Stream Assistant: A Study of Chat Importance, Management Approaches, and Effects of Real-Time Chat Summarization Techniques

by

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Abstract

Live streaming platforms have become established communication channels where streamers and viewers can communicate through the chatbox. However, managing messages can become challenging for streamers, especially during high-activity periods. Building on prior research investigating chat communication and message management approaches, we explore the role of the chatbox and its management strategies from the streamers' perspectives. We also examine the effects of real-time summarization methods by designing a prototype called Stream Assistant and evaluating its efficacy through a study with ten streamers. Our findings highlight the role of chat in boosting engagement and audience growth for streamers. Streamers adopt personalized approaches like prioritization and pauses to manage messages. We also found that the level of interest in an automated polling feature was high; however, chat volume and the stream's agenda might influence the perceived usefulness of the summarization methods.

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to get me where I am today. Thank you for all the times you prayed for me, all the times you stood by me, and all the blessings I get thanks to you.

Chapter 1

Introduction

Live streams have become a prominent phenomenon growing day by day, attracting audiences worldwide through the unique mix of real-time video content and interactive chat engagement. Platforms such as Twitch, Facebook Live, and YouTube Live have witnessed exponential growth, attracting millions of viewers who follow their favorite streamers' broadcasts [6]. Notably, external factors such as the COVID-19 pandemic have amplified the appeal of live streams, compelling individuals and institutions to adjust to live video conferencing platforms for communication and events. Live streams provide a lucrative platform for enthusiasts from diverse fields to create content and generate revenue. These streams encompass a broad range of interests, spanning gaming, art, music, topical discussions, and more. For the majority of Twitch streamers, live streaming is more than just a hobby; it is a full-time profession that generates revenue through paid viewer subscriptions [15].

This dedication highlights the streamers' commitment to producing content for their audience.

Research has been conducted on various aspects of live streams such as audience engagement [26, 4, 5, 46], and chat communication [8, 34, 39, 10]. Additionally, studies have explored ways to enhance live stream interfaces [32, 51, 6, 17, 41], and developed alternative modalities for consuming live stream content [16, 45, 19]. Other related work has delved into chat communication and management [40, 44, 54] , managing large-scale live chats [50, 37] as well as summarization techniques to capture the essence of live stream content [29, 36, 13, 18, 12, 23, 40, 53, 31, 52, 27, 33].

Live streams provide a unique opportunity for real-time communication between streamers and viewers. One of the key aspects that make live streams highly engaging is the chat functionality, enabling viewers to actively participate, interact with the streamer, and contribute to the live stream experience. Unlike other social media platforms that rely on delayed communication in the form of comments and direct messages, live streams foster immediate and direct interactions between the streamer and their audience.

The rapid and continuous flow of chat messages can present challenges for the streamer and viewers, especially as the number of viewers increases [40, 44]. Streamers may find it difficult to keep up with the high speed of the chat interactions, leading to missed messages and potential difficulties in responding to viewers' questions promptly. This fast flow of the chat can affect the streamer's level of engagement and

result in missed opportunities for meaningful interactions [54], potentially leading to a sense of disconnection between the streamer and their audience.

In this thesis, the primary focus is to explore the role of live stream chats for Twitch streamers, along with the chat management strategies that they use. Additionally, we investigate the potential benefits and drawbacks of using real-time summarization techniques during live streams.

1.1 Research questions

This thesis revolves around answering three key research questions:

1. What is the role of the chat in streamers' live streaming experiences?
2. How do streamers manage chat interactions during their live streams?
3. What are the potential advantages and disadvantages of using real-time summarization techniques during live streams?

1.2 Methodology and Approach

To investigate our research questions, we designed and developed a real-time summarization tool called Stream Assistant and ran a study with ten Twitch streamers who used it during one of their streaming sessions. After the stream session, we conducted semi-structured interviews to elicit their impressions of the tool.

1.2.1 Designing the Stream Assistant

To design the Stream Assistant and gain a deeper understanding of the chat communication challenges faced by streamers, we conducted an observational study of 33 Twitch live streams across various categories, such as gaming and arts. These streams had varying viewer counts, ranging from hundreds to thousands. After gaining insight into the challenges faced by streamers, along with the common scenarios that occur during live streams, we began sketching ideas for potential features that could assist streamers. We went through several iterations of brainstorming, sketching, and exploring the placement and functionality of these features. Once we reached a final design, we implemented a high-fidelity prototype.

Our general approach in designing the prototype was to offer streamers a dynamic chat summary, a tool to help them stay informed of conversations within the chat, especially when the speed of chat becomes too fast to read all messages individually. We designed three distinct features to provide streamers with information they might require. These features include a Polling Feature, a Word Cloud Feature, and a Emotes Feature, all designed to assist streamers in staying informed of chat messages and help them handle high-speed chat interactions. The Polling Feature allows streamers to pose verbal queries and access real-time response distributions. The Word Cloud and Emotes features provide streamers with a glanceable overview of ongoing chat conversations by displaying the most frequently used words and emotes.

1.2.2 Interviews and Live Stream Study

To address the aims of the study and evaluate the effectiveness of the Stream Assistant, we carried out a study involving ten Twitch streamers. This diverse group of streamers had various stream viewer counts and engaged in different types of content, ranging from gaming to creative domains like sculpting, drawing, and Lego building.

The study was conducted in two sessions, incorporating both semi-structured interviews and live streams utilizing the Stream Assistant. The first session started with an initial interview, where we gathered insights into the streamers' prior experiences and practices. In the second session, participants engaged in a live stream session, during which they utilized the Stream Assistant. Following the live stream, we conducted another semi-structured interview to obtain their feedback on their experience using the tool.

1.3 Contributions

In this thesis, we explore the role of the chatbox in live streams from streamers' perspective, investigate their chat management strategies, and examine how a summarization tool might support them in handling chat interactions. We investigate these points by interviewing ten Twitch streamers and studying their utilization of the Stream Assistant. Finally, we reflect on areas of future research and discuss

possible improvements for the Stream Assistant.

The remainder of this thesis follows with six chapters: In Chapter 2, we discuss the relevant literature to our research. Next, we discuss the design and development of the Stream Assistant. In Chapter 4, we discuss our study approach and describe the participants involved. Chapter 5 is devoted to the study findings, while Chapter 6 offers a discussion of the study findings. Lastly, in Chapter 7, we conclude the thesis and present ideas for future work.

Chapter 2

Related Work

The scholarly community has dedicated significant attention to the study of live streams. In this section, we explore four areas of previous research related to live streams: research on live stream engagement; advancements in interface design and technology; work on chat communication and chat management strategies; and work on live stream content summarization.

2.1 Live Stream Audience Engagement

Several studies have explored factors that influence the live-stream experience and engagement from both the streamer [26, 4, 5], and viewer perspectives [46]. These studies have examined the influence of audience participation [26] and the streamers' utilization of multimedia tools [4] on the overall live-streaming experience. They

have discovered that providing viewers with options for influence is important for enhancing the live stream experience [26], while multimodal communication (e.g., use of images and videos in chat) offers personal interaction opportunities and increases engagement [4]. Additionally, studies have investigated how support from the streaming community can impact the content creation process for streamers [5]. For example, community support influences the streamer's perception of themselves, which directly affects their intention to create content. Previous work analyzing the effects of live chatting on viewers has also demonstrated that watching the same video together provides viewers with a common ground for conversation and forming new relationships [46]. Our interview findings further expand on this research by identifying the roles and importance of the chatbox in streamers' engagement.

Further research on audience engagement has focused on analyzing chat conversations. Some studies have conducted sentiment analysis on chat messages, providing insights into emote sentiments[8], or have explored how streamers utilize and gather information about their performance and community [34]. These analytical works motivated the interview questions we asked from the streamers who participated in our study. Consequently, we were able to build upon prior work by delving into the experiences of our participants and examining their approaches to chat communication and management. Additional studies have defined specific characteristics of chat messages. They have discovered that chats in high-viewer streams tend to contain more emoticons, while chats in low-viewer streams feature longer text messages

with fewer emoticons[39]. Also, each channel exhibits its own unique language variety, with distinct lexical elements and emoticons [39]. Moreover, in massive chats, messages often consist of short, repetitive content compared to smaller streams [10]. These findings inspired aspects of our system design, particularly the development of features for summarizing frequent emotes and words in the chat.

Studies have shown that viewers are motivated by various factors when watching live streams, and several factors can influence their engagement with the stream [20, 49, 44]. The reasons behind consuming live streams could be personal, social, cognitive, affective, or tension release [44]. Viewers driven by social factors tend to develop stronger emotional connections with the streamer, spend more time watching live streams, and are more inclined to contribute financially, particularly to smaller channels [20]. In contrast, engagement with larger channels is less influenced by social factors [20]. Moreover, researchers have explored the connections between streamer-viewer interactions and different forms of social support, including emotional support, instrumental support (e.g., social presence), and financial support [49]. Creating a sense of community through continued participation can be another crucial aspect in fostering the interactions between the streamer and viewers [15].

Several additional studies have examined specific types of streams and their characteristics, particularly in relation to audience engagement. For instance, one study identified various types of activities present in creative live streams, such as teaching, making, socializing, and performing [11]. Other researchers have focused on ways

to involve viewers in decision-making during gaming streams. They have fostered discussions on how technology can transform viewers' passive activity of spectating game streams into a more active and engaging experience [24]. Furthermore, they have investigated the challenges faced by game developers in designing games that rely on audience participation in live streams, including latency, shared screens, and managing attention. [14].

2.2 Improving Live Stream Interface and Technologies

Streamers' and viewers' experiences and feedback are some of the crucial aspects of live-streaming platforms. These experiences are influenced by factors such as the live-stream interface, the technologies utilized, and the form of communication employed by both viewers and streamers. Within the domain of live streaming, researchers have focused on the exploration of various technologies. They have developed new features for the live-stream interface and communication [32, 51, 6, 17, 41], devised innovative methods of consuming live-streamed content [16, 45, 19], and sought to improve streaming setup [9, 21, 38, 28] and accessibility [3, 22, 35]. We elaborate on this work below.

Several studies have implemented and examined the use of novel features in the live-stream communication interface, particularly by enhancing viewer input modali-

ties with multimedia augmentation. For instance, StreamSketch [32] and SnapStream [51] allow viewers to send sketches, comment on images, and share annotated snapshots in the chat. Other systems such as VisPoll [6] and LiveMache [17] enable viewers to do real-time sketching and send visual inputs to the stream, with Live Mache also enabling writing on a zoomable shared canvas. Additionally, CommonSense [41] integrates audience heart rates into video games to influence aspects like sound, lighting, and difficulty of the game. These innovations provide viewers with alternative ways to engage with streamers and live streams beyond traditional chat messages.

Furthermore, researchers have developed new modalities for consuming live streams. Platforms like Rivulet [16] allow viewers to select audio streams while displaying previews of several streams within their view. DreamStream [45] immerses viewers in the virtual environment of a VR application, enabling them to observe the VR player's perspective. Hartmann and Vogel's tool [19] allows spectators to individually control their own game view in 3D, enabling multiple watching perspectives on the game. This collection of work aims to offer the audience a unique and engaging watching experience, thereby fostering increased engagement with the streamer's content.

In addition to exploring new communication features and consumption modalities, researchers have investigated technological advancements in streaming tools for streamers. They have explored modern live streaming equipment [9], and advancements in audio and video technologies such as spatialized audio[21] and 360-degree

video streaming [38]. They have also proposed design recommendations to enhance the digital delivery of performance arts by providing a better live stream experience [28]. Some of these recommendations include allowing viewers to interact and feel connected, integrating audience input into the stream experience, and emphasizing inclusivity.

Moreover, studies have aimed to improve streaming accessibility for individuals with disabilities, including examining their motivations for live streaming and the challenges they face [3]. Researchers have also implemented features such as added spatialized audio cues [22], real-time captioning, and sign language interpretation [35] to enhance the streaming experience for individuals who are visually impaired or hard of hearing.

2.3 Live Stream Chat Communication and Management

In most live streams, communication between streamers and viewers is limited to a chatbox that continuously updates with new messages from viewers. These chat messages, typically displayed alongside the streaming video, serve various purposes such as expressing reactions, adding commentary, and making requests to the streamer [40]. As the audience size increases, the chat environment often becomes chaotic [44], resembling a fast-moving "waterfall of text" [15]. This influx of messages

presents challenges for streamers in managing and engaging in meaningful conversations within the chat [40, 44, 54].

Researchers have acknowledged the difficulty of managing large-scale text chats in live-streaming platforms and have investigated different solutions. For instance, the popular East-Asian live-streaming platform, Danmaku [50], allows comments to appear directly on the streamer's video feed, enhancing user engagement and facilitating streamer-viewer communication. This feature, commonly used by many streamers, aims to reduce the glancing time by displaying chat messages on the same screen as the streamer's activity. However, when the chat speed is high, there may still be a significant number of missed messages that the streamer fails to acknowledge. Our prototype gives the streamer the option to view popular content of missed messages. Another approach, Conversational Chat Circles [37] aims to reduce chat overload by displaying only a subset of comments to each viewer and highlighting the top three comments based on upvotes. While our approach is similar in terms of showing popular content, we focus on displaying the most popular words and emotes to the streamer instead of presenting the entire message, but for only a subset of the messages sent.

Further research in live stream chat communication involves investigating the role of moderators in fostering engagement and managing interactions within the chat community. Moderators play a vital role in responding to issues that arise in chat and contribute to the community's growth [42]. As live-streaming communi-

ties continue to grow, community management and moderation become essential for maintaining a positive and inclusive environment. Studies have examined the roles and responsibilities of volunteer moderators [43], moderation styles [47] and decision making[30], moderator collaboration as a team [1], and conflict management strategies used between moderators and streamers[2]. Similar to some of the works mentioned above [43], we incorporated questions in our initial interviews to explore the use and role of moderators in our participants' streams.

2.4 Summarization of Live Stream Content

Live streams take place in fast-paced environments, incorporating real-time video and chat interactions, posing challenges for both streamers and viewers to keep up with messages and events [52, 27, 37]. Scrolling through missed messages can further complicate matters, leading users to miss new messages [52]. In response, researchers have introduced various summarization techniques, such as identifying key events [29, 36, 13, 18, 12], detecting the chat's mood using sentiment analysis models [23, 40, 53], or creating real-time summaries using viewer-sourcing techniques [31, 52, 27, 33, 37]. These efforts aim to enhance the accessibility and discoverability of live stream content for both streamers and viewers, which we will discuss in detail below.

Several projects have focused on summarizing the live stream content by highlighting key moments of the stream using the stream's metadata. This work has summarized long-form spoken dialogues [29] or video feed of sports streams [36] us-

ing metadata such as analyst input and player names. Other work either uses the chat messages to generate video highlights of streams [13, 18] or uses audio transcripts of streams and application usage logs to automatically segment the videos into sections [12]. While this work utilizes various sources, including chat messages [13], to summarize the main content of the stream (such as the video feed or the streamer's audio), our approach directly presents a real-time summary of the messages to help streamers extract the most relevant information from the chat, including from potentially missed messages.

Our approach is also inspired by chat summarization work focusing on detecting and analyzing the general sentiment and mood of the audience throughout the stream. For instance, Kobs et al. [23] motivated the inclusion of the emote feature by highlighting the importance of emotes as significant indicators of emotions and showing how they correlate to stream events. However, unlike their approach of sentiment classification on Twitch emotes, our focus is on presenting the most popular emotes as they are used in the chat without explicit labeling. Another inspiring sentiment analysis model was developed by Mendes [40]. Their model effectively analyzed pre-collected chat messages and emotes in Twitch chat, calculating an aggregate sentiment for any given time during the stream. Similarly, our Stream Assistant can present a summary of popular chat content for any given time of the stream, showcasing the most frequent words and emotes without performing sentiment analysis and labeling. Storychat [53] also provides a narrative-based viewer participation tool

that shows the chatroom sentiment as a graphical plot. Similar to Storychat, our Stream Assistant provides a real-time representation of the chat's mood, however, we present it to the streamer in the form of words and emotes used in the chat, rather than a graphical plot. Additionally, our tool offers streamers the flexibility to adjust the time frame for the summary reports.

Other work has focused on generating real-time summaries using viewer-sourcing methods and helping viewers catch up with past events or have a better rewatch experiences [31, 52]. Tools such as Helpstone [27] offer viewers poll options to speculate on the enemy's strategy or provide warnings to the streamer about potential mistakes. Calm Responses [33] provides an aggregate of eye gaze positions and head movements, while StreamWiki [31] incorporates viewer-written summaries and comments. Tools like CatchLive [52], Conversational Chat Circles [37], and StreamWilki [31] employ voting on chat messages to identify and highlight important moments [52, 31] and messages [37] in the stream. Our prototype performs automatic processing and summarization without requiring any input from viewers and presents the results directly to the streamer.

2.5 Summary

Prior research has explored many aspects of live streaming, including audience engagement, motivations behind watching live streams, and improvements to the live stream interface. Additionally, we explored the research on chat communication and

management, as well as various summarization techniques aimed at enhancing the experience for both streamers and viewers. Our contribution to this body of work focuses on streamers, delving into their perceptions of chat and their strategies for managing it. Furthermore, while various communication methods have been introduced in previous work, many of these methods necessitate viewers' active participation in summarizing content. In contrast, we introduce an automated summarization approach that requires minimal streamer effort and no input from viewers.

