Why We Cannot Work without Paper Even in a Computerized Work Environment

JinHa Seong

Dep. of Industrial Design, KAIST

335 Gwahangno, Yuseong-gu,

Daejeon 305-701, South Korea

jeanhi@kaist.ac.kr

Woohun Lee

Dep. of Industrial Design, KAIST,

South Korea

woohun.lee@kaist.ac.kr

Youn-kyung Lim

Dep. of Industrial Design, KAIST,

South Korea

younlim@kaist.ac.kr

Abstract

As work environment becomes more computerized, it has been long expected that the computer will substitute for paper. However, in fact, this expectation has strayed. Paper is still around in the work environment; moreover, computers and papers are used in conjunction with each other. In this study, we suggest the term "human-computer-paper interaction" considering these phenomena. Using contextual inquiry and lab-based user study, we explored the switchover in human-computer-paper interaction and determined what incites this interaction. Through this study, we attempted to provide considerable insights into the HCI design area.

Keywords

Human-computer-paper interaction, computerized work environment

ACM Classification Keywords

H.4.1 [INFORMATION SYSTEMS APPLICATIONS]: Office Automation---Workflow management;
H.5.2 [INFORMATION INTERFACES AND PRESENTATION]: User Interfaces

Introduction

The work environment becomes more digitalized as electronic technology is developed. Currently, numerous companies use office automation systems and many aspects of office work are done using a computer. Additionally, improvements in high technology have produced devices such electronic pens, e-paper, e-ink or e-books, which were made to substitute for paper [1,2,6]. Thus, it has been expected for a long time that the computer will replace paper [11]. However, in fact, this expectation has thus far been false.
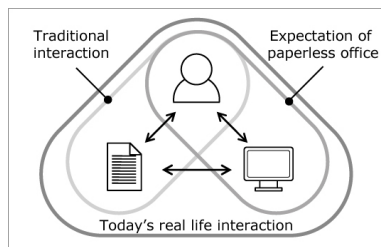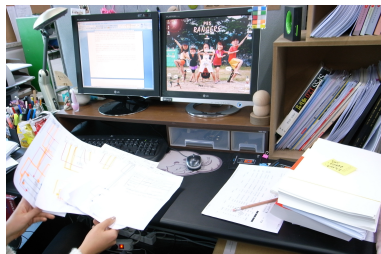
Documents today exist generally in two forms, as paper and as electronic files (Figure 1). In many cases, people create documents using a computer, read the result printed on paper, and work on the computer again with inserted commentary or with revisions of the paper documents. In some cases, the document is created on paper first and converted to a computer format by scanning or typing [3]. Also, in an office, paper is a resource for documents as well as for memos, scheduling, and communications. Using both a computer and paper appears as a mixture in the workflow. This study suggests the term "human-computer-paper interaction" considering these phenomena inclusively.

The current equipment used in work environment that is tightly related to the use of paper includes mostly printers and scanners. However, we view that there is more to be researched and developed for paper use activities in computerized work environment. This research aims to determine when the switchover occurs between a computer and paper in a workflow and to

figure out what makes this occur by observing human-computer-paper interactions in work environment.

Incitement for Paper to Persist in Work Environment

It is clear that paper has not disappeared and that it is commonly used with a computer (Figure 2). Moreover, the use of paper has increased [9]. There are three main reasons for this phenomenon.

First, print technology was enhanced as technology was developed; therefore, producing paper documents became easier. At present, the document is revised on a computer and reprinted, whereas in the past everything was done on paper.

The second reason lies in the settlement process in companies. Though many companies have adopted office automation systems, dreaming about a paperless office, the settlement process comes with paper use when it comes to providing communications and documentary evidence.

Third, certain properties of paper make people use paper continuously. Kurniawan and Zaphiris proved that the reading speed when reading paper is faster than that when reading on a computer [7]. Moreover, according to Hansen and Hass, legibility and tangibility are the main factors in reading and writing [4]. Paper shows superior performance in terms of these factors compared to computer. Thus, it has high readability, and revision is often easy with using paper. Furthermore, a computer cannot operate without power and paper occupies physical space so that it is noticed. People continue to use paper due to such advantages.

figure 1. Expectation of paperless office is delayed, as paper is still around in the work environment.

figure 2. Paper and computer are mixed in the work environment.

