Ubiquitous Sketching for Social Media

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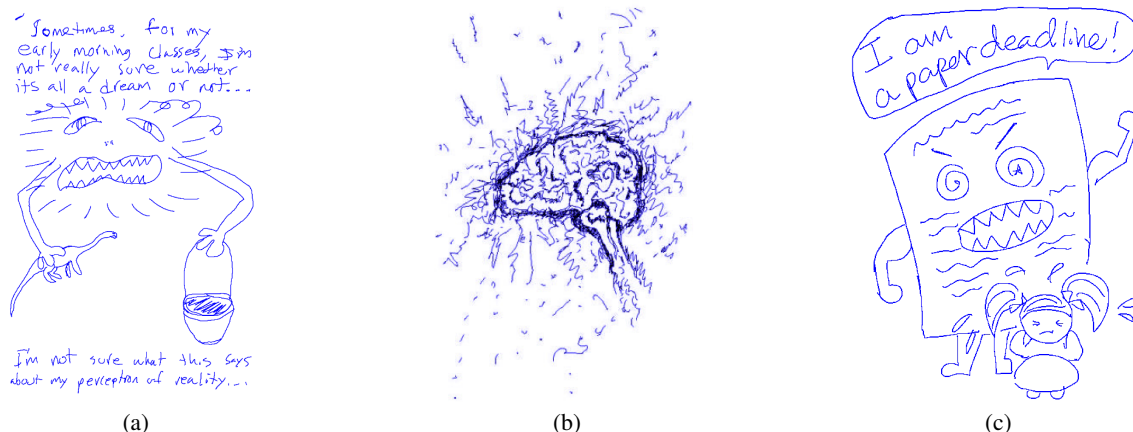{lgcowan, weibel, lrpina, hollan, wgg}@ucsd.edu

(a) (b) (c)

Figure 1. Ubiquitous sketching: *Early morning classes*, *Feeling overwhelmed*, *An impending deadline*

ABSTRACT

Digital social media have transformed how we communicate and manage our relationships. Despite its portability, sketching as a social medium has been largely left behind. Given sketching's unique affordances for visual communication this absence is a real loss. Sketches convey visuo-spatial ideas directly, require minimal detail to render concepts, and show the peculiarities of handwriting. Sketching holds the promise to enrich how we communicate, and its ubiquity is critical for sharing information at opportune moments. We present the results of an exploratory field study of ubiquitous sketching for social media, documenting users' experiences with UbiSketch. This system integrates digital pens, paper, and mobile phones to support the transmission of paper sketches to online services. We learned that UbiSketch enabled participants to leverage sketching's unique affordances, that ubiquitous sketching creates a synergy with the practice of posting context-dependent information, and that it broadens and deepens social interaction.

Author Keywords

Sketching, social media, communication, interactive paper

ACM Classification Keywords

H.5.m Information Interfaces and Presentation: HCI

General Terms

Design, Human Factors

INTRODUCTION

Digital social media tools, such as e-mail, Twitter, and Facebook, have transformed how we communicate and manage our relationships with family, friends, and colleagues. Facebook alone facilitates the sharing of more than 30 billion pieces of information, including text and photos, each month.[1] Yet, although sketching has traditionally played an important role in communication, it is not currently used widely in social media. It is possible to post sketches by taking camera-phone photos of paper sketches or sketching on touchscreen or tablet devices, but we could not find evidence of these activities in sustained practice on Facebook, suggesting that these modalities are somehow inadequate. Given the unique affordances of sketching for visual communication, its relative absence from social media is a real loss.

Like spoken and written language, sketching is a form of communication with self and others, and sketches can externalize ideas for remembering, sharing, discussing, and revising [31]. But uniquely, sketches convey visuo-spatial ideas directly, mapping elements and spatial relations in the world to elements and spatial relations on paper [31]. Thus, it is easier to explain some thoughts and ideas by sketching them than by attempting to verbally describe them. Moreover, Buxton observed that sketches are quick to make, timely (provided when needed), inexpensive, disposable, and show the peculiarities of individuals' handwriting [7]. Sketches require only minimal detail to render intended concepts, and their ambiguous nature encourages multiple interpretations and thus serves as a catalyst for conversation. Accordingly, people sketch to share ideas, to express feelings, and to relieve boredom, and doodling during lectures or meetings has been shown to aid memory and focus [1]. Sketching also creates external

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[1]http://www.facebook.com/press/info.php?statistics

representations that are integral to design and artistic cognition [25, 8] and is used to explore concepts and make abstract ideas concrete [7, 19].

Sketching holds the promise to expand and enrich the ways that people communicate with their online social communities, and ubiquity is critical. People are increasingly accessing social media via their mobile devices, posting information at opportune moments. Over 200 million mobile users access Facebook, and they are twice as active as non-mobile users[1]. Traditional sketching can take place anywhere, and pen and paper are widely used, especially in comparison to digital tools for note taking, doodling, and communicating ideas [29]. With the advent of technologies for digitizing paper-based input, such as Anoto digital pens and paper,[2] we see an opportunity to leverage the affordances of pens and paper to facilitate ubiquitous sketching.

In this paper we present the results of a 4-week exploratory field study of ubiquitous sketching for social media. To the best of our knowledge, this study is the first research to document this communication practice and the associated social interactions. We created UbiSketch, a system that integrates Anoto digital pens, paper, and 3G smart phones, to enable ubiquitous sketching and study lightweight, real-time, mobile, sketch-based communication. The results of our study indicate that ubiquitous sketching enables participants to leverage sketching's unique affordances in their mobile communications. Given that it did so, we learned that ubiquitous sketching created a powerful synergy with the common practice of posting context-dependent, personal information on social media, it broadened and deepened social interaction, and stimulated conversation.

DESIGN SPACE OF UBIQUITOUS SKETCHING

There are many ways to achieve ubiquitous sketching, each with its unique affordances and compromises.

