

Nota Bene V2 - Understanding and Implementing Methods for Synchronous and Collaborative Learning

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Abstract

Students have always been encouraged to learn collaboratively as a means of learning from their peers in order to ask questions, build relationships, and receive feedback. Nota Bene (NB) is an online learning and annotation tool that allows students in a course to annotate web documents to foster online discussions. With the current version of NB that relies only on asynchronous annotations, we have decided to add synchronous features to the tool. After initial user research, we implemented various features, such as notifications and chat-like features, to help keep students engaged when learning online. Afterward, we ran a user study experiment to understand the user engagement and usability aspects of our project, and how those metrics compare between the original NB and the NB with synchronous features.

Thesis Supervisor: David R. Karger
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Chapter 1

Introduction

Nota Bene (NB) is an online learning and annotation tool that allows students in a course to annotate web documents to foster online discussions. While the previous version of NB was very effective for making new comments regarding the content of the document, responses to those comments were oftentimes asynchronous interactions and there were not instantaneous conversations occurring. In order to encourage students to engage more readily and help students get their questions answered more quickly, we decided to add synchronous features to the tool so that the turnaround time for comments getting noticed and responded to is much quicker. After initial user research, we implemented various features, such as notifications, new highlighting mechanisms for those notifications, and chat-like features, to help keep students engaged when interacting with NB. Afterward, we ran a user study experiment with the University of California Davis (UC Davis) to understand whether the new synchronous features were usable and increased user engagement and assistance. From the user study feedback, we introduced new future work that can be used to iterate upon the synchronous features that we incorporated.

1.1 Background

Nota Bene (NB) is a tool that can foster online learning through annotations and discussions online [1]. It is being used at classes at universities and institutes such as UC Davis and Massachusetts Institute of Technology (MIT). At its core, NB is a tool that allows students to make annotations on a HTML or PDF document, so that they are able to make comments on a document, while also exploring other students' or instructors' comments to further engage in

more insightful conversations. When a comment is posted, other users can also reply to that comment, and this chain of replies can go as deep as users like.

1.2 Overview of NB

In NB, students can only view comments from students in their section in the class for a particular document in the class as long as the comment visibility is to everyone in the class; instructors are able to see the comments from all students in their class as long as the visibility is set to everyone in the class or instructors only. Students are not able to see the student name of a comment if the comment is set to be posted as anonymous. Instructors are able to see names for all comments regardless of the anonymity set on the comment.

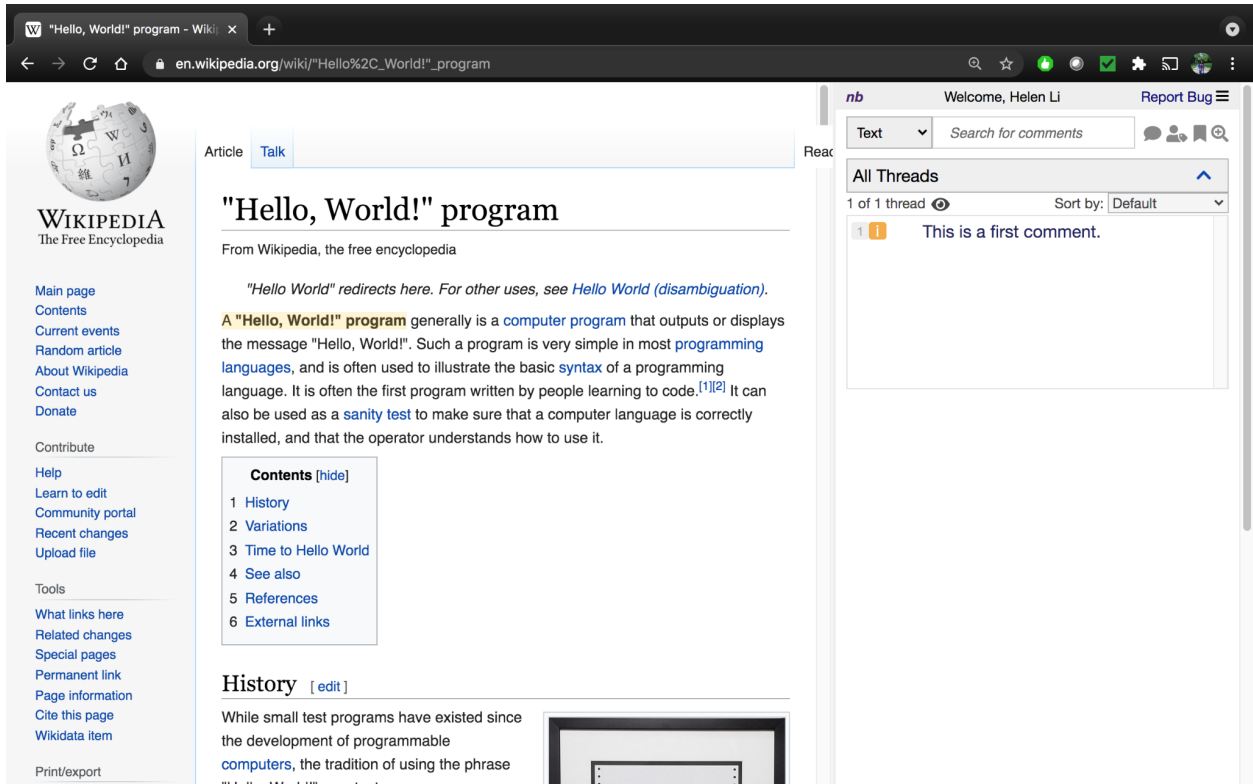


Figure 1-1 (above): Overview of NB

There are two main components that were originally part of NB: the highlights and the sidebar view. As can be seen in figure 1-1 (above), the highlight is the yellow highlight on the document (left side) and the sidebar is one on the right. The highlights consist of rectangles that indicate where on the document students have started a thread or made a comment. The sidebar view is a NB-specific user interface that allows students to see a list of all other threads that are visible to them from their class, as well as view entire threads and the conversations. There are access control features that allow users to make their annotations visible to the entire class, only to the instructor, and only to themselves. Users are also able to post anonymously, if they would like.

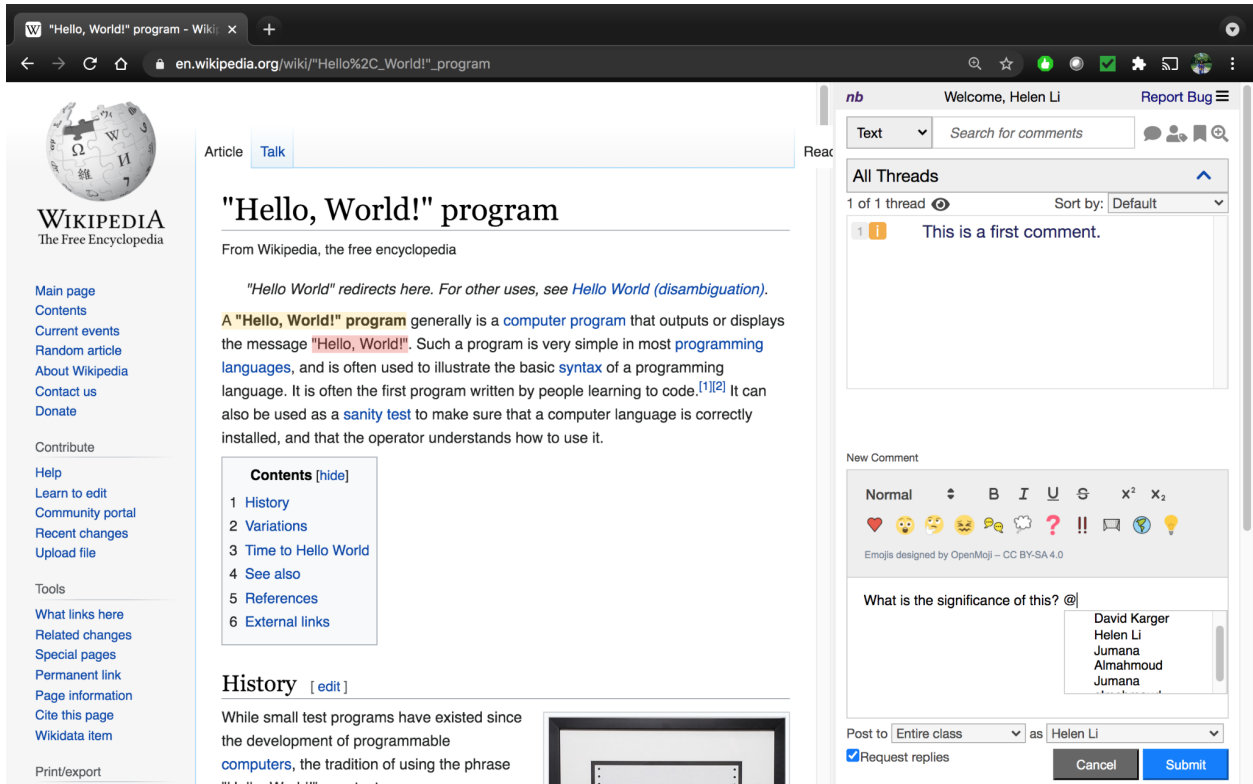


Figure 1-2 (above): Overview of NB: reply requests and tags

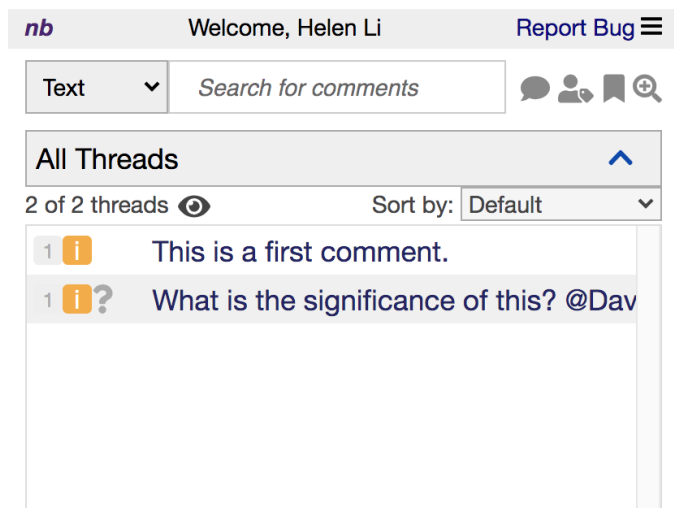


Figure 1-3 (above): Overview of NB: badges in list view

There are other features that also enrich a student’s experience. From the right sidebar shown in Figure 1-2, we can see that highlighting a snippet of the document opens up this rich text editor that enables users to format comments as well as enter emojis.

Next, there is a reply request feature. The reply request is an important way, especially for instructors and other students, to recognize when another student has a question or wants further replies to their post. Students can request replies to their comments by checking a checkbox, as seen near the bottom right in figure 1-2. After the reply requested comment is posted, the thread in the sidebar list has a question mark badge in the sidebar next to it, as can be seen in the second comment in Figure 1-3.

Users can also tag (or mention) other users in their post; when the “@” symbol is typed in, a list of taggable users are displayed, as shown in Figure 1-2.

Instructor comments, which can be important to students who may want more direct explanations or interactions with instructors, are also indicated by an instructor badge. This badge can be seen in Figure 1-3 where the second comment has a yellow square badge with the letter “i” in it. These are all features that make this annotation framework more useful for students who want to engage in further conversation.

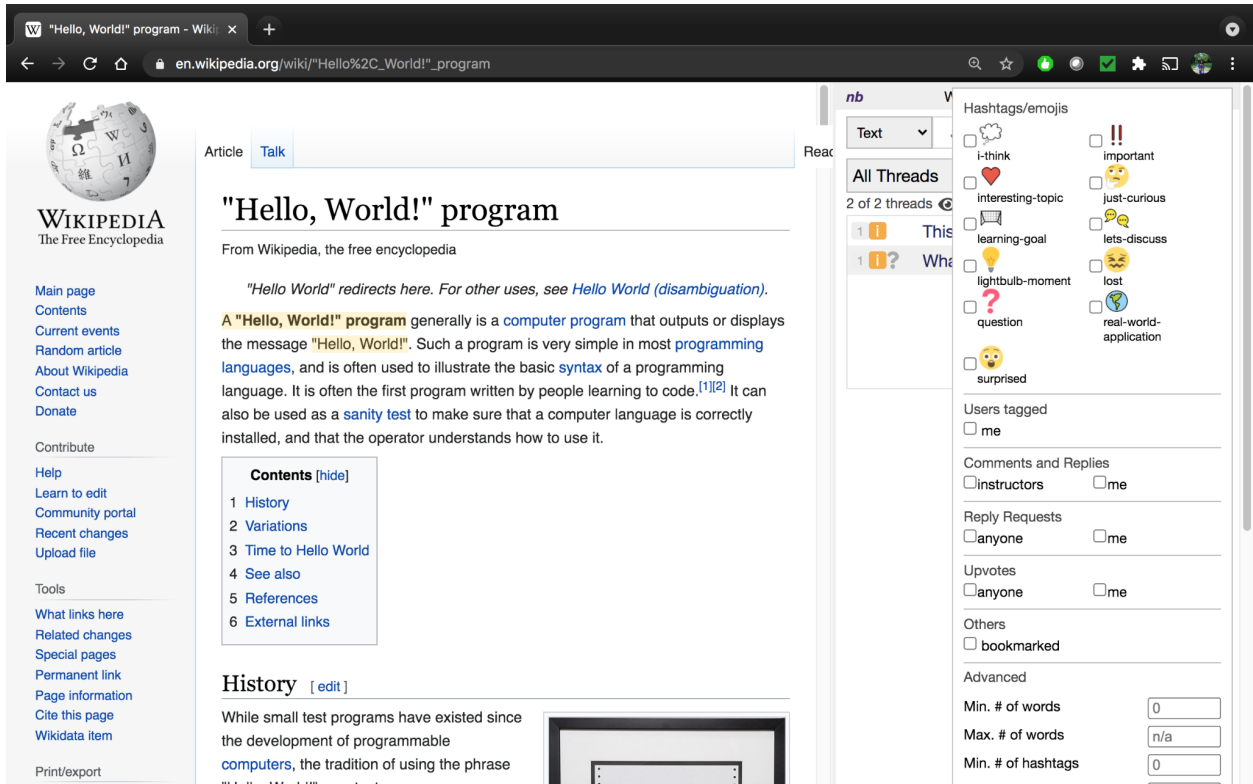


Figure 1-4 (above): Overview of NB: filters

There are also a large variety of filters that allow users to do things such as selectively filter out their comments, their reply requests, comments that they're tagged in, and more. From Figure 1-4, we can see that there are these different filters that users can select to pinpoint specific types of notifications they want to focus on.

