

Project - Summer 2021

CS6750

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Abstract—My final project focuses on the iPhone Markup interface. Markup is a built-in feature which integrates with a number of iPhone apps, and it allows the user to annotate, sign, or draw on a variety of file types. In particular, this feature helps to streamline the process of annotating an emailed PDF attachment and returning it to the appropriate recipient. It appears, however, that many iPhone users are unaware of the tool and its integration with email applications. Although the interface meets many of the standard design requirements, I will also argue that a redesign has the potential to increase the usability and the invisibility of the interface.

1 INTRODUCTION

1.1 Description of the interface

The iPhone Markup tool allows users to include signatures, text, shapes, highlighting, drawings and other annotations on things like photos, screenshots, and PDFs. This feature is compatible with certain applications such as Notes, Mail, Messages, and other iPhone apps (Apple, 2021). This project, however, will focus specifically on the Markup tool's integration with emailed PDF attachments in the iPhone Gmail application.

1.2 Accessing the interface

The Markup interface is accessed by first navigating to an iPhone email application. In this case, I will be explaining this process from the perspective of Gmail.

Figure 1 depicts both a sample email with a PDF attachment and the interface that results from opening the attachment. In order to locate the Markup tool, the user must select the share icon circled in the upper right corner of the second screen. The first screen of Figure 2 demonstrates the process of accessing the Markup tool from the share menu. The next screen shows the actual Markup interface where a user can choose from a variety of ways of annotating the PDF.

For example, in the second screen of Figure 2, the blue pen in the bottom toolbar is selected already. From this point, the user could directly draw on the PDF in blue ink via touching the screen.

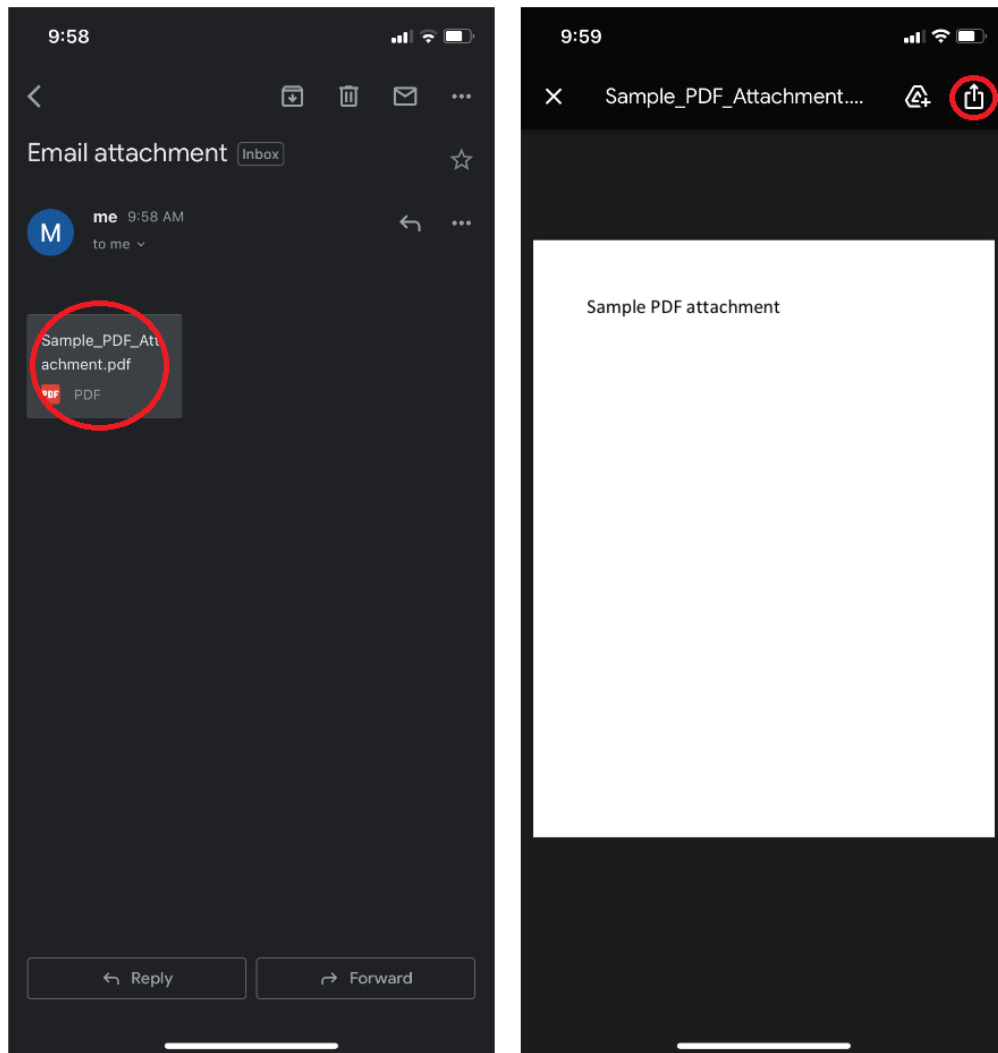


Figure 1—Screenshots of an email with PDF attachment from Gmail account. Screen 1 - an email with no body and one PDF attachment. Screen 2 - the opened email attachment.