Chapter 3

System Description

In this chapter, we outline our approach for supporting streamers in managing chat messages during live streams. We start by addressing the chat management challenges observed in a selection of live streams and describe our design goals for the prototype. In short, our goal is to support streamers in managing chat messages and facilitating their interactions with viewers, especially in high-speed chats where they cannot read and respond to all messages. Based on our design goals, we then explain the systematic design procedure and subsequent development phases of the Stream Assistant.

3.1 Observing Chat Management Practices and Challenges

To investigate challenges in high-speed chats, we observed 33 Twitch live streams in the gaming, arts, and music categories, with active viewers ranging from hundreds to thousands. In selecting streams for observation, we regularly examined Twitch's "Browse" page for popular and active streams in gaming and creative domains over a period of several days. Our goal was to observe diverse domains, different viewer counts, and chat activities. Of the 33 streams observed, 10 were in the creative domains (7 Arts, 2 Crafting, 1 Sculpting), and the remaining 23 were in the gaming domain. The creative streams in our sample had viewer counts ranging from 50 to 200 (the mean was 151 viewers), while the gaming streams had viewer counts ranging from 50 to 141,000 (the mean was 9,321 viewers).

During our observation of the streams, we looked for methods employed by streamers to engage with their audiences and handle messages in the chat. We were also interested in instances where the chat's speed became rapid, and streamers seemed to have difficulty keeping up. For example, we noticed instances where streamers usually read the messages out loud and either answered them or acknowledged them but stopped doing so as the speed accelerated. We also took note of the Twitch channel information to identify the tools and assistance the streamers used or had access to, such as extensions and moderators who helped them during their

streams.

In observing these streams, we noticed that streamers frequently asked questions and scanned the chat quickly for responses. While some streamers used polling tools to ask questions, the more common practice was to ask the questions verbally and scan the chat manually to get a sense of audience responses. We observed that the chats often became chaotic when viewers were discussing an interesting topic or reacting to an exciting event, resulting in a surge of short messages and emotes that expressed their excitement. This occurred most frequently in gaming streams with large viewer counts (e.g., 1000, 3000). During those streams, there were frequent instances where viewers sent emotes or abbreviated slang messages of lengths less than five (e.g., W, L, GG) to quickly let the streamer know of their reaction to the sudden event in the game. However, we also observed very active and fast-paced chats in creative streams that had lower viewer counts, but it is not common for those communities to send lots of short slang text messages suddenly during the stream. In those instances, we saw that streamers no longer addressed all messages by reading them out loud or by reacting to them as they had been when the pace of the chat was slower.

Almost all of the streamers had moderators help them with the stream, as we observed through the chat. Twitch moderators consider it their responsibility to engage with their communities actively [43]. They contribute content, welcome new members, answer questions, and view these actions as a means of setting a posi-

tive example for others [43]. Moderators have different preferences and priorities in their roles. Some moderators focus on helping others and supporting the streamer's success, while others emphasize enforcing community standards and seeking fairness [48]. Some moderators perform their role as a form of surveillance, while others enjoy actively engaging with viewers and fostering conversation to create a positive experience [48].

Streamers often rely on third-party extensions to assist them in managing their streams and enhancing their overall streaming experience. The extensions we observed being utilized by streamers, either through their video feed or accessible via their About page, primarily focused on channel customization, emote creation, stream scheduling, and tracking various statistics, including viewer retention, follower growth, and average view count. While polling extensions were occasionally used, we did not observe streamers utilizing any extensions specifically designed to help them keep up with fast-paced chat conversations.

In summary, we observed that, across a range of viewer counts, chats can become hectic when viewers are expressing something exciting and want to do so quickly, with this situation being more prevalent in streams with a large number of viewers. Finally, even though moderators help streamers manage the chat by responding to simple queries and ensuring a positive and interactive stream, they do not necessarily help streamers understand their audience's feedback and reactions as the chat pace accelerates. Their primary responsibility is to moderate and remove inappropriate

content.

3.2 Design Goals

Our design goals for the prototype focused on developing a tool that would help streamers manage high-speed chat messages and facilitate communication with their viewers during a stream. We wanted to investigate a solution that assists the streamer in extracting key information from the chat to help them process the chat messages within the limited time they have to read and respond. To this end, we created a prototype system that captures chat messages and generates summary reports for the streamer, with a focus on minimizing any extra effort required from the streamer. In providing these summary reports, the objective is to provide streamers with an overview of their audience's responses and reactions without requiring them to read each message individually. We also wanted the summary reports to support streamers' common practices of asking questions verbally as opposed to using formal polls.

3.3 Initial Sketches and Ideas

We started the process of creating the Stream Assistant with sketching ideas, a practice that proved valuable in several ways. Firstly, it facilitated fast design iterations and quick feedback gathering from Human-Computer Interaction experts.

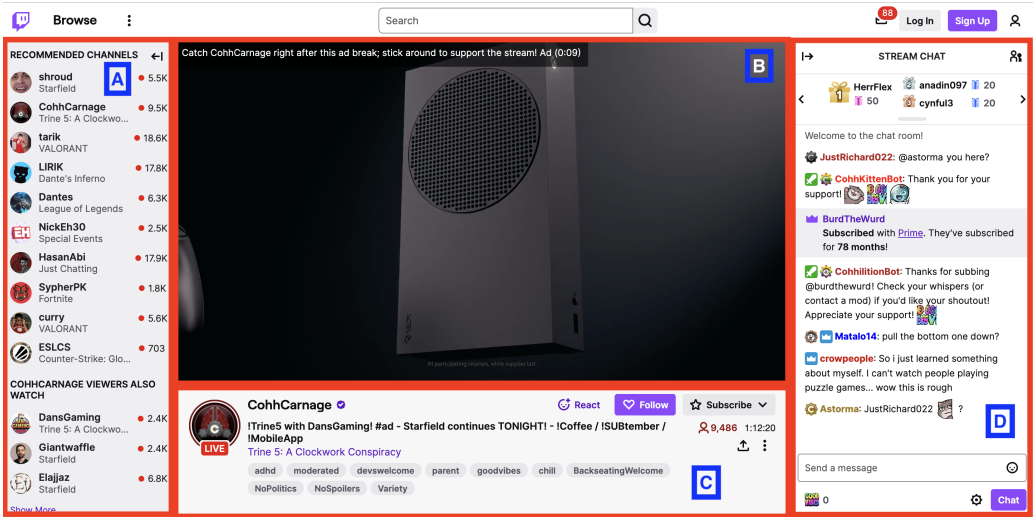

Figure 3.1: The Twitch Interface: (A) Suggested channels to watch (B) The video feed of the streamer. (C) Channel information. (D) The Chatbox.

Additionally, it enhanced our ability to visualize and convey ideas more effectively, while enabling us to identify usability issues, thus assisting in risk mitigation. Here, we outline a few of our more developed prototypes along with their sketches. Our initial design sketches could be categorized into three distinct types. The ideas in the first category mostly made the final version of the Stream Assistant. These designs augmented the conventional Twitch Live Stream Interface (see figure 3.1) by introducing additional segments such as an emote bar, an automated polling tool, a "provide feedback" section tailored for viewers, and a message bar for messages spanning less than five words.

As we observed in live streams and based on prior research [39, 10], emotes, and short messages are prevalent in high-speed chats. To ensure that streamers do not overlook these types of messages and can efficiently manage chat activity, we designed

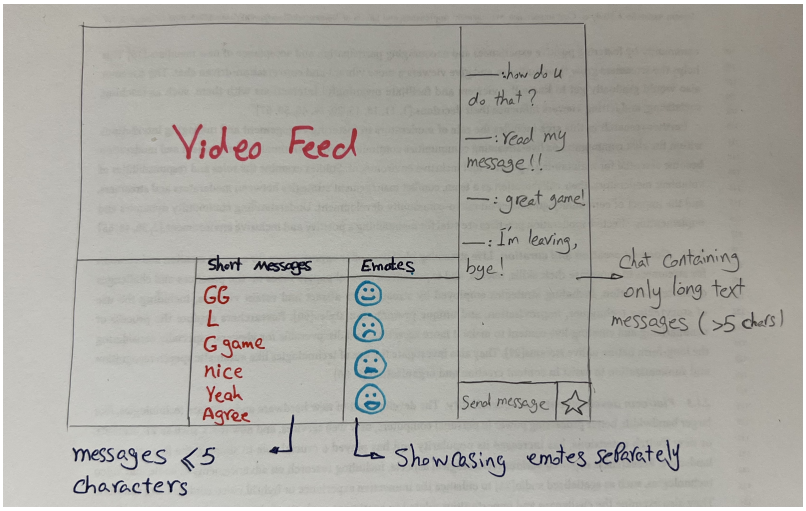

Figure 3.2: Sketch of an emote bar and a short messages feature.

distinct sections for emotes and short messages. These sections would display these messages separately, thereby reducing the volume of messages within the chatbox (see figure 3.2). Another common practice we noticed was that streamers often verbally pose questions and then scan the chat for responses. Inspired by this observation, we designed a polling tool to display instant statistics of frequently used words in the chat. This innovation streamlines the process of conducting polls, eliminating various steps such as question formulation, initiation, and finishing the poll. See figure 3.3 for an outline of this feature.

Another insight we gathered from our live stream observations was seeing viewers suggesting activities and influencing the direction of the stream. In response, we explored the design of a feedback segment that allows viewers to cast their votes for their preferred stream direction. This voting section included buttons with options

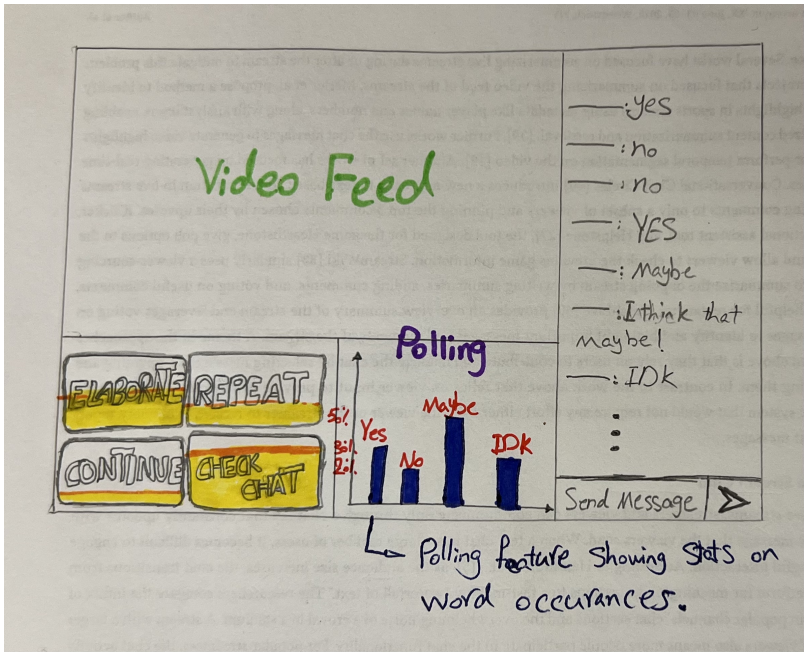

Figure 3.3: Sketch of Polling and Gather Feedback features.

like "Elaborate," "Repeat," "Check Chat," and "Continue." These buttons displayed a graphical representation of the percentage of viewers who clicked on them (refer to figure 3.3). In our observations, we noticed Twitch has implemented a similar feature wherein, after watching a stream for a while, viewers are prompted to express their current feelings using four emojis. This highlights the importance of soliciting viewers' input at various intervals of the stream.

Our next set of ideas mainly involved computation on chat messages, encompassing tasks such as keyword identification, emergent polling detection, and chat speed moderation. We observed a recurrence of specific words based on ongoing chat conversations, which sparked the idea of creating a feature that presents the most

frequently used words in the chat. This feature would also update periodically to showcase new popular terms from new messages. Moreover, we noted that whenever the streamer asked a question from the viewers, the chat responses were mostly the answers to that question. Therefore, we had the idea to recognize this sudden change and pattern in chat messages as an emerging poll, assess the messages, and present a report on them. This feature was quite similar to the Polling feature we designed and required a lot of computation. As a result, we did not follow up on this idea further.

One of our ideas was inspired by a feature on Twitch that enables streamers to restrict messages to their followers and subscribers or enable a slow mode, which limits viewers to sending messages every five seconds. This functionality sparked the idea of monitoring chat messages and identifying instances when the chat speed surpasses a certain threshold that becomes overwhelming for the streamer. When the chat speed becomes excessively high, the chatbox automatically transitions into a slow mode, managing the influx of messages and returning to normal mode once the message rate subsides.

Our last set of ideas primarily aimed to introduce new ways for viewers to engage with and impact the chatbox. Some of these ideas were influenced by previous work, such as enabling viewers to upvote or repost other messages [37], or even having messages played audibly. Through observing numerous live streams to find prevalent challenges and messaging patterns, we noticed instances of repeated messages

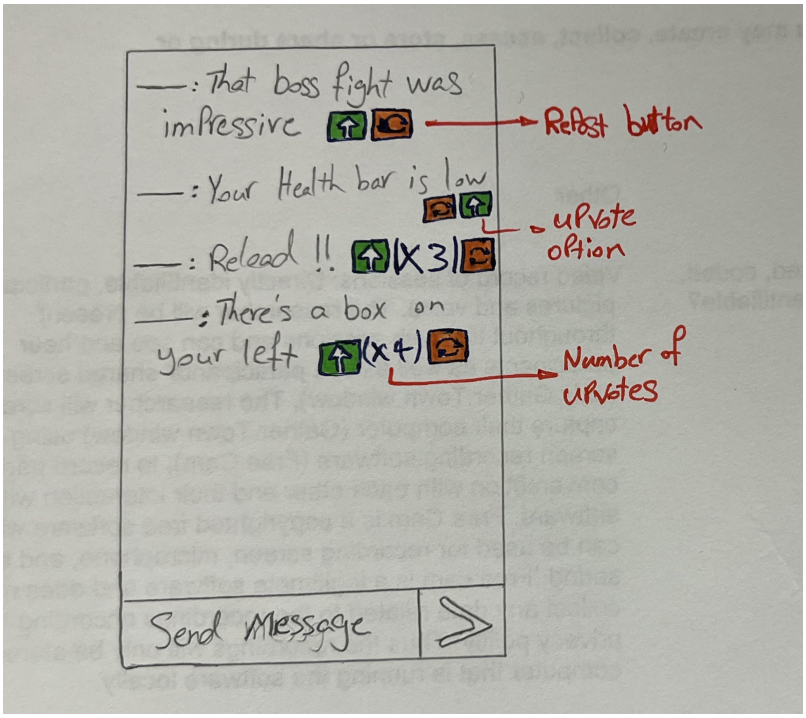

Figure 3.4: Sketch of the Upvote and Repost features in the chatbox.

emerging after interesting events. This observation, coupled with prior research [37], inspired the concept of permitting viewers to upvote other messages, thereby reducing repetition in the chat and managing the traffic. (see figure 3.4.) We also considered the notion of allowing viewers to repost other messages or have their messages read aloud. The "play message" feature already exists on Twitch, where viewers can use a designated amount of Twitch credits to play their messages for the streamer. Upon refining the initial design ideas, we proceeded to develop more detailed features until they became viable and ready for implementation. More sketches and design refinements can be found in Appendix K.

3.4 Stream Assistant

Following an analysis of our initial sketches and gathering informal feedback from human-computer interaction specialists, we chose a selection of features to incorporate into the design of the Stream Assistant. The Stream Assistant is a system containing three distinct features, which present a real-time presentation of words, emotes, and poll results based on chat messages (see figure 3.5). Furthermore, the system allows users to select the time frame they want to get reports and adjust how frequently the features are updated.

Our ideas resulted in three features, which were a mixture of ideas that would process chat messages and augment the interface. Below we will discuss each feature in detail.

3.4.1 Polling

Polling features in live streams serve various purposes, but they also have limitations, often requiring streamers to manually set up a poll and wait for vote results. The applications for polls are diverse, ranging from selecting the next game to be played on the stream to determining the streamer's decisions or paths within a game [25]. However, despite its usefulness, polling can present challenges, particularly in terms of setup and manageability, as it can impede the streamer's ability to make timely decisions [27]. Therefore, our design idea for the prototype was to simplify the process of polling for the streamers both in terms of setup and collection of results.

