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Human-Paper Interaction in the Digital Era: Directions for Human-Information Interaction Design

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Abstract

These days, we receive most information through digital mediums such as emails and social networking applications. Investigating the characteristics of human-paper interactions can help us design more meaningful interactions and better understand why people use paper documents in the age of digitalization.
In this study, the interaction of people with physical documents was studied through a mixed-method of conducting a literature review, gathering expert opinions, interviewing subjects, and analysing Instagram photos. By codifying the gathered information, the human-paper interaction framework was developed. This framework articulates the advantages of physical documents compared to electronic documents and serves researchers and practitioners by providing insightful human factors about human-document interaction.
Finally, we propose six design themes as the solutions to the findings of this study. These implications can provide practical foundations for future design and research.

Keywords: Human-Information Interaction, Human-Paper Interaction, Human-Document Interaction, Human-Object Interaction, Blockchain, Mixed Reality

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1. Introduction

Papyrus, parchment, and paper helped the human civilization store and distribute ideas, whether it was a shallow doodle or an advanced scientific concept description. Paper used to be an expensive material till the industrial revolution decreased the cost of paper manufacturing dramatically. It made paper sheets available in every household, and people started to use paper for various purposes. So, papermakers introduced a wide variety of papers with different sizes, colours, and designs such as plain paper, cardboard, graph paper, and labels.

However, these days, the information technology revolution pushed most of these contents to digital mediums. Nevertheless, this transformation could not stop the usage of papers even by high-tech companies and tech-savvy people. It made us curious to investigate the human-paper interaction in smart device users. Because answering why papers are still practical can inspire new insights. Consider the following story:

One piece of information passes through an interesting journey between paper and computer. The information went on paper by the fingers of an individual. Another individual typed this information on his smartphone. The other person printed this information. Then somebody came and wrote on the printed paper with a pen, and then he gave it to another person. She read the text and held it in a chest for years.

Why didn't they use a cloud system like Google Docs in the first place? Why didn't the last person scan the document instead of keeping it in a box? She might sense something more than actual text in the whole paper. Paper may provide the hidden values, and it makes studying the human-paper interaction worthwhile.

If we want to design systems that enhance user interactions with files and documents, we should expand our horizons; we should think, design, and evaluate beyond the input-output relationship. We should study human-

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paper interaction beyond the plaintext. In light of this approach, activity theory was followed in this study because it provides orienting concepts and perspectives. Limiting HCI research's perspective on cognitive science prevents the researcher from studying the physical objects present in activities. In other words, activity theory suggests that activity cannot be fully comprehended without "understanding the role of artifacts in everyday existence"[1]. Similarly, we cannot explore all aspects of human-paper interaction without studying the holistic perceived value of physical documents in activities.

If we consider the brain as a computer and the human mind as an information processing system [2], papers work as auxiliary ancillary peripheral devices. A peripheral device is "an ancillary device used to put information into and get information out of the computer" [3]. If we have a better understanding of ancient input-output devices that humans used along with their primary input-output devices (sensors and body organs), In that case, we can design more humanized technological products at both the hardware and software levels.

This study makes two major contributions to the field of HCI. First, it provides a comprehensive list of human-paper interaction competencies. Second, it presents six design themes as the foundations for designing the next generation of information products and services.

2. Methods

To explore the current state of human-paper interaction, a mixed-method research design was used; First, we conducted a literature review in scientific databases. Next, we used ResearchGate discussion boards to collect the opinions of experts. After that, we interviewed twelve users who own smartphones and tablets about their interaction with papers. Then interviews were codified to gather advantages of human-paper interaction. Analysis and codification of the records were sensitive to the role of activity theory. Needless to say, Activity Theory does not provide a "clear methodological prescription for the description or analysis of behaviour as a set of procedures to be followed"[4]. The basis of activity is mutual relationships between a subject, an object, and a community, which are mediated by artifacts (Tool) [5-7].

In this study, the human-paper interaction represents an activity system (Fig 1) formed as follows: the subject is the user, the Tools (mediating artifacts) include various types of paper documents. Community aspects involve the user's social circle. Recognition of objects, motives, and outcomes are the main goals of this study.

By the way, Instagram posts of the hashtag #documents were analysed and codified. Eventually, I proposed a framework to present the competencies of human-paper interaction. Finally, the work is concluded by design implications for future work.