1.2 Motivation

With the version of NB that we just described, it is particularly useful if students are reading asynchronously i.e., students have an annotation assignment due at a certain date and students are reading at their own pace and posting comments that allow other students to comment. Features such as filters allow users to search for particular threads that may interest them, and the highlights in the document may also attract users to read them. However, it is crucial to realize

that the amount of engagement that occurs on each thread may be minimal. There are oftentimes numerous threads that only have one comment and are made by one student. Sometimes, even if there are reply requests from classmates, those threads are left unanswered. As can be imagined, students not being able to have their reply requests answered may in turn not engage as readily with other students. Some students may also post annotations for the sake of assignment but do not necessarily read the threads from the other students.

From current research, there are four modes of learning, which are encompassed within the ICAP (interactive, construction, active, and passive) framework [2]. We wanted to explore the interactive mode of learning, where students are able to have open dialogue with each other and think constructively and interactively in their NB experiences. We have also learned that collaboration allows individuals to learn together more than an individual can do alone [3]. Synchronous learning is a way of developing and building those peer-to-peer learning, which can eventually help students develop ways to build relationships and feel comfortable enough learning from each other because students can learn quicker from each other. Synchronous learning will allow students to receive quicker responses on questions or comments they post, decreasing the wait time. When students are aware of other users' (students or instructors) also reading the document with them, they may be more readily and excited to respond because they are more likely to have their comments read and responded to.

We hypothesized that adding synchronous components to NB may improve students' learning since they can receive quicker responses and learn from other individuals in the class. More specifically, we were interested in adding features to NB that can encourage students to be more

aware of other students' comments, especially if students are online because that can give room for more instantaneous conversations. With the previous NB platform, we wanted to explore ways in which we can motivate students to communicate instantaneously. Through this research process, we conducted user studies to understand what types of features were necessary, iterated on different designs and implemented them, and evaluated the quality of synchronous learning by conducting user studies on the final project.

1.3 Related Work

There is some current research going on regarding the benefits of synchrony when conducting online learning. While it builds relationships since students can interact with each other in more real-time situations, having quick responses and non-anonymous learning can also foster an open learning experience that builds relationships among learners [3]. Collaboration can also come in many forms: giving and receiving help, exchanging knowledge, explaining or elaborating on ideas, challenging others' thoughts respectfully, etc [4]. These are benefits of online discussion and real-time collaboration that can help students learn quickly.

In a separate research study to promote synchronous and asynchronous communication in a work setting, there was a user model of sticky chats for anchored conversations. These adhesive chat windows can be attached to certain areas in the documents to provide context about the conversation there [5]. It is particularly interesting to see that these anchored conversations in different places in the documents can revolve around different topics. Having synchronous chats localized to a particular position in a page for users of NB is an interesting topic of related work

for our synchronicity exploration, and we will be brainstorming related topics in our design section (Chapter 3).

1.4 Project Summary

Under the supervision of Professor David Karger and PhD student Jumana Almahmoud, I brainstormed ways to incorporate synchronicity into NB and incorporated numerous features to aim to assist students in identifying noteworthy comments when they are online on NB.

We started by conducting a user study, identifying similar existing software solutions/applications and brainstorming different features to incorporate synchronous features into the current asynchronous version of NB [Chapter 3]. We implemented a prototype [Chapter 4] based on the various modes of exploration explored. Then, we conducted user evaluations [Section 5] on the effectiveness of our new features with courses and students at the University of California (Davis) through user logs and observations.

Finally, we discuss recommendations for future work [Section 6] based on features that we did not incorporate in our final prototype and feedback that we received from our user evaluations. These are important ways to continue exploring how synchronicity may encourage students to engage in more insightful conversations and receive quicker responses to their posts.

Chapter 2

Exploration

Before starting any design brainstorming, we decided to explore the synchronicity problem space a bit more, including existing technologies that are similar to NB and take advantage of student learning or synchronous features. We also decided to learn about students' experiences with online and synchronous learning tools through a user survey.

2.1 Case Studies

In the following section, we will introduce various existing technology solutions that take advantage of synchronicity and/or encourage student engagement and learning. We hope that these case studies will allow us to recognize important features for student learning and engagement and also incorporate them into the synchronicity research work we are doing.

2.1.1 Case Study 1: Piazza

Piazza is a forum-type tool that students often use to ask questions and make comments. Some useful features about Piazza include their push phone or email notifications (that are configurable) whenever an instructor or student asks or posts something. This makes the platform particularly engaging because even though there are no synchronous conversations going on, students can have their questions answered. Configurable notifications would be a good synchronous feature to study and design for the NB system, especially for students who are online and would want to learn together synchronously.

Another reason why Piazza is particularly effective is because responses are driven by instructors. Instructors know to answer questions that students may have, and as a result, students are actively seeking help or conversations on Piazza. From this, it is crucial to notice students value instructors' feedback or chances when their questions may get answered more readily.

2.1.2 Case Study 2: Google Documents

Google Documents (Google Docs) is a collaborative document sharing and editing experience. It is particularly effective for sharing documents and also hosting documents for multiple users to access and collaborate, especially if they are online synchronously. One experience that Google Docs offers is the ability to see who is online. They use users' profile pictures and display icons of them to display to other users also synchronously online. This would help users raise awareness when there is potential for collaboration, and this would be a feature that may also encourage synchronous engagement in NB.

Another synchronous feature that Google Docs offers is the automatic refresh of other users' work as well as their location in the document. By being aware of others' locations as well as not needing to refresh the page to load new work, this further encourages collaborative work. Because users are able to work together in real-time and know where users are working in the document, this helps users feel like they are not working alone.

2.1.3 Case Study 3: Facebook

Facebook is used mostly for a social network connection, and it is built around sharing posts to other friends in your network or having instant chat conversations with them. Unlike Piazza and Google Docs which are used for academia and collaboration, Facebook's main purpose is for

social media usage. However, we decided that Facebook's model and method of having users interact is incredibly engaging. Similar to NB's model of posting comments, Facebook also allows users to make postings. It is particularly interesting how the posting and commenting user interface allows individuals to be more willing to chat and engage. Whether there are instant reply boxes that make it easy for users to make a quick post, a notification model that alerts users and constantly has them engaging with different posts or conversations that may be relevant to them, these are features that may also be applied to NB to encourage users to collaborate and have more thorough conversations.

2.2 Initial User Research

After the case study work and before diving deeper into design iteration work, we recognized that it is important to pinpoint specific solutions that may be useful for actual users. We sent out a Google Form survey to multiple peers and this was circulated to other students, researchers, and instructors. This survey consisted of many multiple choice questions as well as some short response questions to understand what a user would want to enrich their online learning and reading experiences. We have a copy of the survey in the Appendix. It is important to note that these users may not necessarily have used NB before, so they were answering from their different backgrounds of learning and tools that they have used before.

2.2.1 Type of Engagement

From the Piazza-style forums to Facebook where you can chat with one another, one question I wanted to learn more about was: What type of interaction would be helpful for users to help

them stay engaged and collaborate while doing annotations? I offered the following choices for options that might be more targeted for our implementation with NB:

- A public chat that allows me to communicate with all classmate online right now
- A private chat that allows me to communicate with the classmates I choose to chat with (creating individual group chats)
- Synchronous Piazza style - I post something that I want an answer to, and people get notifications to answer my questions immediately.
- Asynchronous Piazza style - I post something, and no one gets any notifications
- Other (enter in textbox)

What type of interaction would be helpful for you to help you stay engaged and collaborate while doing annotations?

21 responses

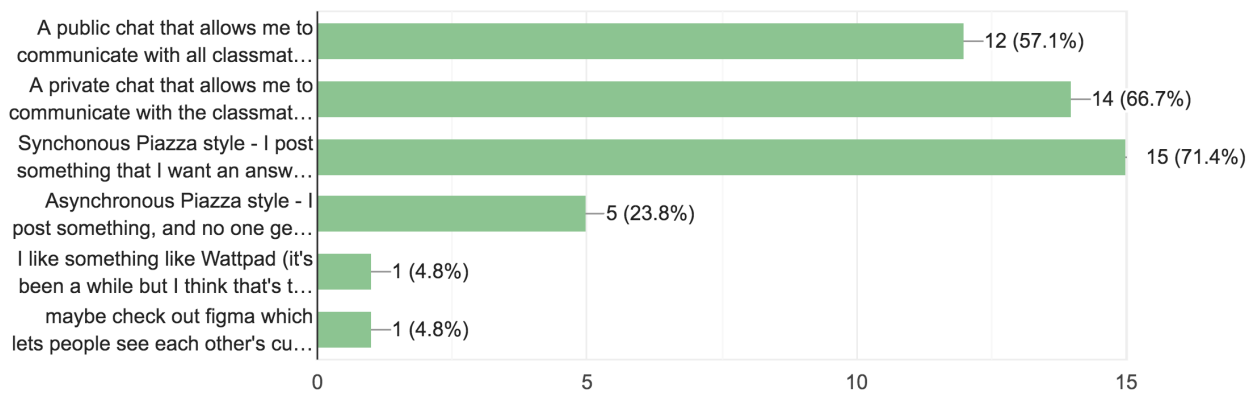


Figure 2-1 (above): Types of useful interactions from initial user survey

From this survey (results in Figure 2-1 above), the synchronous forum style was the most popular, but a majority of the responses indicated a preference of some sort of synchronous

conversation. Whether that is a chat that allows users to communicate with the class or a single classmate or a synchronous forum style experience, the immediacy seemed to be very important. As one resposdee mentioned in the survey in response to what benefits they believe synchronicity can add to online learning, their response was aligned with our motivation for this project: "I think getting instant notifications when other people ask questions helps collaboration happen faster (in a chat-like style) and may encourage question-asking more if people get faster responses" (*anonymous*). Many of the other answers included faster response times and more motivation to engage in conversation at the moment. Another benefit was that it would spart ideas and help students feel more connected to everyone in the class.

2.2.2 Type of Notification

From our case study work, we noticed that applications such as Piazza and Facebook offer different types of notifications. As a result, we wanted to learn more about what types of notifications would be most helpful for students. Because we did not want to necessarily force the students to only think about synchronicity, we also offered offline notifications as an option, as Piazza does an excellent job of notifying students (via email or phone push notifications) when someone responds to a post.

- All students (online & offline) get notifications whenever question/comment is posted
- All students (online & offline) get notifications whenever a classmate posts something that wants a response
- Only online students get notifications whenever question/comment is posted
- Only online students get notifications whenever a classmate posts something that wants a response
- I don't want notifications; they are distracting

- Other: please specify

What type of notifications are helpful?	
All students (online & offline) get notifications whenever a classmate posts something that wants a response	33.3%
All students (online & offline) get notifications whenever question/comment is posted	9.5%
Only online students get notifications whenever a classmate posts something that wants a response	9.5%
Let people set their notifications	9.5%
Only online students get notifications whenever question/comment is posted	4.8%
It would be nice for students to have notifications but can also choose to turn them off	4.8%
Follow certain people or follow certain set of tags or comments	4.8%
Localized comments “near” me	4.8%
Notifications for questions students choose	4.8%
Instructor and replies to my comments	4.8%
Batch notifications and selective ones	4.8%
I don’t want notifications; they are distracting	4.8%

Figure 2-2 (above): Types of useful notifications from initial user survey

From the results of the survey (Figure 2-2 above), $\frac{1}{3}$ of the responses believed that students online and offline should get notifications for things that require a response (i.e. “All students

(online & offline) get notifications whenever a classmate posts something that wants a response”). Almost 10% of the responses thought that all students should get notifications whenever something gets posted, and another 10% of the responses thought that only online students should receive notifications for things that require a response. All in all, these responses indicate how important notifications are for learning and engagement. For our design, we will evaluate more on who should receive notifications (online students, offline students, or both), what they should receive notifications about (only their posts or all class posts), as well as how/where they will see these notifications.

2.2.3 Disadvantages to Synchronous Learning

Another question we proposed in the survey was about the disadvantages of synchronous learning. The purpose of this question was to understand how our features may negatively impact users and to ensure that we can provide users a way to turn off our features at their own desire. Although some of the responses mentioned that there were not any disadvantages, some responses indicated that individuals may feel the pressure to interact. Especially for students who may not be available to be online at the same time or for the individuals who prefer to read quietly without distractions of other users, they may prefer a more focused mode. Some responses suggested a “do not disturb” feature to resolve that. Moreover, responses indicated that the experience can get very hectic, for if there are too many people online at the same time. These were all results from the survey that we will take into account for the design.

Chapter 3

Design Process

From the case study work to the initial round of user research, there were many design features that we can potentially add to NB. In the next section, we will propose different criteria and design iteration ideas; for most of them, we integrated them into our final system design, and for others, they will be included in the future work section (Chapter 6).

One of the biggest outcomes that can stem from synchronous conversations is the potential to engage more users. That is, when someone posts a new comment, because there are other students online, those students are more likely to answer questions, make comments, and push for deeper conversations.

3.1 Automatically Loading New Comments

While brainstorming with the potential synchronicity features we can add, we noticed that with the current implementation of NB, new threads are not loaded as they are posted. For instance, if student A and student B are both online, if student A posts a new thread, student B will not see student A's new thread without refreshing the page. That means even though both student A and student B are online and may have potential and capacity to respond, they may not necessarily engage in a thoughtful conversation because they do not see the new comments coming in. Without automatically loaded new comments, students would need to actively seek out new

comments by refreshing the page, and this is a large barrier to having students rely more readily and quickly.

The first step to synchronous conversation is for comments to load in as they are posted without requiring any users to refresh the page to load those new comments. This was the first step we wanted to make in having more engagement with synchronous conversations: automatically loaded comments meant a potential for more immediate responses while both students are online and without any activation energy from the users' sides.

3.2 Online Users

With the current version of NB, when users log on to read the document and make annotations, they may oftentimes feel like they are the only ones reading and commenting. As a result, they may feel as if they will not get much of a response from anyone and will not decide to engage in conversation. In addition to the awareness of students online by seeing new comments loading into the document and sidebar thread list automatically that we mentioned in the previous section, it would also be interesting for users to be able to see the presence of other students. From our case study 2 with Google Docs (Section 2.1.2), we noticed that Google Docs does an excellent job of showing awareness of other users. They indicate with users' pictures when someone is online, and they also mark places in the document where someone is highlighting and typing. They also immediately show the text that someone is typing.

When designing synchronous features for NB, we wanted to incorporate a way to help users be more aware of who is online. Moreover, it may be important to recognize where someone is on

the document and when a thread has typing activity. These are all important features, as this will raise the awareness of students to know that they have the potential for other students who are also “online,” reading the document, and potentially interacting with the threads in NB.