- *Sketching on paper and posting via camera-phone* affords flexibility in the choice of materials and requires no additional hardware. However, the quality of the posted sketches is subject to the lighting, care in capture (steadiness and positioning of camera), quality of camera, etc. An application could apply post-processing to increase contrast, sharpness, and remove color casts, but would be limited to recovering existing details in the image. Also, the additional effort required to produce a sufficiently high quality photo of a sketch is a deterrent to sharing. Further, photography is not socially appropriate in certain settings, such as classes and meetings, in which handwriting, doodling, and note-taking occur.

- *Sketching on a touchscreen or tablet* affords direct capture and requires no additional hardware. However, this mechanism does not leverage existing paper-based sketching practices. Mobile device screens are typically small, finger or stylus input are often inaccurate, and a

touchscreen's smooth, rigid surface does not provide the familiar experience and tactile feedback of drawing with pen and paper.

- *Sketching with digital pens and paper* affords direct capture of paper-based information, yet requires additional hardware. Nevertheless, this approach leverages the affordances of paper, including flexibility, high resolution, portability, material feel, and potentially large size, while simultaneously leveraging existing paper-based writing and drawing practices. Furthermore, digital pens can stream information to mobile devices in real time and provide other features, such as time-based tracking of strokes and pressure, enabling further processing of sketch data.

Despite the positive affordances of touch-screens, tablets, or camera-phones, we could not find evidence of sustained sketch-sharing practices on Facebook, suggesting that the time/quality tradeoffs of these modalities are mismatched to support widespread use in popular social media. The type and nature of the interaction required by these devices, probably do not support sharing sketches through *in-the-moment*, lightweight interactions. Given the advantages we identified in digital pens and paper, including their accuracy, naturalness and convenience, we chose to explore this part of the design space. We defer investigation of other parts of the design space for future work.

RELATED WORK

Sketching
Paper has many unique affordances [26, 21, 20] that are advantageous for ubiquitous sketching. For example, it can be easily grasped, folded, and carried, and it's texture provides tactile feedback. Yet the difficulty of re-accessing, editing, rearranging, or sharing paper documents has motivated the exploration of digital alternatives. Sutherland's Sketchpad was the first system to introduce pen-based user interfaces to support sketching [30]. Following this work, research evolved to explore pen-based sketching through interactive tablets or pads, such as the Interactive Worksurface Project [22], the NPL electronic paper project [5], and SILK [18]. The Re-Board system supported sharing and re-access of information on whiteboards [4]. Besides these research projects, also commercial products and applications address digital sketching; for instance tablet-based systems based on Wacom[3] or the recent Apple iPad Autodesk app[4] support finger- or stylus-based sketching, while online apps like Graffiti[5] enable sketches to be posted directly to the users' Facebook Wall.

Although these systems enable digital input and interactive feedback, the material properties of digital tablets and boards do not offer the same experience and feedback as sketching on paper, so users often have to adjust their drawing techniques accordingly [12]. We conjecture that the optimal solution is a hybrid system combining paper documents and digital resources [16]. Digital pens based on Anoto technology, enabling tracking of the pen's position on paper documents, support this model. Several pages of handwriting can be captured and stored within these pens or can be transmitted wirelessly to a separate device as a continuous stream of position information. To support developers in accessing this technology

and implementing paper-based interactions, several frameworks such as PADD [14], the iPaper framework [23], and PaperToolkit [37] have been introduced. Anoto technology has recently been used in a variety of applications: paper-digital cohabitation [9, 33], paper-based interactions with digital applications [27], support for field biology [36], natural note-taking [28], and speech therapy [24].

Social media
Wellman's studies of how networked computing systems affect and enable social communication over distance highlighted the importance of technologies which connect people with mutual interests regardless of physical location [34, 35]. In recent years, social networking sites (SNSs) have emerged as important tools for supporting informal communication, with Facebook being the most representative example. While some specialized SNSs are oriented toward displaying high fidelity artwork (e.g., deviantART) or photographs (e.g., flickr), sketching has not yet achieved first class status as a communication medium on SNSs. Researchers have studied various aspects of SNS communication [15, 3] among a range of populations, including rural and urban communities [13] and university students [11]. Other work has studied how SNSs evolve over time and how people adapt accordingly [17], highlighting how important usage patterns emerge due to changes in the user's social context or the introduction of new features. Now, with the increasing functionality and ubiquity of mobile smart phones, SNS interaction is moving from users' desktops into the palms of their hands, and researchers are looking at how mobility influences communication within and around social networks [2].

Although paper commonly serves as a medium for social communication [26] via short notes (e.g., post-its) or more lengthy documents (e.g., letters), it does not traditionally support instantaneous communication over distance. Digital pens and paper open new communication possibilities, and Anoto introduced an early application for sending paper-based notes as MMS messages. In the next section we introduce UbiSketch, a mobile digital pen and paper application we created to study ubiquitous sketching. To the best of our knowledge, this work is the first to research ubiquitous paper-based sketching in the context of social media communications.

UBISKETCH
UbiSketch exploits the affordances of Anoto's digital pens and augmented paper, and Bluetooth-enabled smart phones to extend the reach of paper-based sketching, supporting the real-time transmission of sketches to online services [32].

