HUMAN-CENTRIC STUDY OF DIGITAL-PAPER TRANSITIONS: FRAMING DESIGN OPPORTUNITY SPACES

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ABSTRACT

Although digital devices have their own unique features that differentiate them from other tangible types of resources for reading, writing and sketching, a majority of people still prefer traditional paper media as it provides better user experiences in many aspects: readability, portability, ease of making annotations, shared reading, tactile sensory experiences, etc. This paper identifies barriers and opportunities for paper-related features based on human-centric design research directed towards the overarching goal of providing insights for finding disruptive opportunity spaces. In framing our design research, we define journeys that tangible and digital media follow – from original form, transitions and final form. Our target populations are college students and professionals in diverse majors and work environments. Based on insights from our design research, we present personas and case studies.

Keywords: human behavior in design, new product development, user centered design, human centric design, digital-paper transitions

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1 INTRODUCTION

Although e-books and tablet PCs were introduced in the market decades ago (1970-80's), they have only recently taken off commercially in the marketplace due to prior barriers of unaffordable hardware pricing and the lack of enough content for users. Recently, however, the advent of inexpensive and lightweight e-book readers (e.g., Amazon's Kindle Fire and Barnes & Noble's Nook) as well as digital tablets (e.g., Apple's iPad and Samsung's Galaxy Tab) has triggered a higher demand of digital content. This increased demand has led to a recent explosion of digital content for users to consume (Smartmoney.com, 2012; Reynolds Journalism Institute, 2011). As a consequence, an increasing number of users are now switching from paper-based to digital content for some types of applications and contexts. However, despite the unique advantages of digital devices for reading and learning (DisplaySearch, 2012; Agogino et al., 2011; Datta and Agogino, 2007; Cassell and Ryokai, 2001; Duguid, 1996; Hsi and Agogino, 1994), a majority of people still prefer traditional paper media (Sellen and Harper, 2011; AIIM Market Intelligence Division, 2007; Davy, 2007; Shaikh, 2004; O'Hara and Sellen, 1997; Portigal Consulting, 2012). For example, some evidence suggests that students prefer reading textbooks in print format even when e-texts are given as an option (Vernon, 2010; Leu et al., 2005; Brown, 2001). Our own research indicates that the ability to make annotations in the margins and the ability to quickly access and view arbitrary pages are critical factors in preference for tangible textbooks.

Portigal's *Reading Ahead* research reveals that paper media provides a better user experience by 1) imbuing the media with personal history and memories while reading (e.g., parents reading to a child) that go beyond words and images explicitly contained in the media, and 2) providing unabridged events while reading a book (e.g., tears and laughter). Previous research has explored the strengths and weaknesses of traditional printed books compared to digitalized books to support this persistent trend towards digital media (Weisberg, 2011; Brown, 2001; Christy, 2010; Lau et al., 2009; Oehlberg et al., 2009; Leu et al., 2005; Nunberg, 1996). Users – from children to adults – exploit paper for reading, writing, drawing, creating, and sharing; paper has been a crucial part of our life (ehow.com, 2012).

Prior research shows that users are willing to adapt to digital content and devices only if they can expect a major increase in advantages, such as greater convenience, flexibility and portability (Weisberg, 2011; Davy, 2007; Platt and Hausmen, 2008; Rodden and Wood, 2003; Wilson et al., 2002; Frank and Dryer, 2001; Marshall, 1997; Techcrunch.com, 2012). For example, Reynolds estimates that 25% of new textbook sales in the next five years will be in digital formats and that digital will be the dominant format by 2020 (Reynolds, 2011).