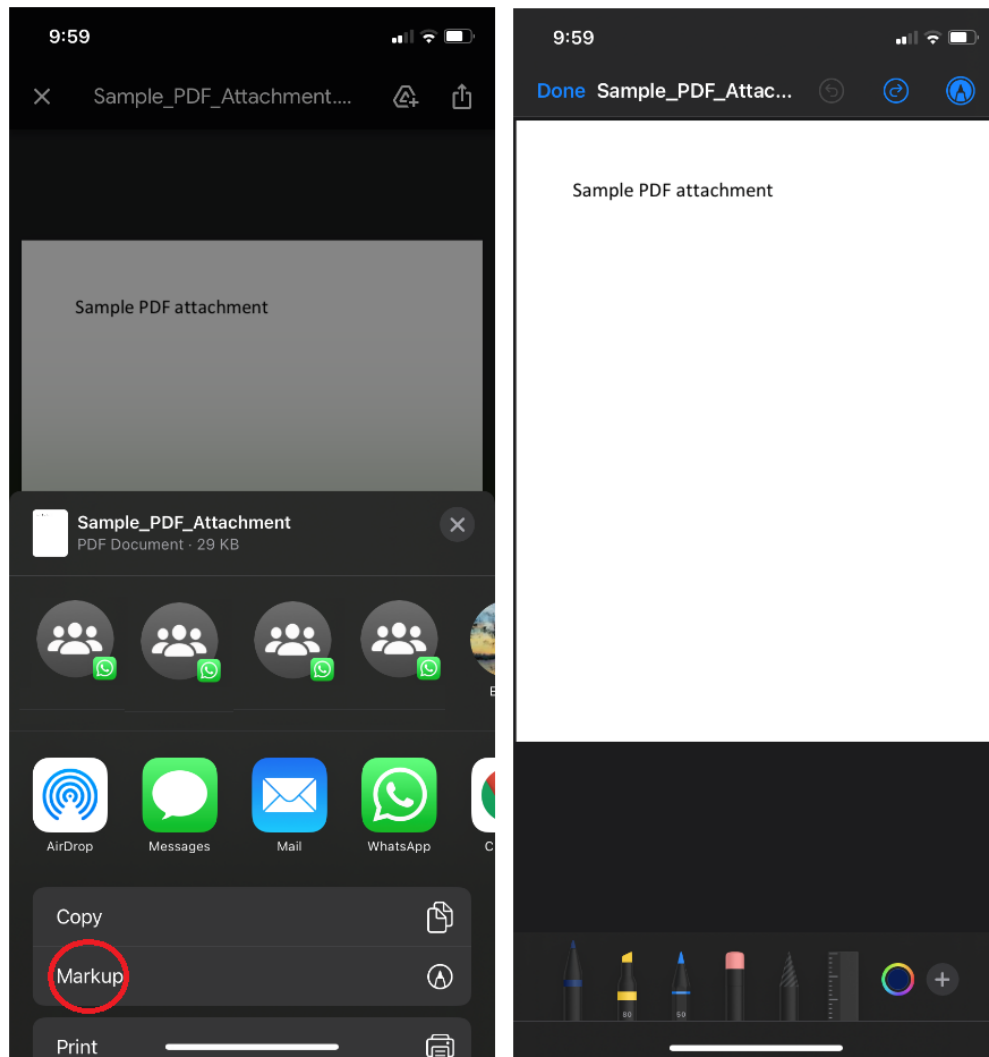


Figure 2—Screenshots of the share menu which contains the Markup option and the Markup interface itself.

2 INITIAL NEEDFINDING

2.1 Needfinding plan

From personal experience and interaction with work colleagues, I have found that the iPhone Markup tool poses difficulties for some users. It also seems that many iPhone users may even be unaware that this feature exists.

The needfinding exercises will seek out additional information to better understand these issues as well as identify any other weaknesses of the interface. I plan to utilize both a survey and a series of three think-aloud sessions towards

this goal.

2.2 Description of needfinding approaches

2.2.1 Survey

First, I will conduct a simple survey to assess engagement and user expectations with regard to the iPhone Markup extension. I will distribute the survey to classmates as well as to friends and family in order to get as much feedback as possible. In total, I have a goal of a minimum of 25 survey responses. The full survey is shown in *Appendix 8.1: Initial needfinding survey*. I have structured the survey to gauge awareness of the iPhone tool and to better understand users' reasons for using it.

2.2.2 Think-aloud

As discussed in *Ways of Knowing in HCI*, surveys cannot offer insight into the exact context of the respondent or allow for any follow-up questioning (Olson and Kellogg, 2014, p. 230). Accordingly, I will follow an analysis of the survey results with a series of think-aloud exercises. These exercises will serve to actively evaluate a user's engagement with Markup and dive deeper into any issues revealed in the survey answers. The sessions will loosely follow the script seen in *Appendix 8.2: Initial needfinding think-aloud exercise script*.

2.2.3 Addressing bias

To avoid observer bias in both of these needfinding exercises, I will have another colleague review the survey and the think-aloud script to check for leading questions. Furthermore, I hope the inclusion of two different needfinding methods and a diverse group of participants will reduce the potential for confirmation bias, or a situation in which I focus too much on my own preconceived ideas.

2.3 Conclusions

2.3.1 Summary of survey results

In total, I received 48 survey responses. The raw data can be found in *Appendix 8.3: Survey results*. About 58% of respondents were in the age range of 20 to 29. Approximately 23% percent were between 30 and 39, and the remaining 19% were 40 or older. Also, about one third of respondents were female and two thirds were male.

Of the 40 respondents who were iPhone users, 21 were unaware of the built-in iPhone Markup tool. The majority of these users stated that they would be likely or somewhat likely to use this feature now that they know it exists. Those who were aware of the tool stated that they use it for signatures, annotation, comments, and highlighting.

Overall, the majority of users had difficulty locating the Markup tool when presented with the second screen in Figure 1. Several participants chose the wrong menu item or stated that they had no idea how to locate the Markup option.

In terms of the data inventory, the survey results shed light on the tasks of the user. Whether or not the participants are aware of this built-in tool, users are annotating, highlighting or otherwise marking emailed PDFs. Their needs include an iPhone, an email application, an emailed PDF, and the ability to send an annotated PDF to the necessary recipients. More importantly, however, they require an easier way of accessing this feature and an interface which better demonstrates that this option exists.

2.3.2 Summary of think-aloud results

The think-aloud sessions provided further insight into the contexts in which users utilize the Markup interface and revealed some additional weaknesses of the interface. The full notes from the sessions are included in *Appendix 8.4: Think-aloud notes*.

In terms of task context, one participant stated that she uses this tool at her work as a civil engineer. Not only does she use it while out at construction sites, but she also uses it at her desk, because it is "the quickest thing for small changes." Another participant had not heard of Markup, but reflected that it would have been useful for when she was building a house due to the large number of PDF attachments that required signing and sending back.

Each of the three participants were unfamiliar with the tool for selecting and moving annotations on the interface. This tool is the final pen-like object shown before the ruler in Figure 3. Additionally, each participant found the toolbar (Figure 3) to adjust line thickness and transparency difficult to locate. Having to double-click a tool to access the menu appears to have been slightly unintuitive.

