or laptop computer.

Extract for attendees: The most commonly reported action taken after transferring the photo was extracting its information into a superseding document, as described in section 4.4. This document was almost always an email which was later sent to the meeting attendees (next stage), indicating that the extracted information was oriented towards team coordination (e.g., summarizing meeting outcomes, and action items). Less commonly, the information was extracted into a word processor such as a Word Document.

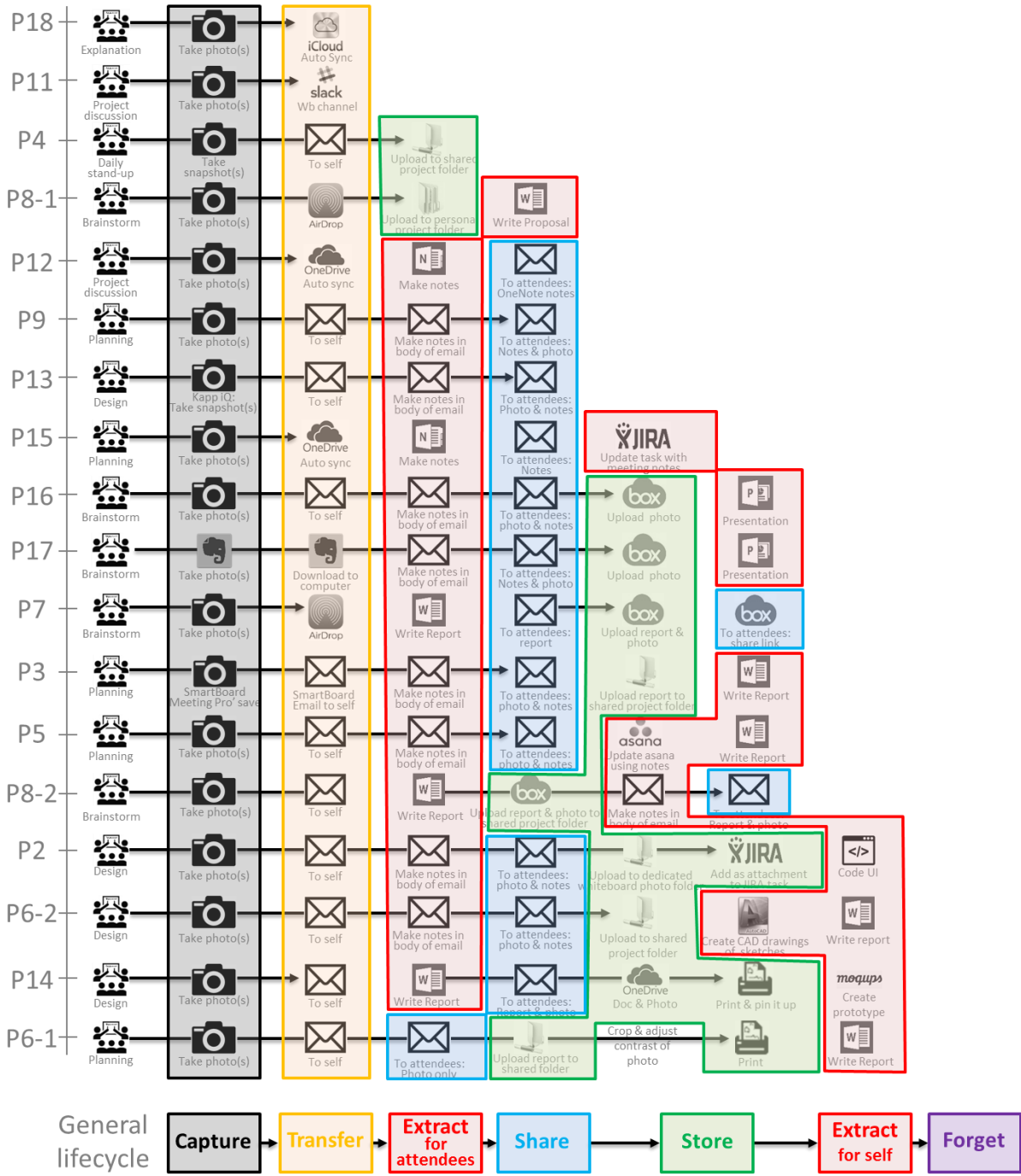


Figure 6. General lifecycle of whiteboard photos. *Note:* The two lifecycles described by P1 and P10 will be described in detail in the next section (4.8) and are excluded from this figure.

Share: After extraction, the most common action participants reported taking was sending an email to the meeting attendees with the extracted information. When the extracted information (in the previous stage) was in the body of an email, the whiteboard photo was almost always attached. However, when the information was extracted to a word processor (in the previous stage), the word document was typically attached to the email, but not the whiteboard photo.

Store: After sharing, the most common action participants reported taking was storing the whiteboard photo, typically in a shared project folder, as described in section 4.6.1.

Extract for self: After storing the photo, the most common action participants reported taking was once again extracting information from the whiteboard photo (e.g., to a PowerPoint presentation or a Word document, but rarely an email), as described in section 4.4. The extracted information at this stage was generally for the purpose of individual work activity.

Forget: While not explicitly an action that participants mentioned when describing the lifecycles of whiteboard photos, the interview data revealed that the last stage was inaction to discard the whiteboard photos, as described in section 4.6.3.

4.8 Power users

The data revealed that two participants (P1 and P10) stood out from the rest as “power users” of whiteboards and whiteboard photos because they:

- Regarded the whiteboard as a critical tool in their daily work
- Their whiteboard content sometimes contained mission-critical information
- Used whiteboards and whiteboard photos frequently
- Had developed processes over the years for dealing with whiteboard photos

- Used whiteboard photos in unique ways

Some of these five behaviours also applied to a few other participants such as P8, and P13, a few these five behaviours applied to other participants such as P11 and P15, and none of these behaviours applied to participants such as P7, P5, and P18. This suggests that there was a continuum of power users.

These five behaviours are expanded below, using as examples P10, the CEO of a boutique UX research and design consultancy, and P1, a senior software engineer at a company that develops solutions for transportation.

4.8.1 Whiteboards are a critical tool for power users

Whiteboards were not just a note-taking surface, but a key tool in the design, development, and management of a product, as P10 explained:

“To me, that whole creative process [on the whiteboard] is really, really important. I try even not to erase. Sometimes I erase on the board, but a lot of cases I don't. I just scribble and do an arrow, because to me where we've been and where we're going is a really important part of the way I think, anyway, that creative process... If I kept erasing and going over top of it, you never see where you've come from.” (P10)

Moreover, in the background questionnaire, P10 and P1 (along with seven other participants) rated the whiteboard as “Extremely important”, in answer to the question “For me, having a whiteboard is” (Figure 7).

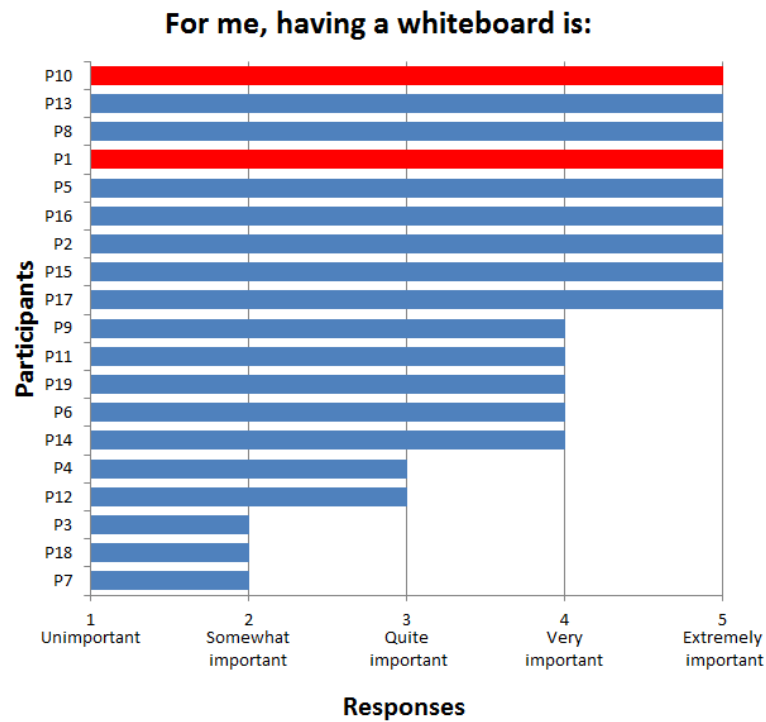


Figure 7. Participant responses to the questionnaire question “For me, having a whiteboard is”. Data for P10 and P1 are coloured in red.

4.8.2 Whiteboard content can be very important for power users

What power users write on whiteboards can become very important by the end of a meeting. For instance, when talking about a list of features P1 (and his team) wrote on a whiteboard during a meeting, he said “...if we lost that list [on the whiteboard photo] we might have forgot to put features in the software, that’s how important it is.” This is in stark contrast to non-power users, like P5, who commented, “honestly, I don’t think anything written on a whiteboard is really ever too important.”