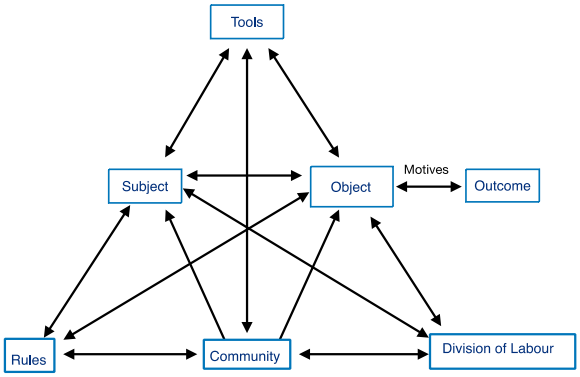

Figure 1. Activity system [7-8]

3. Literature Review

At first, to select the relevant papers from the literature systematically, the term "Human-paper interaction" was searched, but it only returned four results. Using the terms " Paper Archive" and " Human and Paper" in ACM Digital Library returns hundreds of thousands of results. Unfortunately, the term paper is a general word in academic articles, and most results were irrelevant and we couldn't conduct a true systematic literature review. So, literature review was carried out until theoretical saturation was reached. A total of 117 articles were screened, and the records describing the characteristics of human-paper interaction presented chronologically.

In 1988, Hansen et al. [9], outlined factors that impact reading and writing with computers. They described the superior **Tangibility** of paper. Tangible designs assist in learning, remembering, and efficiently using a system. "Text on paper has high Tangibility: it is laid out in particular places on each sheet of paper, the sheets are stacked together, and the user can move sheets from the unread stack to the finished stack".

Kurniawan et al. 's [10] investigation on forty-two participants indicated the superior readability of paper. They reported that **reading on paper** is 10-30 % faster than reading online. They highlighted that paper reading subjects used fingers and pencil to point out the words they were reading. They suggest that slower reading speed in online readers may be associated with the decline of the sense of orientation when reading lengthy texts presented in single wide column pages.

For several years, experts have predicted that the advent of more powerful and compact computers will eliminate papers from the office. However, the office work relies on paper yet [11]. So, in 2003 Guimbretière presented an architecture to manipulate Paper Augmented Digital Documents [11].

In the famous book on this field, "The myth of the paperless office", Sellen et al. describe their investigation of paper usage in different departments. They found out that although companies scan papers for their archive,

they keep many documents physically for **legal** purposes [12].

In [13] instead of focusing on eliminating papers from information systems, author s included paper documents and physical locations in the information system.

Academics create and maintain countless documents, and understanding their goals and techniques in archiving can provide new insights. Kaye et al. [14] studied the personal archive techniques in forty-eight academics. They found out that building a **legacy** is an important objective for many intellectuals. They tend to fill their room with bookshelves and filing cabinets because personal archives represent their personality and life's work. In other words, they are not necessarily for retrieval. Physical documents and archives' objects allow the archiver to represent who the archiver is, and Digital organizational archives may not create a similar sense of identity or identity construction.

In [14], they also observed that even portable computer users print the documents. The interviewees listed the convenience of **reading** print, difficulties in making digital **annotations**, and the low resolution of computer screens as the primary reasons for printing documents.

Fadeyev [15] underlined that the paper as a user interface is more usable than a computer monitor. LCDs glare a bright light in user's eyes that makes them tired.

Seong et al.[16] studied why we cannot work without paper, even in high-tech workplaces. They point out that paper provides preferable performance in terms of **readability** and revision compared to the computer. Besides, computer-based devices cannot operate without electric power. Also, the paper occupies physical spaces, and it made the documents noticeable, but digital files are not tangible in the work environment. Furthermore, they found that papers have high **accessibility**, and its inconvenient for users to change the windows. They observed that users favour writing short memos on paper, then enter them again into the computer.

As mentioned before, papers deliver values rather than information, and if we want to design relevant digital products, we need to address these values. In their cutting edge paper, Kirk and Sellen [17] studied the home archiving of **sentimental** objects. They list the cherished objects in three categories: Physical, Digital, and Hybrid. The physical is separated into 3d and $2^1/_2$D classes. $2^1/_2$D objects are paper, or card-based objects, including certificates, letters, photos, posters, paintings, cards, and cuttings (newspaper and magazine. They propound the issue of **authenticity**. It refers to the **uniqueness of physical objects**.

They also outlined the importance of the **stories of objects**. For example, a photograph sparks its story for its owner. They suggested that using RFID tags attached to the object may be an approach to answer this demand.