3.3 Overall Awareness

With the asynchronous version of NB, all the annotations are highlighted in the documents, and students have to actively choose to click on the highlight to read more. If a student wants to further investigate comments that might be interesting to them, they can use the different filters described in section 1-2. However, it is important to recognize that this requires students to be the one taking action; they are the ones who must have the activation energy to seek out other threads and engage. Since our goal for the synchronous features is to further engage students, we need to find specific threads that may be interesting to them, and raise awareness to the students on or off the document. This can be done through notifications, different highlights, or icons that can capture students’ attention quickly and provoke them to engage more readily.

From the initial user survey, we learned that a disadvantage of synchronous discussion and engagement might be the overwhelming number of notifications or comments that might come from students online at the same time. As a result, it is important to only display what may be relevant to students. From the features that exist in NB and from gathering initial feedback from students, these include

- Instructor Comments
- Tags
- Reply Requests

- Nearby Threads
- Typing Threads

3.3.1 Instructor Comments

In NB, as we described in section 1-2, instructor comments are indicated with an icon, but there are no other ways of propagating instructor comments to students for them to learn more. Similar to Piazza's (Section 2.1.1 Case Study 1) model, of instructors answering student questions, it is important to notice that students are more engaged when they know that they are going to receive answers from an instructor, especially since instructors are usually known to possess the knowledge for them to learn and develop insights about the class. When asking a random group of students about different types of comments that students would want to know about, they also brought up instructor comments, further demonstrating that instructor comments are valuable to students in a class.

As a result, we thought that it would be imperative to let students know when an instructor posts. It is even more crucial for students to learn when an instructor has replied to a comment that they posted in or created a new thread for. Thus, we will be taking this into consideration when thinking about how to raise more awareness for these types of threads.

3.3.2 Tags

In NB, users are able to tag each other in comments. This is a similar model to many software technologies out there, including Google Docs (Section 2.1.2 Case Study 2) and Facebook (Section 2.1.3 Case Study 3). In both of our case studies, users are able to tag others and those tags would propagate notifications to the respective individuals who were tagged. However, in

the previous iteration of NB, there was no way of notifying or not telling students that they have been tagged. As a result, this tag functionality may actually not be widely used, as individuals are not able to capture each others' attention through a tag. Thus, we incorporated notifications to let NB users know when someone has been tagged.

3.3.3 Reply Requests

Reply Request is a feature quite distinctive to NB; with the check of a checkbox, users are able to indicate that their thread requires a response, whether it is a question a student may have or because they would like people to respond with comments. However, similar to the instructor comments and tags, NB does not tell other students when there's a reply request posted. This can be especially discouraging for students who would like those reply requests but never receive them because they never receive a response. We incorporated reply requests as another type of comment to notify NB users about.

3.3.4 Nearby Threads

Especially with synchronous conversations, as two students are reading the same section of the document at around the same time, they may be more likely to respond to each others' post since they are in close proximity to one another in the document. Because they are reading around the same area, they may be able to provide more insight or answer questions around the same time. Thus, it is important to notify users on a basis of recency as well as proximity. In our final prototype, we added a feature to NB that would push notifications to users and make them aware of recent threads that were posted nearby.

3.3.5 Typing Threads

Similar to the idea of recency mentioned in the previous section, synchronicity also allows us to indicate when there's activity on an existing thread. This type of activity includes when another user is replying to a specific thread. If students see other students replying to a thread, they may also be more inclined to open up that thread and make a thoughtful interaction because there may be room for synchronous discussion. This is similar to Google Docs' concept of showing other users' locations on the document to encourage awareness of other users while also pinpointing which thread may spark insightful conversation.

3.4 Awareness On the Document

In NB, as seen in section 1-2, users make comments when they highlight a particular section of the document. When the comment is posted, that section in the document is highlighted to indicate that a comment exists at the particular spot. All the highlights are highlighted yellow. As a student reads through the documents, those yellow highlights (and the more opaque they are, the more individual student comments exist on that thread) help grab a student's attention to help them notice threads that have been posted. Because students are mainly reading the documents full of these highlights, this leaves a lot of room to experiment with different ways to further engage students via these highlights.

There are many means to which we can engage students. Those include:

- Different colors (besides the default yellow highlight)
- Different borders
- Different animations (constant blinking, appear and disappear, etc).

- Tooltips
- Sounds

3.4.1 Different Colors

The current default color for all highlights is yellow. Similar to a student annotating a physical document, students may use different colors to indicate different topics or concepts. As a result, we incorporated different color highlights to capture students' attention and help them classify threads that might be of interest to students. For instance, we can make the threads that we want to associate with certain notifications have different colors to indicate that they are special or interesting threads.

3.4.2 Different Borders

With different color highlights also come the flexibility of different border colors for highlights. This means that instead of changing the color of the entire yellow highlight, we can introduce features that make certain comments stand out by changing the stroke or border design of the highlight. This was be another method of capturing students' attention to help them classify potentially interesting threads.

3.4.3 Different Animations

Animations are usually an eye-catching way of attracting users' attention on a website. Whether it is a flash of a notification or a blink of a clock to indicate changes in time, blinking and/or flashing can be interesting ways to incorporate attention-grabbing annotation highlights in our project. We can make certain important threads, such as threads that have reply requests, have blinking animation; however, because animations are usually associated with activity or recency,

we used animations to indicate typing or recent activities for a highlighted thread in the document.

3.4.4 Tooltips

Tooltips are also common ways of helping convey more information to a user. Oftentimes, when a user hovers over something, a tooltip is a way of providing more insightful information before the user clicks. For NB, showing a user a tooltip about the comment on hover can provide the user with deeper knowledge regarding the comment that was made on that specific highlight as well as any notifications or synchronous features that may be associated.

3.4.5 Sounds

As with many notification platforms, such as Facebook notifications or push notifications on phones, there are usually short rings that can accompany notifications as an audio way of telling the user that there is something interesting to address. This would be interesting to add to NB, as notifying students of important and relevant comments with sounds may help them stay focused until something provokes interactions.

3.5 Awareness Outside the Document

In the previous section, we described ways to engage users on the actual document they are reading on; there are changes to the highlights or tooltips that can be made to attract a users' attention. With NB, however, there is also a whole other feature that we can use to engage users. There is a sidebar element that contains a list of the threads, and that can also be a physical space to show users important threads and to add our synchronous features.

3.5.1 Navigating Between Threads Easily

With the current version of NB, the threads list view in the right sidebar (as seen in figure 1-1) allows users to navigate through threads that might be of interest to them. However, it would be helpful if there are buttons that allow them to navigate from thread to thread while they are reading the threads. For this, we added “before” and “forward” buttons would be a simple way for users to go through the threads without too much effort.

3.5.2 Marking List View Threads

Introducing new threads that are interesting to the user allowed us to also mark them in the threads list. Currently, NB contains a thread list where certain comments are also marked with special icons, such as instructor comments or reply requests. It would be interesting to also add other icons where we can mark certain threads as something the user may want to engage with synchronously. For instance, we can insert a bell icon, as it is often associated with alerts or notifications. We can use that icon to indicate to the user that thread may be something interesting the user may want to engage with.

3.5.3 Exploring Threads Pane

We first explored the idea of a view to explore threads. That is, below the main thread list that already exists in NB, we can incorporate an identical-looking list that contains the interesting threads. We made this part collapsible if the user does not want to be distracted by incoming new comments to explore. As mentioned in section 3.3, these threads would include threads where the user is tagged, threads where other students requested replies, threads that were recently posted, and much more. With the automatic loading of threads, as mentioned in section 3.1, this

additional “Explore Threads” list can showcase the threads that may interest the user more. As these threads come in because of the automatic load of new threads without the need to refresh, then the users will basically have a feed of threads that would prompt them to interact. This is comparable to Facebook’s model of a Facebook news feed that displays interesting new posts, photos, as well as comments that other individuals have made.

Upon prototyping, however, we realized that this additional “Explore Threads” list may look very similar to the regular threads list that the current version of NB already has, and although this may take up some space on the sidebar, the user can merely reproduce the “Explore Threads” list with the use of a few filters.

3.6 Notifications Threads Pane

While users can find interesting threads with the use of a few filters provided in the current version of NB, that would require activation energy and effort on their end. For users who are less likely to do so on their own, we wanted to still provide users with interesting threads without giving them an identical view to the current threads list.

From our initial user research survey (section 2.2), we gathered that notifications are oftentimes very important to engage users. With synchronous conversations, we realized that notifications would also be one of the most effective ways of conveying to users that there is something that they should pay attention to and engage in, especially if there are other students online that may respond to questions more readily.

With these notifications, we proposed that these still contain threads that might be of interest to the user. That is, from section 3.3, we can still let the users know about comments they were tagged in or comments that contain requests for replies. However, we can also annotate and mark these notifications with meaningful labels to let users know what type of notification they might be interested in. For instance, an instructor posting a comment may prompt an “instructor comment” notification.

3.6.1 Type of Notifications

Similar to how we mentioned in section 3.3 about important posts that users may be interested in, we designated specific types of notifications to those different types of new comments. As such, we will categorize the following types of interesting comments with the following labels to prompt the user about specific posts that they might be interested in.

- **Instructor Comments:** “instructor comment”
- **Tags:** “you’ve been tagged”
- **Reply Requests:** “reply requested”
- **Nearby Threads:** “recent comment nearby”
- **Typing Threads:** None, but indicate with typing symbol

This way, if a user is only interested in notifications by an instructor, they can just look for a notification marked with the words “instructor comment.” If an instructor is interested in replying to all reply requests, they can scan for the notifications containing the label “reply requested.” These labels enable users to learn more about what notifications have been popped in before clicking and engaging even more. Since these text labels can clutter the view, we can also use icons to represent these labels.

3.6.2 Recipients of Notifications

Along with the axis of the type of notifications, it is also important to recognize the recipients of notifications. For instance, not everyone should be replying to threads that have been posted nearby. We want to achieve a balance of pushing notifications to people who may be more likely to respond without distracting the users from reading. From our initial user survey about disadvantages of synchronous features, we learned that we do not want to overwhelm the user with notifications. Additionally, it is important to note that NB is still an education learning tool and is not a tool used solely for social interaction and media. Thus, we want to respect students' learning and reading space without being too intrusive. For our final prototype, we fine tuned the recipients of who receives different types of notifications (section 4.1.4.3).

3.6.3 Location of Notifications

As notifications are a vital part to the synchronous features we have implemented, it is also important to consider the location and spacing of these notifications, for they should not clutter the user's view of NB and the document but also should be prominent enough to provide users with insightful comments happening synchronously. We will go over some design ideas we had regarding the placement of the notifications that we would introduce with these new synchronous features.

3.6.3.1 Right Sidebar: Notifications List

Similar to our threads list and our idea for an "Explore Threads" list, we can have a structure that is very similar to the existing threads list for a notifications list. The location can still be on the right sidebar, but the interface can be modified to reflect the notification labels and more notification-specific text. This is to avoid replicating the threads list twice on the sidebar, as we

still want to provide users with an enriching notifications experience if we decide to put it on the right sidebar.

3.6.3.2 Ride Sidebar: Popover Notifications

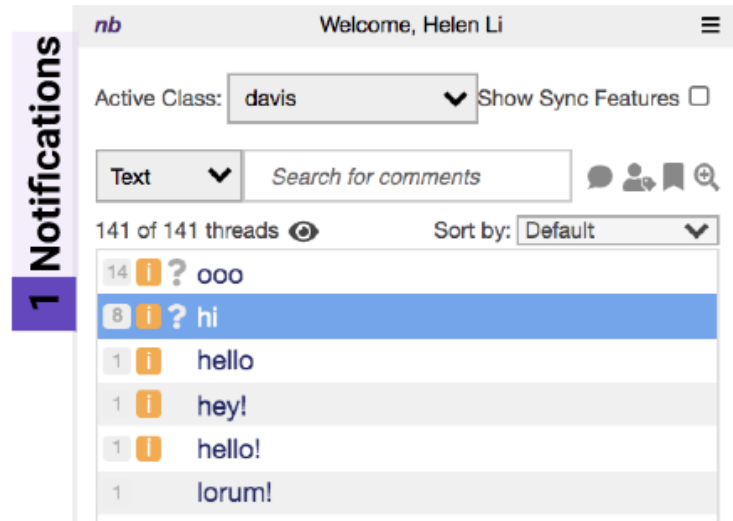


Figure 3-1 (above): Prototype of a popover notification view

Another option was to create a closable notifications tab that can be clicked on next to the right sidebar that exists with NB. This is similar to Facebook's interface of notifications, where clicking on a button can overlay a component containing notifications. This can be seen in our prototype below.

3.6.3.3 Left Sidebar

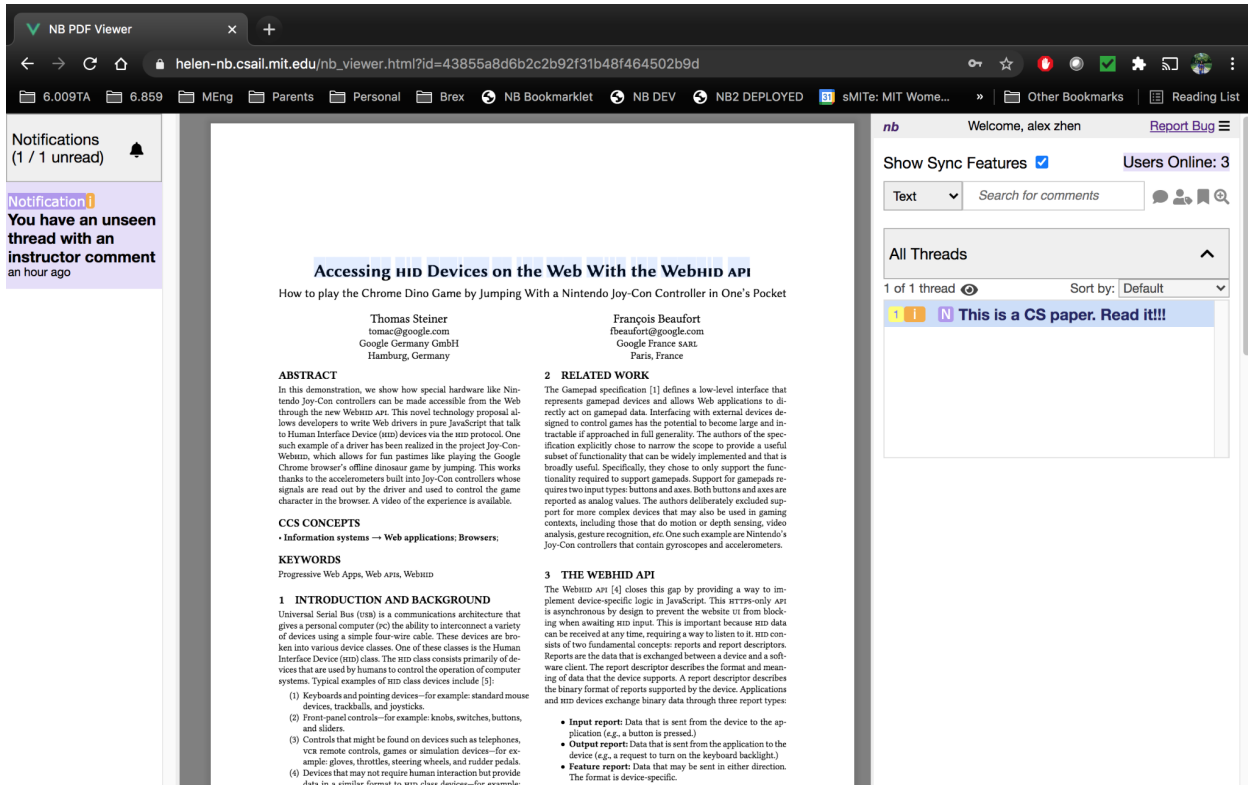


Figure 3-2 (above): Prototype of a left sidebar notification view

Another example was, notifications can go on a left margin sidebar. As opposed to how NB only contains a right sidebar to show the threads listing, a left sidebar for notifications would make the experience less intrusive. However, it is important to note that this would make the margins of the document even smaller. Because the current NB sidebar on the right already takes up some space (and thus making the document view shifted and smaller), introducing another sidebar may further limit the spacing.