This study focuses on the third reason. Some properties of paper make the work more efficient, and this phenomenon makes people to use paper. Then when does it happen and how often? The answers from these questions will help raising the efficiency circumventing bottlenecks in human-computer-paper interaction.

Related Work

Numerous studies have attempted to determine why paper has persisted from the small screen size or readability issues. They have also tried to improve these issues [9]. However, if paper has its non-replaceable advantages, we instead aim to improve fluent interaction between paper and a computer rather than intend to create a paperless office.

Many have applied paper as a medium or a metaphor to utilize advantages of paper in designing new equipment. There have been many attempts to create seamless connection between paper and computers especially for document revisions or paper-as-inputs [8,10]. By projecting PC windows on physical paper, Holman et al. used paper as a screen of a monitor in their study [5]. Also, this system uses paper as an input device by tracking its motion and shape change with a motion capturing system. These concepts make sense since the connection between paper and a computer is needed, but most of these results require new equipment and new methods of use. This is opposed to the easy handling and high accessibility of paper. Thus, regardless of such efforts, technology today cannot substitute for paper completely.

Thus, very little has been done in terms of the usage of paper itself in offices apart from the development of new technology or the idea of a paperless office. Sellen

and Harper stand unrivaled in this area. They have broadly inquired into the paper and computer usage in work environments, especially when paper is indispensable [9]. If the use of paper is indispensable, we attempt to determine what triggers the switchover between computers and paper as well as how often that occurs from a microscopic point of view.

User Study for Human-Computer-Paper Interaction

We employed two methods. First, we conducted a contextual inquiry for exploring human-computer-paper interaction in real life. We then also conducted a lab-based user study to understand more detailed interaction. All participants were master's students in the department of industrial design and their ages ranged from 22 to 27 years old.

This paper will be limited to the consideration of personal work related to generating and revising documents. In the organization situation, people use lots of paper for evidence or communication records in settlement processes (Figure 3-a, 3-b). In this case, the use of paper is often an obligation, and there is little relation with the unconscious use of paper. In our study, we are interested in more controllable situations such as individual document handling process (Figure 3-c) to understand human-computer-paper interaction more deeply.

Contextual Inquiry

We conducted a contextual inquiry with two participants for one hour (Figure 4). One participant was drawing up a proposal and another was creating an animation. Both were working with a computer. Below are the main findings of the contextual inquiry:
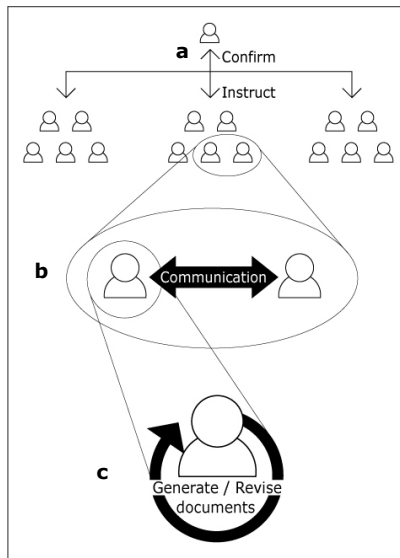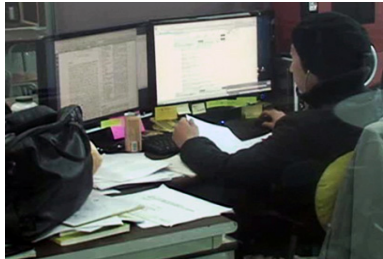

figure 3. The use of paper in an organization
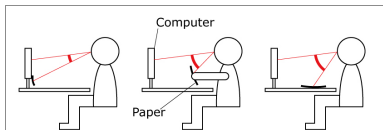
figure 4. A scene of contextual inquiry

figure 5. Degrees of sight depending on the position of paper

	Generate	Revise
Text based	Digital → Digital	→ Digital
	Physical → Physical	-
	Digital → Digital (without paper)	-
Image based	Digital → Digital	→ Digital
	Physical → Physical	-
	Digital → Digital (without paper)	-

figure 6. Experimental conditions

1. They looked at paper holding by hand: The spatial gap between paper and a screen was made to be small and the primary work area was made to be clear while looking at paper when preparing content on paper and on the screen (Figure 4).