The other interesting finding of their research is the concept of **deep storage**. In computer systems, improving the discoverability of documents is a common goal in most cases. However, they found that some objects can be hidden or stored obscure because they are highly personal. They also suggested that bundling digital objects and their stories in a physical object could be a possible approach to answer the **hidden values of physical objects**.

Jabr [18] suggests that even so-called digital natives are more likely to recall a summary of a story when they read it on paper because e-readers make too much dis-traction.

Consterdine [19] lists several established values of the print magazine in the digital age, including:

- **Focused attention**: very little multitasking during the reading print magazines
- Repeat reading: printed magazines are read more often.
- **Timeless**: content kept for reference
- More perceived **trust** in printed media
- Provides a **personal** "me time" for its reader.
- Read thoroughly

In 2014, Shibata et al. [20] compared paper and computer displays in reading including frequent movement between pages. The result of experiments suggests that paper is the most efficient medium to maintain reading with endnotes. In other words, the electronic document reading interaction should be improved to support between page navigation.

Kindle and most eBook readers use e-paper displays because they do not emit light and make them convenient for reading. These displays fail to offer the tactile experience received from bound papers, which is a challenge to make a true e-paper. Bailey et al. [21] proposed a tangible interaction method that uses paper as an input device with sensors embedded in pages to detect the turning of pages digitally.

Graham [22] argues that the lack of satisfactory tactile experience in digital media caused Print media's resurgence in the current digital age (2018). She suggests that magazines can apply a unique coating to magazine papers to improve the magazine's brand positioning because haptic research shows that printed media's physical nature allows readers to sense what they are reading.

Furthermore, the hand-search is conducted on the articles cited above articles to identify other aspects of human-paper interaction. Although the purpose of [23] is to describe the foundations of material design, the video preview of their research reveals a fundamental aspect of human-paper interactions. The **deformability** of paper documents allows users to interact with them differently. One user may bend the newspaper, and another user may roll the newspaper into a tube.

4. Expert Opinions

We used ResearchGate for gathering expert opinions, for this aim, we asked researchers to answer “Why do we use paper-based documents yet? “ [24]. Six experts answered the question, and their answers are compiled below:

- Paper stimulates the **senses** in ways digital cannot and because different print channels bring different benefits [25].
- More convenience in reading printed papers and books
- Printed media is more suitable to read thoroughly
- Better proofreading on paper
- Cultural aspects and Generational factor: Digital natives do not need to have hard copies of paper/textbooks, but older generations feel more convenient in paper-based documents to complete their works.
- No power required to read / write on paper
- Easy and quick annotation
- Paper is **portable** and easy to handle
- Paper provides bigger overview of the global document
- Free spaces of documents provide a good input area, and they can be used for quick sketches.
- Frequent scrolling causes eye fatigue.
- Better navigation in papers
- **Technology obsolescence**: Digital storage technology has leaped forward many times. Users have seen dramatic advancements in speed and capacity, but each solution had a different interface. For example, if a user stored its data on a floppy disk 20 years ago, it is really hard to find a device to retrieve data now.
- Screen glare which causes eye fatigue
- **Fear of information theft**: The amount of information that cybercriminals can steal in a cyberattack is enormous. The file owner may lose the whole data or need to pay ransom to get the description key. Some users perceive less threat from physical espionage and incidents compared to cyber-attacks.
- **Redundancy**: Some people prefer having documents in more than one kind of medium.

5. Interview Sessions Findings

Twelve (12) subjects from different occupational fields were individually interviewed using semi-structured protocols. The subjects were 9 male and 3 female. Due to Coronavirus restrictions, interview sessions were conducted online, and We couldn't observe the subject's residence or work in person. Below questions were asked from all participants. Also, according to their answers, additional questions were asked.

- Where do you use paper?
- Why do you use paper?
- Which paper-based objects do you possess? How long do you have them?
- Why do you print documents?
- What do you do with printed documents?
- How do you keep your paper documents?
- Who else does have interaction with your paper documents?
- What electronic document features do you wish your physical documents had?

The interviews were recorded and transcribed. Transcripts were analysed using codification techniques. Finally, the outcomes are presented in below:

5.1. Always Ready to Use

One significant advantage of paper documents compared to digital systems is that they are always ready to use. Several participants expressed that they can always write, draw or read a paper without the additional load of opening an application or switching the windows.