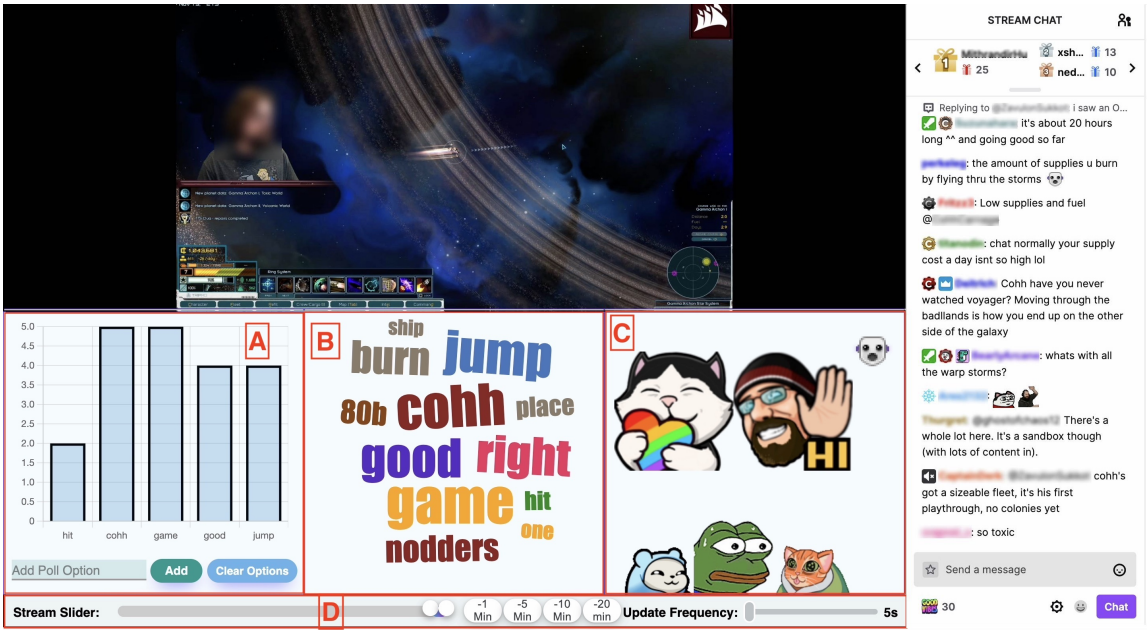

Figure 3.5: The Stream Assistant: (A) Polling feature provides statistics on the most frequently used words in the chat. The feature displays the top four most frequent words and their frequency when a user hovers over the corresponding bar. Additionally, users can add up to 6 custom words to track and remove them using the buttons available. (B) The Word Cloud displays the most commonly used word in the chat, with the size of each word reflecting its frequency. (C) The top ten most used emotes in a chat, with the size of each emote indicating its popularity and rank. (D) The user can control the timeframe of the reports by using the stream slider, which allows them adjust the duration manually or using preset buttons. They can also set the update frequency of the features from 5 seconds to 30 seconds using the speed slider.

We drew inspiration from previous work like Hearthstone [27], which introduced a custom Polling feature for viewers to provide feedback on specific in-game events and aid the streamer in making decisions. However, in contrast to this approach, we automatically extract words from messages and present them to the streamer as real-time poll results, allowing viewers' messages to assist the streamer in their

decision-making process.

The goal of the Polling feature is to support the practice of asking verbal questions. With this feature, streamers can ask a question verbally without typing or setting up a poll and instantly see a distribution of the responses in the chat. By default, the feature displays the four most frequently used words in the chat in the selected time frame which is controlled by a slider. To enable users to add their desired answers and monitor them in real time, we incorporated a text box with "Add" and "Clear Options" buttons for word input and resetting. Moreover, when extracting information from messages, we exclude stop words and usernames to ensure the Polling feature displays meaningful content.

3.4.2 Word Cloud

Our goal for the second feature was to present a summary of popular messages precisely as they are used in the chatbox. Based on previous research [39], messages in streams with larger audiences tend to be shorter and exhibit repetitive patterns [10], which motivated the design of the Word Cloud feature. While other work have focused on classifying message content [40], our approach prioritized presenting popular words in messages as they are sent by viewers.

The second feature in the Stream Assistant shows the streamer the ongoing chat conversation as a word cloud. This word cloud displays up to 20 most common words from the chat within the time frame the streamer selects. We chose the word cloud

format because it highlights more popular words by showing them with bigger font compared to less used words. (see figure 3.5(B))

3.4.3 Emotes

One distinguishing aspect of most live stream chat communications compared to video conferencing platforms is the use of emotes. Emotes are graphical representations that convey emotions, reactions, or specific meanings within the chat and play a significant role in enhancing the chat experience and facilitating communication between streamers and viewers [40]. The unique visual nature of emotes adds a layer of expressiveness to the chat, allowing participants to convey their sentiments in a way that goes beyond text alone.

Previous research has shown that chat messages with high speed contain more emotes and repetition[39]. Furthermore, a linguistic study [39] revealed that larger streams tend to contain a higher number of emotes. Twitch emotes, in particular, can convey complex emotions better than emojis and express feelings faster than words [40]. These findings served as inspiration for the design of the Emotes feature in our prototype. While studies have attempted to classify emotes as either positive or negative [40], we decided not to map and label them to a fixed set of emotion labels. Instead, our focus in designing the prototype was to present them as they are used in the chat.

The Emotes feature displays the top 10 frequently used emotes from the chat,

as seen in figure 3.5(C). Our initial design concept aimed to depict emotes as representations of emotion keywords, conveying an overall chat mood through labeled vectors or color graphs. Our sketches also explored methods to emphasize emote significance, either by indicating their frequency with a number next to them or by enlarging them to occupy more space. Ultimately, we chose the latter approach for the final design. Design iterations and sketches can be found in Appendix K.

3.4.4 Sliders

Given the extended durations of live streams, incorporating a time slider became essential for streamers to choose the specific time period for report generation. Our initially designed toolbox included individual time sliders for each feature section. However, as we progressed in the implementation phase, we realized that managing multiple sliders might be confusing for users. Consequently, we refined this approach and introduced a single slider that controls the time frame for all three features (see figure 3.5(D)).

Initially, the slider section included "Start" and "Stop" buttons that controlled the starting and ending times of the reports. However, after testing the time slider's functionality and consulting with human-computer interaction specialists, we made an adjustment by substituting the "Start" and "Stop" buttons with four preset time range buttons. These options, encompassing intervals of 1, 5, 10, and 20 minutes, were designed to instantly configure the time slider to display the last 1 to 20 minutes

of the stream. This modification aimed to simplify the tool's usage for streamers so that they wouldn't need to fine-tune the slider. Moreover, during implementation, we initially configured updates to occur every five seconds. However, through iterations, we recognized that such frequent updates could be distracting. This led us to add an update speed slider as well, allowing users to customize the frequency at which the features are updated.

3.5 Implementation

We implemented the Stream Assistant as a web application, using front-end and back-end tools. Initially, our goal was to implement features within a Twitch extension so that streamers could easily install and use the tool for the study. However, upon creating a trial extension and consulting with Twitch Extension developers, it became evident that the development process and subsequent approval by Twitch demanded a team of developers and could span a duration of more than 3 to 4 months. This was not feasible with the time constraints of a Master's thesis. Therefore, we used HTML, CSS, and Javascript for the development of the Stream Assistant's front end. For the back end, we employed Express and Node.js, while using MySQL as the database for storing messages. In the following paragraphs, we will delve into the stages of Stream Assistant's development, describing the changes from its initial version to the final prototype.

The development of the Stream Assistant started with setting up a Linux server

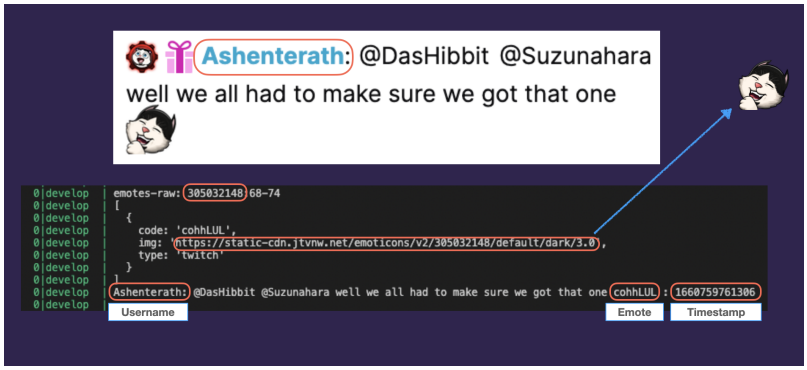

Figure 3.6: The information extracted from a chat message using one of the APIs. You can see the emote image link, username, emote keyword, and the timestamp of the message highlighted in the picture.

on a University of Manitoba server. Subsequently, we used Twitch's API to embed the live stream's video feed and chat box within the web application. The remaining space was subsequently partitioned to accommodate the implementation of the three features. The prototype employs two "npm" packages, namely "tmi-emote-parse" and "twitch-emote-parser," to extract crucial details such as messages, emote images, usernames, and message timestamps. An example message and the information extracted from the output of the API are illustrated in figure 3.6.

Once the messages were extracted, we proceeded to parse them using Node.js, eliminating punctuation, links, and messages sent by bots before saving the words in the database. We parsed messages into words and emotes, storing them in distinct database tables alongside their timestamps and usernames. Our initial choice was to use the Redis database but we later replaced it with MySQL due to its better compatibility with our query requirements. Subsequently, the words from the chat

were presented as a word cloud using the d3-cloud library for Node.js. (see figure 3.5(B)).

To enable data exchange between the server and client, we employed Server-Sent Events and HTTP requests. Every 5 seconds, the server sends data to the client, while slider updates from the user are transmitted to the server via this mechanism. Screenshots of the implementaion steps and iterations can be found in Appendix L.

3.6 Summary

In this chapter, we provided an overview of our journey starting from live stream observations and design goals to the creation of the Stream Assistant. We began by outlining the common challenges and situations encountered during our observation of live streams and the strategies streamers employed to handle messages and engage with their audience. We then presented our design goals and initial concepts for the development of the Stream Assistant. Following that, we described our prototype features and its implementation. With our system description complete, the subsequent chapter will focus on detailing our study methodology.

Chapter 4

Study Method

In this chapter, we describe the design of our study to investigate how streamers manage their chat and the potential for the Stream Assistant to assist with their chat management. Our goal was to explore the role of the chat in participants' streams, their current chat-management strategies, and their views on the potential advantages and disadvantages of using the Stream Assistant when live streaming.

4.1 Participants

We recruited 10 Twitch live streamers (5 Men, 5 Women) to participate in our study by advertising on social media and in Twitch communities and by reaching out directly to streamers (e.g., via email and Discord). In our calls for participation, we asked for streamers with a minimum of 100 viewers per stream (see Appendix F

and Appendix G for the digital and printable posters). However, we also accepted streamers with fewer than 100 viewers whose chats seemed to be quite active. In the end, our participants had 25-130 viewers in their streams, with the exact number of viewers varying throughout the streams (see table 4.1). Our participants stream in the gaming and creative domains, including sculpting, drawing, and Lego building. All participants have been live streaming for a minimum of two years and stream in English. Participants received $75 CAD for their participation. Further details on the participants and their stream session can be found in Table 4.1. The study was approved by our institutional research ethics board (see Appendices C, D, and E for certificates).

Table 4.1: Participant and Stream Session information

Participant ID	Gender	Domain	Stream Hours	Viewers	Messages (approx)	Estimated Chat Speed (msg/min)	Experience
P1	M	Creative (Sculpting)	5	90-110	600	2	10 years
P2	W	Gaming	4	85-120	480	2	2 years
P3	W	Art (Drawing)	4	65-100	720	3	7 years
P4	M	Gaming + Art (did gaming)	3	25-70	360	2	3 years
P5	M	Gaming	6	65-100	720	2	5 years
P6	M	Creative (Lego building)	6	100-130	1080	3	7 years
P7	M	Gaming	6	55-90	720	2	2 years
P8	W	Gaming + Art (did art)	4	25-50	240	1	2 years
P9	W	Gaming	1.5	45-80	180	2	3 years
P10	W	Gaming	7	65-90	1260	3	6 years

4.2 Study Procedure

The study consisted of two sessions, which collectively included two semi-structured interviews and a live stream using the Stream Assistant. In the first study session, we reviewed the consent form with participants and conducted an interview to ex-

plore their streaming experience, communication strategies with their audience, and any chat-management tools that they use. The consent form and initial interview questions can be found in Appendix H and Appendix A. Following the interview, we introduced the Stream Assistant, explained its features, and gave participants the opportunity to ask questions. This first session lasted 30 to 40 minutes, with the interview portion lasting 15 to 20 minutes.

During the second study session, we asked participants to use the Stream Assistant during their live stream. Prior to the stream, participants shared their browser screen showing the tool on a Zoom call, allowing us to observe, take notes, and record their activity. Two of the 10 participants declined to share their screens. All participants used two monitors during their streams, typically keeping the Stream Assistant open on their second monitor. After the stream, we conducted an interview with each participant to collect their feedback on the tool and its impact on their streaming experience. The live streams range from 1.5 to 7 hours (mean: 4.65 hrs, stdev: 1.66 hrs). The interview in this second session lasted 20 to 30 minutes. Final interview questions can be found at Appendix B.

4.3 Data Collection and Analysis

Our primary source of data was the interviews. We transcribed the interviews in full and used open coding to analyze the transcripts. The first author began by identifying and coding relevant quotes from the transcripts according to the research

goals (See screenshots of parts of the open coding in Appendix J). Two researchers subsequently revised the codes and their connotations through several iterations, ultimately categorizing codes with similar definitions into themes [7]. We also extracted some quantitative data from the structured parts of the interview, where we asked participants to rank the features and indicate if they would like to use any of them as extensions in the future. Finally, we used the screen recordings and observation notes to analyze the stream assistant usage and estimate the speed of the chat, the approximate number of messages sent, and the number of viewers during the stream.

4.4 Summary

In this chapter, we presented our participants, outlined the study's design, and explained the data collection process. We discussed the domains within which our participants stream, along with details of their streaming sessions, such as viewer count, and chat speed. Moreover, we further described the study procedure, which was conducted in two sessions. The initial session included a semi-structured interview and the second session involved participants using the Stream Assistant during a stream and providing feedback through another semi-structured interview. Furthermore, we explained our data sources and analytical approach. The next chapter is dedicated to the presentation of the study findings.

Chapter 5

Findings

In this chapter, we describe the findings of our study. We first discuss participants' perceptions of the importance of the chatbox and how they manage the messages they receive. Next, we discuss their stream sessions and how they used the Steam Assistant during their streams. Finally, we present the findings from the interviews conducted after the stream sessions, discussing the participants' perceptions of the tool's benefits and limitations.

5.1 The Role of Chat in the Stream

In this section, we discuss the participants' views on the significance of chat in their streams and its influence on their streaming experience and audience growth.

Engagement and Building Audience

The participants in the study discussed using the chat feature on Twitch to drive conversation, increase engagement, and retain viewers. Almost all participants described how they value Twitch's chat interface due to its live interaction capabilities. For instance, they ask their audience about their daily lives to drive engagement or engage with new viewers to encourage return visits and grow their audience.

> *"When it comes to reading chat, I'm just trying to drive conversation and engagement for sure. So you know, checking in with my community, seeing how they're doing what's going on in their day-to-day lives." - P6*

> *"Yeah, so I'm a very, very chat-focused streamer. When I first started, it was obviously like there was very little chatter, so whenever a new person would hop in, I would essentially try to engage them very much. Not only for my own growth but because it's very good to chat with the viewer and get them to, you know, want to come back type of thing. so I always try to engage from the get-go, and until now, that's kind of carried on." - P2*

Participants also mentioned using some of the chat capabilities to their advantage to increase their interaction with viewers. Twitch chat offers a feature where messages sent by first-time and subscribing viewers are highlighted in a different color. Additionally, viewers can use their points to highlight their message in the chat. A few of the participants mentioned that they employ the highlighting feature to identify new viewers and give them extra attention.

> *"Twitch released a feature there before. I can't remember if it was a couple of months ago. But you can actually put highlights to certain messages like you can highlight moderator messages and subscriber messages, new people saying hi for the first time, that type of thing. When someone is brand new to the stream, I always give them that little bit of extra attention because I want to retain them." - P7*

Twitch channel raids are a feature on Twitch where a streamer can redirect their viewers to another streamer's channel at the end of their own stream. It is a way for streamers to support each other and build a sense of community on the platform. One participant mentioned the usefulness of the message highlight feature when channel raids happen and emphasized its ability to help them focus their attention on new viewers.

> *"I use the Twitch integrated highlights that they have now, which is a lot more convenient for kind of noticing if someone has raided in, so, obviously, you want to make them your priority because they've done you a favor. And any first-time chat as well and make sure to kind of interact with them a lot, so obviously it's their first kind of experience of it." -P8*

Overall, participants' comments indicated that chat plays a vital role in their live streaming. They expressed how they utilized chat messages, whether from loyal or new viewers, to increase their engagement with the viewers and how chat plays an essential role in growing their audience.

Dedication to Reading Every Message

Almost all participants showed a strong commitment to tending to all the messages in their chat. They emphasized how they prioritize the chat and how they want to respond to every person in the chat, which can become a source of stress at times.

> *"There is definitely a small element of stress, I mean, because I don't want to miss messages, and it's definitely, especially for smaller streamers. There's almost a fear of missing a message or trying to make sure that you respond to*

> *every single person because otherwise, you know, they might get upset and not come to the stream or something like that." -P5*
>
> *"My interaction with the viewers is one of the things I prioritize most, so I try to address every single comment in chat as I can." - P6*

One participant, who conducts both gaming and drawing streams, indicated that they used to attend to all messages, but stopped doing so after realizing that it was taking too much time away from their activity.

> *"I've always been very connected with my chat, especially early on, when I was a smaller streamer, where I would be very active with my chat, I would read and respond to pretty much every message. Over the years, it's gotten more difficult because sometimes I'm just doing whatever I'm doing. And I don't have the time to look at chat, and I miss messages and people. [...] So I stopped doing that eventually, and I tend to just focus on messages that directly reference me, like when they add my username or when they say my name is, I read those, but for the most part, I tend just to let them scroll now."-P4*

A Sense of Community

Several participants' comments indicate that the chat is more than just a tool for engagement but also acts as a platform to create a sense of community. For example, the quotes below describe how the chat provides a sense of connection and friendship that sometimes even extends beyond the online world.

> *"I tend to have quite a familiar group of viewers, a lot of the viewers that I have now I've had since I started, and it's a very kind of like friendship-based view of a group" -P8*
>
> *"And it's just cool to really have known some people online. Just did the stream for 10 years, so that's a long time. Actually, I met my wife through a stream too, she was just a chatter when we first met." - P1*

Two participants described how they dedicate significant portions of their streams to engaging in conversations with their viewers and establishing connections. They not only fulfill personal goals, such as making friends and connecting with viewers, but they also aim to improve their stream's appeal to new viewers and encourage their long-term engagement.