The competitive marketplace is continuously providing new technologies that change the digital-tangible landscape for activities that once had been dominated by paper media. Users have a variety of digital devices for readings: tablet PCs, digital tablets, e-books, as well as computers, and the formats have been developed in new ways, such as allowing users to make personal annotations and highlights. Augmented reality technology also promises entirely new hybrid digital-tangible interfaces (Agogino et al., 2011; Billinghurst et al., 2001; Ryokai et al., 2012). Apple recently announced transparent augmented reality technology for a better user experience with digital devices (Slashgear.com, 2012). Google recently announced *Google Glass*™ digital eyeglasses that provide users with a totally different digital experience. (Washingtonpost.com, 2013). In this paper we will present our user research into tangible and digital media usage, and explore the design implications of our findings in the context of this trend towards digital media.

2 RESEARCH METHODOLOGY

Using a human-centric design research approach (Beckman and Barry, 2007; Dym et al., 2005), we focused on paper and digital media users in our target populations of college students and professionals. Our design research has been structured to find new market opportunities that build on these advances in digital media and to discover new innovation spaces. Our design research questions are:

- What are the primary barriers that prevent users from switching from paper to digital media and devices?
- What can we learn from the digital-paper transition of different user segments?
- What is the entire journey of paper-digital transitions by college students and professionals?

- How do people collaborate with peers while using either paper or digital media? What are hybrid digital-media behaviors?

Our data were collected from interviews, observations, and case studies, as well as an online survey. Our team interviewed a total of 61 subjects from the professional and college student demographic. The observations were made in classroom settings, libraries, professional offices, medical facilities and public places. The online surveys were conducted with college students in both undergraduate and graduate level design courses in order to gather preliminary data on general paper and digital device usage. The survey involved questions about the types of digital devices college students used and how often / in what contexts they used digital devices versus traditional paper. Forty-three students from UC Berkeley completed the online survey. Personas and frameworks were created by our internal integration team of co-authors of this paper, as well as student teams involved in this research project.

3 FRAMEWORKS

FRAMING PAPER USE BY USER SEGMENTS

A design matrix was first created for defining our target user segments and exploring each of their relationships with different types of media. In Figure 1 below, darker boxes indicate areas of interest for the target populations with regards to five types of media: textbooks, newspapers, document processing, diaries/journals and photographs. These media types are listed in order from text-based to image-based media. Our focus in this paper is on college students and professionals as we see a large market opportunity with this population of active media consumers and creators. We plan to investigate the elderly user segment in a future study.

Figure 1. Different user segments use of paper versus digital media

FRAMING THE LIFE CYCLE BETWEEN TANGIBLE AND DIGITAL MEDIA USAGE

Based on our user segment matrix in Figure 1, our design research identified and analyzed six types of media life cycles:

1. **Persistent-Tangible**
   Media that was created in a tangible format and stays tangible
   (e.g., tangible postcards)
2. **Transitional-Tangible**
   Media that was created and ends tangible, but has one or more digital transitions
   (e.g., tangible artwork that is digitized and enhanced through digital operations and printed on tangible media)
3. **Tangible→Digital**
   Media that was created in a tangible format and gets converted into a digital format for final form

(e.g., converting old photographs to a digital format)

4. **Persistent-Digital**
   Media created in a digital format that stays digital
   (e.g., social media, such as tweets on Twitter)

5. **Transitional-Digital**
   Media that was created and ends digital, but has one or more tangible transitions
   (e.g., solid models that are converted to tangible 3D models for prototype testing, then digitally photographed and included in a digital design portfolio)

6. **Digital➔Tangible**
   Media created in a digital format that gets converted into a tangible format in final form
   (e.g., printing out digital photos)

These six life cycle paths can be visualized in Table 1.