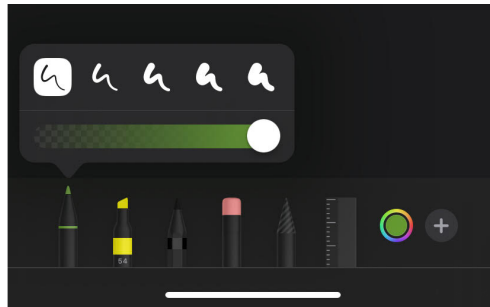


Figure 3—Screenshot of the line thickness and transparency adjustment tool.

Like many of the survey respondents, the participant who had not used Markup before also had trouble locating the Markup interface. She expressed confusion as to why this option would be included in the "share" menu.

Multiple participants also found it difficult to navigate or scroll around a PDF, because it was unclear how to "unselect" a tool. If the pen is selected, for example, any contact with the screen will leave a pen mark. Selecting the pen again does not turn it off, and there is no default tool which allows you to move around the PDF.

Finally, each of the participants expressed difficulties when trying to send the edited PDF back via email. Even the user with experience with Markup stated that she has difficulties locating the appropriate action each time she needs to send an edited PDF. The "Done" menu on the Markup tool interface does not provide an option to send the PDF. Instead, the user must navigate out of Markup to be able to send the file.

The think-aloud sessions revealed that users often utilize Markup in a work or professional context or on the go. Not only do they need to quickly annotate a PDF from an email, but they also need a clear means of returning the edited PDF to the sender. Overall, improvements to the interface should address the difficulties with deselecting a tool, the confusion regarding the pen selection tool, and the gulf of execution that exists between the user's goal of sending a PDF and the action required to do so.

3 HEURISTIC EVALUATION

The following heuristic evaluation relates to both the first and second panels of Figure 2. The first screenshot depicts the share menu which includes the option for Markup (circled in red). The second screenshot is the actual Markup interface integrated with the PDF attachment from Gmail.

As discussed in "Heuristic Evaluation of User Interfaces," having a single person review an interface for usability issues is likely insufficient (Nielsen and Molich, 1990). That being said, I have attempted to highlight some elements which worked well and address some of the features of the design that fell short of the design principles for usability.

3.1 What works well?

3.1.1 *Discoverability and simplicity*

As it currently exists, the Markup interface design has a lot of positive features. As seen in the second screenshot of Figure 2, the interface contains a prominently displayed toolbar at the bottom of the screen. The toolbar is comprised of a variety of markup tools represented by their actual images. In my opinion, the representation of the tools in this manner makes the functionality and options that are available to the user very discoverable. As discussed in the lecture, discoverability relates to the ability of a user to easily determine what action to take. In this case, it is clear that there should be some interaction with the tools displayed.

Aside from this toolbar, there are very few options on the interface. This contributes to the simplicity of the design. Overall, the design seems to balance discoverability and simplicity well.

3.1.2 *Affordances and mappings*

Additionally, representing the tools visually - as a pen, a highlighter and a marker, for example - provides good mapping. The design clarifies what the effect will be in using these specific tools. The pen will draw a thinner line than the highlighter, and the highlighter will not overwrite text but simply provide transparent emphasis on the chosen part of the screen. I would also argue that these design choices relate to affordances for how the interface should be used. Everyone knows how a pen should work. Just as you would pick up a pen and

move the tip across a paper, here you select the pen via touch and then drag your finger across the screen.

3.1.3 Structure

As discussed in *Software for Use: A Practical Guide to the Models and Method of Usage-Centered Design*, good user interfaces should reflect the way in which a user would think about the task, and I would argue that the Markup interface does just that (Constantine and Lockwood, 1999). If I need to draw on a paper in real life, for example, I have the paper in front of me and any other writing utensils required are nearby as well. This model is reflected on the interface, which prominently displays the paper and provides a toolbar of writing utensils.

3.1.4 Gulf of evaluation

The gulf of evaluation is largely bridged by the ability of the system to provide immediate and clear feedback to the user. For example, selecting a tool such as the pen from the toolbar moves it slightly higher on the interface to indicate that it has been selected. Furthermore, selecting a different color for one of the three writing tools changes the color of the tool itself in addition to filling the color selector with the chosen color as well. Figure 4 depicts this color change. Finally, swiping a finger across the screen after selecting a writing tool immediately shows the line drawn as though it was pen on paper. As discussed in *Direct Manipulation*, the reduction of semantic distance in this way lends itself to better sense of direct manipulation with the task at hand (Hutchins, Hollan, and Norman, 1985, p. 323).

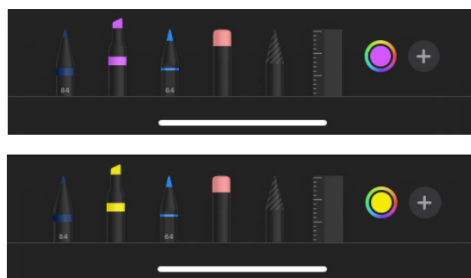


Figure 4—Screenshots of Markup toolbar. Bottom image: highlighter with original yellow color. Top image: highlighter with color change to purple.

3.2 What does not work well?

3.2.1 Discoverability

The interface largely meets the principle of discoverability, however, in my opinion there are some design features which do not. For example, the line thickness and transparency adjustment functions are not very evident. In order to access these options, the user must double click on one of the tools in the toolbar. Additionally, locating the Markup extension in general is rather difficult. The second screenshot in Figure 1 depicts the interface from which the user can access the Markup option. In the absence of many options on the screen, the user may choose to try the "share" button which is circled in red. However, I would not have expected to see a Markup option in the share menu.

3.2.2 Gulfs of execution

The discussion regarding discoverability can also be analyzed from the perspective of the gulf of execution. For the line thickness and transparency tools, it could be argued that there is a gap between the the user's desired action - adjusting line thickness or transparency - and how they can realize that goal. In terms of accessing the Markup interface, there is a disconnect between the user's goal of annotating or editing a PDF and how to achieve this task on the interface.

Furthermore, there is a gulf of execution relating to how to send a revised PDF. For example, selecting "Done," as seen in the upper left corner of panel 2 in Figure 2, does not provide an option to simply email the PDF directly. Instead, the pop-up menu offers the option to save, delete or cancel. This menu is shown in Figure 5 below.