> *"You will get some sort of following to come in for your first stream, and hopefully continues into the future and build [the audience] from there [...] A community and building a community, it's number one. I always made a point to interact as much as possible with my viewers, especially with the regulars. I try to remember some sort of information about the regulars, like where they live, something they're into, you know, or I might have a certain way of seeing their name." -P7*

> *"I really like getting to know people, and yeah, I honestly just enjoy bringing a smile to somebody's face. Or if they're having a hard day, and they want to pop in for like 5, 10 min, that's kind of what my stream is kind of built for." -P2*

This sense of community can have practical impacts on the quality of the stream. For example, the quotes below describe how the streamers' viewer community influences their streaming activities or helps to moderate and control bad behavior.

> *"I leverage my viewers for having a lot of say and kind of what happens within my streams. So one of my normal weekly streams is something I call Viewer Build requests, where they will suggest ideas in chat, I'll put them in a poll, then they vote on it, and then I build whatever is voted on." -P6*

> *"I think it brings control to a community in a chat, and it, and it allows some people to know where the line is, and we've got to the stage now that when somebody comes into my chat with hate, the whole chat kind of goes back at them" -P9*

Overall, chat is considered an essential component of the live stream for participants to create engagement and grow their audience. They demonstrate a dedication to their chat and value the importance of responding to every single message. They mentioned how the chat can help them build their community. However, a few participants shared their concerns about the stress of missing messages and the time-consuming nature of keeping up with the chat.

5.2 Chat Management Strategies

In this section, we discuss the chat management approaches that our participants take and the factors that impact their chat management experience.

Streamers Use Distinct Approaches To Managing Messages

When we asked participants about their approaches to reading and managing messages in the chat, their responses varied, however, one of the common strategies mentioned was prioritizing certain chat messages. Several participants mentioned different criteria they use to determine which messages to prioritize, including the most recent messages, messages that mention their usernames, or messages from known viewers.

> *"I just kind of go talk to the bottom 3 messages one by one, unless somebody is like telling a story, in which case I'll wait for the next bit. I will read that bit out as a whole section, and then I'll go back and this like chunk in the comments I missed, and I'm pretty good at managing." - P9*

> *"So when we're streaming, I tend to glance over, and I read as I skim through all the messages as fast as possible and in order, and I prioritize reading messages that are directed directly at me." - P10*

> *"There are quite a few people in my chat that I know personally outside of just streams, so I tend to read their messages first because I know them the most, but other than that, it's quite a balanced kind of atmosphere in my chats." -P8*

Some participants mentioned reading messages out loud during their streams to ensure that viewers know that the streamer has acknowledged their message, as the following quote illustrates.

> *"Well, I've gotten in the habit of when I see the message, I read it out loud because I am diagnosed with ADHD. So, I've gotten in the habit of reading it out loud first off to acknowledge that I read it because some people get dramatic and think I'm ignoring them when I'm like I read your message. But so that's the first thing I do before I even think about anything, I read the chat message out loud, and then respond to it as soon as I can." - P10*

Other participants mentioned more personalized approaches that they felt worked well with the nature of their streaming activity. For example, P1, a sculptor, indicated that their activity is such that they can use their peripheral vision, whereas P3, an illustrator, would take breaks to dedicate time to the chat.

> *"It has become second nature like I'll be just working, and with my peripheral vision, I'll see the chat move, and I'll automatically look. And the way our artwork is, you don't need to be constantly moving and working the whole 5 hours. So chat's over here, all the way to the right, and I'm just working, and it's really the movement of the chat that gets my attention." -P1*

> *"I don't want to draw 6 hours in a row, so I just take 15 min like off and try to read the chat, and just maybe ask them also like some questions in the meantime, just to make it a bit more interactive."-P3*

Chat Volume Impacts Chat Management

While participants had different techniques for reading messages, they generally agreed that chat volume affects their chat management. Some participants said they have an easy time handling messages when there is a low number of viewers or a slow chat, but as the number of viewers and/or the chat speed increases, they find it difficult to implement their usual strategies.

> *"For the most part, just because of the size of my stream, I do find that generally keeping up with my chat is pretty manageable [...] So it's been a little bit easier to manage, just because I don't have the volume of people that would make it difficult. But I have done a couple of big streams for certain events in the past, and that is definitely when it is much more difficult to keep up. I think the most viewers I had on my stream have been like 17,000 for a large event, and that was certainly one where you kind of just realize you have to pick and choose what you reply to." -P6*

Finally, Twitch has a "Slow Mode" feature, which limits viewers from sending messages for a specific duration of time determined by the streamer and is an approach for streamers to manage fast chats. Several participants in the study revealed that they had used this feature before, but only when they had a high number of viewers.

> *"Yes, I have used that primarily when I've done bigger events. Anytime I had a substantial increase in my viewership, due to, you know, being on the front page of Twitch, or participating in the event that drives a lot of viewers." -P6*

One streamer who used the slow mode in the past said that they stopped using it because viewers prefer not to be limited during the stream.

> *"But there was a time where I would leave it on to like the lowest setting [...] But eventually, I learned that people just like to type, and you don't like having slow mode on, so I just turned it off."-P4*

Stream Characteristics Influence Chat Management

Our findings indicate that participants' chat management is also affected by their stream type, stream agenda for the day, and the topic of discussion or circumstances in the chat. Although the majority of our participants aim to interact with their chat audience as much as possible, they might be busy with their activity at times or change their approach to reading the chat on different occasions. P6, who builds LEGOs in their streams, finds it easy to multitask and engage with their chat audience because the nature of their activity allows for flexibility.

> *"Luckily, LEGO building is, for the most part, pretty easy to multitask with, so I can be doing some building and looking at chat at the same time. It's maybe not as intensive as something like a video game where you have to be really focused on what's happening on the screen at any given time." -P6*

P8, who did a drawing stream for the study, noted that chat activity changes for them based on their stream schedule. They have dedicated conversations with the viewers at the beginning when they are not actively drawing, and as they become more involved with their activity, there is less to discuss and more to learn for the viewers. Therefore chat management is quite easy for them as the viewers tend to shift their focus to the activity and send fewer messages.

> *"They(viewers) will come in and chat a little bit at the beginning, and then because I'm playing music and kind of talking to myself, they'll kind of leave me on in the background (of what they do) because all I'm doing is less interactive. So I do find that usually on art streams, I'll have a very active chat for maybe the first couple of hours because I typically stream for about 4 hours, and then around hour 3, it tends to get a little bit quieter, just because, you know, I'm doing the same thing, and it's more of a background effort." -P8*

On the other hand, chat management becomes challenging for demanding activities such as gaming. Viewers continuously comment on game events and engage in conversation, demanding streamers to actively participate in the chat despite the demands of their gameplay. Therefore streamers are challenged to balance their focus on the game with the ongoing chat discussions. Unlike creative streams such as drawing, where chat activity tends to be more subdued, gaming streams demand more active engagement from both the streamer and the viewers. P5 mentioned that when playing games on their stream, they would rarely stop the game to read the chat and just glance to catch a message every once in a while. P8, who does both gaming and art streams, also compared their art streams which are less demanding, with video games that generally need constant focus throughout the stream.

> *"During the game, I rarely would pause the game to interact with the chat. I'm mostly just trying to glance at the chat and read an odd message or so again."-P5*

> *"With video games, it's often a little bit more interactive, obviously, because there's more to kind of engagement [...] I think [in art streams] when I don't have too many new things going on at once, It's quite an easy way to interact with them, Really" -P8*

In summary, we found that our participants employ personalized approaches to manage chat messages, taking into account factors such as chat volume, stream activity, and specific circumstances of each stream. Participants mostly tend to prioritize specific messages and read and acknowledge every chat message. Most participants noted that they can easily handle the chat due to the manageable volume of messages and the nature of their stream activity. However, in cases where they

have a high number of viewers or when the chat speed becomes overwhelming, they may need to selectively respond to messages. Although there are tools available to slow down the chat speed, they expressed a preference for not using them as they hinder viewers from expressing their opinions freely.

5.3 Stream Session Observations

Almost all participants used the stream assistant for the full duration of their stream. The 10 participants in the study used the stream assistant for an average of 4.6 hours, with an estimated average of 630 chat messages per stream and 2.2 messages per minute. We estimated the number of chat messages in each stream and the chat speed by counting messages in 5-10 intervals of 20 minutes, depending on the stream length. Details on the individual streams are summarized in table 4.1.

Participants had different streaming agendas, such as finishing an artwork or just chatting and playing games, but they all could answer questions and converse with viewers without noticeable difficulties. Some streamers directed their focus to their work (sculpting, drawing) and only took breaks to read messages, while others (lego building, gaming, drawing) had chatting-only sessions at the beginning of their streams and interacted with viewers while streaming, mentioning them by name, and running polls with the Polling feature to get collective feedback.

The streamers ran the tool on their second monitor and interacted with the Stream Assistant to different degrees. Six participants used the tool with the default

settings. The default settings for the sliders were set for reports in the past 2 hours with an update speed of 5 seconds, and the Polling feature showed the top 4 frequent words. When we asked participants about their reasons for not adjusting the sliders, they mostly mentioned forgetting to do so or wanting to experience the tool before making adjustments. Of the other four participants, three adjusted the sliders, and all four made changes to the Polling feature. Some streamers found multiple uses for the Polling feature. They tracked the popularity of specific topic words during their streams in addition to actively engaging with viewers by running polls and posing questions to the audience. Additionally, certain streamers alternated between Stream Assistant and other applications like Discord and OBS. Those streamers suggested integrating Stream Assistant's features into OBS to avoid this context switching.

5.4 Stream Assistant's Advantages and Disadvantages

In this section, based on data from the second interview and observations from the stream sessions, we present findings related to the Stream Assistant's potential benefits and weaknesses.

The Polling Feature was Fast and Effortless

When we asked participants which of the features, if any, they would like to use as an extension, 7 out of 10 participants cited the Polling tool as their preferred feature for an extension. Additionally, when ranking the features based on usage during the study, 6 out of the 10 participants ranked the Polling feature as the most used feature. Participants praised the Polling feature of the Stream Assistant tool for its ease of use. They appreciated the convenience of quickly setting up and conducting polls without the need for switching screens or using separate browser tabs.

> *"I think that part is kind of fun when you ask where you don't have to set up a poll, and then you can see what people are voting for straight away. That's perfect. I don't have to touch anything, you know, because again, on Twitch, you have to do like /poll, and then add all the options you just see."-P3*

> *"Yeah, people would use it because, with Twitch, you have to go on to a separate screen. You have to go into like a separate browser. You have to go to an extension, so it's an extra click, you know. Whereas this, It's there all on the same page." -P7*

In addition to the ease of initiating the poll, one participant who did an art stream for the study commented that the automatic polling aspect could be particularly useful when keyboard access is limited by the streaming activity.

> *"The automatic polling system, I think, could be really useful, especially if you've got kind of like a call-up situation going on where you might not necessarily be able to get to your keyboard, or something like that." -P8*

Limited Usage and Value for Word Cloud and Emotes Features

Participants generally expressed that they had limited use and perceived value for the word cloud and emotes features during or after their streaming sessions. Some participants mentioned that they could easily read and keep up with every message due to their chat speed and stream agenda, or did not have time to use the features due to the nature of their activity.

> *"I could keep up with the chat, and I would just also look at [the Stream Assistant] just for fun to see what it has tracked ... but for me personally, yeah, I don't think for like small stream is that would give much of a help in any kind of way because I can just keep up with the chat. Anyway, I can read almost everything."-P5*

> *"We just never really had an opportunity to be able to use it so, and it's just, you know it. It all depends on what I'm doing in a day, you know, like today it was just us, just me kind of painting this to the finish line." -P1*

Some of the participants who did use the features during their streaming session expressed appreciation for the summaries and the impact these summaries had on their stream experience. They found value in how the content of the summaries influenced their state of mind during the stream and allowed them to grasp the overall sentiment and tone of the chat quickly. They mentioned the features could be particularly beneficial during the chatting portion of their stream, where the conversation can become fast-paced and hard to keep up with. For P2, whose stream heavily relies on chat interactions and who dedicates significant stream time to chatting, the features provided insights into viewer preferences and reactions. P4 noted that the

word cloud and emote summary helped them catch up with the chat conversation after taking breaks.

> *"Yes, it definitely [helped me], especially during the just chatting portion, like I said, because I was able, it felt like I was more on top of things. You know, the happy emotes, the laughing emotes, and stuff like that. So, it just put me in a better frame of mind. Personally, that kind of helped me because I was like. Oh, people are having a good time like I remember having that thought." -P2*

> *"I took a small break doing something else, and I was gone for a while on, instead of like reading all the individual messages, I took the big words, and I did skim through what they were talking about, and it did help kinda like figure out what was going on in chat without me having to moderate the entire log, so just helpful in general." -P4.*

Furthermore, some participants expressed interest in accessing the word cloud and emotes output after the stream. They wanted to be able to review the nature and sentiment of the chat as a way to assess how the session went.

> *"Well, it's. Actually, I was really surprised at how effective like and helpful the word cloud was. That was. That's really smart [...] The only thing I would appreciate is like a way to output afterward, so I can look at it and be like, oh, sweet, I did that great!" -P10*

One participant thought they could potentially use the output of the word cloud to determine keywords to use to filter or moderate the chat in future sessions and use the output for the emotes for inspiration for future emotes that they want to design.

The Tool was Moderately Distracting

When explicitly asked, 6 of the 10 participants mentioned that they found the tool at least somewhat distracting. These participants found that the movement

of bars and the updates of the word cloud and emotes distracted them from their main activity at times, with some participants citing this as a primary reason for not making more extensive use of the tool during their stream. For P9, who stopped using the tool after 90 minutes, distraction was a primary reason.

> *"The information that was provided was more of a distraction, and I wasn't able to utilize it in any way." -P9*

Two participants, a sculptor and a gamer, said that they rely on their peripheral vision to get notified of new messages and that the movement of the polling bars impacted their ability to do so since they kept thinking that there could be new messages in the chat when it was just the movement of poll bars when updating. The updates of emotes or the word cloud features weren't as distracting for the participants since they weren't moving vertically.

> *"Yes, just the word for the polling with the polling window kept distracting. the animated emotes weren't, and the words the way the words kind of work, because it's just the same motion as the chat." -P1*

Some of the participants who found the tool distracting said the level of distraction decreased throughout the stream as they got used to the tool. A few other participants also expressed regret about not adjusting the sliders as less frequent updates could have lowered distractions for them.

> *"A little bit, Yes, initially, but I very quickly got used to it. It's just because, as you can imagine, it's a routine of like having certain things." -P5*

> *"So I think maybe if I had updated the frequency to maybe 30s, or something like that could have been a little bit better." -P2*

Utility Likely to Depend on Chat Volume

The participants' comments in the first and second interviews suggest that the Stream Assistant's usefulness might depend on the number of viewers during a stream. Of the ten streamers interviewed, five mentioned that the Stream Assistant would be helpful for managing big streams with constantly moving chat messages. Although there is no strict baseline for what constitutes a "big stream", all 5 of the participants were speaking from their experience of previously streaming with thousands of viewers. These participants felt that the Stream Assistant would be most beneficial for streamers with a larger audience as it could provide quick insights into what the audience is interested in or discussing without the need to read the messages.

> *"But I do think I could see it being a very valuable feature for people who have a lot of people in their community, and they can quickly get a sense of what kind of keywords are being discussed within their community so that it makes it easier for them to kind of continue to drive conversation and engagement" -P6*

> *"I could see how, in a big chat, and I think I mentioned that during the stream as well when someone was asking about it, is that I can see how, in a big chat with like 1,000 chatters, that could make it easier to get perhaps a feel for what the chat is discussing." -P5*

Similarly, the tool's utility might also depend on chat speed. For example, P8, who had high-speed chat experiences, felt that the tool would be more beneficial in times of high chat activity.

> *"I can think of other streams as I've watched, and other streams I've been in, where I think something like that could be really useful, where you have a lot more chat, direction, and chat involvement and things like that." -P8*

In summary, the Polling feature of the Stream Assistant was perceived as valuable by the streamers, who expressed interest in using it as an extension during their streams. On the other hand, the word cloud and emotes features had limited usefulness for the participants, primarily due to their manageable chat volume and specific stream circumstances. The movements associated with these features were found to be distracting, although some participants either adapted to the distractions or could have adjusted settings to reduce them. Additionally, participants who conducted streams with a high number of viewers and challenging chat management recognized the potential benefits of the tool in such scenarios.

5.5 Summary

In this chapter, we presented the findings of our study. We discovered that streamers use the chat to increase engagement, expand their viewership, and maintain a commitment to reading all chat messages. The chat additionally fosters a sense of community among both viewers and streamers. To manage chat messages effectively, participants employ a variety of personalized techniques, including the prioritization of specific messages and taking occasional pauses to read messages thoroughly. Furthermore, we described our observations of the stream sessions and discussed the potential advantages and disadvantages of employing the Stream Assistant. Notably, the Polling feature received a positive response, whereas the word cloud and emotes features demonstrated limited utility. Our findings suggest that

the effectiveness of the tool could potentially depend on the level of chat activity, with streamers hosting larger audiences and having faster-paced chats potentially gaining more advantages from the features.