4.8.3 Power users used whiteboards and whiteboard photos frequently

Power users reported using whiteboards frequently. As P10 stated, *“I use the board a lot in meetings...I'm a very visual person”*. This is in contrast to non-power users, such as P7, who reported not using whiteboards frequently, *“I don't tend to use a whiteboards...I don't think visually. I think in words, [and] writing words on a whiteboard isn't as affective for me.”*

Further evidence comes from the background questionnaire. In response to “Generally I use whiteboards”, P10 was one of only five participants who responded “Multiple times per day”. As shown in Figure 8, the most common response to this question was “Multiple times per week”. Likewise, when asked specifically about using whiteboards collaboratively, like in meetings (“Generally, I use whiteboards *with others*”), P10 was one only of three participants who responded “Multiple times per day”. As shown in Figure 9, the most common response to this question was also “Multiple times per week”.

Although P1 did not report using whiteboards as frequently as P10, he nevertheless used them frequently. In response to “Generally I use whiteboards”, P1 was one of seven participants who responded “Multiple times per week”, the most common answer to this question, as shown in Figure 8. Likewise, when asked specifically about using whiteboards collaboratively, like in meetings (“Generally, I use whiteboards *with others*”), P1 was one of six participants who responded “Multiple times per week”, also the most common answer to this question, as shown in Figure 9.

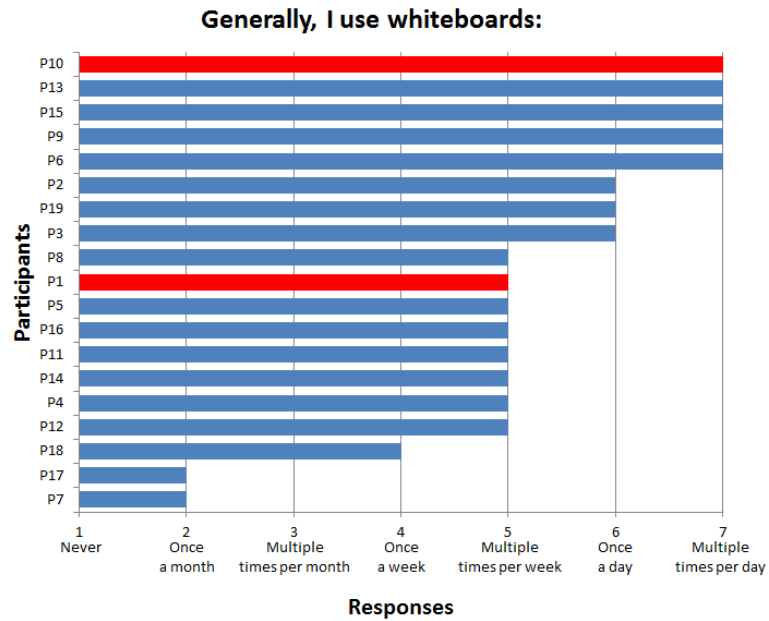


Figure 8. Participant responses to the questionnaire question “Generally, I use whiteboards”.

Data for P10 and P1 are coloured in red.

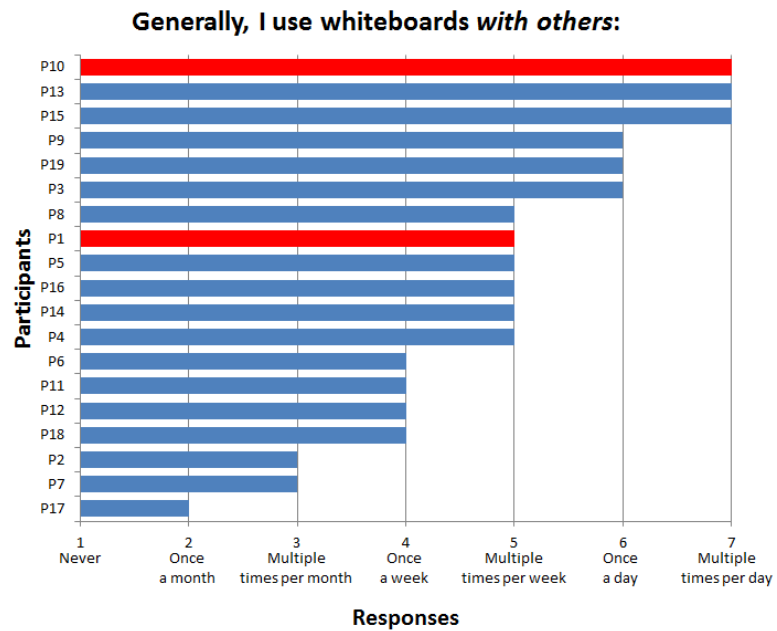


Figure 9. Participant responses to the questionnaire question “Generally, I use whiteboards

with other”. Data for P10 and P1 are coloured in red.

Moreover, power users reported frequently taking whiteboard photos and frequently revisiting them. In the background survey, in response to “I capture whiteboard content”, P10 was the only one who responded “Multiple times per day” and P1 said “Multiple times per week”, as shown in Figure 10. Also, in response to “I return to whiteboard content I’ve captured from a whiteboard in the past:” both responded “Multiple times per week”, as shown in Figure 11.

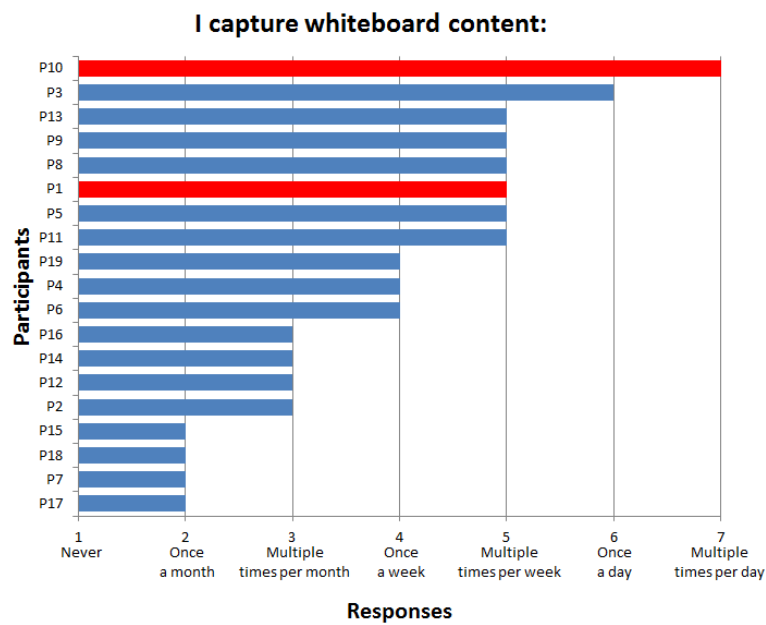


Figure 10. Participant responses to the questionnaire question “I capture whiteboard content”. Data for P10 and P1 are coloured in red.

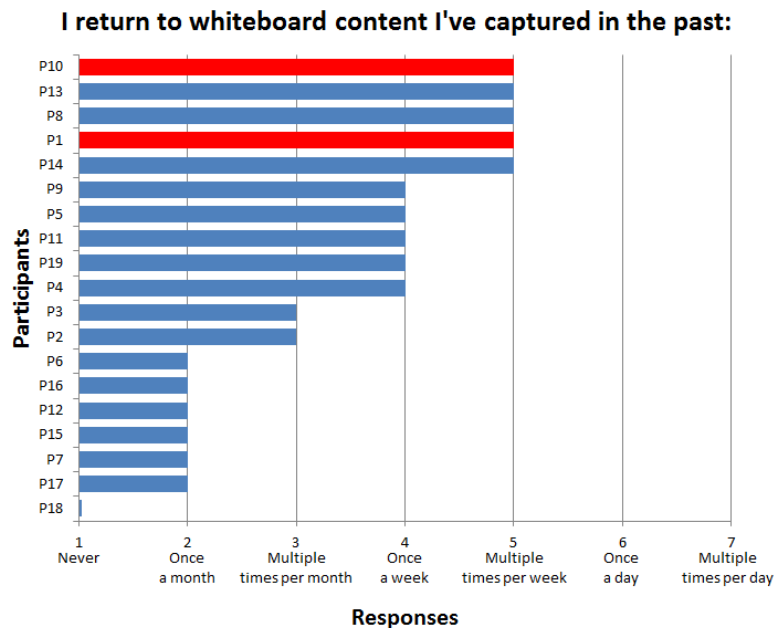


Figure 11. Participant responses to the questionnaire question “I return to whiteboard content I’ve captured in the past”. Data for P10 and P1 are coloured in red.

4.8.4 Power users have developed processes over the years for dealing with whiteboard photos

Power users reported having created processes for managing whiteboard photos. P1, for instance developed a storage “hack” because he used to struggle to retrieve whiteboard photos. P1 and his team used to attach whiteboard photos to tasks in JIRA, a bug and issue tracking software which is popular amongst agile software development teams. But this practice made it difficult for P1 and his team to retrieve whiteboard photos, as he explained, “...generally we find the JIRA task and then it would have the attachment [whiteboard photo], but if we were looking for a specific [whiteboard photo] attachment and maybe we didn’t know what JIRA task it was attached to, we would probably never find it...”. To make it easier to retrieve whiteboard photos, P1 and his team developed a practice whereby for every whiteboard photo they attached to a

JIRA task, they also had to store a copy in a shared folder on a network drive. P1 and his team referred to this dedicated whiteboard folder as “the backup folder” created to be “...a failsafe for when you forget to link it [in JIRA] or you can't find the task [in JIRA] you are looking for... it's kind of like a backup almost. If someone forgot to attach [the photo to the JIRA task] or you can't find it, you can look in there.”