System architecture
The UbiSketch infrastructure is illustrated in Figure 2. It leverages iPaper [23], a framework for developing interactive paper applications, and adds support for mobile phones. Users interact by using Anoto digital pens and paper imprinted with the Anoto dot pattern, which enables tracking of the pen's position on the paper. Pen activity generates data, which is appended to the current sketch unless the user taps a *paper button* with the pen to trigger a specific event. Interactive paper buttons are implemented by mapping regions of the paper

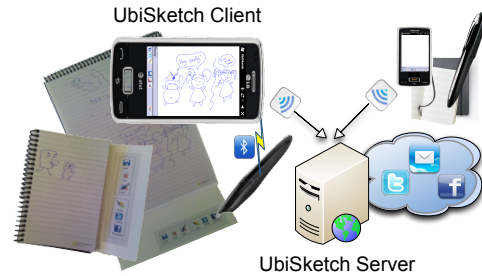**Figure 2. System overview**

to input events. Analogous buttons are also provided in the phone UI. The system uses Anoto DP-201 digital pens, which stream data by bluetooth to the client, running on an LG Expo mobile phone. The client processes and temporarily stores the streamed information, and it is implemented in C# on .NET Compact Framework 3.5, on Windows Mobile 6.5.

The user publishes a sketch by tapping a specific button on the paper or phone UI. The client handles this input event by forwarding the current sketch and some supplementary data (GPS position and ID of the phone, digital pen, and paper document) to the UbiSketch server. The server further processes the recorded pen strokes and supplementary data to generate a JPEG image, and then pushes it to one or more publication channel(s). The published sketch faithfully renders the original sketch, except that digitized strokes do not vary in thickness based on the force applied to the pen.

The UbiSketch server has a plug-in architecture that enables the development and deployment of extensions to support new publication channels. As shown in Fig. 3, we have currently implemented support for three channels: Facebook (via the *SketchBook* plug-in and the *facebook-java-api*[6]), Twitter (via the *SketchTweet* plug-in and the *Twitter4J*[7] library), and email. SketchBook posts users' sketches to a dedicated photo album on their Facebook profiles. Subsequent social interactions, such as comments or *likes*, are directly supported by Facebook's interface. *SketchTweet* provides similar functionality for Twitter. Emailed sketches are sent to the sketch's author for archiving or forwarding.

Exploratory Pilot Study
To inform the design of the paper user interface (UI) for ubiquitous sketching we ran an exploratory laboratory study with 11 participants (6 women and 5 men, age 22 to 55, avg. 32). We asked participants to draw one or more sketches and tap on *paper-buttons* to upload them via SketchBook.

The published sketches, despite being created in a laboratory setting, led to conversations and social interactions on the Web and in person. After interacting with the provided
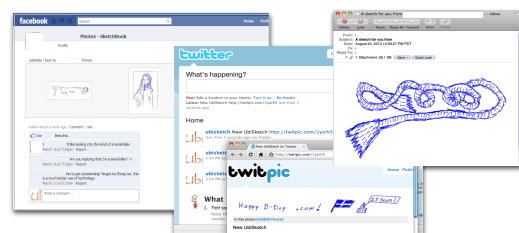

Figure 3. Publication channels: Facebook, Twitter, email

UI prototypes, participants expressed these preferences: (1) The sketching area should be maximized and the digitized sketch should faithfully capture the details of the original, (2) The paper UI should be portable, simple, and easy to use, (3) The primary interface should be the paper (minimizing phone interaction), and (4) The phone UI should be employed to provide feedback. These preferences were fed into the final design, described below.

Paper User Interface

The sketching area is maximized, utilizing the entire page. To balance size and portability, we offered two different paper formats: small (15cm × 10cm) and large (22cm × 28cm) notebooks. A *control panel* was printed on sticker paper and placed on the fold-out flap of each notebook's back cover, easily accessible from any page. We provided additional control panel stickers that users could place in convenient locations. As shown in Fig. 2 and Fig. 4, the control panel allows users to: save a sketch on the phone, clear the current sketch from the application, load a sketch (i.e., resume a sketch that was saved previously, to append or publish it), or publish a sketch to Facebook, Twitter, or email.

Figure 4. UbiSketch control panel

Mobile Phone User Interface

The mobile phone UI is intended to be secondary to the paper UI, providing optional feedback. As users sketch on paper, a digital rendering of the sketch is automatically displayed on the phone. As the sketch evolves, the rendering is dynamically adjusted to the maximum size that will fit on the screen to make optimal use of the display space. The phone UI also contains a control panel (identical to the paper version) and a status bar that displays feedback in response to users' input. For example, after a user taps a button to publish a sketch, the status bar indicates that the sketch is being published and eventually reports when the publication succeeded.

USER STUDY

We conducted an exploratory field study to document the interplay of ubiquitous sketching and social media. We were specifically interested in answering the following questions:

- Why and how do participants communicate through ubiquitous sketching?

- How does using UbiSketch affect sketch publication, and how does social media affect sketch publication?

- How does sketch publication impact social interactions, and how do these impact sketching practices?

Methods

To observe naturalistic usage practices, we ran a 4-week field study. With each participant, we conducted a pre-study training session, in which we defined the study task — sketch as they would normally, but using the pen and paper we provided. We compensated participants up to $105 for simply carrying the equipment, and no incentive was offered for publishing sketches; the compensation was independent of

sketching activity. We provided each participant with an LG-Expo smart-phone, an Anoto DP-201 digital pen, and two notebooks (small and large) containing Anoto-augmented paper. We conducted a pre-study interview, weekly mid-study interviews, and a post-study interview, presenting each participant's own sketches and those of any participating friends to ease recall and elicit discussion. All interviews were audio-recorded and transcribed. Throughout the study, we collected the published sketches and — with the consent of the participants and their friends — logged the resulting Facebook interactions (comments and *likes*). We performed quantitive analysis on the logged data, including UbiSketch usage and Facebook interactions, and performed affinity analysis, based in grounded theory [10], on the sketches and interviews.

Participants

We recruited 10 participants who sketched and used Facebook (4 female and 6 male, ages 22 to 46, avg = 31.9). To explore usage in different social structures, we selected one individual, three pairs, and one three-person group. The participants' Facebook friends also participated indirectly through interactions associated with the published sketches. We identify participant groups as follows: a unique letter (A–E), followed by group size (1–3). We identify participants by their group ID followed by a "–" and a digit (1–3).