Chapter 6

Discussion

Our study provides insight into the roles that chat plays in our participants' live streams, the strategies they employ to manage it, and the effects of using the Stream Assistant during their streaming sessions. The interview sessions revealed that chat messages are of the highest importance to our participants, particularly in contributing to increased engagement and fostering a sense of community among the viewers. Our participants adopted different approaches to managing messages, including prioritizing specific ones and adjusting their reading approach based on chat volume and stream characteristics. During the live stream sessions, we observed that the participants were adept in attending to all messages, however, our participants also mentioned that chat volume and stream activity can impact their ability to manage messages effectively.

Regarding the effects of the Stream Assistant, participants found some of its fea-

tures highly useful, while showing less interest in others. The Polling feature emerged as the most popular among participants due to its speed and ease of use. On the other hand, the Emotes and Word Cloud features were not as widely embraced, with most participants not utilizing them extensively. Some participants also expressed that the repetitive feature updates caused distraction, although some felt that they were able to adapt to it over time.

Despite the varied usage of the Stream Assistant's features, participants saw the most potential for its application in handling high-speed chat interactions during streams with larger viewerships.

6.1 Stream Characteristics Affecting Usage of the Stream Assistant

Participants mentioned several reasons related to stream characteristics for not utilizing the Stream Assistant. These stream characteristics mostly affect the speed and manageability of chat messages.

6.1.1 Stream Assistant Suitable for Fast and Unmanageable Chats

Our findings highlight a potential use case for the Stream Assistant when chat speed is high, and interactions are fast-paced. During our initial stream observations

that informed the design of the tool, we consistently observed a pattern in gaming streams where the chat experienced a surge of emotes and short slang messages during exciting in-game events. Similarly, our observations of just-chatting sessions in these streams, combined with interview quotes from participants, revealed that controversial or interesting topics could trigger a continuous stream of short messages and emotes from viewers expressing their reactions.

We believe that it is specifically in these instances that the design of the Stream Assistant could be highly effective. Stream Assistant displays popular emotes and words within the streamer's selected time frame to provide a longer-lasting presentation of popular chat content compared to the chatbox and could help the streamer stay aware of chat interactions. For instance, this feature could be particularly valuable during intense gameplay moments when streamers are deeply focused on the game and unable to give their full attention to the chat. The tool could potentially prevent streamers from missing significant chat events and help maintain their overall level of interaction by presenting the popular content that was missed by the streamer and providing potential context for the current ongoing chat conversation. In summary, Stream Assistant might be a valuable asset for streamers during moments of intense chat activity by presenting popular chat content and helping them stay connected with their audience.

6.1.2 High-Viewer Streams Might Benefit from the Stream Assistant

Based on previous research and interview quotes, the Stream Assistant shows the potential to be most advantageous for high-viewer streams. During our stream observations, we noticed that streams with high viewership consistently exhibited a faster chat speed compared to those with low viewership, especially during channel raids or when the stream was featured on the front page of Twitch. Moreover, previous studies have consistently shown that as the audience size increases, the chatbox becomes fast-paced and challenging for streamers to manage effectively [15, 40, 44, 54]. Additionally, these studies have found that high-viewer stream chats are characterized by a higher volume of emotes and repetitive content[39, 10], with each channel having its unique set of words when communicating [39].

The feedback from our participants further reinforces the potential benefits of the Stream Assistant in handling large streams. The participants expressed enthusiasm for the tool's application in instances where chat becomes fast-paced and unmanageable, a common scenario in high-viewer streams. In such settings, messages, mostly containing emotes, pass by quickly, leaving little time for streamers to read and acknowledge them all. The streamers could address this challenge by leveraging the Stream Assistant's Emotes and Word Cloud features. The Stream Assistant automatically extracts significant and popular words and emotes from chat messages allowing streamers to still view them even after they have scrolled out of

sight. Whether through the Emotes or Word Cloud features, the streamer could be informed of essential interactions occurring in the chat.

6.1.3 Stream Activity Affecting the Stream Assistant Usage

During the study sessions and interviews, we observed that streamers had different activities and agendas for their streams, which influenced their chat management strategies and utilization of the Stream Assistant. Streamers who engaged in creative activities, such as sculpting, drawing, and Lego building, had the option to pause their activity, read chat messages, and interact with their viewers. Given their ability to engage directly with the chat, these streamers found no particular use for the Emotes and Word Cloud features since they could already access and read all messages in real time. Additionally, some creative streamers were focused on their streaming activity for the day and did not engage much with the chat. This resulted in their viewers primarily watching the stream and sending fewer messages to avoid potential distractions. Consequently, they did not make use of the Stream Assistant as well. On the other hand, gaming streamers received more messages and were fully engaged in the games they played, leaving little opportunity to pause and interact with the chat without interrupting their gameplay.

We, therefore, hypothesize that the effectiveness of the Stream Assistant may vary based on the streamer's activity level, schedule for the day, and ability to maintain interaction with their chat. If a streamer's activity allows them to dedicate time

to reading messages and interacting with viewers, they are likely already aware of the emotes and ongoing chat discussions, rendering the Stream Assistant somewhat repetitious. Moreover, if they have no difficulty keeping up with the chat's high speed and do not miss any messages, the utility of the Stream Assistant's features would be minimal. Therefore, for creative streamers who take intermittent breaks, the tool's benefits might be less apparent compared to gaming streamers who are deeply immersed in gameplay. Gaming streamers, even while engrossed in their activity, could benefit from quick glances at the Stream Assistant's features to stay informed about frequently used words and emotes during moments when they may have missed messages.

6.2 Design Suggestions

Based on our observations and study findings, we have identified several areas for enhancing the functionality of the Stream Assistant and reducing distractions. Our study revealed that the frequent blinking of feature updates posed a distraction for the participants. This issue could be addressed by redesigning the features to provide seamless or less frequent updates. To further mitigate distractions, we propose incorporating an option that allows viewers to receive updates on demand (e.g. by clicking a button). Furthermore, we noticed that many streamers used their own streaming application (OBS) to view their streaming video and chat feed, rendering the Stream Assistant's video and chat feed redundant. For future design iterations,

we suggest either removing the video and chat feed from the tool or integrating the features as extensions for the OBS application. This integration would enable streamers to seamlessly incorporate these features into their streaming application. In the context of future research, it might be worthwhile to investigate the impact of granting users the ability to choose which features to utilize and which to minimize during their streams. This approach could offer a way to manage the level of distraction while optimizing the utility of the features.

Our interview findings revealed that streamers prioritize audience engagement and community growth. Providing feature reports after the stream could offer streamers the chance to review popular topics discussed during their session. This insight could help them better comprehend viewers' interests, allowing for more interaction and conversation by discussing those subjects in future streams. Moreover, sharing Polling results and feature reports with viewers could increase their participation levels. Such transparency would indicate that their input is valued beyond the chatbox. Furthermore, participants valued having a summary of individual viewers' messages. For streamers dedicated to viewer interaction, understanding individual opinions could enhance their connections with them and facilitate deeper conversations. By integrating features that facilitate connection with viewers, we can explore methods to better assist streamers in engaging with their audience and growing their community.

Based on our observations and interview feedback, future iterations of the Stream

Assistant have room for improvement in terms of space optimization, data presentation, and feature functionalities. The space allocated for the Emotes feature could be condensed into a compact bar displaying popular emotes sequentially. Similarly, the word cloud could occupy less space and incorporate fewer words, as participants were observed focusing on larger, more prominent words than smaller ones. Enhancing the functionality of the Polling feature could involve increasing the default word count to 6 - 10 words. Streamers expressed interest in having statistics for more words than the current default of 4 words. The underutilized sliders point to the potential for an alternative design that is intuitive to use on the first try. For example, providing time frame options such as 20 minutes, 30 minutes, and more could be preferable to a slider.

Chapter 7

Conclusion

In this thesis, we explored streamers' perspectives on the role of chatbox in live streaming and delved into their chat management strategies and the factors influencing their approach. We also introduced the Stream Assistant, a tool designed to help streamers in managing high-speed chat interactions. Through a study involving 10 Twitch streamers, we gained insights into the utility of the Stream Assistant and its potential benefits in enhancing streamers' communication with their audience. This conclusion synthesizes our key contributions and highlights the limitations of our study, paving the way for future research in this domain.

7.1 Contributions

Throughout this thesis, we investigated the pivotal role of chat for streamers and the various chat management strategies employed across different domains. Our research delved into the challenges faced by streamers as they manage chat interactions during live streams. We gained insights into the dynamic nature of chat engagement by observing streamers' practices and analyzing the interview data.

We used previous research insights and our observations from 33 live streams to design and develop a real-time summarization tool called the Stream Assistant, which we evaluated in an online study. This study involved 10 Twitch streamers, providing insights into the potential benefits of the Stream Assistant and identifying areas for suggested improvements. Our findings revealed the impact of the tool, with participants expressing appreciation for its Polling feature and seeing potential for it to help them effectively manage fast-paced chats during high-viewer streams.

Reflecting on the feedback provided by streamers, we have identified potential design changes that could increase the utility of the Stream Assistant. We have also gathered a range of insightful suggestions for enhancing the functionality and user experience of the Stream Assistant. Future research should explore how these changes help in customizing the tool to better align with the diverse needs and preferences of individual streamers, according to their specific stream agendas and viewer count.

7.2 Limitations and Future Work

We encountered several challenges before and during the development of the Stream Assistant and when recruiting participants for the study. Initially, our goal was to conduct a preliminary study involving interviews with streamers. The purpose of the interviews was to understand their tool preferences and desired features that would support their chat management and enhance their overall streaming experience. We planned to develop the Stream Assistant using the insights gathered from interviews in the preliminary study. However, as we delved deeper into the planning, we realized that executing this preliminary study would require more time than was available within the constraints of the thesis timeline. Gaining such insights from Twitch streamers would have helped in pinpointing their needs and designing a tool better tailored to improve chat management. Moreover, despite our efforts during the recruitment phase, we faced difficulties in reaching out to and engaging famous streamers with consistently high viewership. As a result, we were unable to recruit participants with considerably large viewer bases. It would have been intriguing to explore the potential increase in feature utilization for streamers who consistently deal with fast-paced chats and often struggle to read all messages. Understanding the challenges and preferences of streamers based on their audience size and chat activity will allow for targeted design to better support streamers with different viewership levels. Refining our recruitment strategy could potentially attract well-known streamers to participate in the study. Offering more compensation, trying

new channels to contact streamers such as reaching through moderators, and working together with Twitch for a study could help get streamers with more viewers to participate in the study.

One area of limitation in our study pertains to the study's structure. Participants ended up using the Stream Assistant for a longer time than originally planned, which was about an hour for each participant. Nevertheless, we noticed that their interaction with the tool was limited, and interacting with the tool over multiple sessions would have given participants more opportunities to explore its functionalities. This aspect was highlighted by the participants themselves, as a significant number chose to keep the default settings. This was primarily because they were using the tool for the first time and preferred to use the default settings rather than making adjustments. Future research could enhance participants' familiarity with the tool by either allowing them to explore it in their own time or conducting the study across multiple sessions over several weeks.

Another limitation of our study was the relatively small sample size, which consisted of ten Twitch streamers. Expanding the number of participants could have potentially enhanced the reliability of the findings. Few streamers in our study shared similar experiences across various aspects, such as their perceptions of chat and message management. Additionally, we observed similar patterns in the feedback received regarding the Stream Assistant. Increasing the number of streamers would solidify the findings by finding more commonalities among participants. This

would also broaden the range of viewer counts and improve the generalizability of the results. Future research could benefit from a larger participant pool to capture a wider range of perspectives.

Our study methodology involved having a stream session with participants using the Stream Assistant and conducting interviews afterward. However, this approach might not have been comprehensive in understanding the complete range of the tool's advantages and limitations. Incorporating alternative methods like controlled experiments and tracking tool usage across multiple sessions could potentially reveal new insights into the usability of the Stream Assistant. In future research, a controlled experiment could be explored, where one group of participants use the Stream Assistant and another group stream with their regular tools. Alternatively, participants could offer feedback over a series of sessions where the Stream Assistant is employed, facilitating a session-to-session comparison of its effects.

Based on the insights from our interview analysis, we identified numerous opportunities to improve streamers' interactions with their audience. This could be achieved through expanding customization options and integrating new features, such as analytics reports. Future studies might delve into the effects of offering more customization options, enabling streamers to adjust the Stream Assistant to their specific needs and preferences. Furthermore, adding new features that provide analysis of viewer messages could further enhance the connection between the streamer and individual viewers. These augmentations have the potential to assist streamers

in promoting audience engagement and growing their community.

Future research holds exciting opportunities to investigate various streaming activities and develop personalized tools tailored to the specific needs of individual streamers. By understanding the unique requirements of each streaming domain, future tools could optimize the live stream experience, engagement, and chat management for streamers across different content categories. Streamers involved in creative domains and activities that permit frequent pauses might find value in features that facilitate ongoing discussions and help them expand on previously sent messages. On the other hand, streamers in gaming and domains that demand constant attention could reap greater advantages from features tailored for usage during breaks, or features that can be utilized simultaneously with their main activity.

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Appendix A

Initial Semi-Structured Interview

Sample Questions

1. How long have you been streaming, and how would you describe your experience until now?
2. Can you please tell me about your interaction with your viewers over the years?
3. How do you describe your experience with the chat and communicate with your viewers?
4. What extensions are you currently using during your regular streaming sessions? How do they impact your streaming experience?
5. Have you ever used slow mode? why/why not?
6. Do you use moderators for your stream? Do you find them helpful? why/why not?
7. Do you currently use any poll extensions or tools that help you ask questions from the audience and get their collective feedback?
8. Please describe your experience when reading the chat messages. How do you approach it, and what kind of information are you usually looking for?

Appendix B

Post Stream Semi-Structured Interview Sample Questions

1. In general, how did you feel about the prototype? Did the prototype change your communication with the viewers? [If yes] How? [If not] Why not?
2. Did the prototype change the way you got information from the chat? [If yes] How? [If not] Why not?
3. How was your experience using the Automatic Poll feature? How would you compare it to other tools or previous experiences when asking questions?
4. Did you find the reports of the Automatic Poll feature useful? Why/why not?
5. How did you find the Emote section? How easy was it to identify the more common ones?
6. How useful did you find the Word Cloud reports?
7. Did you find the features distracting? [If yes] In what way? [If no] why not?
8. How did you feel about the stream time slider and the update speed of the reports?
9. Out of the three types of reports, which one did you find yourself looking at the most? Why?
10. How would you order the features based on your usage?
11. How would you change the three sections if you were to make any changes to them?

12. Is there anything else that would help you manage the chat?

13. Do you have any suggestions to improve the prototype?

14. Out of the features, would you like to have any of them available as extensions? Which ones? [If not already covered] Why?

Appendix C

Research Ethics Board Approval

University of Manitoba | Research Ethics and Compliance

Human Ethics - Fort Garry
208-194 Dafoe Road
Winnipeg, MB R3T 2N2

PROTOCOL APPROVAL

Effective: August 23, 2022 Expiry: August 22, 2023

Principal Investigator: Andrea Bunt
Protocol Number: HE2022-0165
Protocol Title: *Alternative Live Stream Interfaces*

Andrea L Szwajcer, Chair, REB2

Research Ethics Board 2 has reviewed and approved the above research. The Human Ethics Office (HEO) is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*- TCPS 2 (2018).

This approval is subject to the following conditions:

i. Approval is granted for the research and purposes described in the protocol only.

ii. Any changes to the protocol or research materials must be approved by the HEO before implementation.

iii. Any deviations to the research or adverse events must be reported to the HEO immediately through an REB Event.

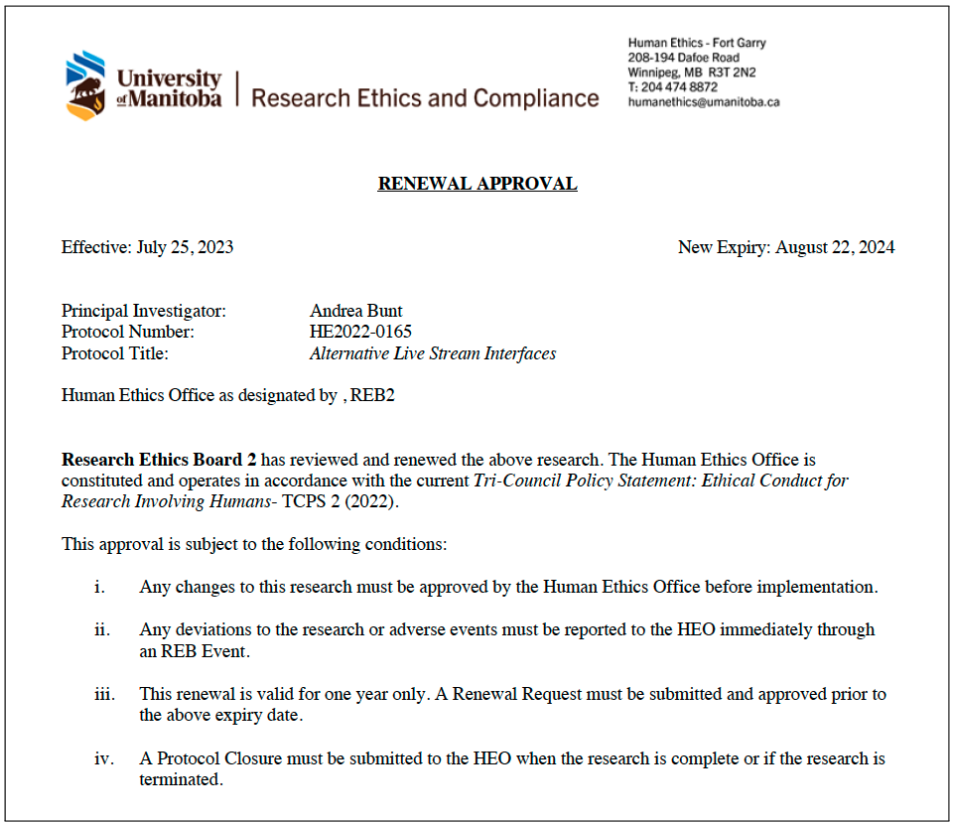
iv. This approval is valid for one year only. A Renewal Request must be submitted and approved prior to the above expiry date.

v. A Protocol Closure must be submitted to the HEO when the research is complete or if the research is terminated.

vi. The University of Manitoba may request to audit your research documentation to confirm compliance with this approved protocol, and with the UM *Ethics of Research Involving Humans*Ethics of Research Involving Humans policies and procedures.