	1		2		3		4		5		6	
Type	Persistent-Tangible		Transitional-Tangible		Tangible ➔ Digital		Persistent-Digital		Transitional-Digital		Digital ➔ Tangible	
Description	• Created Tangible • Stays Tangible		• Created Tangible • Ends Tangible *has one or more digital transitions		• Created Tangible • Ends Digital		• Created Digital • Stays Digital		• Created Digital • Ends Tangible *has one or more tangible transitions		• Created Digital • Ends Tangible	
Information Format	Tangible	Digital	Tangible	Digital	Tangible	Digital	Tangible	Digital	Tangible	Digital	Tangible	Digital
Created	●		●		●			●		●		●
(Phase 1)												
(Phase 2)												
(Phase 3)												
...												
(Phase n)												
End or Stay	●		●			●		●		●	●	
Examples	• Tangible journals • Letters • Books • Postcards • Film Photographs • Sketches		• Tangible artwork that is digitalized and enhanced through digital operations and printed on tangible media		• Converting old photographs to a digital format		• Social media such as tweets on Twitter, Facebook Photos		• Solid Models that are converted to 3D models for a prototype display, then digitally photographed		• Printing out digital photos	

Table 1. Six types of media life cycles

4 PERSONAS AND CASE STUDIES

Based on our interviews, observations, and online surveys, we developed four user categories of interest:

1. **Extreme Tangible:** Someone who won't use digital media at all.
2. **Extreme Digital:** Someone who won't use tangible media if digital is also available.
3. **Parallel Tangible-Digital:** Someone who uses digital for some tasks, sticks to tangible for others and rarely transitions back and forth. A special case of this is "Wannabe Digitals" who would like to go 100% digital, but find solutions lacking for some tasks.
4. **Extreme Transitional:** Someone who is facile with both digital and tangible media and freely moves back and forth depending on the task. Often these transitions are associated with versions of the same product.

Our interviews revealed unique stories behind why and when users preferred to use digital or paper media. The Extreme Transitionals were of particular interest as lead users who produce many iterations of their work in both the digital and tangible worlds. This switching back and forth between media types is a critical part of their process of creation. These extreme users can generally be classified as "makers" – people who produce some sort of creation as a part of their work. For example, many of our users in this category were artists, architects, writers or designers.

Table 2 below addresses successes and failures of digital and tangible media for the user types we have just defined.

Table 2. Perceived Strengths & Weaknesses of Paper and Digital Media by Extreme Personas

	Extreme Tangible Users	*Extreme Digitals*	*Extreme Transitionals*
Perceived Strengths of Tangible	Paper is important for preserving letters as historical documents.		Paper is necessary for the critical first stage of developing new ideas.
Perceived Strengths of Digital Devices	Computers provide easy access to information in large systems.	Computers allow flexibility in work, such as editing & correcting.	Digital design tools are powerful and enjoyable to use.
Perceived Weaknesses of Tangible	Paper is inconvenient for others if the community is primarily digital.	Paper is overused; excessive copying and recycling.	Difficult to translate sketches on paper to the computer. No method to fluidly move from paper to digital media.
Perceived Weaknesses of Digital Device	Digital devices represent a lack of human-centered design; limits intellectual development; injurious to physical & emotional health.	Computers can cause physical discomforts.	Digital design tools are often unintuitive, programs are slow.