3.6.3.4 Drag and Drop notifications

Another location for notifications that was brainstormed during this design process was a draggable window that contained notifications. This draggable window would be advantageous, for it would allow users to drag and drop the notifications window to a location that the user would prefer. This would undoubtedly provide more flexibility. If the user then wants to close the window, it would also be an option, as this would be space-efficient for the limited space we have on NB.

3.6.3.5 Flashing Notifications

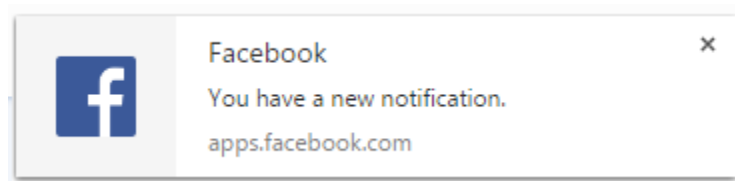


Figure 3-3 (above): Example of Facebook's pop-in notification

Inspired by the Facebook model of notifications, there are also pop-in notifications that come and disappear (Figure 3-3 above). These may be useful for notifications that may be more important for the end user, as they are a bit more distracting and come into the viewport of the document a bit more.

3.6.3.6 Pop-In Notifications

Similar to Piazza (Section 2.1.1 Case Study), email notifications are oftentimes a very effective way of notifying students that something important (such as an instructor response) has happened. While this project focuses on synchronous features to engage online users, it is also important to consider the asynchronous features, such as email notifications, that can engage the

users who are not able to join synchronously. Email notifications would be an important way of notifying users that someone has posted a thread that might be worthy of engagement; in turn, that user may log on to interact and have more meaningful conversations synchronously.

3.6.4 Filtering and Configuring Notifications

Similar to the process of applying filters to the current threads list that NB supports, we noticed that it is very helpful if a user is able to filter certain types of notifications. For instance, if a student is only interested in comments posted by instructors and nothing else, they can filter their comments by the “instructor comment” label or label. If someone is only interested in the important threads that they are tagged in, then allowing them to filter notifications with the label “you’ve been tagged” or icon would be a quick process to find those important notifications. Since we were designing to have a list of notifications for a user to see, a filter is important for the end user.

Another consideration is to allow users to configure their own notifications. For instance, we can add a settings page into NB to allow users to choose to only receive only certain types of notifications. This is oftentimes a very common method of allowing users to design their own experience with web applications, as giving them more control over the types of notifications that interrupt their workflow would provide them with greater flexibility. Additionally, if we were to introduce email notifications whenever a relevant notification is posted, it would be crucial to provide ways to configure email notifications; otherwise, the emails may be marked as spam or become too overwhelming for the user. Thus, notification configuration and filters are ways for users to further customize their own NB experience with our new synchronous features, and we include this in the future work section (Chapter 6).

3.7 Chat-Like Engagement

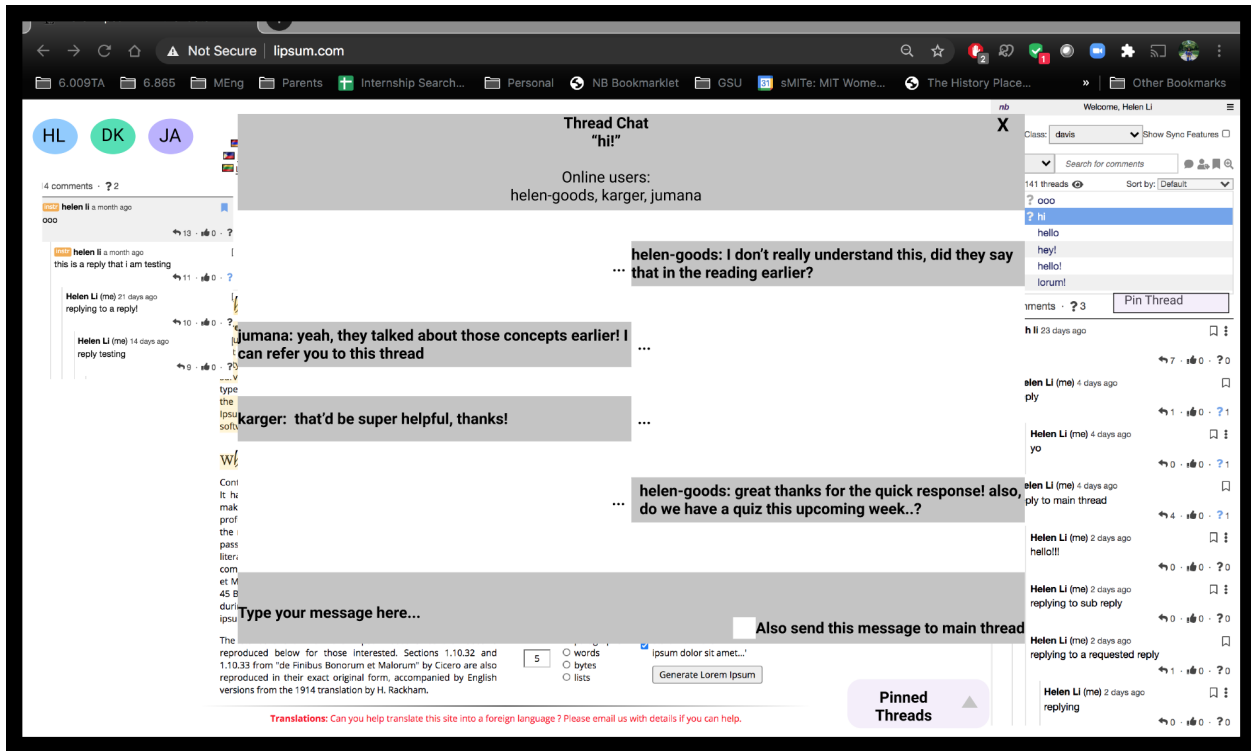


Figure 3-4 (above): Prototype of a NB user chat view

Chats are often well-known within instant messaging applications, as they provide the immediate feedback and responses that users enjoy. With the culmination of some of the designs we mentioned, we also designed a low fidelity prototype (Figure 3-4 above) of how chat functionality would look like within NB. The goal with this was to incorporate a way for students to chat about questions or insights more thoroughly and instantaneously. In addition to the online users, it may be insightful for users to be able to engage in conversation regarding a thread. For instance, as seen in this prototype below, clicking on an online user's icon on the top left may open a private chat window with that user. Messages can be sent back and forth between

the two individuals. Additionally, to make thread-specific chats, it would be interesting if students can instantaneously chat regarding a specific thread.

3.8 Focus / Offline Mode

3.8.1 Muting Notifications

As we have mentioned throughout this research process and from the feedback from our initial user survey (section 2.2.3), we learned that it is crucial for users to be able to have the functionality to mute notifications. Whether this is muting notifications that come into the notifications list that we design or muting only the popup notifications, this was a crucial part of our design.

3.8.2 Focus Mode

To further expand our capabilities for users to go into focus mode and not be distracted by an overwhelming number of synchronous conversations or features, we may also provide a “Focus” mode that allows users to turn off any of the new highlights or new notifications list features that we decided to include. That is, with the click of a toggle or checkbox, providing users with the flexibility to decide for themselves whether or not they want to be introduced to these synchronous features and notifications would be very useful.

Chapter 4

Implementation

After designing and brainstorming, we moved onto a final prototype that we would test with our usability experiment (section 5). We will also be discussing some implementation details for our final prototype.

4.1 Final Prototype

In this following section, we will discuss the final prototype that we decided to test with for our final usability testing experiment.

4.1.1 Automatic Loading of Threads

As discussed in section 3.1, it is crucial that we introduce the automatic loading of threads as multiple users online post at the same time. Because we want to encourage synchronous conversations that would eventually lead to more insightful conversations, this was the first milestone and most crucial part to the experience. As a result, in our final prototype, we implemented the automatically loading in of new threads/replies to comments as they are posted by other users. This happens instantaneously for the user without requiring any effort on their ends.

4.1.2 Sidebar Introduction



Figure 4-1 (above): New synchronous features introduced to sidebar

One of the largest introductions we made for the final prototype was introducing these new icons that represent different meanings for our synchronous features.

4.1.2.1 Focus Mode

The focus mode is a checkbox that a user can check to hide all the synchronous features we introduced in this design. From different types of highlights on the document to introducing new notification panes, this focus mode is a mechanism of allowing users to focus on their own and hide out features, as discussed in section 3.8. By default, because we want to encourage users to explore and use our new features, we will leave this checkbox unchecked. However, providing the user with this option to turn on focus mode at their own comfort would give them more flexibility if they do not enjoy or are distracted by these new features that we introduce.

4.1.2.2 Online Users



Figure 4-2 (above): New synchronous features on sidebar: online users

As discussed in section 3.2, telling users how many people are online allows them to be aware of other students' presence, thereby encouraging them to stay online and engage in conversation.

Existing technology from our case studies, such as Google Docs and Facebook, also have these indications of online users (section 2.1). We included this icon representing groups of people and added a label to indicate how many students are (from the same section and the same class) also online reading the same document at the same time. For a more usable experience upon loading these new features, we also added a tooltip that indicates that this icon represents “Classmates online,” as this would help users understand what these different icons indicate. For privacy reasons, since this is a classroom setting tool, we decided to not show the names or information of the students who are online.

4.1.2.3 Notifications

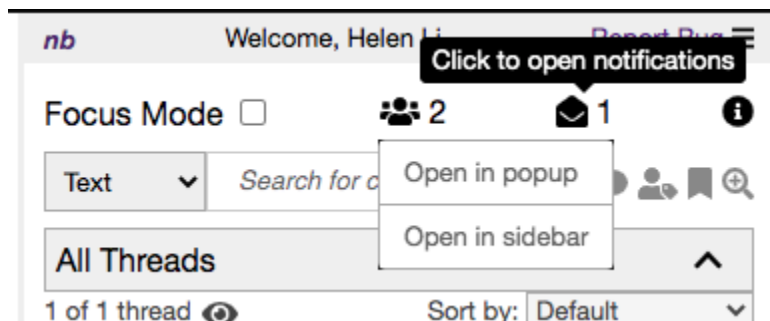


Figure 4-3 (above): New synchronous features on sidebar: notifications

One of the biggest features for adding synchronicity to NB is notifications. On this new sidebar introduction, we have an envelope icon to indicate notifications. We hoped that this would be similar to telling users that they have “mail” or “notifications” that they should pay attention to. Similar to the online users in the previous section, there is also a tooltip that is displayed upon hover; it is used to explain what these new icons represent for a more usable experience upon initial viewing.

When a user then clicks on that same envelope icon, we display our new notifications features. As can be seen, the user will see a “Open in popup” as well as “Open in sidebar” dropdown select view. These different options were the new notification panes we introduced into NB. We will go more into depth in following sections 4.1.3.5 to 4.1.3.6.

4.1.2.4 Information

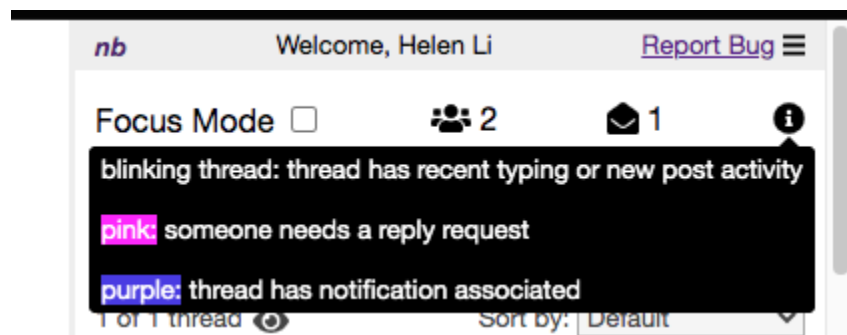


Figure 4-4 (above): New synchronous features on sidebar: information icon

This last icon that we introduce into the sidebar is an information icon. With numerous new synchronous features coming into NB, we wanted a seamless experience for users. Because we introduce new changes into the document regarding threads that might be interesting to engage in for more synchronous conversations, we have this last information icon. Upon hover, the user will see the new changes we introduced. More specifically, these changes are for the new color highlights that we introduce in the document. Because those changes may be more confusing to users, as they are more integral to their usual NB experience, we decided to inform users about what our new changes represent. We include changes such as animated/blinking threads as well as different color threads; we will go more into detail regarding what these new changes mean, but this information icon is used to inform users about any new features they may encounter.