In group A3, A3-2 and A3-3 are married and live in the U.S. about 2,000 miles (3,200 km) from their close friend A3-1. A3-2 (male, age 26) is a chef/photographer, A3-3 (female, age 27) is a seminary graduate student, and A3-1 (female, age 27) is a computer science graduate student. Pair B2 consists of two brothers who live an hour's drive apart. One is an artist and teacher (B2-1, male, age 43), and the other is a salesperson and holistic health instructor (B2-2, male, age 46). C2 is a pair of friends who live near each other in a U.S. metropolitan area: an artist/teacher (C2-1, male, age 37) and a computer programmer (C2-2, male, age 36). Pair D2 consists of undergraduates: (D2-1, male, age 24) and (D2-2, female, age 22). They are friends and classmates who live near one another and see each other regularly. E1-1 (female, age 31) is a stay-at-home mom/jewelry artisan also living in the U.S.

The participants all doodled and hand-wrote notes on paper, but their drawing practices varied: 7 drew regularly, 2 drew occasionally, and 1 never drew. Participants occasionally shared sketches face-to-face but rarely online. The member of group A3 occasionally physically mailed each other pen-and-paper sketches, the 4 student participants sometimes showed their doodles to classmates, and the artist C2-1 posted photos of his paintings on his Website. Two participants had scanned sketches, edited them in Photoshop, and posted them on Facebook, yet they found the digitizing practice to be time-consuming and cumbersome, so they undertook the process infrequently, no more than several times a year.

Facebook was the primary online social networking site for all participants, and none used Twitter. Eight had between 132 and 219 friends, and 2 had larger social networks (651 and 1419 friends). Five read content throughout the day, and the remaining 5 read it once or twice a day. Two participants posted content at least 3 times a day, while the remaining 7 posted weekly or less. They primarily posted status updates

or comments, and they occasionally posted photos, links or events. Participants accessed Facebook in a variety of ways, depending on the context: 6 sometimes used mobile phones, 7 sometimes used laptops or tablet PCs, and 4 sometimes used desktop computers.

Limitations

As participants became comfortable with our system the complexity of their sketches increased, and publishing a complex sketch generated a high volume of network traffic. Situations in which only slow networks (such as Edge) were available induced long transmission times and caused timeout problems on the server side, preventing complex sketches from being published. This problem appeared in our study in Week 2, and in Week 3 we released a software update (compressing sketch data before transmission), which solved the problem. Aside from this technical issue, the study and the deployed system generally ran as expected.

RESULTS

We present the results of our field study, providing data on UbiSketch usage, users' practices and experiences, and social interactions associated with sketches on Facebook. We also highlight the experiences of three example participants.

UbiSketch usage and social activity

We analyzed the usage of UbiSketch over the 4 weeks in terms of the total number of sketches published by our participants. A total of 241 sketches were published with UbiSketch, and individual usage varied (min=3, max=55, avg=25, stdv=18.9). Of the published sketches, 78% went to Facebook (78%), 22% to email. Figure 5 presents weekly publication statistics, which indicate that sketching practices were sustained throughout the study well past the initial burst of activity, likely due to novelty effects. The reduced usage in weeks 2 and 3 was influenced by the technical problems identified above. Usage then increased, with 23.7% of the overall publication occurring in week 4.

Of all published sketches 64.5% contained text and images, 30.7% contained only images, and 4.8% were text-only. In 29.4% of sketches text conveyed a specific message (e.g., "Happy Birthday"), while in 46.3% of them it was used to label elements or to clarify the overall meaning for viewers.

Participants used UbiSketch in a variety of locations (home, work, school, a cafe, a friend's home, outdoors, and in motor vehicles) and settings (in class, in transit, while cooking, at work, at church, during leisure activities, while simply drawing, and even walking). They sketched on a variety of surfaces, including a table, a bed, the floor, lap, knees,
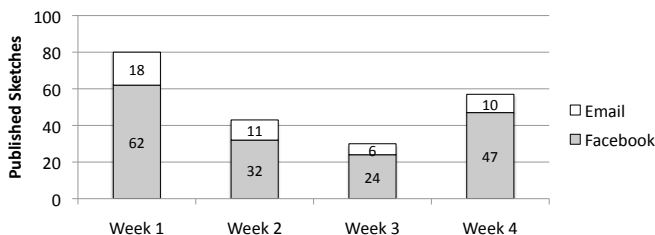

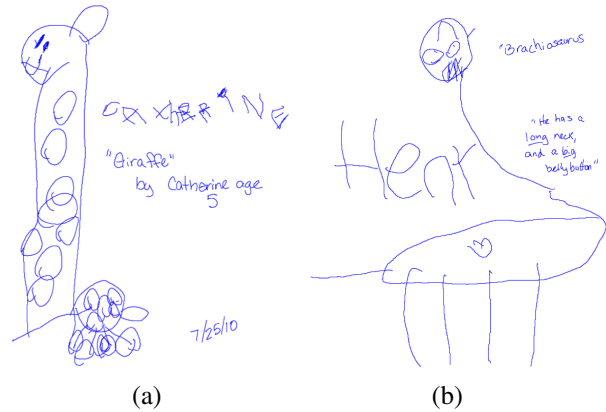(a)   (b)

Figure 6. Children's sketches

or in the hands. Nine out of ten participants typically kept UbiSketch's phone out while sketching, periodically referring to it for visual feedback: to check on the digital rendering of the sketch, or to monitor the application's status (e.g., publication progress, and troubleshoot in case of connectivity issues). The remaining participant, D2-1, kept the phone in his backpack while sketching. A3-1 kept her own smart phone out, in addition to the UbiSketch phone, so that she could tag people in the sketches on Facebook. Eight participants exclusively interacted with the paper UI (control panel), while two sometimes used the phone's UI as well. Six participants exclusively used the small notebook, two exclusively used the large one, and two used both. They carried the equipment in pockets, purses, or backpacks.