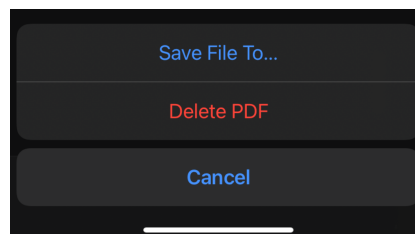


Figure 5—Screenshot of menu that results from selecting "Done" on Markup interface.

This may lead a user to believe that they must first save the file, locate it on their device, and then send it via email. However, it is possible to directly send the

edited PDF without saving. Instead, if a user selects "cancel," they are navigated out of the Markup interface and back to the view of the attached PDF which includes a share icon in the bottom left corner as seen in Figure 6.

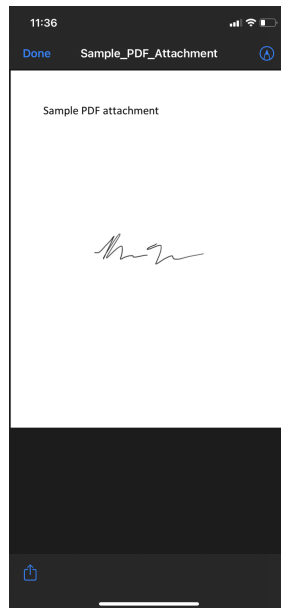


Figure 6—Screenshots of interface resulting from selecting cancel in Figure 5.

This is related to a gulf of execution in that there is a gap between the user's goal of sending an edited PDF and the action required to do so. Furthermore, a potential gulf of evaluation may occur, as choosing the action of selecting "Done" presents the user with different feedback than expected.

3.2.3 *Learning curve*

Finally, I would argue that the interface as it currently stands has somewhat of a flat learning curve. As discussed in the lecture, a good interface allows a user's expertise to grow quickly in relation to experience thus resulting in a steep learning curve. From my perspective, my expertise only marginally improved with each use. For example, I eventually had to search online to learn the functionality of one particular tool (Figure 7). Perhaps this is a known tool, however, I am not familiar with it.

3.2.4 Mapping

For novice users, a better mapping for this tool may be beneficial. For example, Photoshop contains a Lasso tool for this purpose. The tool itself is depicted by a lasso. This provides a better mapping in terms of what to expect from using it.



Figure 7—Screenshots of pen tool for selecting items drawn on screen to move them to another location.

4 INTERFACE REDESIGN

I chose to create a high-fidelity card prototype for my redesign. This offline, "fixed-path prototype" is meant to test specific scenarios related to the changes to the interface (Beaudouin-Lafon and Mackay, 2003).

The redesign includes 11 separate cards and modifies the interfaces depicted in the second panels of Figure 1 and Figure 2. These are the interface of the opened PDF attachment and the Markup interface itself.

4.0.1 Explanation of redesign

The following list outlines the changes that are present on the redesign. The goal of the redesign is to improve upon the task of accessing Markup, annotating a PDF and sending it to another recipient.

- The Drive button (next to share icon on second interface in Figure 1) is moved to the share menu
- The Markup option is moved out of share menu and next to share icon
- The bottom toolbar is reorganized with writing tools grouped together and separated from the selection tool and ruler
- The selection tool from Figure 7 is replaced with a different representation of the tool
- Double-clicking a writing tool no longer brings up the line thickness and transparency adjustment toolbar; it deselects it
- A line thickness tool is added to the toolbar

- The "Done" option is removed
- Selecting a tool which is already selected effectively deselects it and moves it back into its original position

4.0.2 Card prototype



Figure 8—Card prototype. Card 1 is the interface displayed when opening a PDF attachment from an iPhone email app. Card 2 is the Markup interface.

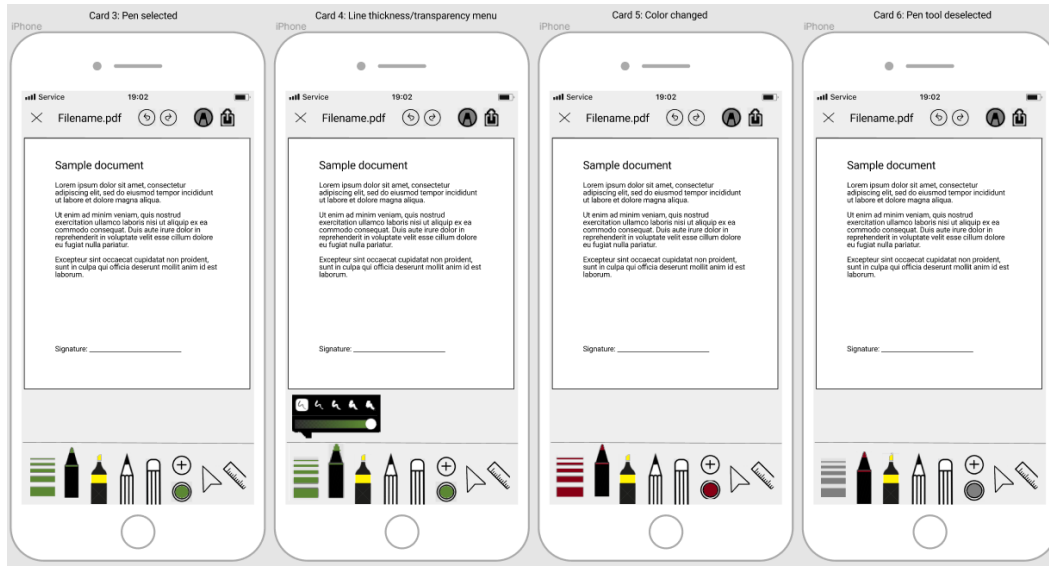


Figure 9—Continuation of card prototype starting with Card 3.
 Card 3: pen selected. Card 4: line thickness/transparency toolbar.
 Card 5: pen color changed. Card 6: pen tool deselected.



Figure 10—Continuation of card prototype starting with Card 7.
 Card 7: signature added to PDF. Card 8: signature moved slightly
 to right.