4.1.3 Changes to Current Sidebar Experience

4.1.3.1 Chat-like Comment Box

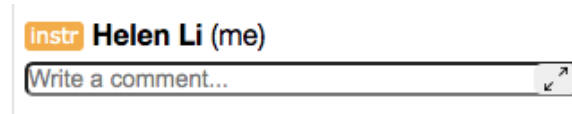


Figure 4-5 (above): New synchronous features: chat-like comment box

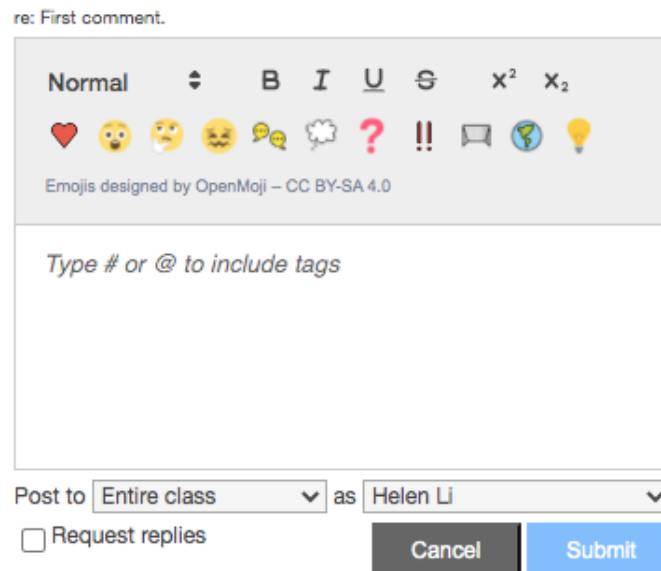


Figure 4-6 (above): Existing NB features: rich text editor

As discussed in section 3.7 regarding how to make the NB experience more seamless and provide a more chat-like experience to the user, we decided to incorporate chat-like comment boxes that will act as another way of posting complements. These simple chat-like comments only support plain text comments (i.e. no tags, no emojis, and no HTML styling elements unlike the original one we show in Section 1.2), as these are a way of replying very quickly to a comment. Users simply need to type their response in the box and press the “enter” key, similar to the experience of a conventional chat feature. If a user wants to type out a longer response

with more rich text elements, we also provide them with an expand icon button. Upon hover, that expand icon button says “Open rich text editor,” which will in turn open the rich text editor that we have in NB (Figure 4-6). This new chat-like comment box would allow users to respond more readily while also giving users the option to stick to their normal rich text editor if they would like.

4.1.3.2 Navigating Between Comments Easily

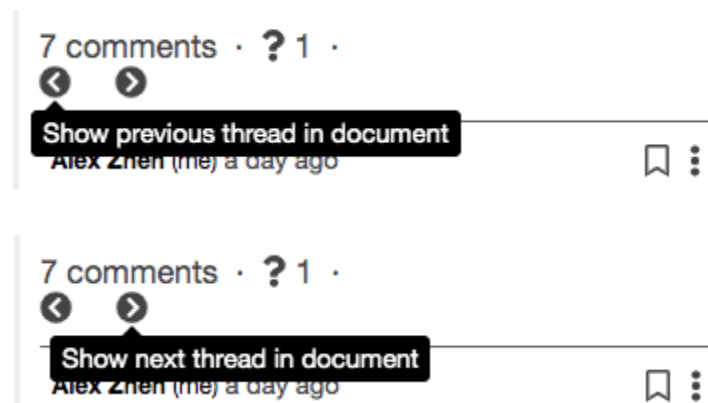


Figure 4-7 (above): New synchronous features: easy navigation between threads

As mentioned in section 3.5.1, we wanted users to be able to open a comment and then go between the previous and next comment in the document easily without having to scroll on the document or the threads list. Having an easier navigation between comments does not necessarily include synchronous features, but this may increase student engagement; a more usable interface for a student to go through more comments may increase the likelihood that they read and even respond to a thread.

In our final prototype, we incorporated simple arrows that allow users to navigate to the previous or next thread in the document with the click of a button. We incorporated these back and

forward icon buttons that help navigate between threads, and similar to the new features we discussed in the previous section, we added tooltips to explain what these new buttons represent.

4.1.4 Notifications

4.1.4.1 Access Control

We followed the same structure of access control that the current version of NB implemented for accessing comments or replies, as described in section 1.2.

4.1.4.2 Notifications Types

From our design (section 3.6.1), we decided that there are particular types of notifications that are important to keep students engaged. In particular, in our final prototype, we hoped to relay synchronous notifications to students when there is something that might be relevant to them; in turn, this would push users to engage in an insightful conversation. These include:

- Synchronous comments where instructors post
- Synchronous comments where users are tagged
- Synchronous comments where there are reply requests
- Synchronous comments that are made in response to a user's reply request
- Synchronous comments that are posted nearby a user
- Synchronous comments where a student is typing

From feedback from instructors that are currently using NB, we also learned that it is crucial for students to be able to receive asynchronous notifications when they are offline. We discussed email notifications in the initial design of these synchronous features, but to take advantage of

these notification panes and highlights that we have introduced with our new features, we decided to also notify users of threads that may interest them while they were offline. We provide them with notifications when the user signs into NB for these types of comments:

- Comments while the user was offline but an instructor comment instructors commented
- Comments while the user was offline but the comments where the user was tagged
- Comments while the user was offline that answers a reply request the user previously posted

We only show the top five of these notifications, as we do not want to overwhelm the user with notifications at the initial loading of the document, and the goal is to have them engage in conversations that they may have missed when they were away from the document.

4.1.4.3 Notification Recipients

From the previous section, while thinking about what type of synchronous notifications to propagate, it is also crucial to think about the group of users who will be affected by these new notifications. We would not want all students to be notified about all new comments, as that may overwhelm students when they are reading the document. From the previous section about notification types, we will expand on who will receive notifications for some of these threads.

- **Synchronous comments where instructors post:** For any new threads that instructors post synchronously, all students online receive notifications. If an instructor posts a reply to a specific thread, then all the students online and in that particular thread will receive notifications.
- **Synchronous comments where users are tagged:** For any threads that users are tagged in, any users online and tagged in comments will be notified.

- **Synchronous comments where there are reply requests:** For threads where students requested a reply, all students online will receive notifications, as we want to encourage all students to reply to questions from their classmates.
- **Synchronous comments that are made in response to a user's reply request:** For threads where a user's reply request is responded to, if the user who posted a reply request is online, they will receive a notification.
- **Synchronous comments nearby a user:** For threads who posted recently (60 seconds) of an online student's presence, students who are in view of the thread (i.e. the thread is visible on their document viewport) will receive this notification that there was a thread posted nearby recently.
- **Synchronous comments where a student is typing:** For existing threads where users are actively typing a reply, we also notify all online students.

4.1.4.4 Notifications on the Document

Since the document is where students' attention will remain for a majority of the time when reading the document, we decided that it would also be important to consider ways we can capture their attention on the document. As mentioned in section 3.4 during our initial design phase of designing awareness on the document, there are a bunch of different ways to modify the existing experience of the yellow highlights on the document. During the final prototype, we decided to introduce changes that are not too different, as we want the experience to remain consistent for the end user, but we also want these animations to be informative.

As a result, we chose to specifically highlight two types of comments, in addition to the existing yellow highlights that are applied to all comments:

- **For comments that have an associated notification** (i.e. they have any of the synchronous notifications that we described in the section 4.2.4.2), those comments are highlighted purple in the document. Because we specifically spotlight those comments as notifications to the user in separate popup/sidebar windows (to be described in section 4.1.4.5-4.1.4.6), we decided that we would also want users to be aware of those special threads as they are reading the document. The main goal was that a student should be able to identify any important, relevant, or interesting threads solely from reading the document.
- **For comments that have some sort of activity**, whether that is a nearby thread or a typing thread, as discussed in the 3.3.4 section where we discussed those types of notifications, we decided to make those highlights blink. It continuously blinks, and because blinking is usually associated with the existence of activity, we thought that this would be consistent in helping users make the association. With these notifications, we hope that users are able to engage with these threads, as this raises the potential that there are multiple users reading at that spot, thereby increasing the chance of engagement if users are aware of others' presence.
- **For comments with reply requests that don't have an associated notification**, they are marked with a pink. The goal with this was that as soon as a student or instructor loads the NB document, their attention would be guided to areas in the document where students requested a reply and would like a response to their thread. Since reply requests are usually more globally targeted towards all users in the class to receive help, we hoped that different color highlights to spotlight these help requests would answer students' questions more quickly. To make the distinction between read and unread reply requests,

unread threads are highlighted with more opacity, as the highlight would be more clear and noticeable for the end user. For reply request comments that have already been read by the user, then the highlight will be pink but will be a less opaque shade of pink.

To give the user more insight about these new comments that we highlight with these new different color highlights, we also introduce tooltips for highlights that have these special colored highlights. For threads that have associated notifications, we mark them with the notification label in the tooltip (the labels discussed in section 3.6.1) as well as a preview of the text of the comment that triggered this notification. For threads with blinking activity, we marked them with “recently commented” and a preview of the comment’s text. For threads with reply requests, we mark them with “reply request:” as well as a preview of the text of the comment that has a reply request.

4.1.4.5 Notifications (Popup)

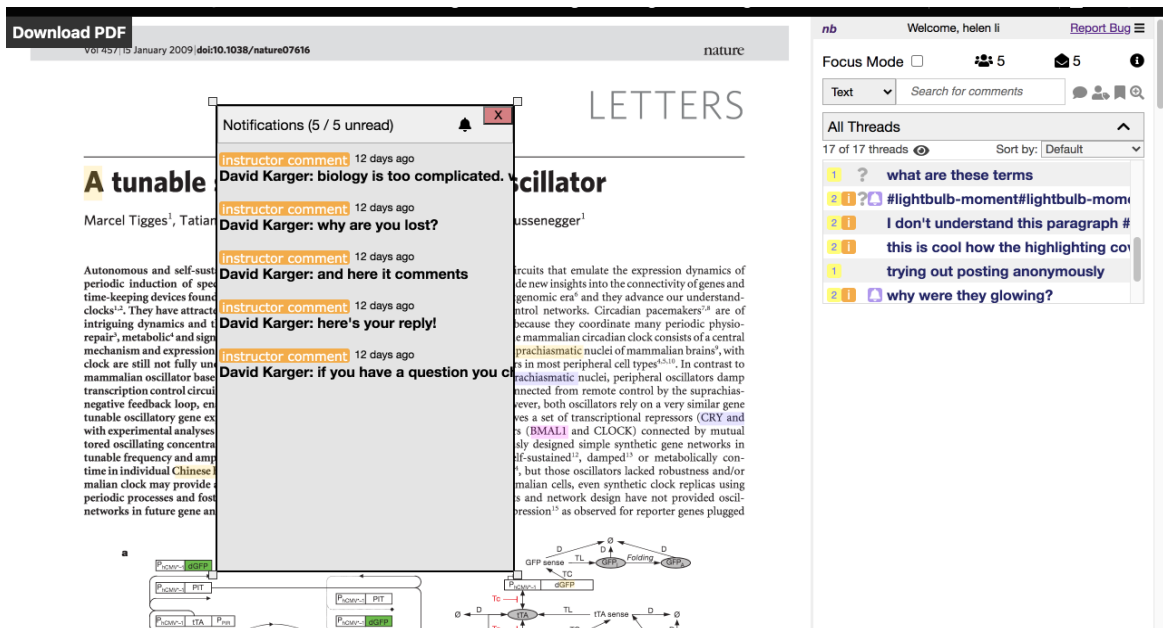


Figure 4-8 (above): New synchronous features: notifications popup

Another integral part of these types of synchronous notifications is how we show users that a notification has arrived. The previous section mentioned highlighting those notifications with highlights in the document. Another way that we spotlight those notifications in the final prototype is through a popup notification window. After the various designs of places to put the notifications, we decided that a draggable and resizable notification window may best suit the needs of the user. This would not take too much space, and this would provide the space and location flexibility that different users may want as they read through the document. These popup notifications would contain any synchronous notifications that may appear upon a new comment being posted. These notification popups will also contain the other notifications we describe in section 4.1.4.2. As can be seen in the notification popup example, this notification window also contains information about the total notifications as well as the number that are unread. This notification window is also reset and cleared every time the page is refreshed so that the user does not have too much notification clutter upon loading the NB document.

4.1.4.6 Notifications (Sidebar)

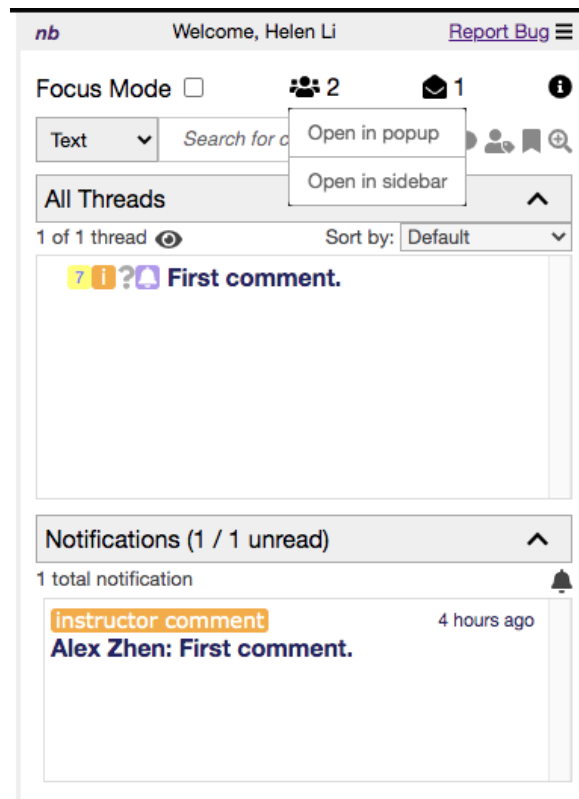


Figure 4-9 (above): New synchronous features: sidebar notifications

In addition to the popup notifications, we decided to also keep the right sidebar notifications that look similar to the thread list that NB already had. While the popup may provide the flexibility to drag and drop the notifications as well as resize the window, we decided that a docked notifications list in the right sidebar may also be helpful for a user. We provide the option to have both options. Similar to the notifications popup, this contains information about the number of unread and total notifications, and this pane also clears out all notifications upon reload.