2. They attached memos and sketches beside or on the bottom of their monitor: This was done to minimize eyesight movements (Figure 5). Moreover, this was part of an effort to remind them of tasks.

3. The desk was covered by related documents: All related documents were on the desk during the task and documents that were not viewed at that time also piled up so that they could be used when needed.

4. They tend to keep utilizing the paper in current use: Even when the space left on the current piece of paper is small, it is preferred to continue to use it rather than using a new piece of paper.

5.   They printed documents to read when the work is based on paper: Dense concentration and high legibility are ensured when reading on paper rather than on the computer screen. Moreover, the workers avoided converting a work situation to a computer based task.

6. Paper is always used when doing revisions: Important documents are always printed on paper for revisions.

7. They used paper and a computer simultaneously as a scheduler: One used paper, and the other used both paper and a cell phone as a scheduler.

Through observation, we found that people tend to avoid frequent switchovers between paper and a computer in work environment. They have a tendency to maintain their work space and their progress. In addition, in revision, scheduling and sketching, paper is very commonly used.

Lab-based user study
We explored overall aspects of paper use in real life from the contextual inquiry. In the lab-based study, we observed more concrete and specific situations of human-computer-paper interaction in order to understand what factors affects the switchover between paper and a computer in work.

Although office work can be categorized by various criteria, we divide it into text- and image-based work to explore two extreme contrasts. For each of these types of work, we set three different conditions (Figure 6): 1) starting to generate a document with a computer and producing the final outcome in an electronic file, 2) starting to generate a document on paper and the final outcome should also be on paper, and 3) same with the first condition but the participants were not allowed to use paper at all during the work. For the condition 1) and 2), we allowed them to use either paper or a computer during the work. After this document generation session, we also added a situation of revising a document for both the text-based work and the image-based work. For this revision session, we applied only one condition that is same with the first condition—i.e. starting from a digital file to produce a digital file, but allowing to use paper.
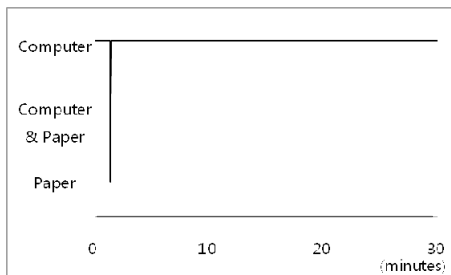
We tried to determine the tasks that commonly occurred in office environments. Text-based work included writing a report comparing three printers in an analysis of the estimated sheets along with a product catalog for the purchase of a printer. Image-based work included making presentation material including
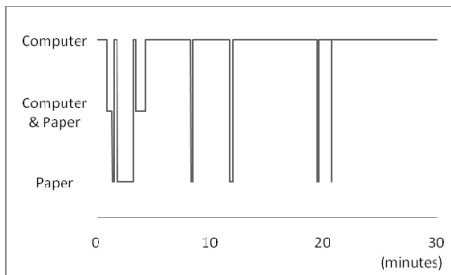
a. Image-based generation work for
participant A
(digital to digital)

b. Image-based generation work for
participant B
(digital to digital)

figure 7. Examples of mode transition in image-based work. Computer & paper mode means a mixture of two types of media at the same time.

visual data such as diagrams and pictures with company introduction material in the form of text. Revisions were done to the documents made in the generation session; to induce the revision, some information was replaced with erroneous information, and adding content was required. Allotting two people to each condition, a total of 16 people participated. All experiments were operated in the same lab environment, and the duration was 30 minutes.

All the participants worked on a computer most of the time even in the "physical → physical" (Figure 6) situation. We made graphs (Figure 7, 8) of 9 participants' mode transitions between a computer and paper due to time and observed which tasks were done when the work base is converted from a computer to paper.