P10 explained that the way she used to capture whiteboard content has “...really evolved...” over the years. Like most of the participants, P10 “... would take a picture of the whole thing...Then I would go back [to my desk], and then I would email it [the photo] to myself...” But unlike most of the other participants, she adds “I'm more efficient with my drawings now” because she is “...thinking ahead as to what I'm going to do with that image now, way more than I used to....now I'm much more aware of that [photo] as an output when I'm doing my whiteboarding.” So “when the meeting's over, I'll just sit and clean up the board... I will redraw the diagram... maybe even adding a few notes right onto the whiteboard after the meeting... I'll erase the stuff around it so I can get a better picture right here, so I don't have to do it [later] in Photoshop. Then what I would do is, usually take pictures in small pieces, because often there may be like 10 thoughts on the whiteboard...as separate conversations, or separate decisions, or separate processes.”

4.8.5 Power users used some whiteboard photos very differently

For power users, some whiteboard photos are more than just a reference document to create a superseding document, or a piece of evidence. For instance, P1 described one special whiteboard photo that became the project's status tracker, despite that P1 and his team used JIRA, a professional project tracking tool. As P1 explained, this whiteboard photo contained a

“...list of [twenty-two] features that we were going to put in a product that we’ve probably looked at every day for 6 months, going through the list and crossing things off of it...digitally, like open it in Paint and put a line through it...or add stars to it as priorities change.”

Every time P1 or his team digitally edited the whiteboard photo, they would “...create backup copies, you would just copy [and paste] the Paint picture [file] and rename it.” At the time of the interview, there were nine versions of this whiteboard photo with the same description but different date in the name of the file to demark when the version was created. The unusual use of this whiteboard photo created the unusual need for revision control, as P1 described, “...if we could have our ultimate system, there would be something that could track revisions on the image, so you could look back and say ‘Show me what this [whiteboard photo] looked like six months ago or three months ago, what changes have happened to it’, and that kind of thing.” The lifecycle of this whiteboard photo is depicted in Figure 12.



Figure 12. Lifecycle of a whiteboard photo described by P1.

P10 also described using whiteboard photos in a unique way. Instead of using the whiteboard photos *a reference* to create a document like the other participants typically did, P10 reported frequently importing them into the document itself as actual document content, as she described, “Let’s say I’m working on a big deck of something that I’m going to present to the company...I was leaving my actual whiteboard drawings in the PowerPoint...instead of a PowerPoint diagram or a Visio diagram...because it [the whiteboard photo] had a better impact I

found...it was more creative looking, and more interesting looking, and just sort of more engaging, because it was different.”

As P10 explained “*I could [have] probably turn[ed] that into a Word doc with a whole bunch of words, but that’s not how I work. That picture really [did] tell a thousand words for me.”*

The lifecycle of this whiteboard photo is depicted in Figure 13.

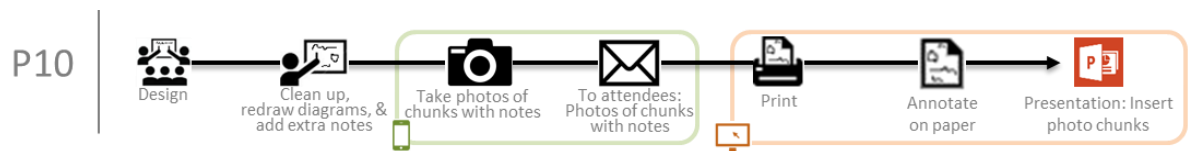


Figure 13. Lifecycle of a whiteboard photo described by P10.

4.9 Chapter Summary

Nineteen participants who were regular users of whiteboards were interviewed to uncover how they used, valued, and managed whiteboard photos. The findings presented in this chapter revealed that whiteboard photos were used primarily to create a superseding document, and secondarily, as evidence of agreement between meeting attendees. Given that whiteboard photos were used primarily in the short-term, they were perceived as most valuable when they were recent. Moreover, long-term memory of whiteboard content was poor, although participants rarely retrieved them in the long-term anyways. A few special whiteboard photos were highly valued throughout the life of a project because they tended to be the result of extensive group work not documented anywhere else. Analysis of the reported lifecycles of whiteboard photos revealed a general seven-stage lifecycle. Finally, a few participants stood out as “power users” due to how frequently and differently they used whiteboards and whiteboard photos. The following chapter discusses the implications of these findings.

Chapter 5

Discussion

This thesis investigated post-meeting use of whiteboard photos by interviewing whiteboard users. This chapter discusses the findings in the context of the literature reviewed in Chapter 2 on whiteboard studies, meeting records, and information management of personal photos. It begins with a discussion of the transitions whiteboards photos support. Then, it discusses the findings in relation to the literature on meeting records. It continues with a comparison of whiteboard photos to personal photos. Finally, design implications and the limitations of the study are discussed.

5.1 Whiteboard photos support work transitions

Section 2.1.2 detailed Tang et al.'s (2009) study of whiteboards that identified three types of transitions (i.e., function, temporal, and collaborative) that allowed users to seamlessly switch between related sets of tasks. In this research it was hypothesized that these transitions also occurred when the whiteboard content was captured with a photo. The findings presented in the previous chapter not only confirm that these transitions occur, but also reveal how they occur, as discussed below.

5.1.1.1 Functional transitions

The literature was inconclusive as to whether whiteboard photos enable functional transitions, that is, whether the content on the whiteboard takes on a different function after it is captured through a digital photo. One of the reasons was that previous work had not investigated in-depth how people use whiteboard photos, thus making it difficult to compare the functions whiteboard photos support to the functions whiteboards support. The findings from this

research provided evidence that functional transitions do indeed occur. While participants commonly reported using whiteboards during a meeting for activities such as brainstorming, planning, and explaining, this research found that after a meeting, whiteboard photos were primarily used by the study participants to aid the creation of another document. In other words, during meetings, the general function whiteboards supported was content *creation*, while after a meeting the general function whiteboard photos supported was content *extraction*. Another functional transition occurred from the fact that participants reported reaching an agreement after collaborating on a whiteboard during a meeting, while after the meeting, whiteboard photos were used as evidence of such an agreement.

Branham et al.'s (2010) whiteboard studies found that functional transitions occurred on whiteboards when people who serendipitously encountered un-erased whiteboard content "...at different times, under different circumstances..." (p. 79) derived new insights or re-used the content in unanticipated ways. However, this research found no evidence of such serendipitous encounters with whiteboard photos, most likely because it is difficult to accidentally encounter a whiteboard photo that is stored digitally. Whiteboard content in a photo is not as persistently visible as un-erased content on a whiteboard and unless users make a purposeful effort to retrieve and open the whiteboard photo, it is unlikely that they will unintentionally encounter the content.

In relation to transitions, the findings from this research expand on Cherubini et al.'s (2007) findings by showing that whiteboard photos supported the transition from low effort drawings (i.e., transient and reiterated) to high effort drawings (i.e., rendered, archival). That is, the participants in this study captured low effort whiteboard drawings with a photo which they later used when digitally rendering the drawings in a superseding document. Moreover, the

findings on special whiteboard photos (section 4.5.3) suggest that an indicator of how likely whiteboard drawings were to turn into an important drawing that was later rendered depended on how much effort people expended during a meeting to create that drawing. The longer the meeting was, the more attendees who contributed to the whiteboard, and the more the meeting was for the purpose of ideation or creation, the more likely that the drawings became very important and were later rendered digitally after the meeting.

5.1.1.2 Temporal, collaborative, and spatial transitions

Whiteboard photos supported temporal transitions from synchronous work (during the meeting) to asynchronous work (after the meeting). Klokmose et al. (2013) speculated that "...photographing the content of a whiteboard for later remediation may be a disservice to one self, because knowing that the content is persisted safely induces a reluctance to actually deal with it" (p. 52). This research did not find any evidence for this claim. In fact, the findings of this research revealed that the temporal transition was short-term, that is, interviewees worked with whiteboard content fairly recently after a meeting, sometimes within the same day.

Although it was hypothesized in the literature review that whiteboard photos supported collaborative transitions between group work in the meeting and independent work after the meeting, the literature lacked evidence of how this happened. The findings showed that usually only one person takes a photo of the whiteboard content, and individually creates a superseding document. The findings also showed that after the superseding document is created, another collaborative transition may occur from independent to collaborative work. This transition is facilitated by the worker sharing the superseding document and the whiteboard photo with the original meeting attendees who may then use the photo as a form of evidence of agreement to settle a dispute.

Whiteboard photos also allowed people to work at different locations (conference room, and desks). This fourth transition did not apply to Tang et al.'s (2009) study of traditional whiteboards for two reasons. First, traditional whiteboards are normally fixed in place and cannot be moved. Second, traditional whiteboards do not support remote collaboration due to their analog nature so contributors must be co-located. In other words, the time-workstyle matrix used by Tang et al. (2009) to categorize whiteboard tasks fails to capture the fact that the post-meeting tasks that whiteboard photos enable typically happen in a different place (e.g., people's desk or cubicles) than where the meeting occurred (e.g., conference room).

5.2 Whiteboard photos as a meeting record

The way participants described extracting information from whiteboard photos to create superseding documents resembled the information *salvaging* behaviour described by Moran et al. (1997; section 2.1.7). Like audio records, the content of whiteboard photos was not easily consumable, which forced people to engage in this salvaging activity as an active process of sense-making that is more involved than mere information consumption.