4.1.4.7 Notifications (Threads List)

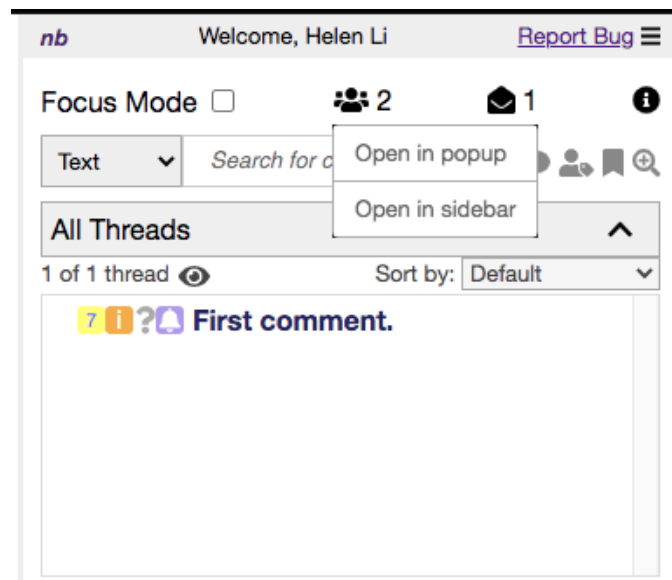


Figure 4-10 (above): New synchronous features: notifications icons in threads list

Similar to how we highlight threads purple on the document, we also hoped to make comments with associated notifications clear on the sidebar. With the hope that students would still notice notification-worthy threads without necessarily having to open the notification panes that we described in the two sections above (sections 4.1.4.5-4.1.4.6), we decided that the threads list should also have a marker to indicate special comments with notifications. Similar to how NB marked threads with instructor comments with a yellow “i” badge and reply request with a “?” badge, we decided to incorporate a purple bell icon badge for threads that have notification associated with them, as seen in Figure 4-10 above. As can be seen in the right sidebar threads list pane, the notification badge also provides insight on which threads may be interesting to the user and provide potential for synchronous conversations.

4.1.4.8 Other Notifications

In an attempt to also introduce notifications that are similar to Facebook's notification that pops in and then disappear after a few seconds but navigate to the relevant post/comment upon clicking that notification (as described in section 3.6.3.6), we also decided to incorporate that with these synchronous notifications features that we created with NB. As a result, upon threads that are more relevant to the user and may want the user to interact or read them more urgently, we introduce these additional notifications. These more urgent notifications include: comments that replies to a thread that the user requested a reply from in addition to threads that tagged the users. Because these are more directly targeted at the user, it may be important for users to view them while reading the document. These notifications pop in on the top left of the document and disappear after 5 seconds. The goal is that the user can notice these more urgent notifications and click on them to view the thread as well as the notification associated with this pop-in notification; if the user does not want to interact, then they can simply close this notification or wait for it to disappear automatically. Like the tooltips that we incorporate in the document as well as the previews that we incorporate in the popup notifications pane and the sidebar notifications pane, these pop-in notifications also contain a preview of the comment that triggered this notification.

We also provide a mute button in both the sidebar notifications pane as well as the popup notifications pane to specifically mute these popin notifications. Because these can be the most intrusive of our different notifications features, especially if there are numerous of these types of notifications coming in at a time, providing the user with a mute/unmute functionality on these notifications would allow them to customize their experiences.

4.1.4.9 Summary of Notifications

Figure 4-11 and Figure 4-12 (below) show a summary of the different synchronous and offline notifications we propagate to users (as discussed in section 4.1.4.2), including what event triggered those notifications, who receives the notifications, as well as how they are notified, as these are different dimensions to understanding user interactions with synchronous features.

Synchronous Event: A new comment is loaded in synchronously, and...	Notification Label	Who receives synchronous notifications?	How are people notified now?
Someone is tagged	“you’ve been tagged”	The person who is tagged	<ul style="list-style-type: none"> • Notification in the sidebar • Person who is tagged receives a pop-in notification • Purple highlight in the document
Someone posted a new comment	“recent comment nearby”	Everyone in view of the comment	<ul style="list-style-type: none"> • Notification in the sidebar for people nearby** • Blinking highlight in the document <p>**nearby: people in view of the comment</p>
Someone posted a reply request post	“reply requested”	Everyone	<ul style="list-style-type: none"> • Everyone receives a notification in the sidebar

			<ul style="list-style-type: none"> • Purple highlight in the document
Someone responded to a reply request	“reply requested”	Reply requester	<ul style="list-style-type: none"> • Reply requester receives notification in the sidebar • Purple highlight in the document
An instructor posted a new comment	“instructor commented”	Everyone	<ul style="list-style-type: none"> • Notification in the sidebar • Purple highlight in the document
An instructor posted a new reply	“instructor commented”	Everyone in the thread	<ul style="list-style-type: none"> • Notification in the sidebar • Purple highlight in the document
Someone is typing on a thread	N/A	Everyone	<ul style="list-style-type: none"> • Pink highlight in the document

Figure 4-11 (above): A summary of new synchronous notifications

Offline Event: A new comment was posted and a user logs in to see...	Notification Label	Who receives synchronous notifications?	How are people notified now?
An instructor posted a new comment	“instructor commented”	The user who logged in	<ul style="list-style-type: none"> • Notification in the sidebar • Purple highlight in the document

Someone answered their reply request	“reply requested”	The user who logged in	<ul style="list-style-type: none"> • Notification in the sidebar • Purple highlight in the document
Someone tagged them in a comment	“you’ve been tagged”	The user who logged in	<ul style="list-style-type: none"> • Notification in the sidebar • Purple highlight in the document

Figure 4-12 (above): A summary of offline notifications

4.2 Frameworks and Libraries

4.2.1 Existing Frameworks and Libraries

Because we were adding and enhancing the experience of an existing instance of NB, we were using the same code base to perform our implementations. NB uses libraries that are open-sourced, well-documented, and actively maintained, making it easy to find resources to continue to expand and include these synchronous features we added in our final prototype. The backend of the project was built using Node.js, which is a well-known JavaScript based framework to build network applications. Is it also supported by Node Package Modules (NPM), which are open source libraries that integrate well with Node.js, thereby allowing us to import and use open-source libraries for the new features we introduced into NB. In addition to Node.js to support the backend, we used Sequelize, a powerful library that makes it easy to manage SQL databases, and PostgreSQL, an open-source relational database system; we made use of the

existing database infrastructure to implement and optimize parts of our project, such as the automatic loading of new comments [6][7].

The client application of NB is built using Vue.js, an open-source reactive JavaScript framework, which is where we built most of the user-facing synchronous features [8]. Within the client side application, we also made use of other JavaScript libraries that already existed in NB, such as V-tooltip that would allow us to show tooltips on highlights.

4.2.2 Socket.IO

At the core of the new synchronous features we introduced in our final prototype, we needed a way of communicating between users on the client side to notify the users of new comments and online users. From there, we can notify users of notifications that may be worthy of capturing their attention. As a result, we decided to use Socket.IO, an open-source JavaScript library that is used for real time web applications. Socket.IO is a powerful framework and is used by a wide variety of developers, including Microsoft and Zendesk but also startups. Because it enables real time bidirectional event-based communication, we would be able to use it to communicate between our server and clients [9].

In terms of our usage with Socket.IO, our client side NB is configured to listen to any Socket.IO messages that may be sent from our server. The client side code also used a Socket.IO library specifically for clients [10]. Our client side is also allowed to emit any update messages to the server. Our NB server is also configured to listen to any messages coming from the client side, and it can also emit messages to the clients online and listening.

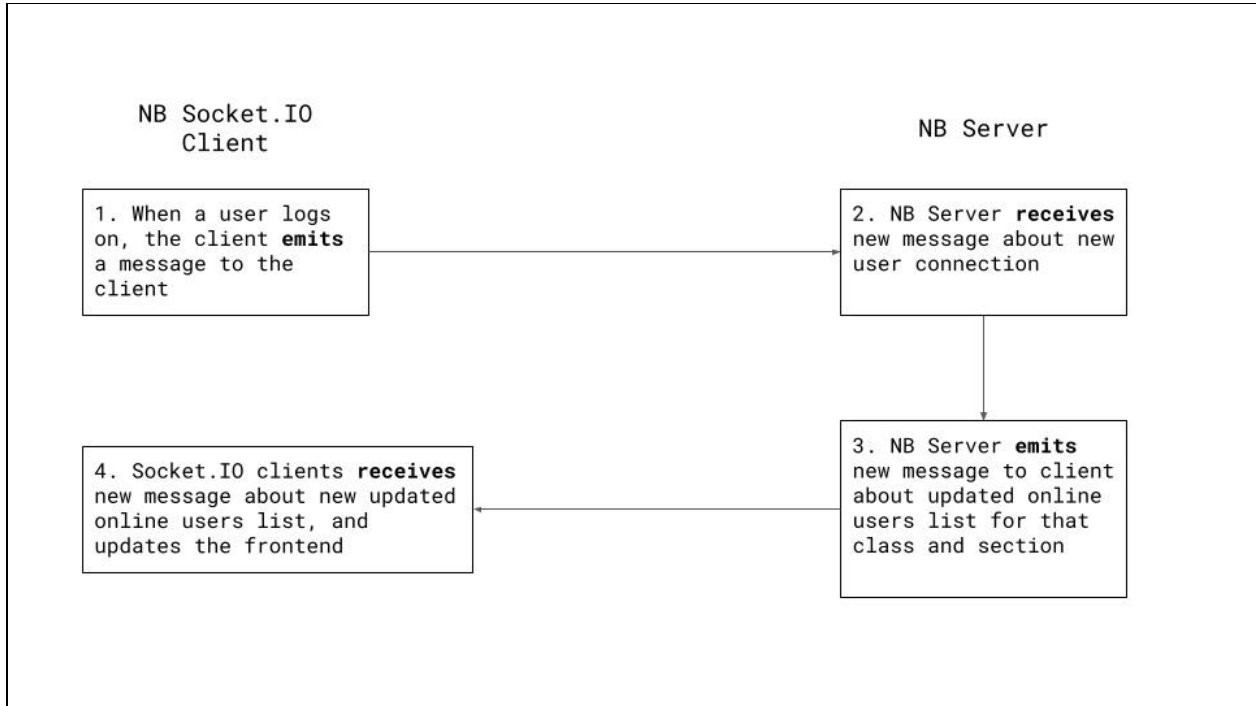


Figure 4-13 (above): Workflow of updating online users using socket.IO

For instance, to display the number of online users, whenever a user logs into NB, the NB client emits messages to our server (Figure 4.13). Our server is set up to support these messages coming in, and as a result, it updates the data of who is online for which class. After receiving these messages, it then emits messages back to the corresponding client side students who are in that class and section, so that all the students online in that class and section can get an updated list of online students.

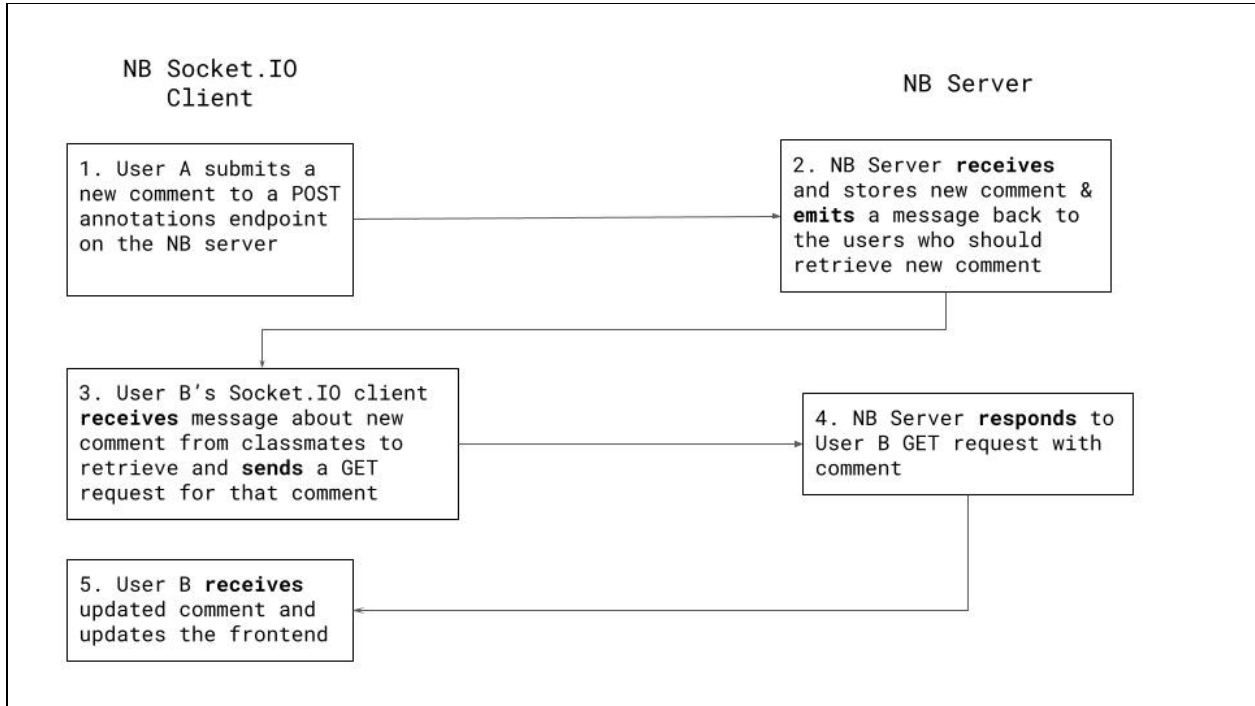


Figure 4-14 (above): Workflow of notifications with new incoming comments using socket.io

For other synchronous features such as the automatic loading of new threads (and in turn, we decide whether or not they are worthy of pushing notifications to the online student on the client side), we follow a similar but slightly different format (Figure 4.14). When a user submits a new comment (the start of a new thread or a reply to an existing comment), a POST endpoint in our server is contacted. After the server stores those new comments, we also emit messages, using Socket.IO, and include information about the students who have visibility to see those comments (students in the same class and section and based on the defined visibility of the comment, as described in the access control Section 1.2). In that emit message, we also include identifiable data about the new comment the client should know about. The NB clients who receive those messages make sure they are part of the targeted audience, and they then contact the server to retrieve the new comment through our GET endpoint to load the new comment in. After

retrieving the new comment, on the client side, we display this new comment and also decide whether or not this new comment is a type of notification that we want to push to the online user.

4.2.3 Additional Frontend Libraries

Because a majority of our user-facing features were on the client side, we also used additional frontend libraries to make the experience smoother for the end user.

4.2.3.1 Bootstrap Vue

Bootstrap Vue is a frontend CSS library that is compatible with Vue.js projects. With over 85 components, 45 available plugins, and 1200+ icons, Bootstrap Vue was also in use for NB before our synchronous work. We decided to continue to use it to format new icons we incorporated to make the experience more usable [11].

4.2.3.2 Vue Draggable Resizable

With our new notifications popup window that is resizable and draggable, we thought that it would provide a more customized experience for the user. Vue Draggable Resizable is an open-source JavaScript library for Vue.js projects, and it is used for draggable and resizable elements, as well as allowing for other customizable features for those elements [12].