5.2. Anthropomorphic Emotional Value

The materialization of information enables the aging of the information-carrying object. One interviewee mentioned that some of his books have age because when he has written the purchase date on the first page of the book. He assigned the biological trait of humans to his books. The attribution of human-like characteristics to non-human objects is called anthropomorphism [26],[27]. Human-likeness in technology implies human-like physical characteristics, behavioural and emotional intelligence, functions, and roles in machines [26] that facilitate technology acceptance [28].

5.3. Authenticity

It's easy to change the file creation information, but it's hard to hide the actual age of paper documents. Old paper is even noticeable with plain naked eyesight, and ink dating experts can detect the age of paper documents by analysing pen ink accurately. Subject 4 reported that he held draft and handwriting of his articles and books because they can be used as evidence of priority date.

5.4. Collectability

The authenticity and scarcity of a paper document can make it valuable for collectors. One interviewee reported that he collects the tickets and stamps of the early 19th century. The tickets are invalid, but the scarcity makes them valuable. Similarly, we know the object value can be modified by manipulating the number of objects [29].

5.5. Creativity Actualization

There is no doubt that we can create many things with computers, but paper facilitates the actualization of

creativity. Four subjects explained that it allows them to express their creativity when I asked them more questions, such as “what's the difference between sharing artwork on Instagram and printing it? They stated that printing or drawing a text allows them to actualize their ideations. A photo on a computer is part of a computer, but a printed picture is a distinct photograph the whole time; It conveys its meaning all time.

5.6. Direct Access to Information

It's impossible to access data of storage devices like hard drives and flash disks with-out tethering them to computers. In contrast, users are able to skim the physical documents. Several subjects reported this issue. I asked them about using cloud services; some expressed a sceptical view toward storing data on third parties, but their main concern was navigation through the digital media.

5.7. Durability

Subject 5 told us that she regretted using digital media because she stored most photos and videos on her daughter's childhood on compact disks and her smartphone. The CDs are unreadable, and she lost her phone gallery after a factory reset. She just has few printed photos of her daughter's childhood.

5.8. Findability

Three subjects expressed they found more findability in paper-based archives. One of them reported that although he bookmarks important URLs digitally, he prints the first page of online documents to keep them physically. He pointed out that he can find some of his bookmarks because he does not know what to search for, but he can find the aimed document by a flip through the printed papers.

5.9. Identity Representation

Similar to the findings of [14], One professor placed the books his selected books on a shelf behind him. It shows viewers how he desired to recognize him.

Another interviewee, a medical doctor, had placed an immunology book behind him. It was significantly observable. It tells his patients that he knows about immunology.

One participant reported that he decorated his living room with the complete col-lection of Lords of the Ring and Harry Potter Books. These physical books show her interests to her guests.

5.10. Legal Value

All subjects stated that they keep some physical documents for legal concerns. The governmental system workflow relies on paper documents, and digital scans do not represent the legal value.

5.11. Ownability

Subject 2 reported mentioned the issue of ownability for him with e-books. He noted that he purchased several books from e-book stores. Although he paid for the books, the Digital Right management system of the eBook store does not provide full possession.
He explained that the e-book store stopped service for his old devices, and He did not have access to his books in his older devices natively, so he removed the DRM protection to convert them, which might be illegal. He mentioned that he buys his favourite books physically because he wants to own them forever.

5.12. Readability & Annotation

Several subjects mentioned readability as a primary driver for using paper documents. One participant mentioned that although he usually reads books on his e-ink book reader, he prefers the readability of the paper. He reported that the e-ink display refresh process is too disturbing.

One interviewee, a management professor, stated that he prints most documents because it's easier to read and annotate. Also, he can review a thesis in the taxi while he is on his way to university.

5.13. Security & Perceived Trust

Seven subjects perceived more security in paper-based documents. Three subjects stated that they keep some of their critical passwords in the tiny notebooks and card-boards. When they were asked about using password management systems, two subjects expressed that they lost their all passwords that stored in Apple Keychain because their devices got out of the service, and after trying to retrieve iCloud passwords, interviewees found out that the security measures of Apple don't permit password recovery, because before device reset, they hadn't activated two-factor authentication.

The other subject stated that he holds cryptocurrencies, and it is safer to keep his wallet's private key on paper. He argued that cybercriminals use tracking scripts to target blockchain wallet users. Digital environments are always connected to the internet, and it made them vulnerable, so instead of using Apple Notes or Google Keep, he keeps the mnemonic phrase on cardboard stored in his safe box.