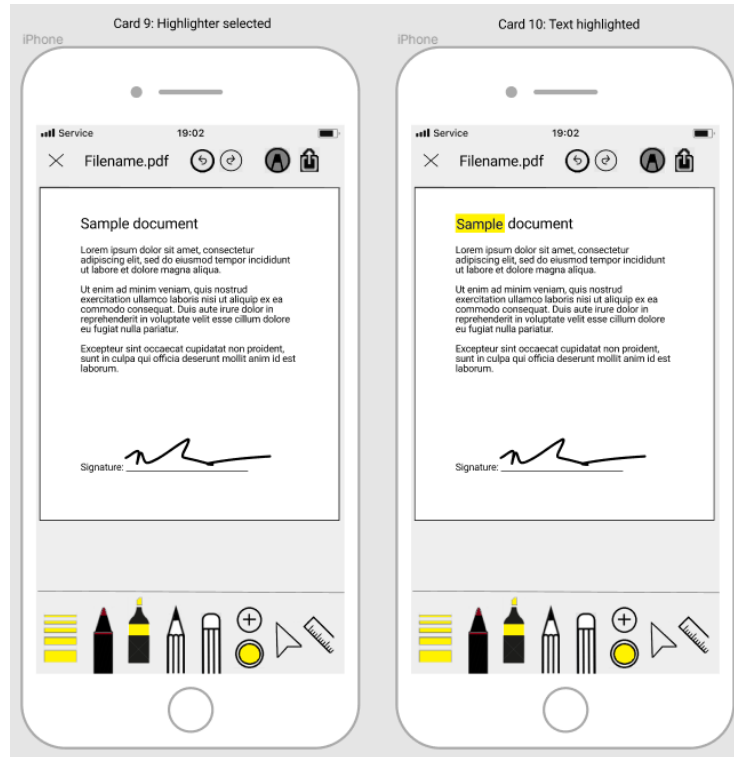


Figure 11—Continuation of card prototype starting with Card 9.
Card 9: highlighter selected. Card 10: text highlighted.

5 INTERFACE JUSTIFICATION

My redesign includes a number of small modifications to address the following issues that were revealed in the needfinding exercises and heuristic evaluation.

5.1 Locating the Markup interface

Users struggled to locate the Markup functionality on the interface depicting the opened PDF attachment. The redesigned version of this interface is depicted in Card 1 of Figure 8. The new design increases the discoverability of this feature by prominently displaying the Markup button in the upper right-hand corner. In the current version of this interface, the button to "save to Drive" filled this position. However, as evidenced by survey results, many participants were unfamiliar with this button. Given that the share menu contains options for saving files, I believe the Drive button is better suited there. This redesign bridges the gulfs of execution related to the user knowing how to accomplish their goal of accessing either option.

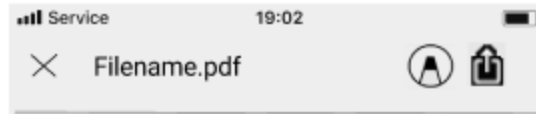


Figure 12—Redesign of Markup upper toolbar.

5.2 Sending an annotated PDF

In the redesign, the share icon (Figure 12) remains visible through all interactions in Markup, thus giving the user the ability to send an edited PDF at any time during the process. In the think-aloud exercises, users were confused by the current interface's "Done" option, which does not include the option to send a PDF. Instead, it lists only options to save or delete. Because the share menu contains a myriad of options for saving and sending the attachment, the "Done" button becomes obsolete. Instead, saving can be accomplished via the share icon and deleting edits can be achieved by selecting the "X" in the upper left-hand corner.

I believe that this retains the simplicity of design while making actions more discoverable. The gulf of execution between the user's goal of sending an annotated PDF and their understanding of how to do so is significantly narrowed. Additionally, I have retained the highlighting of the Markup button to indicate that it has been selected. This sort of system feedback is key to being able to understand the state of the system and narrow any gulfs of evaluation.

5.3 Accessing the line thickness and transparency tools

Rather than require double-clicking of a writing tool to locate the line thickness and transparency adjustment, I have included a tool for this in the bottom toolbar. In order to meet the principle of consistency, this tool is a well-known representation for line thickness adjustment. This tool is only active when a writing tool - pen, highlighter, or pencil - has been selected. This helps to retain a clear representation of the state of the system. Also, the color of the new line thickness tool will match that of the tool selected.

Additionally, double clicking a new tool now results in that tool being deselected. The user can then navigate the PDF without accidentally drawing on it. I think the ability to deselect a writing utensil does a better job of meeting the mental model of a potential user. For example, when writing on a physical piece of

paper, a person may select a pen. If they need to perform a different task before writing more, they can set the pen down and flip through the pages for example. One need not select a different tool in order to be done with the pen.

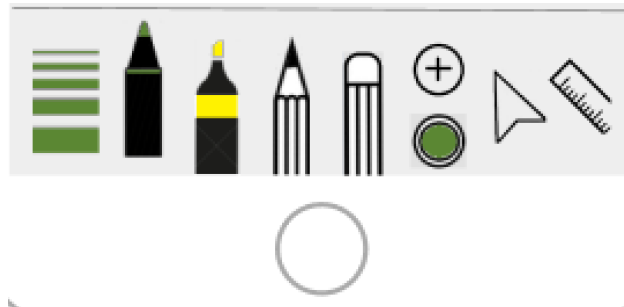


Figure 13—Redesign of Markup bottom toolbar with pen tool selected.

5.4 Addressing the selection pen tool

The selector pen which caused confusion in the think-aloud exercise has been exchanged for a tool that more users may be familiar with. This increases the consistency of the interface and will bridge the gulf of execution that may occur when a user needs to move an annotation. Furthermore, the selector itself provides a clearer mapping of the tool to the effect that it will have.

5.5 Positive design elements retained

The functionality of the interface as it currently exists remains unchanged. Users can accomplish everything they were previously able to, however, now some of the functionality is slightly more perceivable or discoverable. I would also argue that the addition of a line thickness tool to the toolbar does not detract from the simplicity of the interface. Instead, the positive features of the interface are retained and further improved upon with the goal of increasing usability and steepening the learning curve.

6 EVALUATION PLAN

As this prototype attempts to improve upon existing functionality, it is well-suited for an empirical evaluation.

6.1 Control and experimental conditions

The two treatments which will be compared are the card prototype and the current Markup interface.

I am interested in understanding how efficient the redesign is in comparison to the current interface. However, interactions with a card prototype cannot be exactly compared to the working interface. For this reason, I believe that measuring the time required to accomplish a task on either treatment is not a suitable means of comparison. Instead, I plan to measure the number of selections (or clicks) made as a proxy for efficiency.