Consistent with Jaime et al. (2004), this research found that whiteboard photos were a general meeting record that was used to support group activities. For instance, whiteboard photos served as evidence of mutual agreement which could be used to settle disputes between team members arising from later interpretation of meeting outcomes. Although whiteboard photos were typically taken by one group member with a personal cellphone, the photos were perceived by participants to be collectively owned by the group and served as group memory. As a result, whiteboard photos were often shared through email with meeting attendees and stored in shared locations such as team project folders. Unlike a personalized redrawing of a diagram in a notebook by a meeting attendee which is subject to recopying errors, the

photographic medium of whiteboard photos was well-suited as a consensual evidentiary record because it is less biased.

However, whiteboard photos also supported activities normally supported by personal meeting records. For instance, Whittaker et al. (2006) found that personal meeting records were used “to provide enough contextual information to carry out personal actions” (p. 7) and this research found that a key personal action that whiteboard photos enabled was creating a superseding document. Moreover, consistent with Whittaker’s finding that personal meeting records were used “to check the accuracy of the minutes” (p. 7), this research found that whiteboard photos were used to check the accuracy of superseding documents. Finally, similar to personal meeting notes (Khan, 1993), whiteboard photos were found to be most valuable in the short-term.

5.2.1 Recall of whiteboard content

Consistent with Jaime et al.’s (2004) findings, the results from the memory recall task showed that interviewees recalled general characteristics about a meeting four months prior, such as the topic of the meeting, the meeting attendees, and the location of the meeting (section 4.6.4). The findings from this research add to Jaime et al.’s work by showing that most interviewees did not recall characteristics of whiteboard content that was created during those meetings (section 4.6.4). The only whiteboard specific-characteristic that interviewees remembered was who had written on the whiteboard. In a way, however, this is just an extension of them having remembered the meeting attendees, which is, again, a general characteristic of meetings. The implications of these findings for retrieval of whiteboard photos are discussed in section 5.5.

5.3 Whiteboard photos are different than personal photos

Despite the fact that whiteboard photos and personal photos share the same photographic medium, this research found that whiteboard photos were valued differently than personal photos. For instance, people's archives of personal photos were perceived to be very important and irreplaceable (Petrelli et al., 2008; Whittaker et al., 2010), whereas this research found that many participants did not care if they lost their whiteboard photos after they were replaced by another document. Moreover, this research found that whiteboard photos were most valuable in the short-term (i.e., days to a few weeks), their value quickly faded, and they became obsolete when the project ended. In contrast, previous research has found that personal photos are valuable in both the short-term (e.g., to show friends photos of a recent vacation) and in the long-term, and may increase in value over time (e.g., baby pictures and photos of ancestors; Petrelli et al., 2014). This difference in how whiteboard photos and personal photos are valued may be due to the fact that personal photos have affective informational properties (i.e., sentimental value; Whittaker, 2011; Petrelli et al., 2014) whereas this research found that whiteboard photos rarely had affective properties. Instead, whiteboard photos commonly had actionable properties.

This research also found that whiteboard photos were managed differently than personal photos. Although personal and whiteboard photos were captured with a cellphone, a personal device, this research found that whiteboard photos were considered a *work* artefact and people strived to keep them separate from personal photos. Moreover, whereas other studies have found that people on average collect over 4,000 personal photos (Sarvas et al., 2011; Whittaker et al., 2010), the participants interviewed in this study reported owning only a few dozen whiteboard photos. This research also found that whiteboard photos were only

shared with meeting attendees. In contrast, on sites like Facebook, personal photos are routinely shared with others who were not present at the time the photo was taken (Sarvas et al., 2011).

5.4 Lifecycle of whiteboard photos

The lifecycle of whiteboard photos presented in this research (section 4.7) shares some similarities with the information curation lifecycle proposed by Whittaker (2011; section 2.2.1.1). For instance, consistent with Whittaker's findings that not all information is captured in the Keeping stage, this study revealed that at the end of some meetings the whiteboard content was not captured. This happened because sometimes the process of drawing was more important than the resultant drawing artefact (Bly, 1988; Tang, 1991). Also, consistent with Whittaker's (2011) finding that the decision to keep or not to keep information is difficult, this research found that participants struggled with determining whether whiteboard content was important enough to merit capture. The strategy used to cope with this uncertainty was *over-capturing* (Whittaker, 2011) whiteboard content which allowed interviewees to defer the evaluation of the utility of the content into the future. The lifecycle of whiteboard photos presented in this research is also similar to the information scrap lifecycle described by Bernstein et al. (2008; section 2.2.1.2). For instance, this research found that participants extracted information from the whiteboard photos into another document similar to how Bernstein et al. found that people "translat[ed] an information scrap from one form into another" (p. 25).

However, there are several key differences between the lifecycle of whiteboard photos in this research and Whittaker's (2011) and Bernstein et al.'s (2008) lifecycles. Both of these lifecycles describe long-term actions that are not described in the lifecycle of whiteboard photos

because whiteboard photos were rarely used in the long-term by the participants in this study. For instance, Bernstein et al. found that people organized information scraps (by adding structures and metadata) to aid retrieval in the long-term, whereas this research found that intentional archiving practices to aid future retrieval efforts were rare, and long-term retrieval was also rare among the interviewees. Likewise, unlike information scraps which are eventually archived or discarded, whiteboard photos were rarely made of archival quality or deleted; they were simply forgotten about. Finally, neither of the two aforementioned lifecycles describe the short-term actions participants commonly took with whiteboard photos (e.g., transfer, and share) that are described in the lifecycle of whiteboard photos in this research. These activities have important implications for design, which will be discussed below.

5.5 Opportunities for design

This section presents design implications to build on the key findings of this research. It was found that whiteboard photos had a short useful lifespan. They were primarily used to support the creation of a superseding document after the meeting, and secondarily used as evidence of shared agreement. This research also found that whiteboard photos generally went through a seven-stage lifecycle: Capture, Transfer, Extract for attendees, Share, Store, Extract for self, and Forget. Finally, the findings from the memory task revealed that most users' long-term memory of whiteboard-specific characteristics was poor; they typically only remembered general meeting characteristics. However, poor long-term memory of whiteboard-specific characteristics was generally not reported to be a pain point because participants rarely retrieved whiteboard photos in the long-term.

We use these key findings to draw design implications for two types of systems, 1) *mobile-centric* whiteboard capture systems, and 2) *whiteboard-centric* capture systems. Mobile-

mobile-centric whiteboard capture systems such as Evernote and Snappt differ from whiteboard-centric capture systems such as ReBoard (Branham et al., 2010) and DUMMBO (Brotherton et al., 1999) in two key ways. First, mobile-centric whiteboard capture systems typically capture whiteboard content using the camera of a mobile device whereas whiteboard-centric capture systems do not require a mobile device; they use board-centric capture mechanisms such as special marker casings or cameras attached to the board or the meeting room. Also, mobile-centric whiteboard capture systems typically capture content *discretely* (i.e., users decide when to capture, typically at the end of a meeting, as this research showed), whereas whiteboard-centric capture systems typically capture whiteboard content *continuously* throughout the meeting (not just at the end).

Due to these key differences, mobile-centric whiteboard capture systems are most applicable to the context studied (i.e., the current practice of taking whiteboard photos with the camera of a mobile device at the end of a meeting). However, the design implications were extended to whiteboard-centric capture systems because the ability to capture whiteboard content continuously during a meeting provides additional opportunities to support post-meeting use of whiteboard content.

Both sets of design implications are applicable to SMART kapp—the original motivation for this work—which is a hybrid between mobile-centric and whiteboard-centric capture systems in which the board itself captures the whiteboard content and saves the content to a paired mobile device, as if the mobile device had captured the content. It is also a hybrid system because while SMART kapp continuously captures whiteboard content throughout a meeting, users must discretely specify (by selecting a button) when (if at all) to create and save a snapshot (the equivalent of a photo) of the whiteboard content.

5.5.1 Design implications for mobile-centric whiteboard capture systems

It was found that the first two stages (capture and transfer) in the lifecycle of whiteboard photos involved a mobile device while the remaining stages (extraction, share, etc.) involved a productivity-oriented device such as a desktop computer. Consistent with this finding, a mobile-centric whiteboard capture system aiming to improve this current practice would involve a mobile application and a desktop application. Design implications for such a mobile application and a desktop application are presented below.

5.5.1.1 Implications for a mobile application

5.5.1.1.1 Support quick capture

One of the reasons people used cellphones to capture whiteboard content is that it was simply much quicker than having to rewrite the content on paper. This implies that users should be able to capture whiteboard content with a mobile application as fast as or faster than they can already capture whiteboard content with the native camera photo application on a mobile device. A mobile application which slows down the capture risks not being used. This is an issue, for instance, in the companion mobile application to the SMART kapp whiteboard because to save whiteboard content, it requires the user to pair the mobile device with the board via Bluetooth by scanning a QR code²⁰.

5.5.1.1.2 Support transfer and storing

Aside from capturing whiteboard content, this research revealed that mobile devices were only used to transfer whiteboard photos to a storage location that was easily accessible on a desktop

²⁰ The author of this thesis has observed many people taking a photo of whiteboard content on SMART kapp with the native camera application on their cellphones instead of using the SMART kapp application.

or laptop computer. There are several reasons people did not use cellphones to work with whiteboard photos. One reason may be that it is difficult to view whiteboard content on a cellphone display due to its small size compared to the whiteboard. Another reason may be that the way people utilized whiteboard content (i.e., salvaging behaviour in creating a superseding document) was better suited to productivity-oriented devices such as laptop or desktop computers. Also, participants reported that transferring the whiteboard was a pain point.