Seven of the ten participants sometimes sketched collaboratively with friends and family. Some of these sketches were influenced by suggestions regarding their content, and 13% of them were directly authored by friends. 10% of all sketches were created by children (Fig. 6); three of the participants' young children (ages 3–6) sketched under their parents' supervision. Friends' or family members' sketches were usually identified by text labels or by Facebook comments.

The sketching experience

According to all participants, sketching with a digital pen felt more natural — like using an ordinary pen and paper — especially compared with drawing on a touchscreen or tablet. A3-2 valued the paper's tactile feedback, *"when you're trying to draw without the feel of actual resistance that the paper gives you, it's like you're ice skating with a pen."* C2-1 enjoyed the familiarity: *"It's not like I'm drawing on a computer screen, you have that natural feeling of paper and pen, which we all know."* However, several participants complained about the pen's width and its ambiguous vibratory feedback.

Participants were generally positively surprised and highly appreciative of the immediateness and directness of publication. E1-1 related, *"It does what you want it to do, and what you're used to. There's not that interface between doing what you want to do and doing what it's actually doing."* A3-2 described his and his wife's (A3-3) initial surprise at UbiSketch's directness: *"You touch the pen to it, and [the sketch] is on Facebook. You're like, 'Whoa . . . this is unreal'."*

Some participants adapted their drawing styles to UbiSketch's constraints. For example, stroke thickness and color did not

Figure 5. Sketches published per week

vary with pen pressure, so A3-2 adopted a simple graphic style to avoid the need for shading. Similarly, B2-1 drew continuous strokes whenever possible because, *"[the digital lines] don't always meet up the same way [as on paper]"*.

Impact on social interaction on Facebook

We analyzed data collected from participants' Facebook profiles to understand how sketches, in particular as compared to photos, impacted social interactions. Fig. 7(a) compares the average number of comments, *likes*, and friends that commented or *liked* per sketch versus per photo (control group). To avoid the perturbance of sketches on photo behavior, we used the 48 weeks of photo data preceding the study. In order to validate our analysis we performed independent T-tests on the collected data (number of comments, likes, and commenting friends) that confirmed the statistical significance of the results for all three dimensions (P-value < 0.01). Compared to prior photo practices, participants' sketches received more comments and *likes*, and a larger group of friends responded. We conclude that ubiquitous sketching drove substantially more attention and social interaction than photos.

We ran an additional analysis on the contents of the comments on the sketches and photos. Building on previous work [6], we quantified the personalness of sketches and photos by counting the number of specific personal pronouns, such as 'I', 'we', and 'you'. Figure 7(b) highlights how sketch comments, on average, contained significantly more personal pronouns than photos (T-test: P-value < 0.01). We conclude that sketching enables people to be more personal than photos.

(a) Social participation   (b) Pronoun use
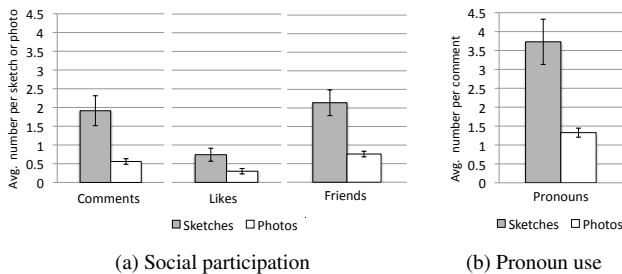
Figure 7. Social Interaction: Sketches vs. photos on Facebook (error bars show 95% confidence interval of the mean)

Example users

We describe three participants' experiences in detail to illustrate some examples of UbiSketch usage. Although further study would be required to identify general patterns, these users' distinctive experiences give a sense of the possibilities of ubiquitous sketching. We analyze and discuss the implications of participants' experiences in the next section.

Participant C2-1: The artist

C2-1 is an artist who sits in a cafe and draws in a sketchbook for an hour every day. His sketchbooks are private, and he rarely shows them to anyone. In his work he uses recurring shapes and visual themes, which he describes as a visual language that he uses to express himself. His sketches tend to be abstract, energetic, and highly aesthetic.

With UbiSketch, C2-1 has continued his existing practice of sketching in a cafe, simply swapping his ordinary sketchbook and pen with those we provided. He shares all of his sketches

(a)   (b)
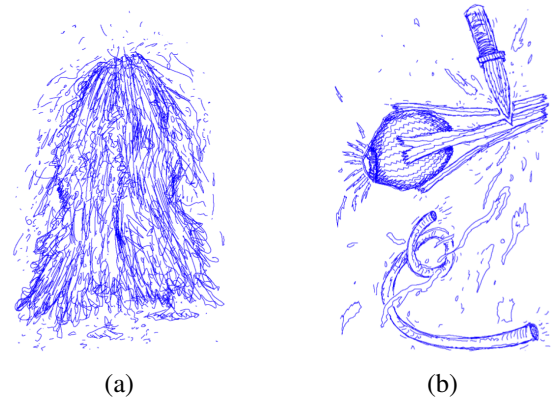
Figure 8. The artist: *Feeling hot* and *Upcoming surgery*

on Facebook, because he wants to connect more with people through his art and enjoys the new experience of publishing his sketches rather than keeping them hidden. He gets lots of feedback from friends and family, who comment on and *like* his sketches, and enjoys hearing from people with whom he would not ordinarily share or discuss his art and people with whom he does not ordinarily interact on Facebook.

He has changed the content of his sketches somewhat since he began publishing them online, shifting from a purely aesthetic style to a more expressive, narrative style. He thinks more about what he wants to tell people, rather than just drawing for practice, just for himself. For example, he has expressed his feelings of being overwhelmed as the father of a newborn baby (Fig. 1(b)), his discomfort during hot weather (Fig. 8(a)), and concerns about his upcoming eye surgery (Fig. 8(b)). His sketches never contain words, yet he adds a title or comment to each sketch on Facebook, in a post-publishing step, to hint at the significance of the sketches' often abstract contents.