Another Subject explained the story of losing his Master's thesis due to a ransom-ware attack, and he could recover some of his work because of the printed version. As a result, he tries to print essential documents from time to time.

5.14 Spatiality

The importance of using paper documents in physical locations was evident in interviews. For example, one subject reported that he uses several sticky notes and keeps them in highly visible spots. I asked him about using sticky note apps, but he emphasized the importance of accessing information in different positions. Also, he mentioned that using multiple apps is disturbing for him.

The other participant pointed to the achievement frames that were hung on the wall. He notes that although he shared these achievements on his social media, the presence of these objects near him gives him self-confidence and impresses his visitors.

5.15. Tactile Representation

Papers have different levels of texture and coating. One subject, a fashion designer, reported that although she consumes numerous digital content every day, she buys printed many fashion magazines and books, digital media doesn't represent the sense of touching (tactile). She admitted that printed magazine does not represent the exact feeling of cloths, but she argued that paper documents are made of different type of papers. When you interact with digital devices, all contents represent "the same sense of touch, and it is boring for me."

5.16. Tangible Social Networking

Electronic documents can get shared in millions of copies with people around the globe regardless of their location. Still, conversations with interviewees indicated that the tangible aspects of the paper are impactful in sharing the documents. For example, two subjects reported that they share flyers, catalogues, and business cards. One participant mentioned that before the coronavirus pandemic. He used to share the brochures and business cards at networking events because physical documents let him have more personal communication

Similarly, Nägele et al. study [30] demonstrated that tangible objects create an emotional connection to services. In other words, tangible nature of paper, facilitates social networking.

5.17. Work without power & Affordable

Two subjects reported that they installed posters in their bedroom. Posters are affordable and can work without power. Posters are cordless and can show their content without the need for charging.

5.18. benefits of electronic documents

Finally, after interviewing participants about the paper-based documents, they were asked on the advantages of electronic documents. Ten (10) participants mentioned the search within the text is an outstanding benefit of using electronic documents. Furthermore, several interviewees said that they could carry the digital version of their library anywhere (Portability of massive document collection).

6. Hashtag #Documents

1050 Instagram posts using the #Documents hashtag were analysed to determine what makes a physical document, a shareable content for digital users. The stock photos, illustrations, and advertisements were excluded from the analysis. A total of 97 images were included. All posts used the photos of the physical document (instead of renders or scans) to demonstrate the authenticity of the content. Analysis of the con-ten of posts in the physical world context implies that the users use paper documents because they carry history and authenticity. Also, identity representation and creative activity are among the functions of paper documents.

Table 1. Paper-based document competencies in Instagram

Functionality	Description	Total Posts
Authenticity	Historical Books, Historical Letters, Proof of Ownership	97
Identity Representation	Show off Bookshelf	19
Creative Activity	Making Artwork with Paper	3

7. Human-Paper Interaction in The Digital Age Framework

The findings of all steps were codified and gathered in figure 2. This framework includes a list of physical document competencies, a list of user requirements, and a list of discovered issues in user interactions with digital documents. It can be a helpful resource for the design and evaluation of information systems..

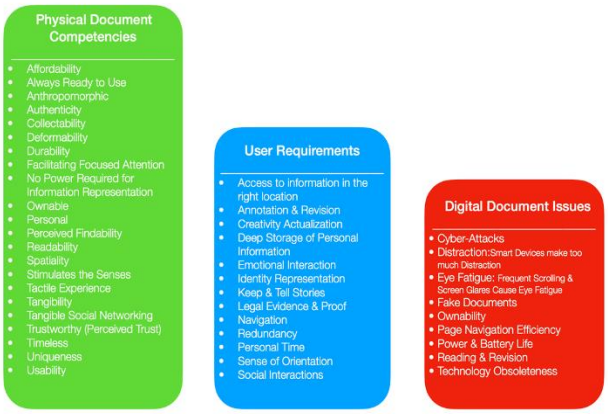

Figure 2. Human-Paper Interaction in the Digital Age Framework

8. Design Implications

Technological products serve diverse consumers with different needs, requirements and disparate world of thoughts. In the same way, various people perceived varying benefits in human-paper interaction. So we need to address several ways that designers can enhance human-document interaction based on the findings of this study. Like Orth et al. [31], we finished this work by discussing design implications through design themes. These implications are synthesized based on the results of this research, conducting manual research, iterative ideation, and author's prior experiences.