Appendix D

Research Ethics Board Renewal Approval



University of Manitoba | Research Ethics and Compliance

Human Ethics - Fort Garry
208-194 Dafoe Road
Winnipeg, MB R3T 2N2
T: 204 474 8872
humanethics@umanitoba.ca

RENEWAL APPROVAL

Effective: July 25, 2023 New Expiry: August 22, 2024

Principal Investigator: Andrea Bunt
Protocol Number: HE2022-0165
Protocol Title: *Alternative Live Stream Interfaces*

Human Ethics Office as designated by , REB2

Research Ethics Board 2 has reviewed and renewed the above research. The Human Ethics Office is constituted and operates in accordance with the current *Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans*- TCPS 2 (2022).

This approval is subject to the following conditions:

i. Any changes to this research must be approved by the Human Ethics Office before implementation.

ii. Any deviations to the research or adverse events must be reported to the HEO immediately through an REB Event.

iii. This renewal is valid for one year only. A Renewal Request must be submitted and approved prior to the above expiry date.

iv. A Protocol Closure must be submitted to the HEO when the research is complete or if the research is terminated.

Appendix E

TCP2: CORE Certificate

PANEL ON RESEARCH ETHICS
Navigating the ethics of human research

TCPS 2: CORE

Certificate of Completion

This document certifies that

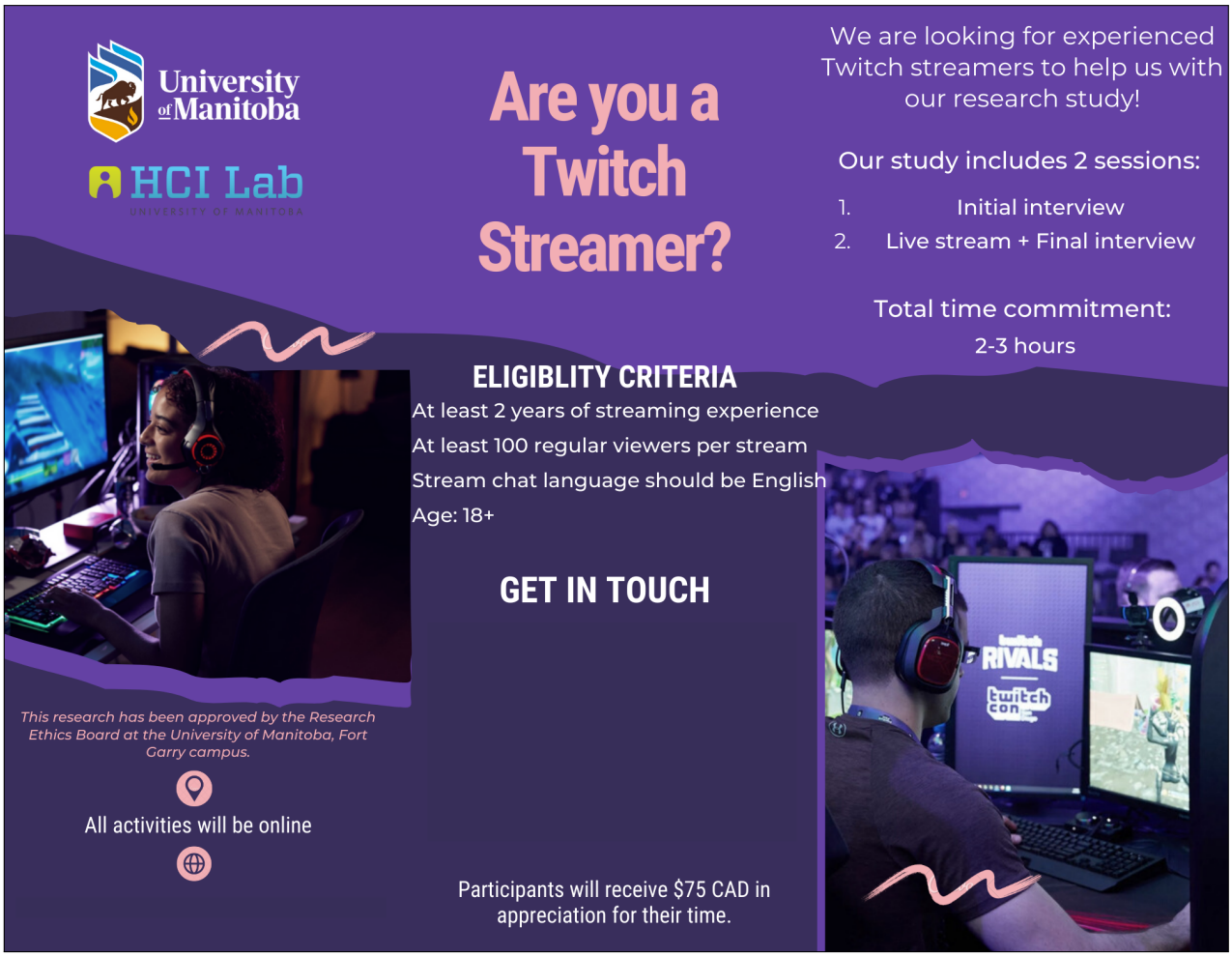
Pouya Aghahoseini

has completed the Tri-Council Policy Statement:
Ethical Conduct for Research Involving Humans
Course on Research Ethics (TCPS 2: CORE)

Date of Issue: **25 January, 2021**

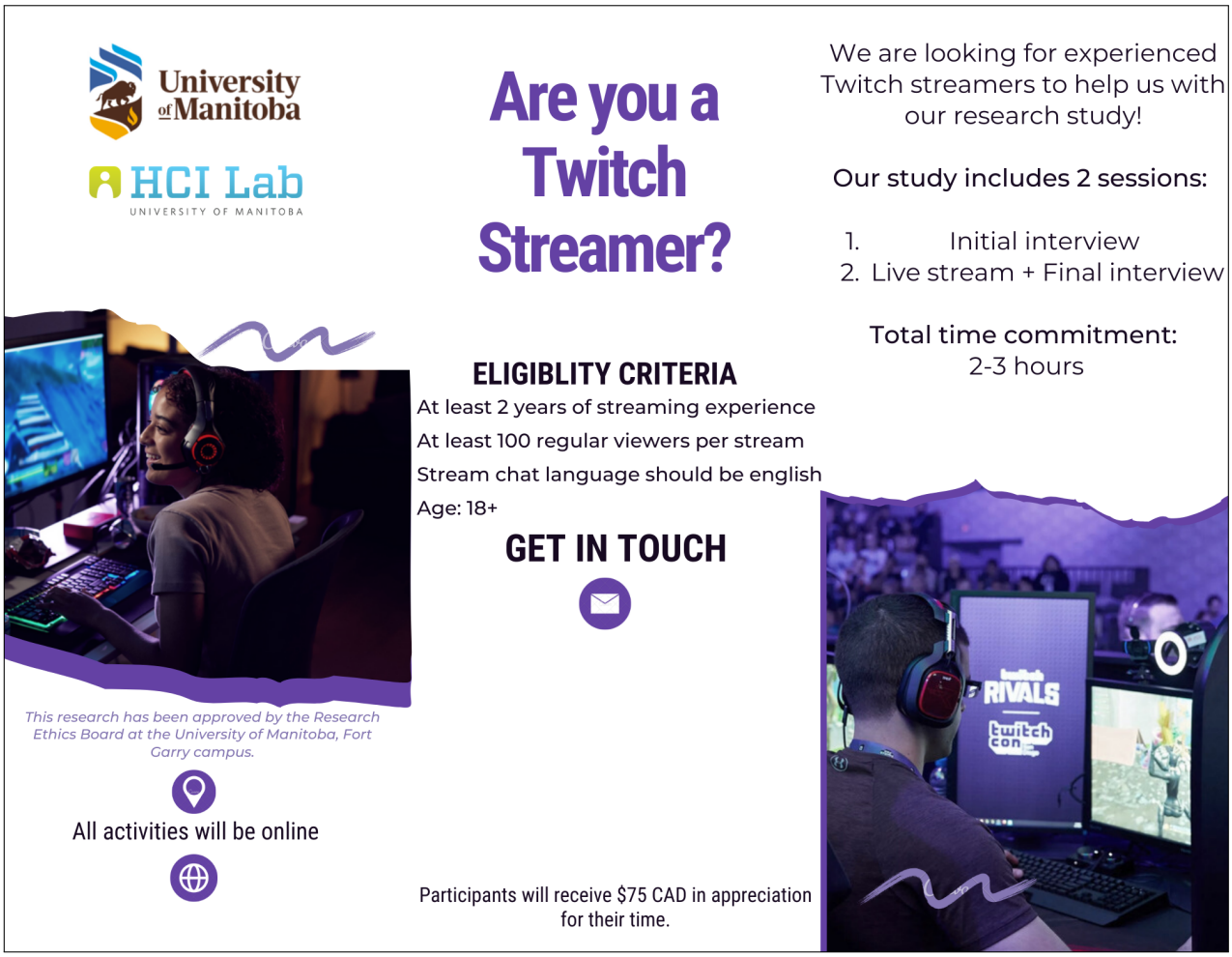
Appendix F

Digital Recruitment Poster



Appendix G

Printable Recruitment Poster



Appendix H

Consent Form

Appendix D

University of Manitoba Faculty of Science

Department of Computer Science
University of Manitoba
Winnipeg, Manitoba
Canada
R3T 2N2

Appendix D – Consent form for Streamers (Online study)

Research Project Title: Alternative Live Stream Interfaces

Principal Investigator: Dr. Andrea Bunt

Co-Investigator (Master's student): Pouya Aghahoseini

Co-Investigator (Undergraduate student): Millan David

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

Purpose of the research:

You are invited to participate in a research study about live stream chats and how their interfaces can be improved. You should be at least 18+ years old, have at least two years of experience in live streaming, have English as your stream chat language, and have more than 100 regular viewers per stream. Our research study aims to better understand the challenges streamers face when interacting with their viewers over chat and to evaluate different chat interfaces.

Study Procedure:

The study will be online, using UM Zoom (University of Manitoba licensed copy of Zoom), Twitch.tv, and a prototype website. You will stream on Twitch as usual but will be using the prototype as your stream assistant. Your participation in this research study involves two sessions. The first session will be an initial interview and the second session includes an hour of streaming and a final interview.

The first session which only includes the initial interview, will start in the Zoom meeting and once you have sent this form to Aghahoseini and/or David. The interview will take between 30 to 40 minutes and will be about your experience in streaming, and the interactions you have with the viewers over chat. After the interview, we will familiarize you with a prototype website that you will be using to help you with your live stream, and finally we will schedule a time for the second study session.

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The second session will start with an hour of streaming on Twitch. We will meet you on UM Zoom and ask you to first open the prototype website to make sure it runs smoothly. Next, we ask you to start your streaming session on Twitch as usual but use the prototype website as your main tool for getting stream information. We also ask you to share the prototype website screen with us so we can record and analyze your interactions with the tools later. We ask you to notify the viewers that the stream is part of a research study and pin a message to the chat so the new viewers will be notified as well. Once the stream is finished, we will have a 30-40 minute final interview to ask you some questions about your experience with the prototype website. The whole study will take between 2 to 3 hours.

Before the first study session (the initial interview), you must sign this consent form. This form will be administrated via Microsoft Forms authorized under a UofM server. After signing this consent form, we will start the interview in the ongoing UM Zoom call. If you have any questions or concerns, please feel free to contact Aghahoseini and/or David at the above email address or phone number.

Recording:

We will ask you to share your screen with us during your stream so we can observe, record, and later analyze your interaction with the prototype. The viewers' messages will be recorded too, but there will be no mention of their usernames and all quoted messages will be anonymized. We are interested to see how you feel the prototype and its tools might impact your streaming sessions. The initial and final interviews will be recorded too, and you can turn off your video during the interviews if you wish but your video needs to be turned on during the stream. As the researchers Aghahoseini and/or David will be present throughout both study sessions, they will record the audio and video using the screen capturing tool of UM Zoom. Recorded sessions will be stored on Aghahoseini or David's computers in the HCI research lab (EITC E2-534). These are large recordings; therefore, they will be stored on a local drive, but the recordings will be stored in a Zip file and encrypted. Only research team members have access to video recordings and your data will be kept private and secure.

Benefits:

This research will give insight into how streamers communicate with their viewers and manage the chat. It will also contribute towards the design of new interfaces that can better support streamers and their viewers.

Risks:

There is minimal risk in participating in this study. Participation in this study is voluntary and it is possible that you will get frustrated using the prototype website, overwhelmed by using new

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features and not have the same streaming experience as usual. You might also have fewer viewers than usual because of the notice that you need to give about the stream being recorded and part of a research study. Otherwise, the risks to this study are no greater than in everyday life.

Confidentiality:

Since Twitch streams are public content, the stream would be recorded, and you and the viewers' will be aware of your participation in the study. The collected information won't be confidential, but they will be kept private. All information you provide is considered completely private; your name and the viewers' username will not be included or in any other way associated with the data collected in the study. However, you can mark the checkbox below if you want to waive your anonymity and have your name mentioned in the research presentation.

The video recordings will be stored on a password protected computer of the researchers in the HCI research lab (EITC E2-534) and will be kept private and secure. Only the researchers will have access to the recordings. Email correspondence will be kept secure on the UM email account of the researchers which is on the UM servers. Other identifiable data (Code sheet, Compensation receipts) will be stored in the MS Teams project on the University of Manitoba servers and only the three researchers of this project will have access to the data.

Video and audio recordings of the stream session and the two interview sessions are essential to the research analysis. Data collected during this study will be used for data analysis purposes only. The viewers messages will be recorded as part of the stream recording and some quotes might be used in the research presentations, but they will be anonymized and there would be no mention of the viewers' usernames. We may use anonymized quotes from interview for purposes of public presentation; however, we will not present video, screenshots, or audio. Each participant will be assigned IDs that will be used to present anonymized quotes (e.g., P3, P4). That is, your image and voice will not be used in papers, presentations, put on the internet, etc. The transcripts of interviews will be created and stored in the MS Teams project folder on the University of Manitoba servers by Aghahoseini and David. The MS Teams project is created by Aghahoseini and only the three researchers have access to this data.

☐ I wish to waive my anonymity and therefore allow my name, and interview quotes to be mentioned in the results. (Optional)

Compensation:

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In appreciation for your time and participation in this study, you will be compensated $25 CAD for the first study session and $50 CAD for the second study session. We will give the compensation at the beginning of each session using e-transfer or PayPal, or any acceptable way you wish at your choosing. Please let us know your preferred way of receiving the compensation along with one of your preferred email addresses or phone number where we can send the e-transfer or PayPal. You can email this information to

Withdrawal:

Participation in this study is voluntary and if you wish to withdraw from the study, you are free to do so at any time. Upon withdrawal from the study, you can keep the amount that you were compensated until that point. You can either verbally ask to withdraw from the study on the Zoom meeting or send an email to Aghahoseini and/or David and we will immediately finish the study and remove the collected data. During the live stream, you can send an email to Aghahoseini and/or David, or send them a private chat message on Zoom if you wish to withdraw from the study. You can continue streaming after withdrawal as you wish. We will stop the recording and finish the study and remove the collected data. You can also withdraw from the study until one week after the second session by sending an email to Aghahoseini and/or David. After one week from the end of the second session, participants will no longer be able to withdraw from the study as analysis will begin.

Result Dissemination:

The results of this study will be reported in a Master's thesis and will be available in MSpace (https://mspace.lib.umanitoba.ca). Once published (in journals, conferences, MSpace, or thesis of the student), a summary of research will be available on HCI lab's website by April 2023 at hci.cs.umanitoba.ca. You can mark the checkbox below if you are interested to be notified about the study results. Upon checking this box, we will store your email in a password protected file in the MS Teams project on the University of Manitoba servers and will delete your email after notifying you about the results. Again, no personal information about your involvement will be included. Please note that the University of Manitoba may look at the research records to see that the research is being done in a safe and proper way.

☐ I wish to be notified about the results of this research study through email, once they are published. (Optional)

Data destruction:

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All the data (anonymized and directly identifiable) will be retained for a maximum period of three years and will be destroyed by April 2025. The stored emails will be deleted after notifying the participants of the published results.

Consent:

Please initial your response below.

I CONSENT to be recorded while being interviewed by Aghahoseini and/or David at the beginning of the interview sessions and am aware my audio and video (you can turn off your camera during interviews) will be captured. _____

I CONSENT to sharing my screen and being recorded via UM Zoom software during the stream session of the study and am aware my audio, video, and my computer's screen (only prototype window) will be captured. _____

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and /or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your research records to see that the research is being done in a safe and proper way.

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. If you have any concerns or complaints about this project, you may contact any of the above-named persons or the Human Ethics Officer at or . A copy of this consent form has been given to you to keep for your records and reference.