The UbiSketch interface has also impacted his drawing style. He likes how the nature of the drawing interface constrains his sketches to be relatively simple, small, and quickly drawn. He also appreciates how the inability to erase or undo pen strokes frees him from dwelling on details and getting caught up in striving for perfection.

Participant D2-1: The doodler

D2-1 is an undergraduate student who doodles in his notebook during class. Doodling helps him stay alert in early morning classes and provides a creative outlet to pass the time when he's bored. He rarely shares his sketches, except sometimes with friends sitting near him in class. He believes that he is not good at drawing, yet he draws prolifically.

With UbiSketch, D2-1 continues to doodle in class, but now he shares his doodles on Facebook. He brings his UbiSketch notebook and his ordinary class notebook, and uses the Anoto pen both to sketch in one and take notes in the other. He prefers to organize the material in separate notebooks and simply moves his hand back and forth between them. Because he typically creates quick, simplistic doodles, UbiSketch has not greatly impacted D2-1's sketching style.

D2-1's doodles, such as Fig. 1(a) and Fig. 9, consist primarily of handwritten text accompanied by quirky,

cartoonish drawings, which together tell a rambling, stream-of-consciousness story in words and pictures. He describes dreams, past and recent experiences, current feelings, and the adventures of fictional characters he invents. His sketches generally contain the implicit message that he is bored during class and is reaching out to his friends. He enjoys getting feedback on Facebook from his friends, and uses UbiSketch as a sort of diary that talks back.
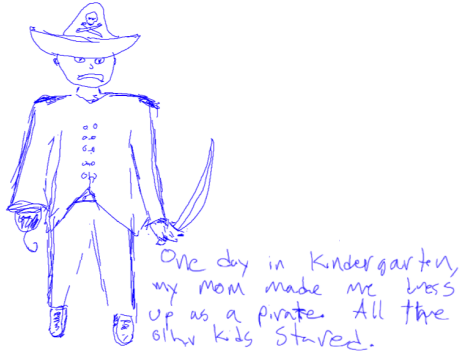

Figure 9. The doodler: *Pirate*

Participant A3-1: The socializer

A3-1 is a graduate student with a long history of sharing comic strips with her old friends, A3-2 and A3-3, a married couple who live in a distant city. Years ago, they created a set of cartoon avatars to represent themselves, and they periodically draw comic strips portraying their real and fictional adventures and physically mail them to each other. They also draw these comics together when they get together in person for vacations or holidays. Hardly anyone else knows about their comics, except for close friends and family members who have seem the comics at their homes.

UbiSketch brings Group A3's long-standing, but relatively private, practice of sharing sketches to Facebook, where more of their friends can see them. A3-1's sketches frequently depict her triad's avatars, as exemplified in Fig. 10, along with avatars representing other friends and family members. After posting a sketch to Facebook, she often tags people depicted in it so that they'll be notified — using sketches to send "thinking of you" messages to particular friends, who often respond with comments or *likes*.

She also uses UbiSketch as a form of visual microblogging, updating her friends on how she is feeling and what is going on in her life (e.g., an impending deadline (Fig. 1(c)), a fun vacation, an outing with friends). In the past, she would intend to create lengthy comics, but there were many that she never got around to finishing or sending to her friends. Because she can publish sketches easily and immediately with UbiSketch, she now shares more short vignettes in-the-moment.

A3-1 sketches in many different contexts, such as while at work, at home, in transit, and out with friends, and she sometimes sketches collaboratively with friends and family — letting them draw, drawing together, and incorporating their suggestions into her drawings. Her sketches usually primarily contain drawings along with some hand-written words, used to label elements of the scene or clarify the activities being depicted.

Figure 10. The socializer: Remote friends' drawing together

DISCUSSION

We now discuss what we have learned about ubiquitous sketching, as realized by UbiSketch.

Leveraging the communication affordances of sketching

Sketching enabled users to communicate things that they could not, or would not, express with words or photos. Sketching has unique affordances for visual communication that text cannot replicate. E1-1 related, *"There are certain things you just can't type up with words,"* and A3-2 used UbiSketch *"whenever words wouldn't do something justice."* And in some cases, even if one could express something with text, one might not feel comfortable doing that. D2-1 remarked, *"In this kind of format, I feel like it's socially okay for me to say whatever it is that I'm feeling ...But if I actually write it out as a status thing ...then it's just kind of awkward."* Because A3-3 felt more comfortable expressing herself through drawings than through text, she was able to share more about her life on Facebook. She explained, *"I didn't really post many updates to Facebook before UbiSketch ...I could let people into what was going on with me because drawing was so much more fun than saying, 'Hi, I'm having a good day"'* (Fig. 11). She added that her friends sometimes perceived her as a serious person and that sketching enabled her to reveal a more playful, funny side of her personality. Sketching also affords different kinds of communication than photography, enabling people to express thoughts and feelings that do not have physical forms. For example, the participants in Group A3, who lived in distance cities, created sketches that expressed a sense of wanting to be together (Fig. 10). A3-1 explained, *"we can't take [photos] together when they're that far away, but we can still draw pictures where we're all together"*.
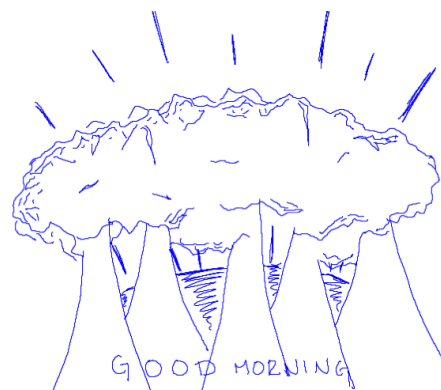