I am also interested in the number of errors users make while interacting with the interfaces. The number of clicks can also act as a proxy for this. More clicks may indicate the presence of inefficient or incorrect actions.

Accordingly, the dependent variable, or human behavior that will be measured, can be considered to be the number of selections a user makes during the task (Mackenzie, 2013, p. 160). Independent variables will include those elements of the interface which have been modified in the redesign. For example, the line thickness and transparency menu has been moved to the main toolbar, and the selection tool has been replaced by a different representation.

A control group of participants will work through several stages of a task using the interface as it currently exists. The experimental group will similarly work through the task on the card prototypes. I will track the number of selections or clicks required per stage.

6.2 Experimental method

The task will be the same for both treatments, and the experiment will be a "between subjects" design. Although a "within-subjects" design has many benefits, I wanted to avoid "interference between test conditions" (Mackenzie, 2013, p. 176). For example, because there are similarities between the two treatments, users could learn elements of the first interface which then influences their experience with the next treatment.

The "between-subjects" experiment will require that participants be randomly split into two groups, each participant will interact with only one of the two treatments, and the resulting data will be compared across the two groups. I

plan to recruit a diverse set of at least twenty participants.

As discussed in Mackenzie's *Human-Computer Interaction*, a crucial step in designing an experiment involves ethics approval. Accordingly, all participants will be fully informed of the nature of the research, the methodology, the risks and benefits of the experiment, the right to forgo participation at any time, and the right to privacy (Mackenzie, 2013, p. 160).

6.3 Task outline

Depending on their group, the user will be presented with either Card 1 (Figure 8) or an iPhone starting from the interface depicted in the second screenshot of Figure 1. This will be done in a lab setting. For those viewing the card prototype, at each stage, they will be shown the correct corresponding card. Cards are depicted in Figures 8 - 11 and additional cards have been included in *Appendix 8.5: Additional cards*.

- Stage 1: Please open the Markup interface
- Stage 2: Open the line thickness adjustment for the pen tool
- Stage 3: Open the color adjustment for the pen tool
- Stage 4: Draw a line with the pen tool
- Stage 5: Select and move the line you drew
- Stage 6: Please attempt to send the PDF via email

In addition to the total number of clicks, the number of selections for each stage can be compared across treatments as well. This will help in understanding the usefulness of the separate modifications.

6.4 Hypotheses

Null hypothesis: The current Markup interface is as efficient and requires the same amount of clicks or selections as the card prototype does in accomplishing the task.

Alternative hypothesis: The card prototype redesign is more efficient, has less user error, and requires fewer clicks to complete the task than the current interface.

6.5 Lurking variables:

A factor which could confound the data is that participants may be more comfortable with the working interface than they are with the card prototype. Interacting with cards is not the same as a real mobile interface. However, the cards are relatively high fidelity, and I hope that each stage of the task is simple enough that the interaction should be clear.

Additionally, human characteristic such as skill level or technical expertise can also impact the results of the study. Accordingly, the two groups should have a similar distribution of gender, skill-level, and age in order to be able to properly compare results across treatments.

6.6 Planned statistical analysis

My hypothesis testing will take the form of a two sample t-test, which compares the means of two sets of unpaired data. The data accumulated from the between subject experiments will be continuous and will lend itself well to this form of testing.

7 REFERENCES

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8 APPENDICES

Appendix 8.1: Initial needfinding survey

Survey description: I am looking for classmates who utilize iPhone apps such as Gmail and Outlook. I would like to assess not only the usefulness of the Markup functionality for emailed PDFs, but also better understand how many people are even aware of it. You need not have used markup before to complete this short survey.

1. Select your age (choose one):

- Under 20
- 20 - 29
- 30 - 39
- 40 - 49
- 50 - 59
- 60 +

2. Select your gender (choose one):

- Male
- Female
- Other
- Prefer Not To Answer

3. Are you an iPhone user (choose one)?

- Yes
- No

4. Are you aware of the ability to markup pdf attachments in email apps on the iPhone (choose one)?

- Yes
- No

5. If yes, what do you use this feature for (signatures, highlighting, annotating)?

- (Short answer response)

6. Please view the interface provided below. It displays a pdf attachment opened

in the Gmail iPhone app. What steps would you take to locate and use the markup functionality?



- (Short answer response)

7. How likely are you to use the markup feature?

- Very likely
- Somewhat likely
- Neutral
- Somewhat unlikely
- Very unlikely

Appendix 8.2: Initial needfinding think-aloud exercise script

Pre-task questions:

1. How often do you need to annotate or add some sort of text or markings to an emailed PDF?
2. Are you aware of the built-in iPhone Markup extension?
3. Do you use this or other applications to edit PDFs which you receive from email?
4. If you do, in what context do you need to do so?

Task instructions: Please navigate to your preferred iPhone email application. I have sent you an email with a PDF attachment. Please open this email and then open the attachment. From this point, attempt the following things. Please vocalize your experience as you go. I will ask some follow-up questions afterwards.

- (a) Add your signature to the PDF
- (b) Add some typed text to the PDF
- (c) Draw a thick pencil green line on the PDF
- (d) Highlight any text on the PDF
- (e) Draw a black line on the PDF
- (f) Remove the black line
- (g) Move the green line to a different location
- (h) Remove the green line
- (i) Remove the text you added from the PDF
- (j) Add a shape to the PDF
- (k) Send the edited PDF back to the original sender

Post-task questions:

5. Were you aware of what this black pen was used for?



6. Please discuss your general experience with this process. Was it easy? Was it

frustrating?

7. Are there any features missing here or improvements you would make?
8. How likely are you to use this feature again?
9. Was it difficult to take the edited PDF and send it back?
10. Is it intuitive that if you double-tap the items on the toolbar that a menu for line thickness will appear?
11. What would you typically expect from a "+" symbol on an interface?