Taken together, these findings imply that a better transfer and storage mechanism is needed. A better transfer mechanism is one which is quicker and requires fewer steps from the user. For instance, right after users capture whiteboard content, the mobile application could prompt the user to transfer the photo, or automatically transfer the photo so that no action is required by the user.

This research also found that whiteboard photos were transferred to a variety of storage locations, including email, shared cloud folders, and collaboration tools like Slack, and JIRA. Participants reported that transferring the photo to these usable locations was a pain point. This implies that better integration is needed so that users can easily transfer whiteboard photos to their desire storage location. While it is difficult to provide integration with such a wide range of possible storage locations, one simple solution would be to transfer the whiteboard photo from the mobile device to a companion desktop application so that as soon as users return to their cubicle or office to create a superseding document, the whiteboard photo would be readily available.

Finally, consistent with the finding that people disliked having their whiteboard photos stored with their personal photos, whiteboard capturing mobile applications should keep whiteboard photos stored separately from personal photos on the mobile device. For instance,

it is recommended that whiteboard photos be stored within the mobile application itself and not in the mobile device's native camera roll.

5.5.1.2 Implications for a desktop application

5.5.1.2.1 Support extraction and creation of a superseding document

The primary way in which participants used whiteboard photos was to create a document by extracting the useful information from the whiteboard photo and expanding on it in the document. This extraction, which was a reported pain point, always happened on productivity-oriented devices such as a desktop or a laptop computer.

Together, these findings imply that users would benefit from a desktop application that simplified the extraction process. However, the extraction of information from the whiteboard photo to the superseding document was not a matter of simply extracting every word from the whiteboard photo and copying it to the superseding document. The extraction process was similar to the active-sense making behaviour of *salvaging* described by Moran et al. (1997). Thus, this extraction process should be cultivated in an enhanced extraction solution and not merely bridged over. The design challenge is to make the extraction easier while not completely automating the process where the user is removed from the process. For instance, a fully automated extraction of the content in Figure 14 would mistakenly extract all the words, when only the content in black ink may be relevant.

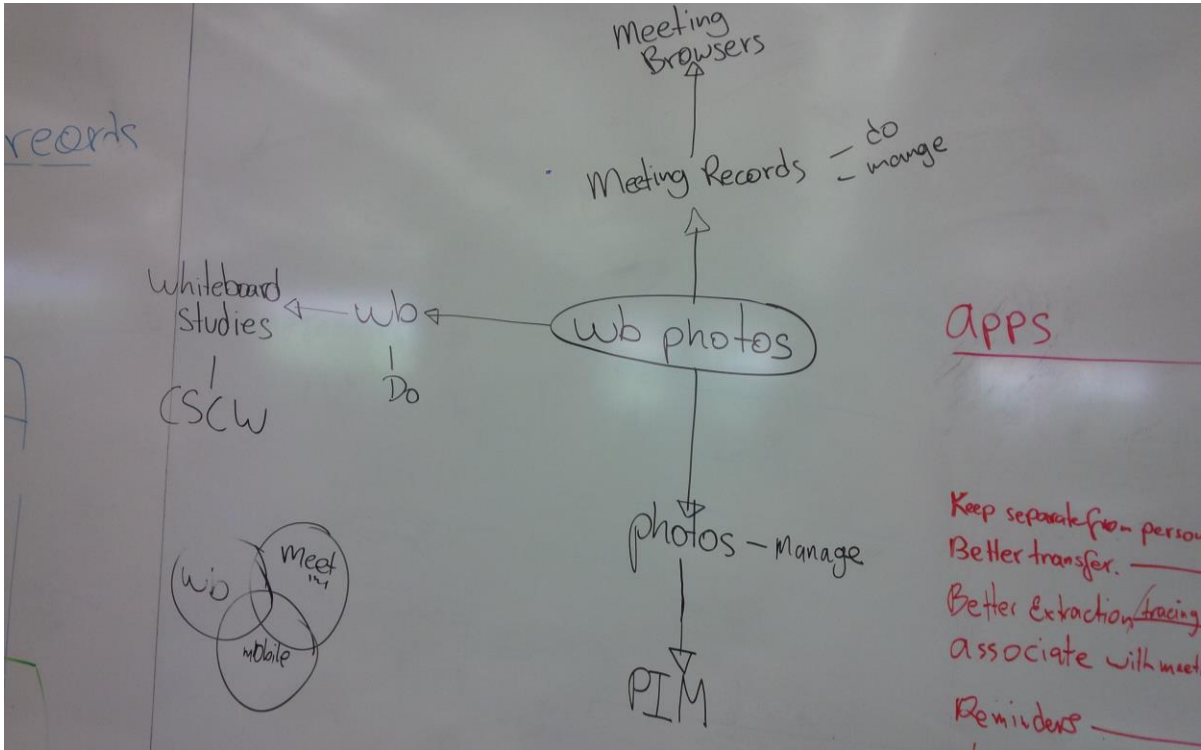


Figure 14. In this whiteboard photo, the content in black may be relevant for the extraction task, but not the surrounding text in blue and red. A fully automated extraction process may mistakenly extract everything.

A potential solution that would facilitate content extraction is to allow users to select an area on the whiteboard photo, then copy and paste it into the superseding document. But instead of pasting the selection in image format, hand-writing recognition software (e.g., optical character recognition (OCR) software), would extract the words and paste them as typed words. Likewise, when the selected area of the whiteboard photo contains a diagram, what is copied and pasted would be a digitized diagram. This potential solution could help alleviate another extraction pain point: the ability to track the whiteboard content that users have already extracted. For instance, the content on the whiteboard photo that the user has already extracted (i.e., selected, copied, and pasted into the superseding document) would become highlighted in the whiteboard photo.

5.5.1.2.2 Support management

This research found that participants overcaptured whiteboard content just in case some of it turned out to be useful later. The findings also revealed that power users had more whiteboard photos than other non-power users due to how frequently they used whiteboards and how frequently they captured whiteboard content. A design implication is to manage whiteboard photos in such a way that it does not increase the management burden on users. For instance, consistent with the short-term way in which whiteboard photos were used, a potential solution is to decrease the saliency of whiteboard photos that are no longer recent. That is, prominently displaying recent whiteboard photos, while subtly displaying non-recent ones.

Similarly, it was found that after whiteboard photos were superseded by another document, they were rarely used again. A way for users to mark actioned whiteboard photos as “done” which would be filed away separately from the recent and un-actioned whiteboard photos is recommended. Moreover, unlike personal photos which people keep primarily for their sentimental value and affective properties (Whittaker, 2011; Petrelli et al., 2014), this research found that many whiteboard photos had actionable properties, usually requiring users to do something with them by a certain date. According to Whittaker (2011), action-oriented information typically benefits from features like reminders. Thus, associating calendars or to-do list-type action properties to whiteboard photos may help users better manage these artefacts.

5.5.1.2.3 Support retrieval

The research found that power users used some whiteboard photos in the long-term and reported that retrieving whiteboard photos was sometimes a pain point. The findings from the memory task (section 4.6.4) revealed that most people remembered general characteristics of a previous meeting (e.g., topic of the meeting, meeting room, attendees) but not characteristics of

the whiteboard content itself (e.g., what colour markers were used, which quadrants of the whiteboard were used, etc). Based on these findings, one way to improve the retrieval of whiteboard photos for power users would be to associate it with the topic of the meeting, attendees, and meeting location so that they can be used as search terms. This information could be extracted from people's calendars given that meeting invites usually contain the topic of the meeting, the time, attendees, and the location of the meeting. In this potential solution, when a whiteboard photo is taken, the mobile application would check the user's calendar application to see if he or she is currently scheduled to be in a meeting or if a meeting just ended (given that whiteboard content is typically captured at the end of a meeting).

5.5.2 Design implications for whiteboard-centric capture systems

Building on the design implications presented above for mobile-centric applications, design implications are now presented for existing whiteboard-centric capture systems such as ReBoard (Branham et al., 2010) or hybrid systems such as SMART kapp.

First, utilizing a whiteboard-centric capture system changes some of the aspects of the whiteboard photo lifecycle presented in Section 4.7. Namely, the explicit capture stage may be eliminated completely if the system automatically and continuously captures content. However, depending on where the system stores the captured content, the Transfer stage may still need to be supported. Similarly, the Share and Store stages may or may not need to be supported, depending on where the system stores the captured content. If capture is stored locally, design advice provided in the above sections 5.5.1.1.2 (Support transfer and storing) and 5.5.1.2.2 (Support management) would apply, or could be used to improve existing server or cloud-based capture storage. Extract for attendees and for self would still need to be supported; thus,

regardless, the design advice from section 5.5.1.2.1 above would apply. In addition to these carry-over design implications, unique implications can also be derived for whiteboard-centric capture systems, described next.

5.5.2.1 Evidence implications

One implication stemming from the finding that whiteboard photos were used as a form of evidence and shared understanding, is that whiteboard-centric capture systems should enhance this ability. However, some existing whiteboard-centric capture systems capture whiteboard content in a (often proprietary) format that is less useful as a form of evidence than a whiteboard photo. For instance, Equil Note Smartmarker²¹ lets users continue editing whiteboard content after a meeting. When there is a dispute, it may be unclear which sketches were agreed upon by the group during the meeting and which were created by individuals after the meeting because the system does not distinguish between these two kinds of contributions.