PERSONAS

Six personas were developed based on composites of people interviewed in each of the four user categories: Extreme Tangible, Extreme Digital, Parallel Tangible-Digital and Extreme Transitional. These personas cover a 2x2 space of Tangible versus Digital shown in Figure 2. Extreme lows in both digital and tangible were not considered, as their lack of interest in media of any kind makes them an unlikely target for a media product.
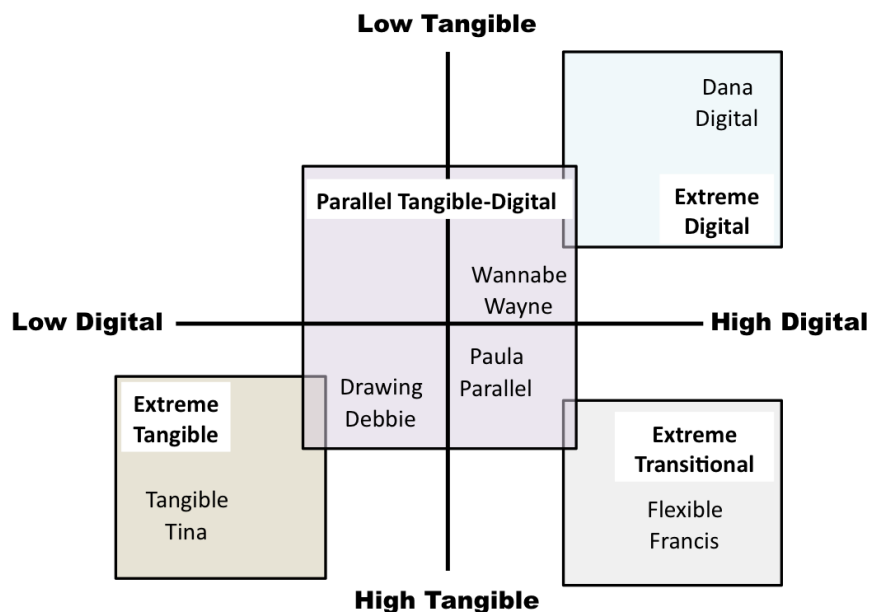

Figure 2. Personas mapped by level of digital tangible media use

Tangible Tina is a college professor in the social sciences and falls into the category of an Extreme Tangible user. Not only does she prefer traditional paper, she refuses to incorporate technological devices into her life wherever possible. Tangible Tina identified several "failures" of digital devices, including their negative impact on the environment, physical and emotional health, and intellectual development. Tangible Tina believes technology contributes to loss of focus, efficiency, and

consequence thinking. She also believes digital devices are detrimental to communities. Tangible Tina asserts that new technology is aimed at "adapt[ing] the human to the machine instead of the machine to the human,"– essentially, that current digital devices are not human-centered.

"I'm never going to use digital. People say that new technologies help us connect more. But we're more disconnected than before the computer. We're forgetting face to face and have less communities" – Tangible Tina

Architecture student **Paula Parallel** is an example of a Parallel Tangible-Digital user: one who is familiar with digital devices and incorporates them into daily life but stays with the digital format for some tasks and tangible for others. Paula uses the computer and various design programs to develop her architecture projects. As an example of a digital device failure, Paula Parallel noted that design software is often unintuitive, and that programs in her field are too slow. Paula Parallel did not directly identify failures of paper; however, it is notable that while her work incorporates both tangible and digital media, the two do not interact. While Paula stressed that both digital and tangible stages are very important in the design process, there was no medium for her to fluidly translate her initial paper-based ideas to secondary digital-based iterations.

"I sketch the idea of it, but then I do it on the computer again." – Paula Parallel

Wannabe Wayne is an engineering college professor who also keeps his digital and tangible worlds somewhat separate, but would like to be able to convert all of his current tangible media to digital. He is a special case of Parallel Tangible-Digital. For example, he keeps both a tangible design journal and a digital one, as seen in Figure 3. He would love to use his tablet computer to take all of his notes and create/ archive design sketches but has not found effective computer devices or software for this.

"I always take both my journal and a Tablet PC together. I tried to use some applications on my device to get rid of my journal, but haven't found good features to substitute them."– Wannabe Wayne

Figure 3. Parallel uses of tangible and digital design journals

Drawing Debbie is a college senior who teaches a drawing class in her spare time. Although she prefers tangible media, she uses a computer for school work and therefore falls into the Parallel Tangible-Digital user category. Whenever she is taking notes or drawing, Debbie completely prefers paper over digital devices. To her, drawing and writing on paper is an aesthetic experience that digital devices cannot achieve. She thinks that drawing is important and believes that it should be something students want to do. According to Debbie, visual note taking is a way to listen to information, process it, and translate it into a visual. "*It's a mental process*" and this process is naturally achieved by using paper as the medium. Debbie is open to using digital devices, but is not interested in putting in the time and effort to overcome the learning curve associated with mastering a new device for her professional work.