Having read the provided information and after all my questions were answered to my satisfaction, I understand that I will participate in this study and understand what I am freely consenting to it.

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Participant's Printed Name and Signature: _____
Date: _____

Researcher and/or Delegate's Signature: _____ Date: _____

Researcher and/or Delegate's Signature: _____ Date: _____

Appendix I

Broad Consent Document

A) Stream Announcement

The streamer should read this announcement before the second study session during one of their streams.

I have opted to participate in a study run by the Human-Computer Interaction lab in the Computer Science department of the University of Manitoba. You can access the lab website at hci.cs.umanitoba.ca. The researchers running the study are investigating how live stream interfaces can be improved. They have implemented a prototype I will use while streaming as part of their research. To evaluate this prototype, they need to observe, record, and analyze a one-hour live stream session later. The prototype does not impact the viewers; the differences are only visible on the streamer side. As Twitch Privacy Policy has indicated, users' activity and information in the chat are public content; "Given the social nature of some of the Twitch Services, that information (when you broadcast content, participate in a chat room, post profile information, follow a channel, or subscribe to a broadcast channel) may be collected, used, or disclosed by others who are part of that social interaction."
Any quotations used in publications will be anonymized, and there will be no mention of your username or information in the research results. We also recommend you use aliases for your username and in the messages.
No information about you as individuals will be written down as part of the observations. Therefore, you agree to participate in the study upon participating in the live stream and chat conversation.
The researchers observing the stream have completed the ethics training required of human-subjects researchers in Canada. You can visit Hornbill.cs.umanitoba.ca/info for more information about the study. The webpage link will be available in the pinned message in the chat. I am telling you about this so you can choose not to participate in the stream and the study.

This research has been approved by the Research Ethics Board at the University of Manitoba, Fort Garry campus. If you have any concerns or complaints about this project, you may contact any of the above-named persons or the Human Ethics Coordinator at or

B) Stream Pinned Message

This message should be pinned to the stream chat and visible to all viewers during the streaming session.

“This live stream is part of a research study and is being recorded. For more information, visit Hornbill.cs.umanitoba.ca/info”

Appendix J

Open Coding Labels

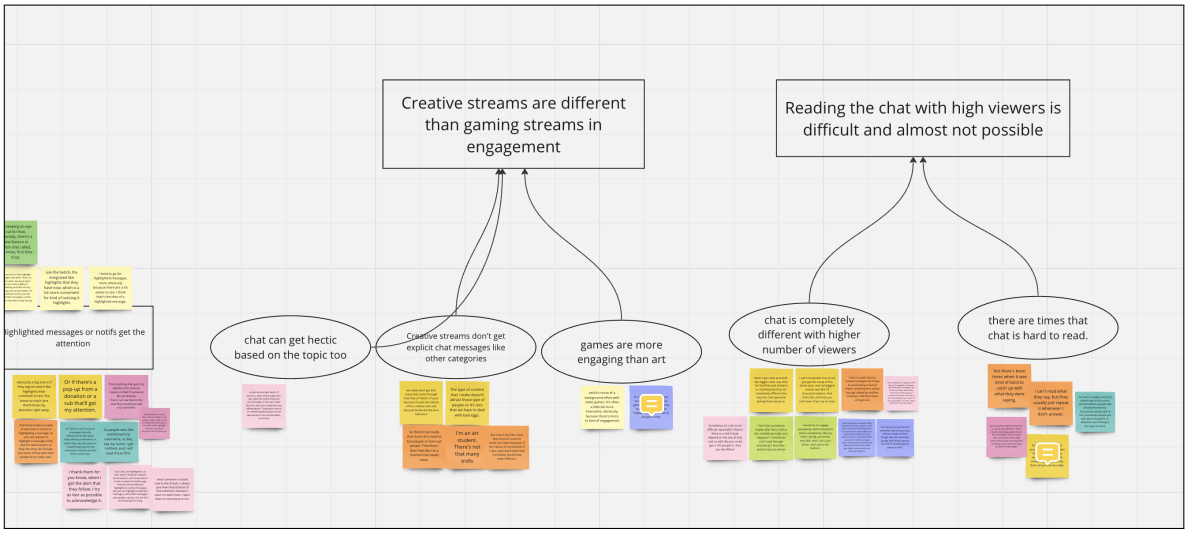

Figure J.1: A view of the thematic analysis for the initial interview. Quotes with similar themes were categorized into clusters which led to identifying higher-level themes.

Figure J.2: An view of the initial thematic analysis of the final interview. Quotes were color-coded based on participant IDs to identify possible new themes.

Appendix K

Initial Design Sketches

In this section, we will discuss all the steps and details of the design sketches of the Stream Assistant. Our goal for the initial design was to present four different types of reports to the streamer. These reports included a Yes/No and multiple-choice report for polling questions, along with two sections reporting on the mood and topic of discussion in the chat. Figure X provides an overview of our initial ideas and designs. K.1.

In the next iterations, we merged the Yes/No and Multiple Answer polling sections to show only three types of reports. These reports included Polling, the mood of the chat, and the topic of discussion in the chat which eventually turned to Emotes and Word Cloud features. Furthermore, we sketched different data representations for the three features (see figures K.2, K.3).

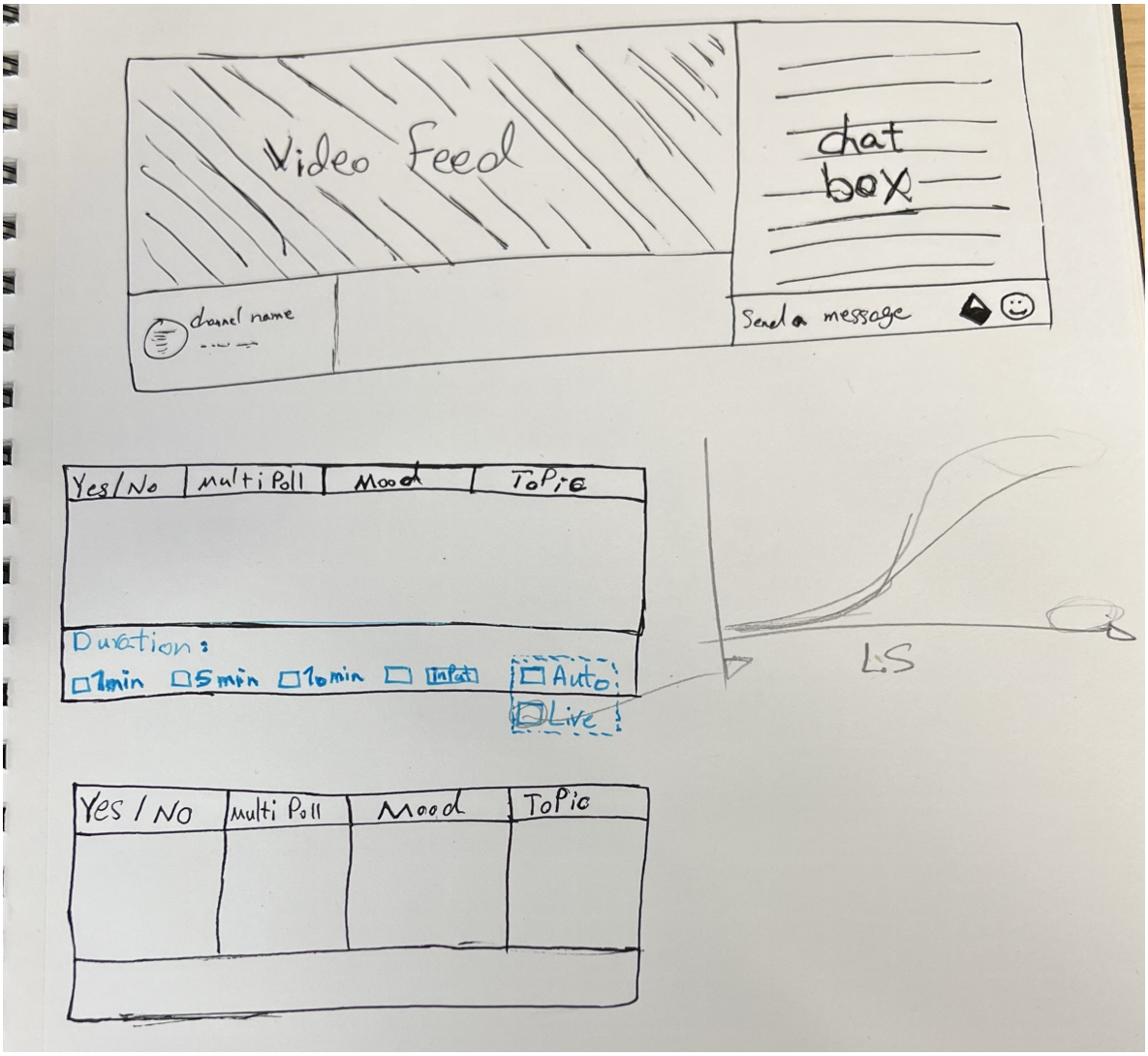

Figure K.1: Initial design of the features and their functionalities. These features were intended to present four distinct types of reports, including real-time polls with options like Yes/No and others. Additionally, the other two features were designed to provide reports on the chat's mood and the ongoing chat discussion topics.

The Polling feature's design went through many changes before reaching its final form. At first, we had a toolbox where streamers could choose how many options the poll should have and what kind of answers they expected to see (see figure K.5). There was also a slider in the toolbox to pick how long the poll should run. However, after trying different things and getting advice from experts, we realized that putting answers into specific categories might not cover all possible responses. Additionally, it would have added a step to the process of setting up a poll. We also tried different ways to show the results of the poll using graphs, and we ended up using bar and pie graphs (see figure K.4). However, we decided to keep only the bar graph in the final

Figure K.2: These sketches depict various data representations for the Polling, Emotes, and Word Cloud features. Originally, the Emotes feature was named 'Mood features,' and we explored different data representations, including emojis, Twitch emotes, and sentiment keywords. Similarly, the Word Cloud feature was initially conceived as both a list and a scatterplot of words. Additionally, we experimented with different placements for the slider features, originally considering the use of Start/Stop buttons and preset time duration buttons.

version to keep things simple. In the beginning, the Polling feature showed statistics for a set of common words by default, but later in the implementation, we added the option for users to add their own words to track with the option to clear them.

Regarding the Emotes section, we initially designed various concepts where emotes

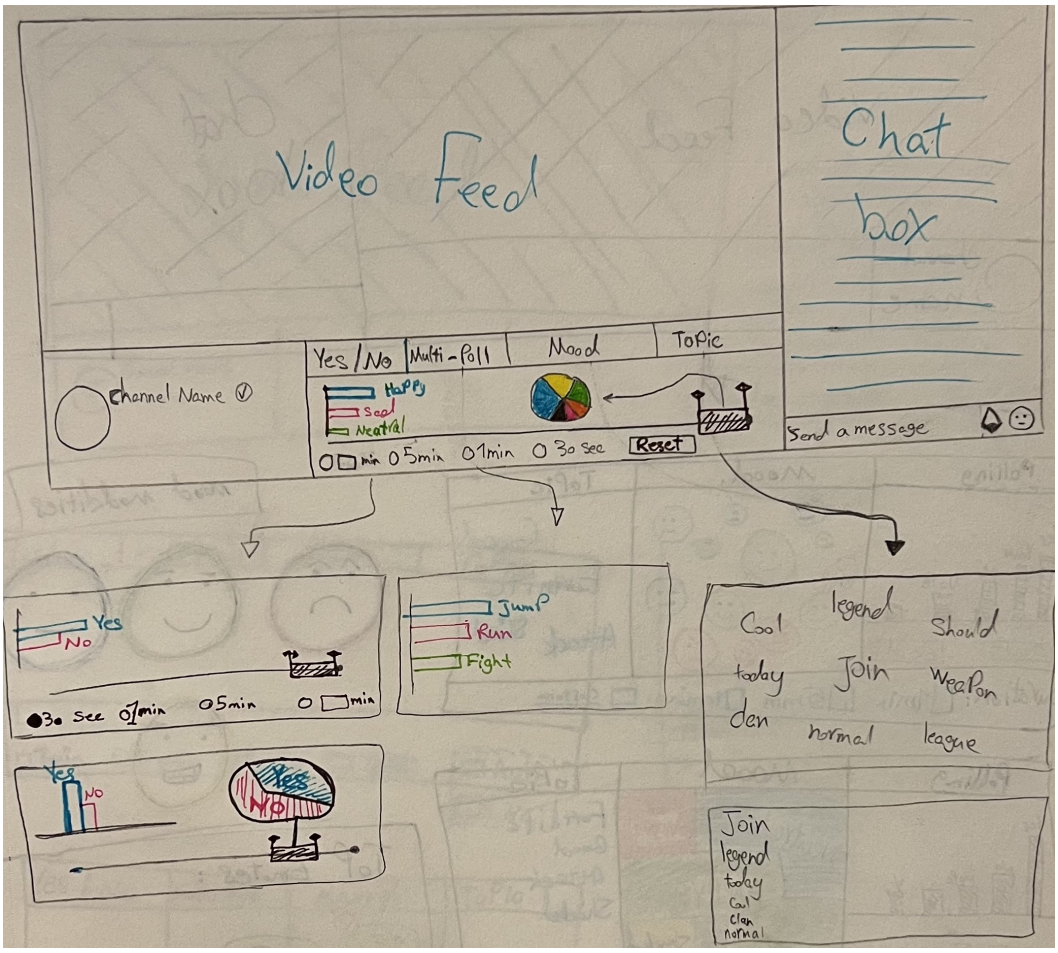

Figure K.3: Refined sketches of different data representations in Polling, and Word Cloud features in addition to the Sliders. Enhanced sketches showcasing various data representations for the Polling feature, Word Cloud feature, and Slider. Initially, polling results were depicted as both bar and pie charts, but in the final implementation, only the bar chart was retained. The slider was originally located within the Polling feature and featured custom time durations as radio buttons.

were represented as visual representations of keywords, either through labeled vectors or color graphs. However, we ultimately decided to display emotes in their original form rather than replacing them with words. (see figures K.6, K.7.)

The sliders also went through changes to reach the final design. (see figure K.8)

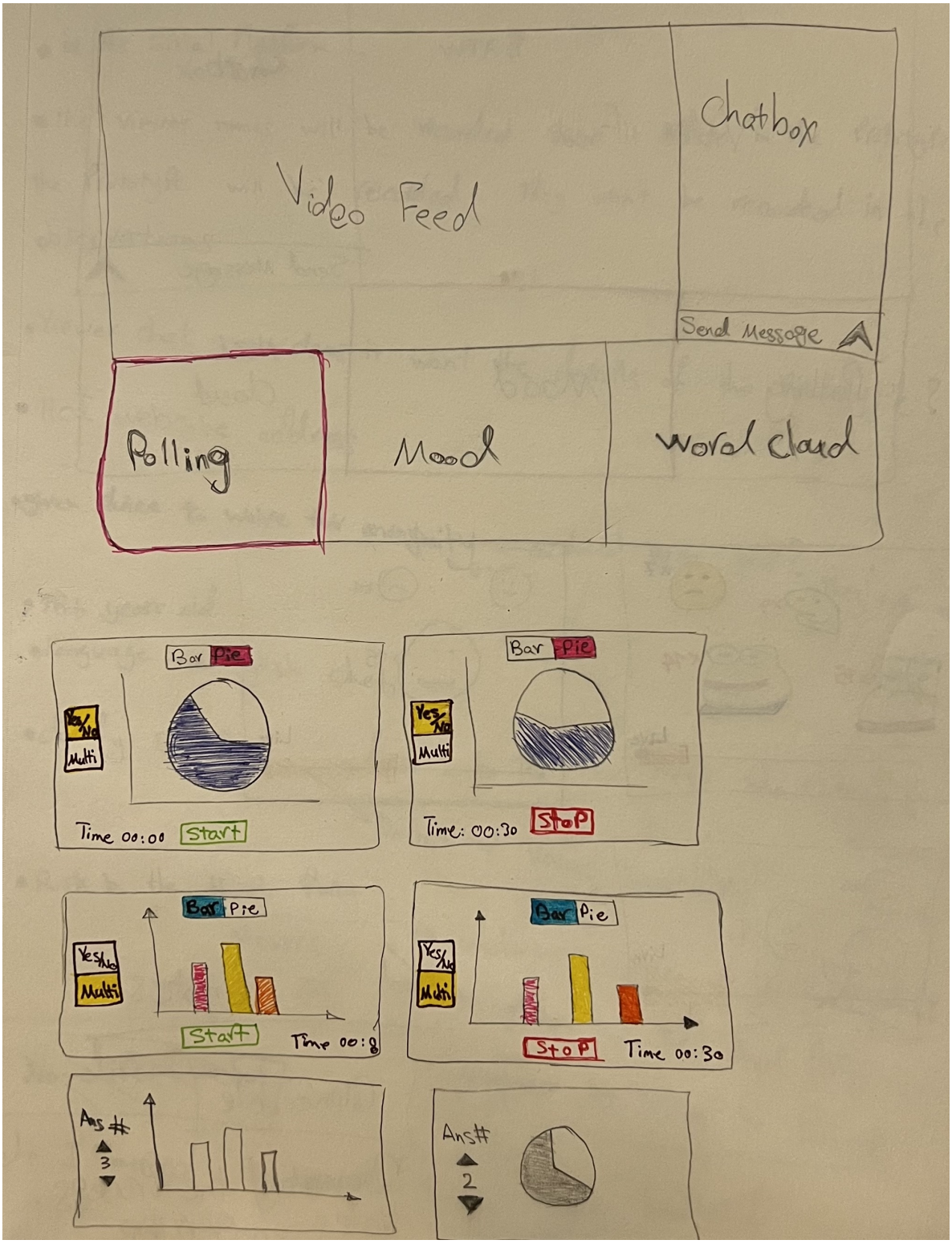

Figure K.4: Different data representations for the Polling feature as bar and pie charts.