Whiteboard capture systems should enhance, not diminish, the ability of captured whiteboard content to serve as evidence of agreement. For instance, the whiteboard could capture the verbal conversation during a meeting so that when there is a disagreement and the meaning of a sketch is ambiguous, in a desktop application users could listen to the conversation around the time that sketch was created. This ability is available in some systems (e.g., DUMMBO (Brotherton et al., 1999)), but usually for the purpose of reminding meeting attendees what happened during a meeting, not as an enhanced form of evidence. Another potential way that whiteboard systems could enhance their evidentiary utility is to capture who

²¹ <http://www.myequil.com/smartmarker/>

wrote what on the whiteboard during the meeting so that users could easily review this information post-meeting using a desktop application.

5.5.3 Summary of design implications

In summary, based on the study findings, design implications were derived for mobile-centric whiteboard capture systems, whiteboard-centric capture systems. Both sets of design implications are applicable to SMART kapp—the original motivation for this work—which is a hybrid between a mobile-centric and a whiteboard-centric capture system. A mobile-centric whiteboard capture system would involve a mobile application and a desktop application to support the use of whiteboard photos at different lifecycle stages. In addition, whiteboard-centric capture systems, due to their ability to continuously capture during a meeting, can enhance the evidentiary utility of whiteboard photos. The design implications for both of these systems are summarized in Table 5.

Mobile-centric capture system	In mobile application	Support quick capture
		Support quick transfer
		Support integration to storage locations
		Store whiteboard photos separately from personal photos
	In desktop application	Support extraction
		Support tracking of extracted information
		Reduce burden of managing whiteboard photos by increasing or decreasing saliency based on recency, using reminders, and allowing users to mark photos as “done”
		Support retrieval by linking whiteboard photos to meeting invites
Whiteboard-centric capture systems	In board and desktop application	Enhance the evidentiary utility of whiteboard photos by capturing who wrote what, audio, and distinguishing between in-meeting and post-meeting content

Table 4. Summary of design implications.

5.6 Study Limitations

The validity of the findings is limited by the chosen methodological approach (i.e., interviews). Participants were asked during the interviews to recall actions that they had taken in the past with whiteboard photos. Recall of these actions is likely to have been inaccurate to some extent due to a host of memory biases. For instance, previous research has shown that people “often remember the gist of an event without being able to remember its details” (Koriat et al., 2000, p. 491). This is a limitation because it potentially undermines the validity of the reported lifecycles of whiteboard photos given that it was important that participants accurately recalled in minute detail the actions they took with a particular whiteboard photo. However, the consistency across participants’ recalled actions provides support for the lifecycle validity.

Moreover, although it was found that whiteboard photos were primarily used to create superseding documents, the need to uphold confidentiality prevented the researcher from obtaining copies of the whiteboard photos and the superseding documents that the participants described during the interviews. This limited the researcher’s ability to analyze what content is typically extracted from whiteboard photos and the form that content takes in the superseding documents. As a result, the researcher’s ability to recommend more sophisticated extraction techniques was limited.

The validity of the findings was also limited by the way the data was analyzed. Due to the fact that the data analysis was conducted by only one researcher (the author of this thesis) the analysis lacked analyst triangulation (Patton, 1999), which may have biased the findings or limited them by the experience and training of the researcher.

Another limitation has to do with the representativeness of the findings. First, the findings lack quantification given that the aim of the study was to answer “what”, “how”, and

“why” questions rather “how much”, “how many”, and “how often” questions. This made it difficult to assess the prevalence of the behaviour reported by the interviewees. Second, rather than sampling a representative sample of whiteboard users, regular users of whiteboards were recruited with the aim of maximizing the range of insights. As a result, some of the behaviours reported by the participants of this study may be more or less common among the general population of whiteboard users who, on average, may use whiteboards and whiteboard photos much less frequently.

Finally, the validity of the memory recall task is limited by the small sample size (n=6). Also, none of the meetings which participants were asked to recall had produced whiteboard content characteristically of “special whiteboard photos” (Section 4.5.3). Thus, one of the reasons people exhibited such poor recall of whiteboard-specific characteristics may have been that the whiteboard content created during those meetings was ephemeral. It is possible that people may have remembered much more whiteboard-specific characteristics if the meetings in question had produced such “special” whiteboard content.

Ways to address some of these limitations are presented in the Future Work section (Section 6.2) of the Conclusions chapter.

5.7 Chapter Summary

This chapter discussed the findings presented in Chapter 4 as they apply to relevant findings in the literature of whiteboard studies, meeting records, and information management. It discussed how whiteboards photos supported work transitions, and their role as a meeting record. A comparison of whiteboard photos to personal photos showed the many dissimilarities between them despite sharing the same medium. The general lifecycle of whiteboard photos found in this research was discussed in relation to the information curation lifecycle

(Whittaker, 2011) and the lifecycle of information scraps (Bernstein et al., 2008). Design implications were presented for mobile-centric whiteboard capture systems and whiteboard-centric capture systems. Finally, the limitations of the study were also discussed.

Chapter 6

Conclusions

In today's mobile-centric world, whiteboard users commonly use their mobile devices to take photos of whiteboard content to keep a record of a meeting. However, little is known about what people do with these whiteboard photos after a meeting. The HCI literature has focused almost exclusively on understanding and supporting the in-meeting whiteboard experience, with a dearth of research focused on the post-meeting experience. The few related studies have found that people took photos of whiteboard content primarily "as a security net" (Branham et al., 2010, p. 78), and that their function was unclear (Klokmoose et al., 2013, Brown et al., 2000). As a result of this knowledge gap, little technological support has been developed for whiteboard users to effectively use their whiteboard photos after meetings. Hence, this thesis investigated the post-meeting usage of whiteboard content captured with mobile devices to inform the design of future mobile-centric whiteboard capture systems. The findings of this research also provide implications for the design of whiteboard-centric capture systems—those systems which continually capture content at the pen-stroke level as it is produced on the whiteboard.

6.1 Research Objectives and Summary

Section 1.2 introduced the following research questions to be investigated by this thesis:

1. What HCI theories, concepts, frameworks, and findings are relevant to the study of post-meeting use of whiteboard photos?
2. How have existing systems supported post-meeting use of whiteboard content?

3. What are the main post-meeting activities that whiteboard photos support? How do people value whiteboard photos, and how does that perceived value change over time? How do people manage their whiteboard photos, particularly, where do they store whiteboard photos, how do they organize them, and how do they search for them?
4. What is the typical lifecycle of whiteboard photos?
5. What characteristics do people remember well about whiteboard content from prior meetings that could be used as search terms to retrieve whiteboard photos?

The first two questions were addressed by the literature review presented in Chapter 2. The first was addressed by reviewing the HCI literature on whiteboard studies, meeting records, and PIM with a particular focus on the management of personal photos, and the second was addressed by reviewing how multimedia meeting browsers and whiteboard systems currently support the capture and the post-meeting use of whiteboard content. The remaining questions were addressed by conducting a series of semi-structured interviews with a diverse set of 19 regular whiteboard users to get insights into post-meeting whiteboard usage practices.

During the interviews, participants were asked to detail their usage practices around one or two recently captured whiteboard photos. The described workflows were then used to produce diagrams to represent the lifecycle of the associated whiteboard photos. These diagrams were then analyzed for patterns to provide insight into the typical lifecycle of a whiteboard photo (research question 4 above); a seven stage lifecycle was revealed by this analysis.

To answer the final question, six of the 19 recruited interviewees were asked additional questions during the interviews probing what characteristics they could recall about the

whiteboard content created during a prior meeting and what characteristics they could recall about that meeting itself.

Findings from the study led to the following key contributions:

- **Deeper understanding of the main activities that whiteboard photos support.**
Analysis of the interview data revealed that whiteboard photos were primarily used in the creation of a superseding document such as a project report (or similar), presentation slides, or an email to the meeting attendees. They were also shared so that they could be used as evidence of mutual agreement.
- **Deeper understanding of how knowledge workers value whiteboard photos, and how they are managed.** Participants perceived whiteboard photos to be most valuable in the short-term. They lost their most of their utility after their information was extracted into a superseding document. A few “special” whiteboard photos were particularly important. Whiteboard photos were rarely retrieved or used in the long-term.
- **Identification of the typical lifecycle of whiteboard photos.** Whiteboard photos generally went through a seven-stage lifecycle: Capture, Transfer, Extract for attendees, Share, Store, Extract for self, and Forget.
- **Empirical evidence related to long-term memory recall of characteristics of previous meetings where a whiteboard was used.** Well remembered characteristics of a prior meeting in which a whiteboard was used were: meeting room, topic of meeting, meeting attendees, who drew on the whiteboard. Whiteboard-specific

characteristics, such as the colour of dry-erase markers used, were not well remembered.

- **Identification of power users of whiteboards and whiteboard photos.** A small number of participants stood out from the rest as “power users” due to how frequently and uniquely they used whiteboards and whiteboard photos.
- **Design implications for the development of whiteboard capture systems.** The findings suggested a set of unmet design needs for the development of improved whiteboard capture systems, including mobile-centric capture and whiteboard-centric capture as described in Section 5.5. For mobile-centric capture systems, design implications include the need for a mobile application that supports quick capture and the effortless transfer of whiteboard photos to productivity-oriented devices, and the need for a desktop application that supports the extraction of whiteboard content to aid users in creating superseding documents. For whiteboard-centric capture systems, design implications include the need to enhance the ability of captured whiteboard content to serve as evidence of agreement among meeting attendees.