Figure 11. *Good morning*

Participants found the medium of sketching to be especially powerful for creatively expressing their emotions. For example, C2-2 sketched himself bent into the shape of a pretzel to illustrate how he felt after helping a friend install insulation (Fig. 12). C2-1 made light of his concern about his upcoming surgery in a sketch he titled "Strabismus Massacre Feared Dead" (Fig. 8(b)). He related that the sketch is *"showing you the over-the-top silliness of the fear of this surgery,"* and added, *"I'm sure it will be fine and not a big deal, but in my mind it's this horrible thing."* Also, A3-1 vented her stress about an impending deadline in a series of sketches depicting the deadline as a monster attacking her (Fig. 1(c)).
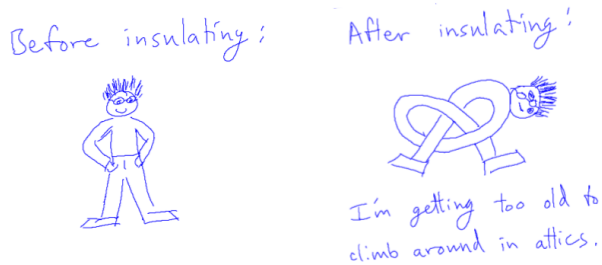

Figure 12. *Feeling like a pretzel*

In addition to providing authors with unique affordances for self-expression, sketching gave viewers unique insights into authors' thoughts and feelings. In the prior example of A3-1's paper deadline, she used UbiSketch because she thought sketches would enable her friends to relate to her situation more effectively than textual status updates would. She explained, *"It's easier to see yourself in that [situation] and think 'I've been there',"* and when her friend A3-3 viewed the sketches she agreed, *"There's just no better way, and I knew exactly how she felt."* A3-3 also related how her husband's sketches were easier for her to understand than his verbal communication: *"Normally, he's trying to verbally describe his thoughts to me and I get so lost . . . the pictures make a lot more sense."* She explained that because she felt that *"the sketches just expressed a whole lot more"* than her friends' other online updates, she consequently paid more attention to the sketches. This perception could be a factor in the increased social interaction we observed on Facebook with sketches, compared to text and photos (Fig. 7).

Participants used many representational techniques to convey messages within their sketches. They constructed the meaning of their sketches with handwritten text and drawn images, often in combination. B2-1 sometimes hand-wrote words to *"add information to a sort of ambiguous drawing,"* explaining that he used text in his sketches *"only to back up the drawings."* E1-1 annotated her young daughter's sketches to externalize information for remembering and sharing (Fig. 6(a)), relating, *"she explained to me what she was drawing, and I made little notes."* In contrast, D2-1 published many handwritten notes in which text was primary. Sketched images often contained symbolism. For example, five participants used recurring cartoon avatars (e.g., Snoopy, a *"creepy cat creature"*) to represent themselves. Participants also expressed themselves figuratively, as exemplified by one of C2-1's sketches (Fig. 13(a)); the elements of the drawing appear stretched, and he explained, *"I was feeling really worn out and stretched thin."*
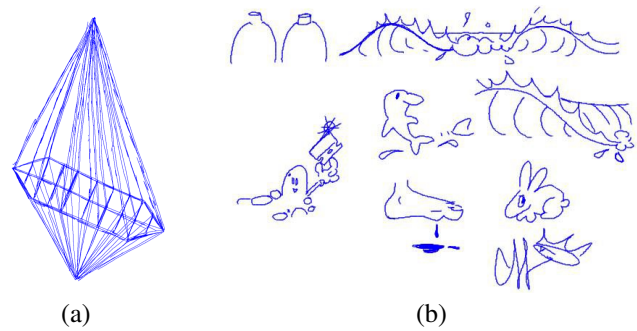

Figure 13. Visual expression: *Stretched thin* **and** *Day at the beach*

Participants also leveraged structure within individual sketches and across multiple sketches to convey information. They used the spatial layout of vignettes within a single sketch to organize stories, as in B2-1's account of his day at the beach (Fig. 13(b)). They also published sequences of sketches to construct narratives, as in D2-1's fictional sequence of a shark approaching and attacking a boat (Fig. 14). Also, C2-1 published a series which documented the temporal evolution of a single drawing as he created it. His friend C2-2 created a steganographic sketch in 4 parts, published sequentially, intending for specific viewers to superimpose the images in their minds and see the hidden message.

The synergy of ubiquitous sketching and social media
UbiSketch's lightweight interface for capturing sketches and publishing them in real time brought sketching from the privacy of paper notebooks and sketchbooks into the public domain of social media. The artist C2-1 recounted before the study, *"A lot of my work just ends up being hidden away in a sketchbook,"* and he was glad that UbiSketch enabled him to connect with people through his work. As one might expect, the publication of sketches influenced sketch authorship. For example, A3-2 explained how he filtered his sketches for the audience: *"Just like you would filter out things that you would say over a social network, you filter out the things that you would draw."* Also, D2-1 tried to draw *"something that other people would possibly be interested in"* instead of *"random doodle stuff."* And C2-1 created more *"diaristic"* and *"personal"* sketches, explaining, *"It's my Facebook page. I suppose I should be doing things about me."*

A number of factors enabled UbiSketch to bring sketching into the public realm. One factor was the ease of sharing, which lowered social barriers, effectively changing authors' perceptions of what was worth sharing. D2-1 didn't previously share his sketches, explaining, *"They're nothing to write home about. So why would I make an effort to show people?"* Yet with UbiSketch he shared many sketches, because
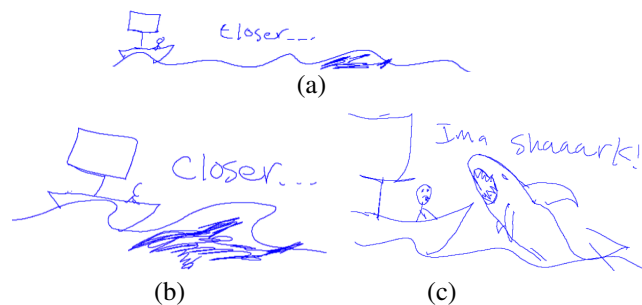