4.2.3.3 Vue Sweet Alert 2

Vue Sweet Alert 2 is a responsive and customizable open-source library for JavaScript popup boxes. We use this library to display the pop-in notifications (as described in section 4.1.4.8), so that the user can see a responsive box when a relevant notification appears [13].

Chapter 5

User Evaluations

5.1 Experiment Overview

We worked with a course at the University of California (Davis) to test the functionality and usability of our new synchronous features. Because we have been working with this UC Davis group for a while, including to evaluate the initial iteration of NB, we continued to conduct an experiment with one of their spring quarter classes. The main contact for this course is Professor Marc Facciotti. Professor Facciotti teaches a Biological Sciences course that consists of numerous PDF readings for third and fourth year students at UC Davis. Because this is a smaller course, we were unsure of the chances for synchronous conversations to occur. However, we wanted to study this course to see how our features would work for this available class, and it would give us better insight in ways to improve for future work. We also plan on conducting a study for Professor Facciotti's Biological Sciences course (Bis2A), a large course of about 1,000 students, for the summer quarter.

We first deployed our features and ensured that we only enabled these features for Professor Facciotti's class. Because Professor Facciotti is using a PDF viewer¹ that we created to support his PDF readings, we decided to only turn on our synchronous features for documents that use

¹ This PDF viewer is one that we designed for Professor Facciotti's class to specifically support his PDF documents. With the help of PDF.js and a PDF viewer that Professor Satyanarayan uses for his Data Visualization course, we were able to support PDF documents that are uploaded to NB.

our NB PDF viewer. There are also other classes who use NB; this includes a course at Massachusetts Institute of Technology with Professor Arvind Satyanarayan for Interactive Data Visualizations. Because Professor Satyanarayan's class was coming to an end when we deployed our features, we decided to enable the automatic loading of synchronous comments for their class, since that is a basic feature that we would like all of our users to have. However, we chose to only display the notifications features for Professor Facciotti's class, as those were the newer features that users may be uncomfortable with. At the conclusion of the experiment, we plan on refining our synchronous features from the user feedback and turn these features on for all the classes using NB.

5.2 Questions for the Experiment

Overall, for our usability experiment, we are particularly interested in ways that synchronicity assists the students in being more engaged in conversation. Our hope is that with the automatic loading of comments as well as the new frontend features we introduced, students are able to interact more readily with other students who are also available online. For students who were not online with other students, they can also use the notification windows to notice some notifications that may be relevant to them when they were offline. Thus, we have two overarching questions that we would like to consider for the experiment.

- Do threads get help requests and get more comments i.e. do people receive help quicker?
- Are students more engaged i.e. are threads getting more responses vs. without the sync feature?

There are also numerous questions that we used to answer those overarching questions.

- What is the time difference between replies where two users are online vs. where two users aren't online?
- What type of notifications are clicked on most? This includes the notification types we outlined in section 4.1.4.2: instructor, reply requests, recent thread, tags, typing threads
- What were the locations of the notifications that were clicked on?

5.3 Experiment Metrics

With the assistance of Jumana Almahmoud, we were able to create a PostgreSQL table that consists of logs. We also have the NB database that consists of other information regarding users, annotations, etc., but these logs would be crucial to record more detailed interactions. We are using these logs to also log interactions for this synchronous project as well as another project that Jumana is working on. To get a more concrete answer to some of our evaluation questions, we logged the timestamp, type of notification clicked, and location of notification clicked.

Types of notifications:

- INSTRUCTOR_COMMENT: user saw comment with instructor response
- REPLY_REQUESTED: user saw comment with a related reply request
- USER_SAW_RECENT_ACTIVITY: user saw recent comment nearby
- USER_TAGGED: user saw comment with a tag

Locations of notifications:

- NOTIFICATION_HIGHLIGHT: the different color highlights we introduced with notifications in section 4.1.4.4

- NOTIFICATION_POPUP: the popup window we designed for notifications in section 4.1.4.5
- NOTIFICATION_LIST: the right sidebar view for notifications in section 4.1.4.6

Since we have a similar experience for instructors and students, we also log whether the user interacting with our interface was a student or instructor of the course. That will provide insight to how to make these notification features more suitable for instructors and students separately. Eventually, for future experiments, we can also incorporate other interaction information, such as the hovering of highlights to see tooltips to get a clearer idea of the full interaction with our synchronous work.

5.4 Experiment Results

In the following section, we will discuss some results and observations from our usability experiment, as well as discuss key takeaways on how to continue iterating and improving our synchronous features.

In order to run the experiment and notice student engagement and use with our new features, we asked Professor Facciotti to designate an “office hours” time to devote to these staying online. Because his class consists of 40 students, the chance that multiple students are online at the same time and receive the notifications may be slimmer, so we decided to have Professor Facciotti encourage students to read the document at around the same time. This occurred around one day before the deadline as well as a little bit before the deadline of the assignment.

5.4.1 Instructor Feedback

During Professor Facciotti's time hosting office hours, there was some immediate feedback regarding his experience engaging with students' comments.

- Having sound notifications would be helpful, especially if the instructor is looking away.
- Having an idea of who is actually online for instructors -- currently, it's just a number for privacy reasons, but for future work, we should allow students to configure their appearance on the list of online users (i.e anonymous or their names).

5.4.2 My Observations

As I observed the interaction of students and Professor Facciotti during the office hours that Professor Facciotti mentioned, I made some key observations about ways our synchronous features can be improved.

- For Professor Facciotti's class, students post in different areas in the document, and they do not necessarily receive notifications because recent comments nearby are only if students are near that area. Since this was a relatively smaller class, we may want to alert students of any recent comments, not just the ones nearby. Another option is scaling the number of recent comment notifications based on the number of users online, so that the number of notifications does not fluctuate too much and users receive a relatively constant number of notifications every time.
- Students often use emojis/hashtags more than reply requests or tags, so we can use hashtags to target students. There is also a question emoji that students use, but that is separate from the reply request checkbox that we designed notifications for. Students often use the question emoji but not the reply request checkbox. This is also closely

related to the work that UC Davis has been researching with the previous NB platform, as emojis and hashtags are often ways to help students express themselves in a social media platform. This may be something they are comfortable with, and sending notifications regarding these would also be very interesting [14].

5.4.3 Logs Results

With log data for one week’s worth of readings, where the students had two readings due at the end of the week, we were able to gather some data to answer some of our initial questions.

5.4.3.2 Overall Statistics

BEFORE synchronous notifications
Aggregation of Median Amount of Time Taken For Each Comment to Be Read (via highlights or sidebar)
Total # of Comments: 556
25th Percentile: 9 hours
Median Time: 41 hours
75th Percentile: 81 hours
Mean Time: 87 hours

Figure 5-1 (above): Aggregation of time taken for comments to be read before synchronous notifications

To make use of the data, we first wrote a Python script to calculate statistics for the amount of time that passed between comments being posted and being read by others. In Figure 5-1 above, we can see the statistics (before the synchronous features were introduced) for the median amount of time that passes between a comment being posted and then read. Note that these only include comments that are read (we excluded the ones that were never read), as we wanted a

good comparison of the overall time that elapses after a comment is posed until it is read by others. Additionally, we only used student data from Professor Facciotti class and did not include Professor Facciotti in the calculations since he was hosting office hours for our usability experiment and that may skew the student data for our experimental data and result. As can be seen, the amount of time for comments to be read can take almost two to three days.

AFTER automatic loading of new comments
Aggregation of Median Amount of Time Taken For Each Comment to Be Read (via original highlights or sidebar (no notification indications))
of comments: 129
25th Percentile: 2 hours
Median Time: 30 hours
75th percentile: 62 hours
Mean Time: 35 hours

Figure 5-2 (above): Aggregation of time taken for comments to be read after automatic loading of new comments

The statistics in Figure 5-2 above shows time statistics for after our automatic loading of new comments were introduced. For each comment, we calculated the median amount of time that elapsed between the student posting the comment and other students reading that comment for Professor Facciotti’s course via the original sidebar or yellow highlights. Then, we calculated the different statistics as seen in Figure 5-2. This is significant because even though these original features do not include any notifications, they still represent the impact of automatically loading new threads in for students to notice if threads are read more quickly. As can be seen, automatically loading comments helps decrease the amount of time that elapsed for comments to be read. However, since these original sidebar and highlights are still shown to offline students

who will see the comments later on, there can still be a couple hours between a comment being posted and others signing in to read it later on. We will explore the impact of notifications and the automatic loading of new threads in the following section.

AFTER notifications	
Aggregation of Median Amount of Time Taken For Each Comment to Be Read (via offline notifications)	Aggregation of Median Amount of Time Taken For Each Comment to Be Read (via synchronous notifications)
# of comments: 19	# of comments: 44
25th Percentile: 15 hours	25th Percentile: < 1 minute
Median Time: 43 hours	Median Time: < 1 minute
75th Percentile: 63 hours	75th Percentile: <1 minute
Mean Time: 43 hours	Mean Time: < 1 minute

Figure 5-3 (above): Aggregation of time taken for comments to be read after notifications

In Figure 5-3 above, we can see the statistics for the aggregation of the median of times that elapsed between a comment being posted and a student interacting with one of our notification features (either on the notification popup, notification sidebar, or new notification highlights). Note that from section 4.1.4.2, we discussed how when a user logs on, we display some relevant notifications regarding comments that occurred while they were offline. The first column in Figure 5-3 represents the median time that elapsed between a student posting a comment and others viewing it through the offline notifications. As can be seen, since students were offline when the comment was posted but only viewed the comment through the notification when they signed into NB again, the time elapsed is much bigger and comparable to the original times from Figure 5-1.

The second column in Figure 5-3 represents the median time that elapsed between a student posting a comment and others viewing it through synchronous notifications. Since these were all synchronous notifications we discussed in section 4.1.4.2, the time that elapsed between the posting of the comment and viewing of the comment via these synchronous notifications is under a minute. It is significant that there were still 44 comments read through these synchronous notifications; 44 comments read under a minute each is significant for encouraging interaction.

AFTER all new features
Aggregation of Median Amount of Time Taken For Each Comment to Be Read (via notifications & original highlights or sidebar)
of comments: 129
25th Percentile: 2 hours
Median Time: 31 hours
75th percentile: 62 hours
Mean Time: 35 hours

Figure 5-4 (above): Aggregation of time taken for comments to be read after all new features

In Figure 5-4 above, we can see the aggregation of statistics for all the different notifications and automatic loading of new comments features we incorporated from Figure 5-2 and Figure 5-3. Overall, with our new features, some features decreased the elapsed time by many hours while others decreased them by a little bit. With the decrease in time of comments getting read, this indicates that synchronous communication opens up the potential for more conversation and questions getting answered. However, because the control group calculations before the synchronous features were retrieved from many weeks' worth of reading, it would be important to continue to run our experiment for the same period of time since comments read after a week's worth of time may also affect the results.

5.4.3.1 Breakdown of Notification Types

One question that we had was the type of notification that was clicked on the most. What type of notification was clicked on the most? This includes the notification types we outlined in section instructor comments, reply requests, recent thread, tags, typing threads.

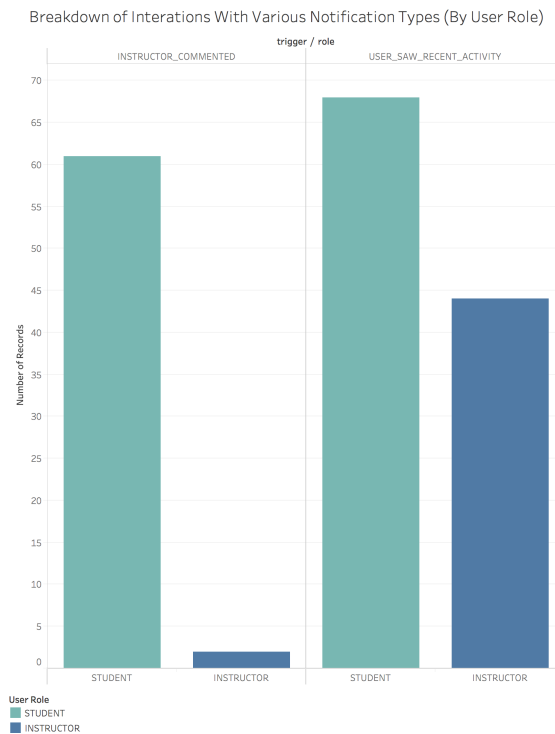


Figure 5-5 (above): Breakdown of interactions: notification types
user_saw_recent_activity indicates notifications for recent comments. instructor_comment indicates notifications for comments with instructor responses

From the logs, we can tell that comments that instructors interacted with and comments that had users saw more recently (USER_SAW_RECENT_ACTIVITY) were most clicked on. In fact, the other types of notifications were not even interacted with, as users did not seem to tag each other in comments frequently nor actually check the reply requests boxes to request replies to their comments. From the bar chart below, we can notice that there were between 60-80 interactions with those two types of notifications. Professor Facciotti (grouped under “instructors” in Figure

5-5) also took advantage of recent comments posted by students so that they know where to guide their attention and respond to comments.

5.4.3.2 Breakdown of Notification Locations

Since it would also be insightful to learn about which of the new notifications features were most interacted with, we also recorded data on the locations of these notifications that were clicked.

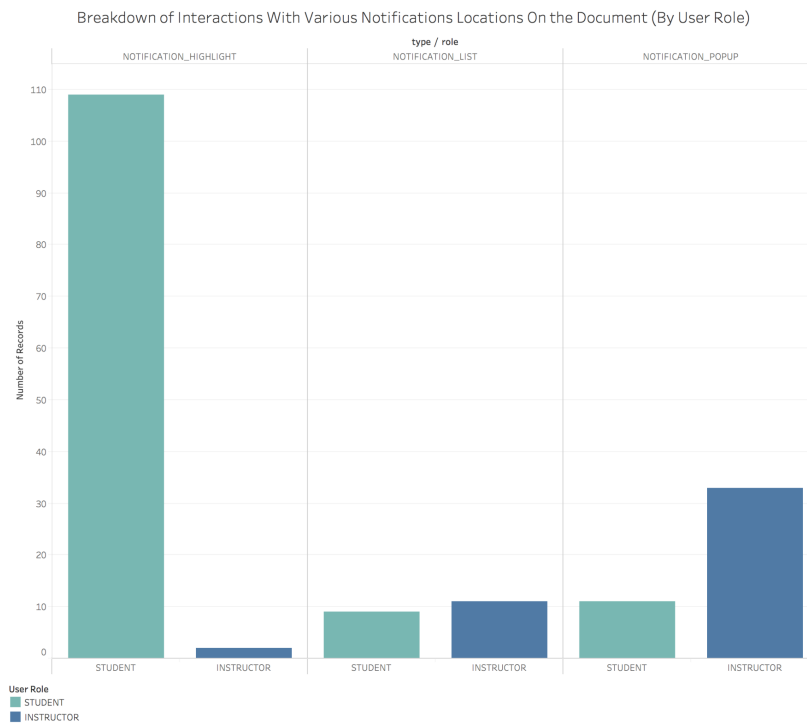


Figure 5-6 (above): Breakdown of interactions: notification locations

From the results of the logs, we can see that students interacted with the notification highlights on the document a lot more than the notification list or popup. Meanwhile, instructors (Professor Facciotti) interacted with the notification popup window a lot more. This is interesting because this indicates that we should aim to capture students' attention by the document they are reading (since their main assignment is to make comments on the document), while we should aim to

capture instructors' attention by a more centralized location where they can view new student comments.