6.2 Future Work

This research suggests a number of opportunities for further investigation, including future work that addresses the limitations of this work, and future work that extends this work.

6.2.1 Further investigations into post-meeting whiteboard photo usage practices

This research employed semi-structured interviews as its main data gathering method. As any method, it has limitations, including the fact that all data is subjectively reported by participants

and as such relies on honest and accurate memory recall of past practices and behaviours (Patton, 2002). Participant recall or reporting during interviews is also known to lack key low-level details that may be important to an investigation (Koriat et al., 2000). While this research found many consistencies in the post-meeting whiteboard photo practices reported across participants—giving a certain level of confidence to the reported data—further research utilizing other methods that address this limitation would provide beneficial corroborating evidence to the findings reported in this thesis and further understanding of the reported practices.

For instance, an observational study of post-meeting practices, for example that included observations of users creating superseding documents from whiteboard photos may provide more in-depth, minute details on how whiteboard content is extracted. This would not only provide more accurate data than the self-reported information gathered in this study but it would also make it possible to further study how whiteboard content is extracted. For example, what are the most commonly extracted types of content from whiteboard photos, how do people track what information they have already extracted, and in what order is the whiteboard content extracted?

Additionally, an observational study that includes in-meeting whiteboard capture activities as well as post-meeting practices may help shed light into several other important questions, such as what information is captured during meetings and what are the associated verbal conversations around the produced whiteboard content, how does this content and related conversations related to the information extracted into a superseding document, do different kinds of meetings lead to different post-meeting use of whiteboard content or different lifecycles of whiteboard photos? Observing meetings and the actions people take with

whiteboard photos afterwards could inform, for instance, the design of machine learning algorithms that use audio or video data of meetings to automatically create a first draft of a superseding document and automate some of the actions people take with whiteboard photos.

Another limitation of the chosen interview method, and the above proposed observational studies, is the relatively small sample population that can be included in these studies. While this research took methodological steps to recruit participants from a specific population of frequent whiteboard users in order to maximize potential insight with the limited data collection resources available, it is possible that the selected population has developed unique whiteboard photo usage practices. To improve the generalizability of this research, another avenue for further research would be to investigate the prevalence of the behaviours found in this study in a broader, more representative sample of whiteboard users. For instance, a future study could involve surveying a larger population of whiteboard users from different professions and industries. Moreover, given that the study participants were selected from diverse background, future work could investigate how post-meeting use of whiteboard content differs between professions and industries. This could help the development of profession- or industry-specific whiteboard capture systems.

6.2.2 Investigations into whiteboard-centric capture and interactive whiteboards

This research focused on whiteboard capture from mobile devices, and their related post-meeting practices. Extensions of this research could include investigating similar post-meeting practices involving content captured by digital whiteboarding system, which capture content continuously during whiteboard interactions, or interactive whiteboard systems, which allow users to create whiteboard-style annotations directly over other digital content displayed on

the board, such as presentation slides. Many such digital whiteboard systems exist, as reviewed in Section 2.3, and provide different types of in-meeting and (some) post-meeting features. It is unclear at this point how similar the post-meeting practices found in this research, related to the capture of a static image captured of the whiteboard content, extend to how people may work with capture from these systems, especially given the continuous nature of the captured data. Do users simply use the final, complete captured state, and then treat this captured state like a whiteboard photo (i.e. a final snapshot of the meeting outcome)? More work is needed to better understand the relationship, between the practices of mobile-centric capture and whiteboard-centric capture to understand how to best support users of such digital whiteboard systems.

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Appendix A Study Material

A.1 Recruitment Material

Recruitment Email

Email subject: Request for interview. What happens to whiteboard content after a meeting?

Email body:

Hello _____,

My name is _____.

I was wondering if you would be interested in participating in a 30 minute in-person interview? We are currently conducting a study in conjunction with researchers from the University of Waterloo on what people do with whiteboard content after a meeting so that we may provide better support for saving, searching, and reusing those notes afterwards.

Ideally we are looking for people who have saved notes from previous meetings that they could show us during the interview. If possible, we would like to video record how people find and remember those notes as search and meeting recall are important to us.

I've attached an Information Letter, with more details about the study. This study has been reviewed by and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participation is yours.

If you are interested in participating, let us know what date and time works best for you. Our schedule is pretty flexible in the month of August.

Thanks again, your feedback will help to inform the next versions of our products!

A.2 Study Material

Letter of Information

Hello, my name is Danniell Varona-Marin. I am asking you to volunteer in a study that is part of my Masters' degree research in Human-Computer Interaction at the University of Waterloo and my research internship at SMART Technologies.

Purpose of the study: My research focuses on how people use dry-erase boards (whiteboards). A whiteboard is a wipeable board with a white surface used for brainstorming, teaching, presentations, and the like. They are very common in meeting spaces and offices. The goal of my research is to understand what happens to captured whiteboard content (such as pictures) after a meeting so that we may better support the storing, searching, and reuse of this content in the future.

Procedure: If you agree to participate in this study, you will be interviewed regarding your use of whiteboard notes. The interview will last approximately 30 minutes and it will be audio and video recorded for the purposes of permitting accurate analysis by the researchers. Some basic background and demographic information will be collected at the end of the interview.

Participation in this study is completely voluntary and you may stop at any time by advising the researcher. Should you choose to stop participating, we will remove any information gathered about your participation immediately. Your decision to participate or not, or withdraw from participation will have no impact on your employment status from your employer, your relationship with SMART Technologies, nor your employer's relationship with SMART Technologies.

Risks: There are no known or anticipated risks to you as a participant in this study.

Eligibility Requirements for Participation: You are eligible to participate if you use a whiteboard at work.

Remuneration: You will not receive remuneration for participating in the study.

Confidentiality and Data Retention: All data collected is considered confidential. We will not disclose any information about the content of the meetings or the notes from those meetings, only the ways in which the whiteboard-captured content was used. (We are interested in work processes.) Codes (for example: P1, P2, etc), rather than names or other identifying information will be used. Data collected during the interview will be retained for at least 5 years in a secure location at the University of Waterloo or SMART Technologies in a locked cabinet or encrypted in a computer. Only researchers associated with this project will have access to the study data. You will explicitly be asked for consent for the use of photo/video/audio data captured during the study for the purpose of reporting the study's findings. If consent is granted, this data will be used only for the purposes associated with teaching, scientific presentations, and/or publications and you will not be identified by name. In any image or video recordings shown publicly, we may not blur your face.

Questions and Contact: If you have any questions about participation, or would like additional information to assist you in reaching a decision about participation, please contact me: *Daniel Varona-Marin* via email at *daniel.vm@uwaterloo.ca*. Also if you prefer, you may contact my faculty supervisor Professor Stacey Scott (*stacey.scott@uwaterloo.ca*) of the Systems Design Engineering department at the University of Waterloo.

Ethic Review and Clearance I would like to assure you that this study has been reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. However, the final decision about participating is yours. In the event you have any comments or concerns resulting from your participation in this study, please contact Dr. Maureen Nummelin, the Director, Office of Research Ethics, at 1-519-888-4567, Ext. 36005 or maureen.nummelin@uwaterloo.ca.

Student Investigator: Daniel Varona-Marin (*daniel.vm@uwaterloo.ca*), University of Waterloo
Faculty Supervisor: Stacey Scott (*stacey.scott@uwaterloo.ca*), University of Waterloo
Project Supervisor: Edwards Tse (*edwardtse@smarttech.com*), SMART Technologies

Consent Form

By signing this consent form, you are not waiving your legal rights or releasing the investigator(s) or involved institution(s) from their legal and professional responsibilities.

I agree to participate in a study being conducted by Danniell Varona-Marin for his Masters' thesis research, under the supervision of Professor Stacey Scott from the department of Systems Design Engineering at the University of Waterloo. I have made this decision based on the information I have read in the Information-Consent Letter and have had the opportunity to receive any additional details I wanted about the study. I understand that I may withdraw this consent at any time by telling the researcher without penalty. I was informed that my decision to participate or not, or withdraw from participation will have no impact on my employment status from my employer, nor my relationship and my employer's relationship with SMART Technologies.

This project has been reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. I was informed that if I have any comments or concerns resulting from my participation in this study, I may contact the Director, Office of Research Ethics at the University of Waterloo at (519) 888-4567 ext. 36005.

	Please Circle One	Please Initial Your Choice	
With full knowledge of all foregoing, I agree, of my own free will, to participate in this study.	<input type="checkbox"/> YES	<input type="checkbox"/> NO	_____
I consent to the use of non-identifying quotations in publications, talks, and promotions.	<input type="checkbox"/> YES	<input type="checkbox"/> NO	_____
I consent to being video and audio taped while participating in this study for the purposes of permitting accurate analysis of my actions during this study.	<input type="checkbox"/> YES	<input type="checkbox"/> NO	_____
I consent to the use of still images and short video recordings made during the study in publications, talks, and promotions, even though my face may not be blurred.	<input type="checkbox"/> YES	<input type="checkbox"/> NO	_____

Name of the participant: _____

Signature of the participant: _____ Date: _____

Name of the witness: _____

Signature of the witness: _____ Date: _____

Interview Questions

Capture and Store

Think of the last time you used a whiteboard with other people:

How was the whiteboard content captured during or after the meeting?