"I want to go digital but there is time commitment to learn something new. I have been working with papers for my entire life." – Drawing Debbie

Office employee **Dana Digital** is an example of an Extreme Digital user, and uses digital devices to copy, scan, and print documents. She noted that a negative aspect of using paper is excessive copying and recycling, leading to waste. Dana believes a negative aspect of digital devices is that they can wear on the body after excessive use.

"The basic thing about working on a computer is its flexibility. I can work on more things and easily edit/correct them on computer." – Dana Digital

Finally, an example of an Extreme Transitional is **Flexible Francis,** a landscape designer who always uses both tangible media and digital devices for design projects. Francis uses the mobile phone and a computer to digitalize tangible drawings, sketches, and scratches to share with others promptly. There were an extremely large number of transitions between papers and digitals to finish the design project discussed in the interview. Francis believes that mobile applications and design software programs make professional work much easier and simpler to communicate with other designers.

"Once my boss made early design concepts on scratch papers, I digitalize them right away and print them out, then I ask my boss to review and correct them. Our team goes though this design process multiple times over the project until the final design concept is fixed." – Flexible Francis

MOBILE DEVICES AS A COLLABORATION TOOL

Along with the increased usage of mobile devices, we observed active communication among members of design teams to share and explain ideas, images, and documents throughout their work. The online survey we conducted with college students revealed that 93% use tangible white/black boards for shared teamwork, 42% used laptops and 38% used paper. A surprising 44% of respondents used mobile devices when collaborating with a group/team (Figure 4); this is a higher percentage than those who used sketchbooks, tablet PCs, flip charts or large rolls of paper to collaborate.
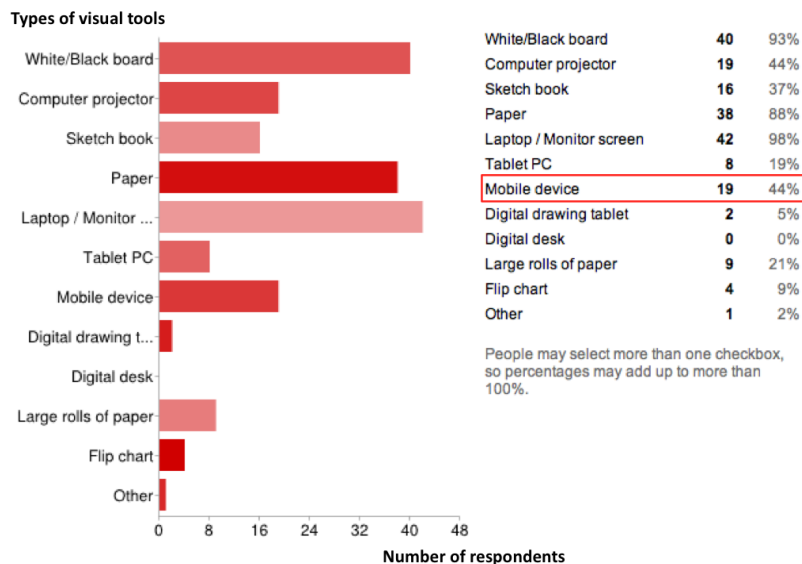

Types of visual tools		
White/Black board	40	93%
Computer projector	19	44%
Sketch book	16	37%
Paper	38	88%
Laptop / Monitor screen	42	98%
Tablet PC	8	19%
Mobile device	19	44%
Digital drawing tablet	2	5%
Digital desk	0	0%
Large rolls of paper	9	21%
Flip chart	4	9%
Other	1	2%

People may select more than one checkbox, so percentages may add up to more than 100%.