Appendix 8.3: Survey results

	Age	Gender	iPhone User?	Aware of Markup?	Reason for using	Steps user would take	Likeliness to use Markup
0	30 - 39	Female	Yes	Yes	All of the above	I was not sure what the first icon was so I would select the share icon and see what happens.	Somewhat likely
1	20 - 29	Female	Yes	No	NaN	maybe the triangle	Somewhat likely
2	20 - 29	Male	Yes	No	NaN	NaN	Somewhat likely
3	50 - 59	Male	Yes	Yes	some highlighting and annotation	I would click on the icon with a plus sign on the menubar.	Somewhat unlikely
4	30 - 39	Male	Yes	Yes	Signatures	ok	Neutral
5	40 - 49	Male	Yes	No	NaN	Select the text and right-click to see the drop-down menu	Somewhat likely
6	40 - 49	Male	Yes	No	NaN	i would press and hold on the pdf	Somewhat likely
7	20 - 29	Male	No	No	NaN	It doesn't look like there's any way to use markup functionality	Very unlikely
8	20 - 29	Female	Yes	No	NaN	click the send arrow	Very likely
9	20 - 29	Male	Yes	No	NaN	I would hit one of the icons in the top right	Neutral
10	30 - 39	Prefer Not To Answer	Yes	Yes	i know the feature is there but I have a separate note taking app and I rarely use the builtin feature	I don't see the option. I'll try the share icon and see if the markup option is listed there.	Somewhat unlikely
11	20 - 29	Male	Yes	Yes	signatures	hit the up arrow button	Somewhat likely
12	30 - 39	Male	Yes	No	NaN	unsure	Very unlikely
13	40 - 49	Male	Yes	Yes	signatures, anotations	not clear, perhaps click the + icon.	Very likely
14	60 +	Female	Yes	No	NaN	I would look for a drop down menu, or double tap the doc, but no method was obvious.	Neutral
15	20 - 29	Female	No	No	NaN	i would have no clue	Somewhat likely
16	20 - 29	Male	Yes	No	I use a similar app on my iPad for signing documents. The iPad has a stylus so writing is much easier than on a phone.	I don't see an obvious place?	Somewhat likely
17	30 - 39	Female	Yes	No	NaN	Click on the PDF?	Somewhat likely
18	20 - 29	Male	Yes	No	NaN	If I knew markup existed as a feature I'd look for it in the share menu. Otherwise I wouldn't be able to find it.	Neutral
19	20 - 29	Male	Yes	No	NaN	I'd click and hold area's around the text for a pop up menu	Somewhat likely
20	20 - 29	Male	Yes	No	NaN	NaN	Somewhat likely
21	30 - 39	Male	Yes	Yes	NaN	na	Somewhat likely
22	20 - 29	Female	Yes	Yes	Signatures, highlighting, comments, measuring	Not sure how to locate without actually doing it and trying out - perhaps button in right top, then find the mark up?	Very likely
23	30 - 39	Female	Yes	Yes	Signatures	I would click the triangle with the plus sign icon.	Somewhat likely
24	40 - 49	Male	No	No	na	na	Neutral
25	40 - 49	Female	No	No	N/a	I don't have an iPhone. I don't know how I'd mark up the pdf.	Somewhat unlikely
26	20 - 29	Male	Yes	No	NaN	NaN	Somewhat likely
27	30 - 39	Male	Yes	Yes	I don't use it	Click the box arrow icon	Very unlikely
28	60 +	Male	Yes	No	NaN	Not sure how to use on iPhone. Screen is to small for this kind of work so I would work on it using computer.	Neutral
29	30 - 39	Male	Yes	No	NaN	I have no clue	Very unlikely
30	20 - 29	Male	Yes	No	NaN	not sure	Neutral

31	20 - 29	Male	No	No	highlighting	drag cursor over text, highlight it	Very likely
32	20 - 29	Female	Yes	Yes	Signatures and highlighting	Click on far right menu button, select "Edit Actions..."	Very likely
33	20 - 29	Male	No	No	NaN	click on top right button	Somewhat likely
34	20 - 29	Male	Yes	Yes	Signatures	No idea, but given the triangle button is the only one I don't know, probably that one	Somewhat unlikely
35	20 - 29	Male	Yes	No	NaN	Legitimately no clue.	Very unlikely
36	20 - 29	Male	Yes	Yes	signing	I have no idea	Somewhat unlikely
37	50 - 59	Female	Yes	Yes	highlighting	not clear	Very likely
38	20 - 29	Male	No	Yes	signatures	click the markup button	Somewhat likely
39	20 - 29	Male	Yes	Yes	signing	No idea.	Somewhat unlikely
40	30 - 39	Female	Yes	Yes	highlighting	make edits	Neutral
41	20 - 29	Female	Yes	No	NaN	not sure what this q is asking	Neutral
42	30 - 39	Female	Yes	Yes	highlighting	click the symbol in the right hand upper corner and follow the on-screen prompt	Somewhat likely
43	20 - 29	Female	Yes	Yes	viewing documents on the go	tap the screen and wait for a new set of buttons to appear and click one that looks like a pen	Somewhat likely
44	20 - 29	Male	Yes	No	NaN	search	Very likely
45	20 - 29	Female	Yes	No	NaN	I would tap the screen because I don't see any related icons	Somewhat likely
46	20 - 29	Male	Yes	Yes	Signatures, annotating and saving	It is weird (admittedly) - you select the "Share button", the button that looks like a square with an arrow pointing out of it in the top right, then, you scroll down to the "Markup feature"	Somewhat likely
47	20 - 29	Other	No	No	NaN	I have no idea	Very unlikely

Appendix 8.4: Think-aloud notes

Participant 1: Female, 60 years, retired

1. How often do you need to annotate or add some sort of text or markings to an emailed PDF?

> Very infrequently under normal circumstances. However during home building, the work around during design was to print an attachment, scan or take a picture of the marked up design.

2. Are you aware of the built-in iPhone Markup extension in email apps like Outlook, Gmail, or the iPhone default Mail app?

> Not at all

3. Do you use this or other applications to edit PDFs which you receive from email?

> No

Task:

A) Add your signature to the PDF – just free handed it, possibly there was a better way

B) Add some typed text to the PDF – that wasn't hard to figure out

C) Draw a thick pencil green line on the PDF – I initially didn't see how to make it thick

D) Highlight any text on the PDF – I had trouble ending the highlighting

E) Draw a black line on the PDF

F) Remove the black line – I just hit the undo button, but I bet I was supposed to delete which I learned later

G) Move the green line to a different location – I used cut and paste, seems like I ought to be able to drag it

H) Remove the green line – Ok

I) Remove the text you added from the PDF – Ok

J) Add a shape to the PDF – Ok, are there really only 2 shapes?