Walk me through your process of what you did after the meeting with that [photo] whiteboard content you had captured?

What was the motivation behind capturing the whiteboard content?

Reviewing/reusing

Did you ever look to that photo again after the meeting?

If yes: Why? What were you hoping to get from it? What did you use it for?

If no: Recall the last time you did go back to a whiteboard photo...why did you go back to it? What were you hoping to get from it? What did you use it for?

Can you tell me about a time when you went back to a whiteboard photo but when you found it, you couldn't make sense of it...you had no memory of what the sketches were about?

What do you wish you had captured during/after the meeting to help you jog your memory and be able to understand those notes?

Searching

Think of a time when you had to back to the whiteboard notes from a previous meeting, but you couldn't find it (or had a really hard time).

If yes: What made it so hard/impossible to find it? What do you wish you (or some technology) had done so that you could easily find those notes?

If no: How is it that you are always able to find the whiteboard photos so easily?

For all other participants	For the participants who had participated in previous observational study
<p>Task: Think of a whiteboard photo/note in your archive from a previous meeting that you remember. Could you show me how you would find it?</p> <p><i>[If the participant is scrolling through pictures of whiteboards:]</i> How do you recognize it...what features are you looking for?</p> <p>Which of these sketches would help you the most to remember in the future what was discussed during the meeting? Which of these sketches would be most important to keep if you had to</p>	<p>Task: Let's recall the meeting Andy and the UofWashington students observed a while back. Can you recall what this meeting was about?</p> <p>Who attended (remote/local)?</p> <p>Who drew?</p> <p>Who were the notes/pictures shared with afterwards?</p> <p>What colours were used? Predominant colour?</p> <p>Percentage of the whiteboard used?</p> <p>Parts/quadrants of the whiteboard used?</p> <p>The order in which you wrote things?</p> <p>Erasing the board completely?</p>

<p>erase most of the sketches in this photo?</p>	<p>Were stickies/paper artefact posted on the whiteboard? Location/owner of whiteboard?</p> <p>Task: Were there any diagrams/sketches/drawings (non-text stuff) drawn on the board during this meeting? Could you redraw for me one of these sketches as accurately as possible on this blank piece of paper? Do you remember where on the whiteboard it was drawn?</p> <p>Task: Could you show me how you would find the photo?</p> <p><i>[If the participant is scrolling through pictures of whiteboards:]</i> How do you recognize it...what features are you looking for?</p> <p>Which of these sketches would help you the most to remember in the future what was discussed during the meeting?</p> <p>Which sketch(es) would be the most important to keep, if most of the information on this photo were wiped out?</p>
--	--

Importance of whiteboard notes

If you had to go back and rate each of your whiteboard photos in your archive as “Important, not important, or maybe important”:

What would you base your decision on?

Do you currently have some way of marking a whiteboard photo is important or not?

Imagine some disaster occurred and you could only save a handful of all your whiteboard photos. Which would you save and why?

Feedback Letter

We appreciate your participation in our study, and thank you for spending the time helping us with our research!

Summary: In this study, you were interviewed regarding your use of captured whiteboard content after a meeting. We obtained your feedback with respects to how you organize, give importance, search, remember, and reuse captured whiteboard content. We intend to use this information to develop better ways to support whiteboards users to utilize their captured whiteboard content beyond the meeting.

Background: Whiteboards are a wipeable board with a white surface used for brainstorming, teaching, presentations, and the like. They are very common in meeting spaces and offices. Although *in-meeting* whiteboard use has been previously studied [1], we know much less about what people do with the captured whiteboard content afterwards. It is clear, though, that some whiteboard content continues to have value beyond the meeting where it was created. For instance, looking at a whiteboard sketch from an earlier meeting can trigger new and different ideas [2].

It is becoming increasingly more important to enable users to effectively engage with saved content. With paper and other analog mediums, knowledge worker have to constantly assess what is important to avoid paper clutter and space limitations. However, digitalization has significantly reduced the cost of keeping information, leading us to hang on to much more information “just in case” [2]. Thus, we may often feel like we are swimming in a vast sea of unimportant documents before we are able to find what we are looking for. This is particularly a problem for whiteboard content, which is much less text-searchable than most other forms of digital information found in the workplace such as emails, text documents, etc.

The inevitable digitalization of whiteboards will create unique challenges, but also opportunities to interact with its content during and after meetings in ways that analog whiteboards do not support. This project is particularly interested in finding ways to empower users to make the most out of their archives of whiteboard notes.

Please remember that any data pertaining to you as an individual participant has been collected confidentially. Once all the data are collected and analyzed for this project, we plan on sharing this information with the research community through seminars, conferences, presentations, and journal articles. If you are interested in receiving more information regarding the results of this study, or would like a summary of the results, please provide your email address, and when the study is completed (anticipated by August 2016) we will send you the information. In the meantime, if you have any questions about the study, please do not hesitate to contact Danniell Varona-Marin via the contact information provided below. As with all University of Waterloo projects involving human participants, this project was reviewed by, and received ethics clearance through a University of Waterloo Research Ethics Committee. Should you have any comments or concerns resulting from your participation in this study, please contact Dr. Maureen Nummelin, Chief Ethics Officer, Office of Research Ethics, University of Waterloo, at 1-519-888-4567, Ext. 36005 or maureen.nummelin@uwaterloo.ca.

Further Reading:

1. Tang, A., Lanir, J., Greenberg, S., & Fels, S. (2009, May). Supporting transitions in work: informing large display application design by understanding whiteboard use. In *Proceedings of the ACM 2009 international conference on supporting group work* (pp. 149-158). ACM.

2. Walny, J., Haber, J., Dörk, M., Sillito, J., & Carpendale, S. (2011, September). Follow that sketch: Lifecycles of diagrams and sketches in software development. In *Visualizing Software for Understanding and Analysis (VISSOFT), 2011 6th IEEE International Workshop on* (pp. 1-8). IEEE.

Daniel Varona-Marin

University of Waterloo
Systems Design Engineering
daniel.v.m@uwaterloo.ca

Dr. Edward Tse

SMART Technologies
External Research Program Manager
EdwardTse@smarttech.com

Dr. Stacey Scott

University of Waterloo
Systems Design Engineering
stacey.scott@uwaterloo.ca

Background Questionnaire

Age group: 18-25 26-35 36-45 46-55 56-65 65+
Gender: Male Female Other: _____
Company: _____
Tenure at company: _____
Profession: _____

For me, having a whiteboard is:

Extremely important	Very Important	Quite important	Somewhat important	Unimportant	No opinion
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Generally, I use whiteboards:

Multiple times per day	Once a day	Multiple times per week	Once a week	Multiple times per month	Once a month	Never
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Generally, I use whiteboards with others (i.e., in meetings):

Multiple times per day	Once a day	Multiple times per week	Once a week	Multiple times per month	Once a month	Never
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I capture whiteboard content (i.e., take a picture):

Multiple times per day	Once a day	Multiple times per week	Once a week	Multiple times per month	Once a month	Never
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I return to content that I've captured from a whiteboard in the past:

Multiple times per day	Once a day	Multiple times per week	Once a week	Multiple times per month	Once a month	Never
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

A.3 Ethics Clearance

UNIVERSITY OF WATERLOO
OFFICE OF RESEARCH ETHICS

Notification of Ethics Clearance of Application to Conduct Research with Human Participants

Faculty Supervisor: Stacey Scott	Department: Systems Design Engineering
Student Investigator: Danniel Varona-Marin	Department: Systems Design Engineering
Collaborator: Edward Tse	Department: SMART Technologies

ORE File #: 20890

Project Title: What happens to whiteboard content after a meeting?


This certificate provides confirmation the above project has been reviewed in accordance with the University of Waterloo's Guidelines for Research with Human Participants and the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans. This project has received ethics clearance through a University of Waterloo Research Ethics Committee.

Note 1: *This ethics clearance is valid for one year from the date shown on the certificate and is renewable annually. Renewal is through completion and ethics clearance of the Annual Progress Report for Continuing Research (ORE Form 105).*

Note 2: *This project must be conducted according to the application description and revised materials for which ethics clearance has been granted. All subsequent modifications to the project also must receive prior ethics clearance (i.e., Request for Ethics Clearance of a Modification, ORE Form 104) through a University of Waterloo Research Ethics Committee and must not begin until notification has been received by the investigators.*

Note 3: *Researchers must submit a Progress Report on Continuing Human Research Projects (ORE Form 105) annually for all ongoing research projects or on the completion of the project. The Office of Research Ethics sends the ORE Form 105 for a project to the Principal Investigator or Faculty Supervisor for completion. If ethics clearance of an ongoing project is not renewed and consequently expires, the Office of Research Ethics may be obliged to notify Research Finance for their action in accordance with university and funding agency regulations.*

Note 4: *Any unanticipated event involving a participant that adversely affected the participant(s) must be reported immediately (i.e., within 1 business day of becoming aware of the event) to the ORE using ORE Form 106. Any unanticipated or unintentional changes which may impact the research protocol must be reported within seven days of the deviation to the ORE using ORE form 107.*



Maureen Nummelin, PhD
Chief Ethics Officer

8/5/2015

Date

OR
Julie Joza, MPH
Senior Manager, Research Ethics

OR
Sacha Geer, PhD

A.4 Lifecycle diagrams