5.4.3.3 A Closer Look At Threads

As seen in Figures 5-7 below, we have mapped the comments that received the notifications interactions on them. That is, for a specific annotation id, how many associated notifications with that thread were interacted with? We will also go into some more specific examples of the threads that had high interaction.

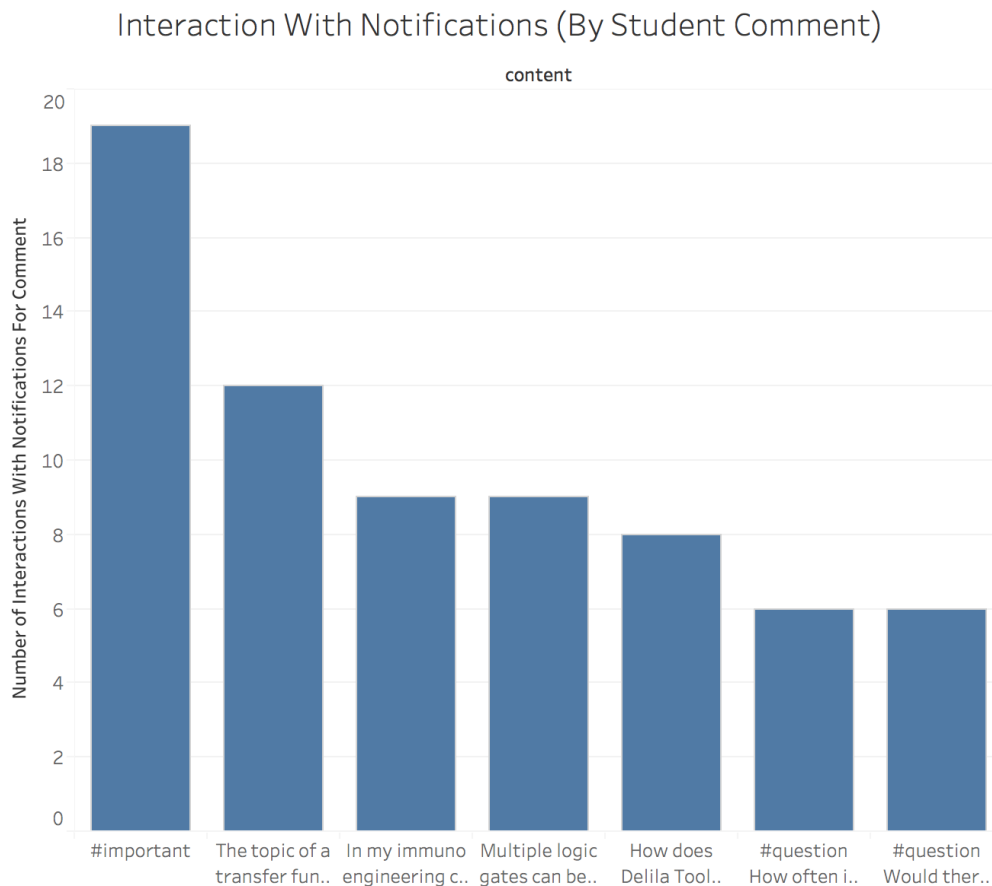


Figure 5-7 (above): Breakdown of notification interactions for student comments

Example 1: For that second comment in the visualization with a total of 12 notification interactions since the last time we retrieved the data, we noticed that the thread had 4 total comments. That one was also a comment that Professor Facciotti noticed that he had a “back and forth” with a student for, indicating that there was increased engagement on NB in a small time period. This happened on May 14th, 2021. To be more specific, here was the interaction logged in our records:

1. A student posted a comment at 3:43pm².
2. Professor Facciotti responded by asking the student a question at 3:44pm.
3. The student responded to the professor’s question at 3:44pm.
4. The instructor then made another comment to the student’s response at 3:45pm.

Thus, with the new synchronous feature, the student and instructor were able to have a quick exchange on NB, without having to refresh the page to load new comments in, in the matter of a few minutes. As a result of this thread being posted a few days before the reading deadline, other students also noticed the notifications for the comments because of the instructor responses, thereby indicating the increased awareness with these new synchronicity and notification features.

Example 2: For the fourth comment in the visualization that has a total of nine notification interactions, we noticed that it has a total of two comments. Even though this was not a lot of comments, it is important to realize the closeness in response times again. A student posted a comment at 4:22pm and the instructor responded at 4:27pm. The student then read the response a minute later at 4:28pm. This is important because the instructor was able to respond within 5

² Note: All times are reported in the GMT timezone. UC Davis’ students and instructors mostly interacted with NB in the PST timezone.

minutes and make a note of the student's comment, allowing the student and other students to benefit from the instructor's comment; as a result, the quick response rates would allow other students to also benefit, even if they are not directly interacting with the thread.

Other Examples: There were also other examples, such as the third comment with nine comment interactions and last two comments with six notification interactions where the instructor responded and the students responded to the comments later in the day. Thus, this indicates the importance of the instructor-related notifications.

These examples are crucial to help us understand that recent activity comments will receive more interaction than usual, even if that means users are just reading the threads and not responding. Moreover, we see that comments are noticed more quickly than previously, whether that is by the instructor or other students. It will be important to continue running this experiment with the ongoing class to see if these notifications will increase engagement by calculating the number of comments per thread. Even though students may respond quicker for this experiment's readings compared to previous weeks' readings, the total amount of engagement in terms of the number of comments for each thread, especially between students, seems to be relatively similar to the previous weeks' readings. That is a takeaway that is important as we iterate on our features, as we should brainstorm how to target even more engagement for smaller classes.

5.5 Experiment Takeaways

Overall, there were many areas of improvement for our synchronous features. Because we are just at the tip of exploring the ways we can incorporate synchronicity into an originally

asynchronous application, we must consider the various classes and their use cases for commenting. Here are some major takeaways:

- Instructor comments and recent comments seem to trigger the most number of notifications and interaction with the notifications.
- It is important to tailor the notification features and the locations of the features for instructors and students, as students may have more involvement by reading through the document, whereas instructors may appreciate a more centralized place for notifications.
- For classes that are smaller or for times when the document does not have a huge influx of users online, we can choose to show recent comments to more users, not just targeted to the users nearby the posted comment, as described in section 4.1.4.2. We must have a method of scaling and normalizing the number of recent comments notifications received.
- We should incorporate sound notifications, so that users are more aware of notifications, especially if they are not viewing the NB page at all times when they are preoccupied with other tasks.
- We can incorporate notifications for hashtags too. It seems like reply requests and tagging are used less frequently than hashtags, so this would be an area where we can explore more about how to trigger notifications to the right group of recipients.
- We can allow users to toggle between displaying the number of online users or displaying the actual names of the users online. In order to protect the privacy concerns of all users, we should let users decide how they want to be displayed in the online users list (i.e. anonymous or their names).

Chapter 6

Future Work

With the initial design and brainstorming phase of the project, in addition to the feedback we received from the usability experiment, there are many features that we would still like to explore to expand this project even further.

6.1 High Priority Features

6.1 Email notifications

With feedback from Professor Facciotti as well as Professor Satyanarayan during their time using NB this year, they thought it would be crucial to notify students when their comments receive some response. Thus, we can integrate these with email notifications, as email notifications are oftentimes the most formal and direct way to make students aware of any progress on their work.

6.2 Sound notifications

As mentioned in the initial design phase as well as from user feedback, sound notifications are crucial to add for even more engagement with our synchronous features. In addition to the highlighting and popup windows we provide, sound provides another way of notifying, especially if a student is not actively on the NB window. For instance, if a student changes to another screen for class materials, they can still be notified immediately through sound notifications on NB.

6.4 Notification Filters

As discussed in section 3.6.4, it is important to allow users to decide which types of notifications are important to them. Thus, a future feature to incorporate are filters for any notifications we offer on NB. Because NB offers a multitude of filters available for different types of threads, we also want to be able to provide a simple filter for notifications that push to the user.

6.5 Notification Configuration

In addition to notification filters, it would also be crucial to implement notification configurations. We initially brainstormed this during the design phase, as we thought that we want to provide users with a customizable experience. Similar to how many other software applications provide user configurations for notifications, we want to be able to allow a user to select which notifications they receive. For instance, does a user want to receive a notification for all the new comments coming into their class? Do they want to receive notifications offline? How do they want to receive these notifications (emails or through NB)? From our user feedback and experiment results, we learned that notifications regarding recent comments were the most useful for users, so at a minimum, we may provide users with those types of notifications. A prototype of this may look like the following, and this may be configurable from the NB page. Because the notification types we experimented with were solely types of comments we thought were most unique to NB and may warrant more users' attention, it would be interesting to allow users to decide for themselves.

6.6 Displaying Online Users and Locations

As given from Professor Facciotti's feedback, it would be helpful to display the names and locations in the document of the online users in order to know exactly which users' comments to read or interact with. Currently, we just display a number. However, if we are able to allow users to make themselves visible/invisible on this list of online users, we may be able to address a privacy concern as well as make it even easier for instructors and students to pinpoint where in the document there is potential for meaningful conversations.

6.2 Open-Ended Design Features

In the following sections, we will also discuss other potential features that we can incorporate that may also take advantage of synchronous readings and conversations. However, they may contain some more open-ended design thinking, as the specifications of these features are not as well sketched out. These features can still take on many variations, so these are other future areas for improvement.

6.2.1 Other Notifications

Additionally, we may even want to expand the different types of notifications that we notify the users about. Instead of limiting to topics such as reply requests, instructor comments, tagged comments, or recent comments nearby, we may want to expand the notifications to include any responses to a user's thread. This may be a basic and useful functionality that we did not include in this project's exploration, as we wanted to explore other avenues of intriguing notifications. This future work also provides a design space where there may be other notifications that users may want to receive; from our user research, emojis or hashtags may be a place for notifications.

Moreover, we may want to scale notifications based on the class size or the number of users online, as that may provoke more engagement and provide a relatively constant rate of notifications a user receives. Because having a notion of notifications in NB is new within the platform, there are many other platforms in which we can explore synchronicity and notifications.

6.2.2 In-app chats

One of the most interesting features that we brainstormed during our design phase were in-app chats. We decided to shy away from a replica of the existing chat applications out there because we wanted to focus on other features that may add to the NB experience. We still incorporated features that would provide a chat-like experience to the user, such as the comment boxes that mimicked messaging apps (section 4.1.3.1). Additionally, with the automatic loading of comments, instant notifications, as well as a thread comment structure that NB inherently contains, we thought that students would be able to chat through the comments they post. However, an instant messaging chat platform integrated within NB may provide even more insight for users. Chats are oftentimes known to be more casual, and if this is implemented within NB, and users are able to take advantage of it, students may be more comfortable posting multiple comments after having chat discussions with others. Thus, chats would be an interesting branch off this synchronous exploration that we did in this project.

6.2.3 Reading Time With “Friends”

A more far-fetched idea that we proposed during the design iteration for this project was a concept of having other users in the class that you designate as “friends.” Following the Facebook model of receiving more notifications and being more aware of friends activities. For

instance, when these “friends” log onto NB for a reading, we can send email notifications to those friends to let them know that someone is online and may be a chance for insightful conversations. Moreover, along the lines of notification configuration, we can allow users to configure the number of notifications they receive from friends they are more familiar with versus friends they may not follow as much. We would want this to be an equitable experience for all users, as we do not want to exclude students who may not know their classmates as well, so that would be another factor that we would have to take into account throughout the design of this model. All in all, this reading time with “friends” would allow for synchronous conversations but customize notifications for users so that they are more targeted and appropriate for certain users.

Chapter 7

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Lastly, I would like to thank my friends, family, and loved ones who have supported me through this process. Without their care, support, and time, this project would have been impossible without them.

This prototype is able to build upon the previous NB because of its exciting features to allow users to further engage with one another. Through the user testing experiment, we receive incredibly helpful suggestions for improvements, as we continue to iterate and work on these features. With the power of synchronicity, we can continue to work towards helping students get answers and replies more quickly, thereby making this online experience incredibly helpful.

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Appendix

Copy of Initial User Survey (Section 2.2)

⋮

What type of interaction would be helpful for you to help you stay engaged and collaborate while doing annotations?

- A public chat that allows me to communicate with all classmate online right now
- A private chat that allows me to communicate with the classmates I choose to chat with (creating individu...
- Synchronous Piazza style - I post something that I want an answer to, and people get notifications to answ...
- Asynchronous Piazza style - I post something, and no one gets any notifications
- Other...

⋮

What type of notifications would be helpful?

- All students (online & offline) get notifications whenever question/comment is posted
- All students (online & offline) get notifications whenever a classmate posts something that wants a respo...
- Only online students get notifications whenever question/comment is posted
- Only online students get notifications whenever a classmate posts something that wants a response
- I don't want notifications; they are distracting
- Other...

What would encourage you to read/annotate together with classmates?

- Being able to schedule a time to read/annotate together on this platform
- Scheduling a time spontaneously outside via another platform (ex: Google Calendar, Zoom Invites, etc.)
- I usually prefer to read on my own. I would not want to schedule a time to read with other classmates.
- Other...

What would encourage you to post non-anonymously in a forum?

- If other people also don't ask questions anonymously
- If other people addressed me by my name when they respond to my comment
- I would want to remain anonymous when I post but then allow myself to "unmask" myself and show my na...
- I would want to remain anonymous all the time.
- Other...

What type of dashboard might be interesting to you?

- A bar graph dashboard that tracks my stats - how many people I'm interacted with, how many posts I've m...
- A social network tree/graph dashboard where I see which students I've interacted with synchronously
- A dashboard will not be useful for me to track my learning and interactions.

What benefits does synchrony add to online learning?

Long answer text

What disadvantages does synchrony add to online learning?

Long answer text

What other platforms can you learn synchronously on? How do those platforms work?

Long answer text