Figure 4. What kinds of visual tools do you use when collaborating with a group/team?
*Source: Next Digital Online Survey, 2013

In professional work, Flexible Francis provides us with an example of a design process that exhibits multiple iterations of communication with colleagues while working on a landscape design competition. In this case, the subject used a mobile phone to take photos and send them back and forth through a mobile text message application while refining design concepts (Figure 5).
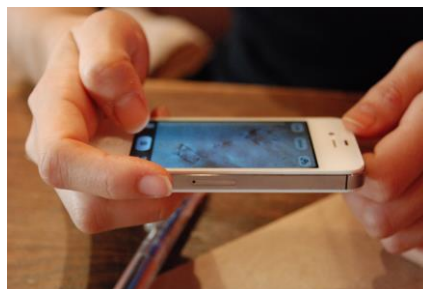

Figure 5. Demo of capturing images, sharing with others through mobile device

Paper sketches, ideas, thoughts produced by designers were converted into digital form to share with other collaborators in the design project. Figure 6 shows how the iterations between Francis and another member of his design team involved multiple transitions between digital and tangible media. Because designs are frequently converted back and forth in their form, sharing designs with their mobile phones is the easiest way for Francis to communicate with other designers promptly.
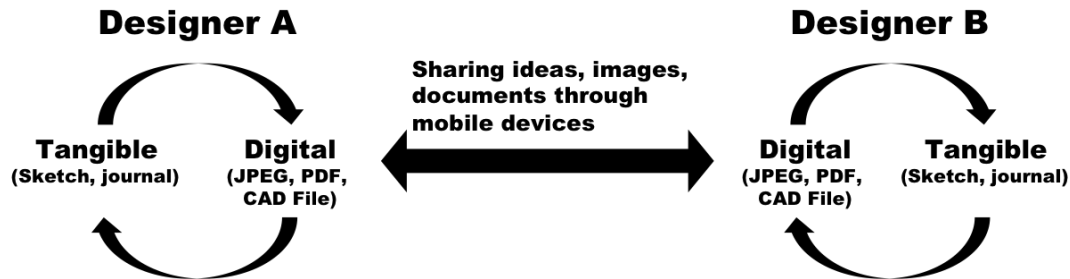

Figure 6. An example of a design process between two extreme transitional design collaborators

5   CONCLUSIONS AND FUTURE RESEARCH

The goal of our human-centric approach is to understand users' media transitions between paper and digital formats. In this paper, we have defined user segments by media usage, ranging from mostly text-based to mostly image-based media and six different types of media life cycles: Persistent-Tangible, Transitional-Tangible, Tangible → Digital, Persistent-Digital, Transitional-Digital, and Digital → Tangible. From these user categories, six personas were created to further define and explore particular types of users and how they interact with media. Our personas and case studies, along with insights from interviews, observations and an online survey, provide several frameworks to help find design opportunity spaces and develop disruptive technologies for the next generation of digital devices.

From our research, we realized that there are many people who want to go digital, but that certain barriers fundamentally prevent them from changing their behaviors. We believe this is the area in which future stages of research should be focused. We present the following recommendations for future research opportunities by other researchers and practitioners working on similar research topics, so that they may learn from our findings and build upon the foundation discussed in this paper:

1. Continue to observe the Extreme Transitional and the Parallel Tangible-Digital user cases in order to develop disruptive technologies stemming from the contradiction of users who want to go digital, but cannot yet find digital technologies that suit all of their needs.
2. Determine how to make the switch from tangible to digital media smoother and more hassle-free, especially for users with slower adaptation rates who struggle with the behavior change associated with using new technologies.
3. Investigate the media-sharing aspect of digital devices, as more and more people are showing a willingness to go to digital for the purpose of sharing their thoughts, ideas and shared experiences in order to collaborate more easily with others.

People have been using paper for 2000 years. We are currently in a transitional age where media now exists in a digital form alongside paper; today's digital devices have not entirely caught up to this new medium. In order to find a critical form of the next generation of digital devices, more research must be conducted in order to develop a deeper understanding of human behavior regarding tangible and digital media usage: a fundamental understanding of what people want to accomplish, and how their devices can assist them in these goals. Our future research will also look at the role that age plays in digital-tangible transitions.

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