K) Send the edited PDF back to the original sender – Having trouble figuring out how to do this smoothly.

5. Were you aware of what this black pen was used for?

> No

6. Please discuss your general experience with this process. Was it easy? Was it frustrating or easy?

> Initially, I couldn't even locate the markup button, but eventually found it. I never figured out how to scroll around in the document. I couldn't quickly end an activity like using the pencil. I thought it was hard to toggle between the document and the email with instructions. To save time, I just opened the email on my laptop while I did the tasks on my phone.

7. Are there any features missing here or improvements you would make?

> Make it easier to attach the document? Make it more obvious how to end an activity, so that I can easily scroll around the doc. When I save the document, it ought to automatically update the name as a new version.

8. How likely are you to use this feature again?

> Now that I'm aware of it, I might use it very infrequently, but only for the simplest of markups. Anything detailed would be easier to print, markup, scan and send.

9. Was it difficult to take the edited PDF and send it back? > Yes

10. Is it intuitive that if you double-tap the items on the toolbar that a menu for line thickness will appear?

> Nope

11. What would you typically expect from a "+" symbol on an interface?

> I expected to get more options

Participant 2: Female, 28 years, civil engineer

1. How often do you need to annotate or add some sort of text or markings to

an emailed PDF?

> Many times a week

2. Are you aware of the built-in iPhone Markup extension in email apps like Outlook, Gmail, or the iPhone default Mail app?

> Yes, I use Outlook. I use it for work.

3. Do you use this or other applications to edit PDFs which you receive from email?

> Not on my phone.

Task:

A) Add your signature to the PDF – used the highlighter cause it was already selected. Q: Are you aware that there is also a signature function? A: Oh, hm maybe at some point.

B) Add some typed text to the PDF – able to add a text box, but the keyboard doesn't open with it. There's just a "Text" there and I have to double click for a menu to edit it.

C) Draw a thick pencil green line on the PDF – the thickness functionality was a little hidden, I remember having trouble finding it before.

D) Highlight any text on the PDF – it overwrote the text; oh I can change the transparency

E) Draw a black line on the PDF – ok, done

F) Remove the black line – used the back button, but i guess there's this eraser. but its a bummer - it only erases where i touch it and not the whole thing that i drew. Q: did you see the eraser menu? A: oh theres a pixel eraser or object eraser.

G) Move the green line to a different location – Hm I tried but I just keep on writing. I can't figure out how to do it. Ok, now I somehow got it, but I can only copy delete?

H) Remove the green line – ok done

I) Remove the text you added from the PDF – ok

J) Add a shape to the PDF – ok I added circle

K) Send the edited PDF back to the original sender – I clicked "Done" but the menu doesn't get a send option. I clicked out of the menu and then saw the share button. I've had a hard time with this in the past

5. Were you aware of what this black pen was used for?

> No, I have not seen it before. Q: Is there another image that makes you think of being able to select and move something? A: I would have thought if I clicked out of the drawing tool I was using that i could just select items on the pdf and move or drag them that way. I think a hand or something could be better.

6. Please discuss your general experience with this process. Was it easy? Was it frustrating or easy?

> Even though I use it a lot, I don't know all the features. I also think its still confusing - first of all how I get there (its not intuitive) and also with sending an edited PDF I can never remember the order so I'm looking around. Its not clear to me.

7. Are there any features missing here or improvements you would make?

> No for an built-in tool its great. Especially when you work with people and you want to quickly highlight something or add a signature. I'm using it while I walk or am out of the office. Or even in the office, cause its really the quickest thing for small changes.

8. How likely are you to use this feature again?

> Very likely. For work.

9. Was it difficult to take the edited PDF and send it back? > Yes

10. Is it intuitive that if you double-tap the items on the toolbar that a menu for line thickness or transparency will appear?

> Nope. Instead I thought it would deactivate the tool I was currently using.

11. What would you typically expect from a "+" symbol on an interface?

> That there are more options. Or that I could add a person to something.

Participant 3: Male, 35 years, lawyer

1. How often do you need to annotate or add some sort of text or markings to an emailed PDF?

> Quite often - I am constantly getting emails with attachments to sign. Q: For work? A: Yes, only for work.

2. Are you aware of the built-in iPhone Markup extension in email apps like Outlook, Gmail, or the iPhone default Mail app?

> Yeah, I use the iPhone Mail application mainly.

3. Do you use this or other applications to edit PDFs which you receive from email?

> No

Task:

A) Add your signature to the PDF – I don't use the Gmail app; I think its different from Mail's markup. Had a hard time finding the markup option. But then I could add a signature with the + menu.

B) Add some typed text to the PDF –

C) Draw a thick pencil green line on the PDF – I hadn't changed thickness before but when I clicked on the pen again the menu came up. Would not have thought about that being how to do it.

D) Highlight any text on the PDF – it overwrote the text; oh I can change the transparency

E) Draw a black line on the PDF –

F) Remove the black line – used back button

G) Move the green line to a different location – I haven't tried to move a line like this before. Not sure how to get out of this pen tool to click on the line to move it.

H) Remove the green line – used eraser

I) Remove the text you added from the PDF –

J) Add a shape to the PDF –

K) Send the edited PDF back to the original sender – Looks like "Done" doesn't have a send option.

5. Were you aware of what this black pen was used for?

> No not at all

6. Please discuss your general experience with this process. Was it easy? Was it frustrating or easy?

> I think the Gmail Markup is a little different from the iPhone Mail app. In general, there were a couple of things that were not clear. Like, finding the Markup option at all was hard.

7. Are there any features missing here or improvements you would make?

> Hm, just making some of the things clearer would be nice.

8. How likely are you to use this feature again?

> Very likely. Especially for work, but I'll continue to use Mail.

9. Was it difficult to take the edited PDF and send it back?

> Yeah not very clear

10. Is it intuitive that if you double-tap the items on the toolbar that a menu for line thickness or transparency will appear?

> Not really, but I did kind of stumble upon it pretty easily.

11. What would you typically expect from a "+" symbol on an interface?

> Another menu

Appendix 8.5: Additional cards