Figure 14. A sequential narrative: *Shark attack*

"there's really no cost to [sharing them], so ...it's kind of a casual thing." The Facebook milieu also contributed to authors' comfort with sharing sketches, as B2-1 related: *"No one's really judging it very heavily."*

Immediacy was another crucial factor in sharing sketches. C2-1 explained, *"I really like being able to draw something and have it immediately on a digital image, and then be able to immediately post it,"* adding that if additional steps were required to publish a sketch, *"I would never do that."* A3-2 agreed: *"Without [UbiSketch], I definitely would not have ever published any of those sketches online."* E1-1 explained that sharing in-the-moment was critical to realizing her intentions to share her children's drawings: *"Often they'll draw little stuff, and I'll save it and mean to mail it to my mom, and I never do ...[With UbiSketch] it was done, and I sent it."*

UbiSketch's mobile, real-time publication mechanism enabled participants to share time-dependent information, and Facebook's *news feed* and the common practice of posting about contemporaneous events encouraged it, creating a powerful synergy. Immediacy was critical to conveying this sort of information: *"Once a day passed, there [would be] no point in posting it up. It just wouldn't have the same meaning"* (A3-3). A3-2 agreed, *"It's all about living in the moment and using it when it's opportunistic. It's really important to be able to publish it in that same context."* UbiSketch's immediacy supported micro-publication of *"really small snapshots ...trying to capture the moment"* (A3-3). A3-3 explained that these sketches helped him and his friends maintain a sense of awareness and connectedness: *"it's just another way to say I know you're there and I'm thinking about you and here's what's going on with me."*

Stimulating conversation and social interaction
Ubiquitous sketching stimulated conversation and social interaction, both online and in-person. Our quantitative data indicates that, compared with prior photo practices, participants published more sketches on Facebook and their sketches received more comments and *likes* (Fig. 7). Our qualitative data confirms these results. A3-3 remarked that her Facebook interactions increased because she posted more: *"Being able to post the sketches, I ended up having a lot more interaction with people ...comments and conversations."* Facebook comments were often encouraging, sympathetic, or funny. For example, E1-1's mother expressed her enjoyment at seeing her grandchildren's drawings: (*"oh Grandma Just loves your pitcher"*). D2-1 related how sketches became topical resources for face-to-face conversations with *"here-friends that also look on my Facebook."* The prevalence of collaborative sketching further suggests that ubiquitous sketching creates social interactions in the physical world as well as the digital.

Ubiquitous sketching also broadened participation in Facebook interactions, as evidenced by the increased number of friends commenting on a given sketch (Fig. 7), and our qualitative data confirms this result. D2-1 expressed surprise at the set of people who commented: *"My close friends, I expected that ...but random [people] I wouldn't have expected."* A3-3 remarked that several lines of comments back and forth with some people was more interaction than she'd had with them in years, and even such a seemingly small increase could be significant. For example, C2-1 forged a new connection with his brother-in-law, relating, *"To have him see my work and comment on it and seem interested ...it was gratifying to connect with him. He's not someone I connect with in any way."*

Viewers' feedback on sketches also impacted authors' sketching practices. For example, B2-2 remarked that positive feedback *"made [him] really want to draw more."* Sometimes feedback had a direct impact on what participants drew, such as when B2-1 responded to his friend's comment (*"Curse you right-handed butter knives"*) with a drawing of a left-handed butter knife. A3-1 also subtly suggested that her friends A3-2 and A3-3 should publish more sketches by depicting them drawing in one of her sketches (Fig. 10). She also commented (*"CARTOON!"*) on A3-2's intriguing Facebook status (*"just saw a pig give birth"*) to encourage him to elaborate, and her effort was successful. She related, *"The [UbiSketch] picture showed up later, and I was very happy."*

Participants and their friends expressed interest in expanding support for ubiquitous sketching. Participants wanted to enable their friends to share sketches, as D2-1 explained: *"It shouldn't just be one person drawing and everyone commenting. It's more fun if everyone's drawing and you can comment on each other."* And friends expressed similar sentiments in their comments, wanting to use UbiSketch themselves. For example, one of E1-1's friends commented, *"I love this!! I wanna draw, now!".* Despite their interest in posting sketches on Facebook and the availability of other means to do that (e.g., camera-phones), none of them did.

CONCLUSION
When other media went online, sketching was left behind. To consider a remedy for this loss, we created a working prototype system, called UbiSketch, which integrates digital pens, paper, and mobile phones. We conducted an exploratory field study of ubiquitous sketching for social media, as realized by UbiSketch, and we summarize our results:

- *With UbiSketch, participants with a wide variety of practices, styles, and skills were able to leverage the unique affordances of sketching for visual communication.* In the study, participants conveyed thoughts and feelings that they could not or would not otherwise express using other modalities, such as text or photos.

- *A lightweight sketching interface and instantaneous publication mechanism creates a synergy with prevailing social media.* The study participants shared sketches in-the-moment. They micro-published personal, context-dependent information, fitting the practices typical of today's social media applications.

- *Ubiquitous sketching broadens and deepens social interaction, stimulating conversation.* Compared with prior photo practices, participants posted more sketches on Facebook, their sketches received more comments and *likes*, more friends responded, and the comments were more personal.

All told, with ubiquitous sketching, the digital medium can embrace an additional form of communication, bringing it one step closer to fulfilling the promise of capturing the full spectrum of human experience.

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