We expected that there would have been different tendencies between text-based work and image-based work. However, there was no clear difference as shown in Figure 7-b and Figure 8-a. Instead, there was individual variation as shown in Figure 7. Some participants drew an outline and sketch on paper before creating a document on the computer, but others did not except taking memos. Furthermore, 7 participants did not use paper at all regardless of the work conditions. However, the participants who were prohibited to use paper appealed to its inconvenience when they need to compare several electronic documents. And in the revision session, they mostly did not use paper, but took a note on paper while using calculating program (Figure 8-c). In case that the initial data was given as paper, participants typed information into a computer while looking at paper (Figure 8-b). In many cases, they tended to type a considerable

amount at one time and edit it using the computer. And even they already finished typing, they glanced for one or two seconds the paper for checking contents of the document several times.

Discussion

Paper plays an important role in the work environment because people want to use their work space according to their preferences and prefer convenient media. We suggest considering the following in HCI design in relation to the issue of human-computer-paper interaction:

1. *People want to maintain their specific work space*. People like concentrate on one window and prefer using paper rather than switching to a window during computer-based work. Therefore, we can discuss how HCI design provides people with a consistent state.

2. *People prefer maintaining working on one task.* People want to stay on one task as long as possible rather than shift to several tasks. Such work inertia should be considered in design.

3. *There is individual variation when selecting media*. Particularly, there are numerous differences between individuals when drawing a draft. Some people draw almost all drafts and sketches on paper, whereas others do not use paper at all. It is necessary to consider how HCI design supports individual variations.

4. *People have a desire to check errors continuously when they enter content into a computer*. People checked their paper several times, even when they had finished entering contents into the computer after moving contents from the paper to the computer. Reflecting on this desire to resolve errors should be considered.
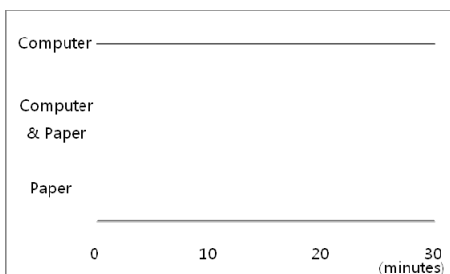
a. Text based generation work
(digital to digital)
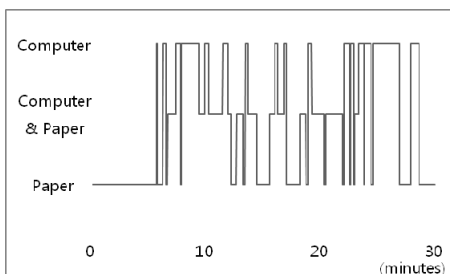
b. Text based generation work
(physical to physical)
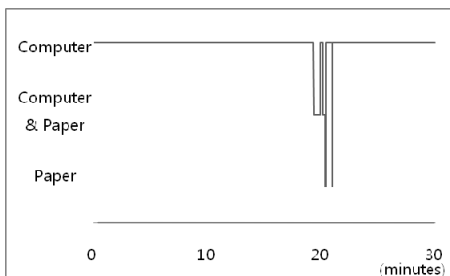
c. Text based revision work

figure 8. Examples of mode transition in text based work

5. *People regard shifting windows to be inconvenient*. When people operate a computer, especially a calculating program, they tend to write short memos on paper then enter it again into the computer. This causes them to feel that it is not intuitive to shift windows. Intuitiveness when changing modes and high accessibility of paper create this phenomenon.

6. *Different tasks require different properties of work media*. Readability and legibility are the most important properties for revision. Paper provides high readability and legibility relative to a computer. Thus, most people use paper when they revise. However, scheduling tasks involve moving from paper to a computer. In this case, accessibility, visibility and portability are required. Recently, as ubiquitous computing systems become more common, the computer provides these properties better compared to paper. In other words, the use of paper or computer does not matter; rather, people will change their preference of media which gives better conveniences and efficiencies.

Conclusion and Future Work

This article has attempted to explore how human-computer-paper interaction occurs in work environments. We looked at which trigger incites a switchover between paper and a computer in individual document handling processes. Additionally, considerable insight into the HCI design field was gained.

The complete disappear of paper in the office seems to be undesirable. If the existence of paper is inevitable, we hope that this study can lay the foundation for future work on assisting with fluent interaction between humans, computers, and paper.

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