8.1 Blockchain-enabled Design

We mentioned that authenticity, collectability, and ownability are among the competencies of paper-based documents. Furthermore, we discussed that users perceive paper documents as a technology obsolescence-proof medium for data storage. Designing blockchain-enabled interactions can employ these competencies in digital files.

Blockchain is a decentralized and immutable data structure initially used for "value transfer between parties" without using a central institution [32]. In other words, Blockchain architecture makes the records persistent. Moreover, blockchain ledgers can store transactions of fungible and non-fungible tokens (NFT). By Minting an NFT, the user can create a unique tradeable asset. Each NFT holds specific metadata. Using NFT can bring scarcity and collectability to digital files. Considering all the above, blockchain is a promising digital material for designing computational artifacts[33].

An application that follows the blockchain-enabled design would integrate connection to blockchain network within its interface. Also, a blockchain-enabled design benefits from the interactions that are only possible through blockchain systems, such as immutability and tokenization.

For example, CardanoWall *utilizes the metadata field of the Cardano blockchain for creating imperishable messages. Users can share a message in CardanoNetwork transactions, and transaction records are not editable or removable. Each message can contain up to 5000 characters, and it costs one Ada coin.

To illustrate the application of blockchain-enabled design in bringing authenticity and ownability to digital files, the low fidelity prototype of a blockchain-enabled word processing software is proposed (See Figure 3). This design facilitates blockchain-related interactions. The user can select a cryptocurrency wallet and, instead of printing the document, share it in a blockchain network or mint it as a rare ownable artifact.

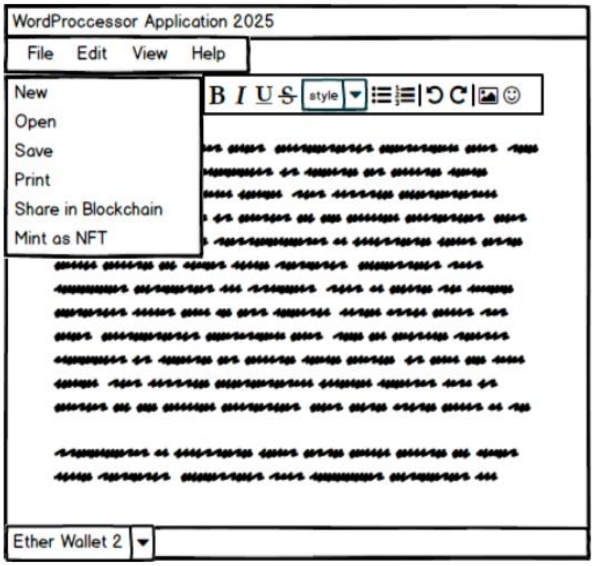

Figure 3. This UI facilitates using blockchain and provides authenticity and digital preservation
Acknowledgements.

8.2. Connected Documents

Instead of dematerializing and trying to simulate physical document competencies into electronic document systems,

* *https://cardanowall.com/en/*

this approach focuses on bringing connectivity and smartness to physical documents. The main objectives of connected documents are:

- Delivering electronic user interface functionalities such as information extraction and sharing via physical documents [34].
- Keeping information updated by Syncing physical documents with their digital twins.
- Providing interactivity and responsiveness on physical documents [35].
- Keeping the advantages of paper documents
- This approach toward human-document interaction can get addressed in several levels:
- Dumb Documents: At this level, connectivity to the electronic document management system is delivered through computer vision technology. The physical document itself has no interactivity or computing capability.
- Microchip-integrated Documents: This level of connectivity delivers interactivity through printed conductive inks or integration with microchips. These documents can connect to the internet through IoT chips and retrieve additional information [36].

8.3. Isolated Interaction Design

Increasing the connectivity domain was the dominant attitude in designing computing devices, but it does not always bring user satisfaction. We mentioned that how people use paper documents to satisfy their security requirements. Some users want to cache information secret or maintain their documents safe from digital espionage. Hardware cryptocurrency wallets are the most notable commercial example of the demand for isolated interactions with computers.

For a long time, users want to achieve the most tasks on their smartphones. How-ever, it is noticeable that cryptocurrencies created an opportunity for a new market space, the hardware wallets. A Bitcoin account is defined by two keys. The public key creates the address for assets, and the private key is used to sign transactions of that address [37]. A hardware wallet allows users to store the private key of the as-sets isolated from the internet. In other words, on a smartphone, there is always the possibility of data tampering, so Hardware wallets are designed to offer a tamper-resistant environment [38]. These gadgets" do not offer network connectivity; instead, they operate in an offline mode."[37]

It is worth mentioning that the isolated interaction design should not be limited to hardware designs, and the software user interface may facilitate isolation too. For example, airplane mode facilitates a very basic isolated interaction.

8.4. Smart Device Centric Documents

Participants' remarks about electronic document competencies indicated the importance of new possibilities that can enrich the usability of interactions. Users may need to spend hours finding a word in a physical document, but they can find it in an electronic book at a glance. In other words, although human-computer interaction has short-comings compared to human-paper interaction, Human-computer interaction can offer opportunities "not possible in other types of interaction" [39].

In other words, instead of simulating the physical documents by skeuomorphic methods like page flip animation, we need to create documents to serve computers and smart devices. Digital documents are mostly made through desktop publishing and word processing applications that follow print media's layout and composition standards. We need to question the whole process of document creation and document consumption flow, similar to business process reengineering efforts [40]. If we want to implement human-paper interaction competencies in human-computer interaction, we need to focus on the potentials of computers. For example, instead of creating a header and footer for each page of an eBook, the author should enter metadata of each page for use in the AI of the book reader application. Then instead of scrolling, the reader can ask questions from the book.

8.5. Spatial UI & Spatial Publishing

We mentioned that the spatially of paper allows users to find and use information based on the position of documents. Augmented Reality (AR) makes it possible to present virtual elements such as text and pictures in a real-world context. Prior studies demonstrated the feasibility of positioning information on different points with the help of NFC, IoT, barcodes, image recognition, object recognition, and near field positioning sensors such iBeacon [41- 44]. Spatial Authoring applications can bring spatiality to digital files via spatial user interfaces. Several efforts have been conducted to present associated information of artifacts in museums [45, 46].

Spatial UIs were used in the virtual environment of video games for several years, but recent breakthroughs in consumer augmented reality provide potentials for displaying Spatial UI in user's location. Spatial UI creates the opportunity for virtual spatial publishing. For example, in Fig 4, we see a word processing application that allows users to select virtual spatial printers and print documents virtually by placing them in the environment.

Finally, designing methods for using augmented reality in document organization and information communication can represent an interesting topic for future works.

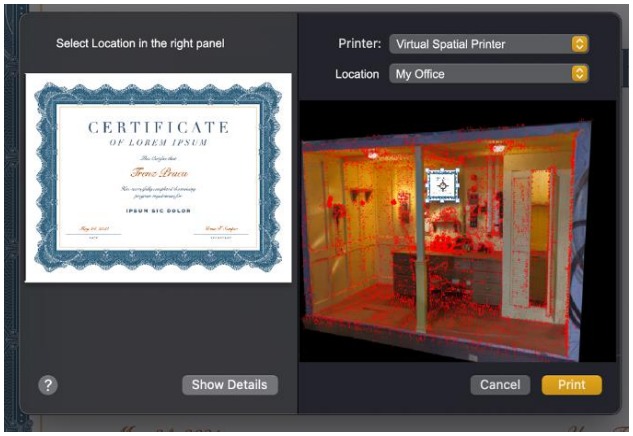

Figure 4. This prototype allows users to select a position for placing the virtual document in a scanned room.

8.6. UI Design for Sentimental Information

The physical documents carry more information than their actual text, such as legacy values, anthropomorphic emotions, tactile emotions, and invisible personal stories. A PDF file may represent texts of a physical document, but it does not convey the physical document's sentimental information. Creating an additional layer of information for storing and representing sentimental information may make digital files more cherishable. For example, an eBook reader can record the heartbeat from the user's smartwatch and keep it alongside the original file. Or it can display the age of the book based on the purchase date on the first page.

9. Concluding Remarks

This article has presented a study examining how people interact with physical documents and their reasons for using paper-based documents in the digital era. The literature review, expert opinion, interview sessions, and Instagram post analysis were used to reveal the advantages of using paper in the age of smart devices. These findings were used to develop a framework to represent the human-paper interaction competencies. Finally, six design themes were presented to provide HCI researchers and practitioners opportunities for developing more human-centred interactions with documents. The outcome of this study aims to contribute to further research in the field of interaction design, including human-document interaction and human-object interaction.

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