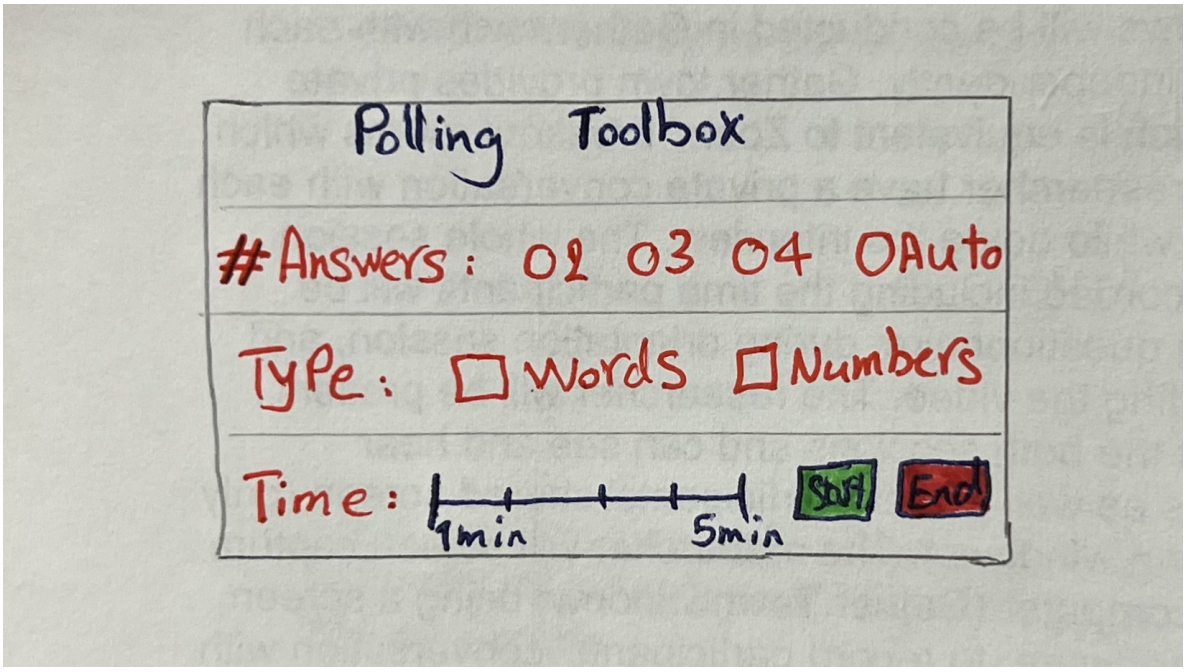

Figure K.5: An initial sketch of options toolbox. The toolbox enabled customizing the poll answers while including a slider for the duration of the poll as well.

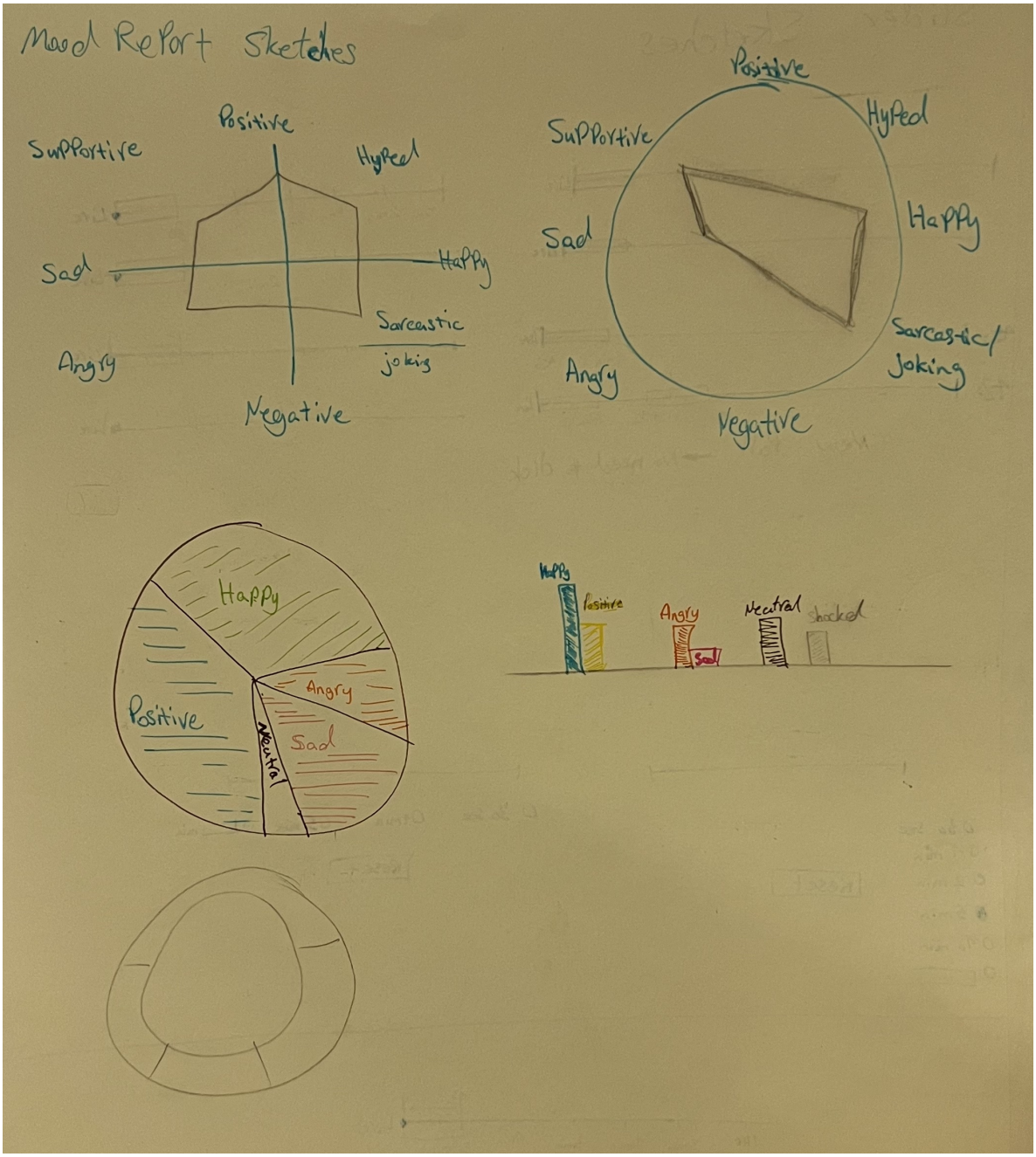

Figure K.6: Different data representations for the Emotes feature, showcasing emotes as vectors and charts of emotions.

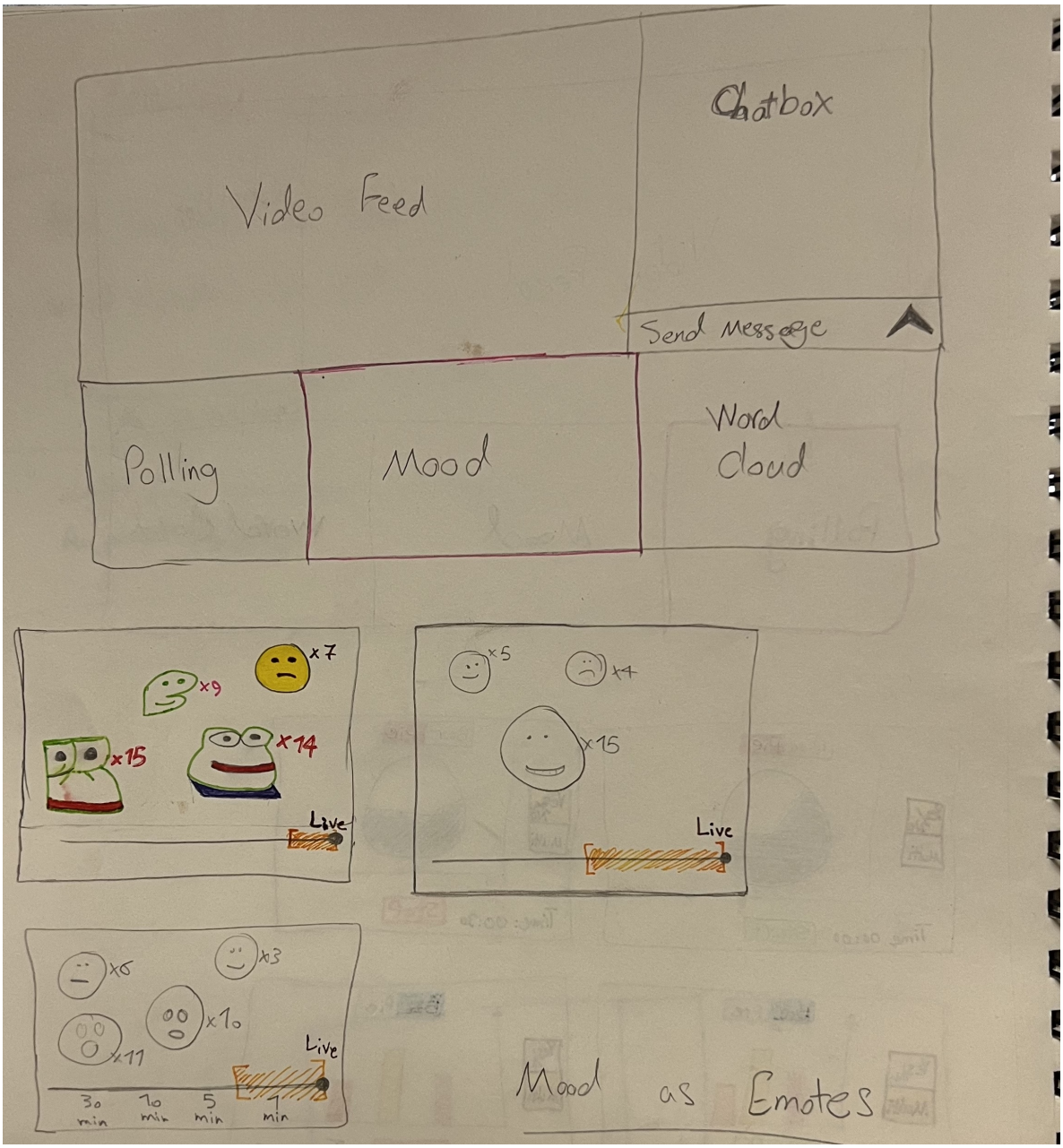

Figure K.7: Different data representations for the Emotes feature, including a slider.

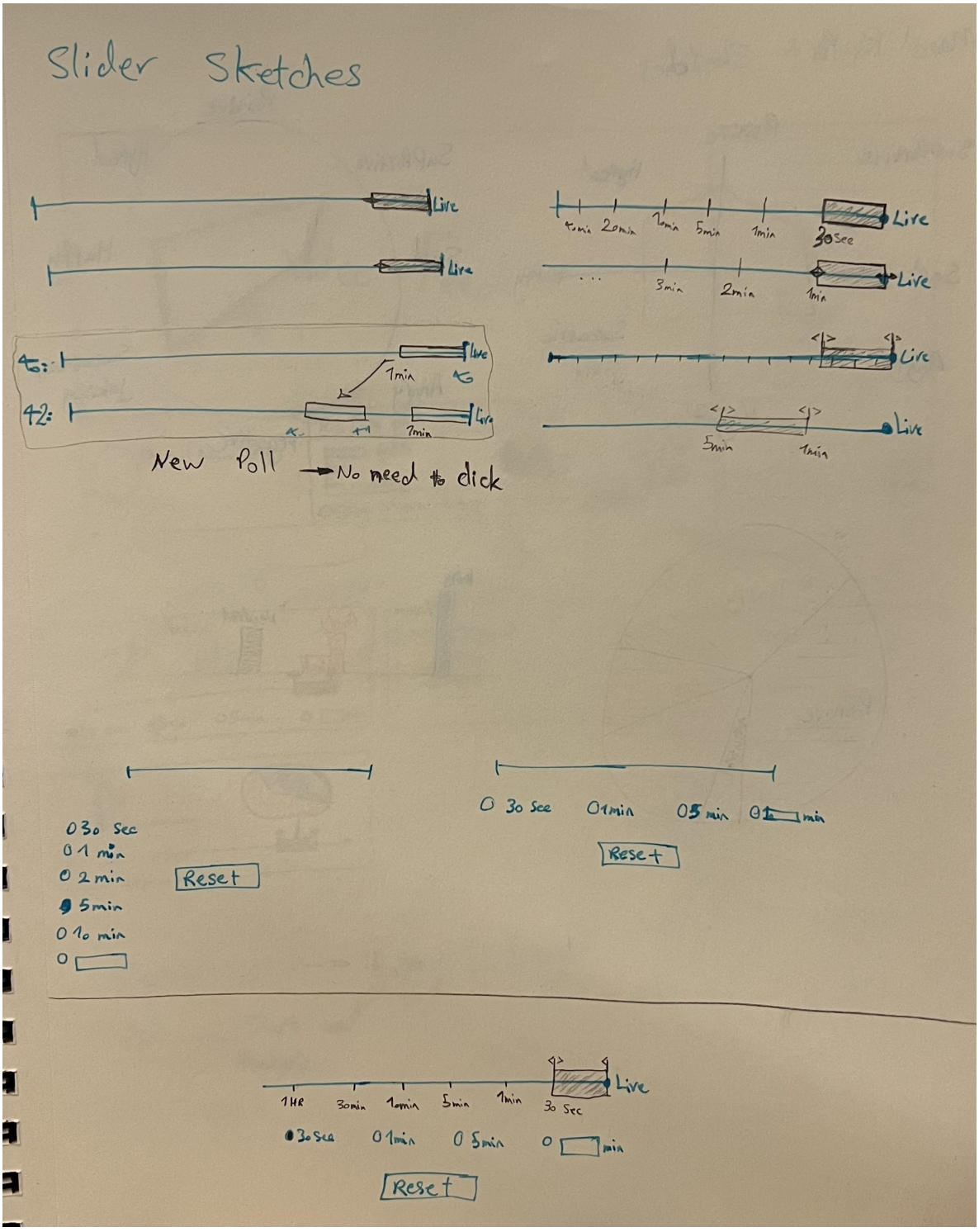

Figure K.8: Time Slider Sketches.

Appendix L

Iteration Screenshots of the Implementation Process

The initial iteration of the Stream Assistant featured a Twitch video and chat feed, alongside three placeholders for the upcoming implementation of its three key features. (see figure L.1)

Furthermore, our next version included the Polling feature equipped with start and stop buttons, along with bar and pie graph options. Additionally, we increased the

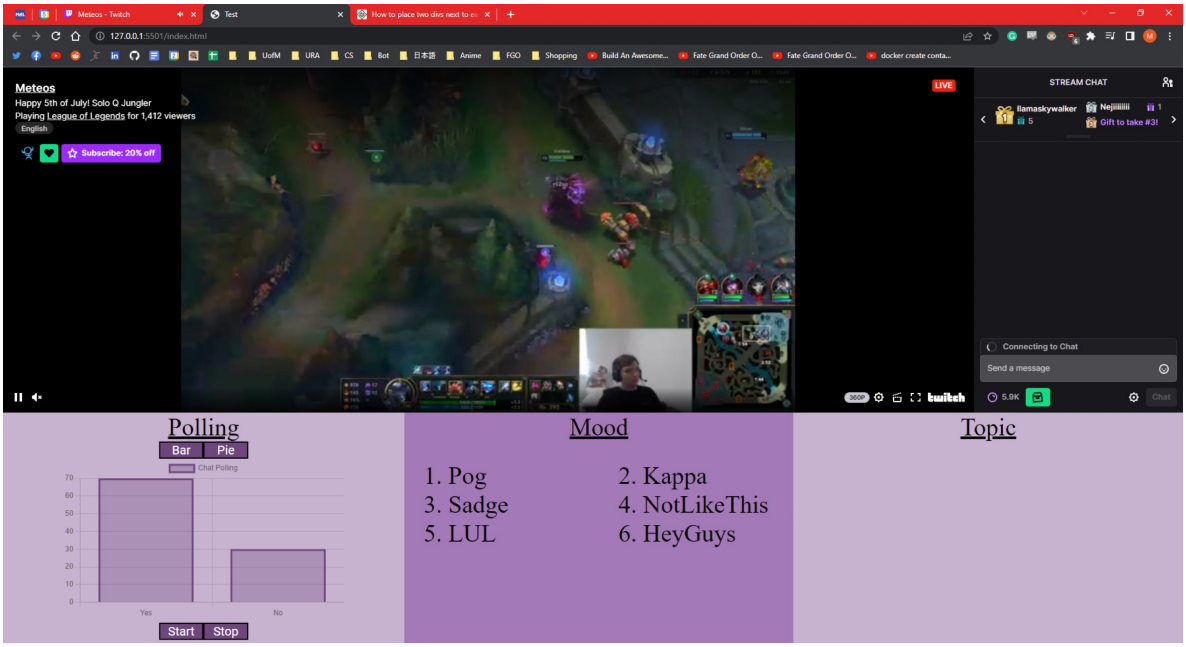

Figure L.1: Initial version of the Stream Assistant.

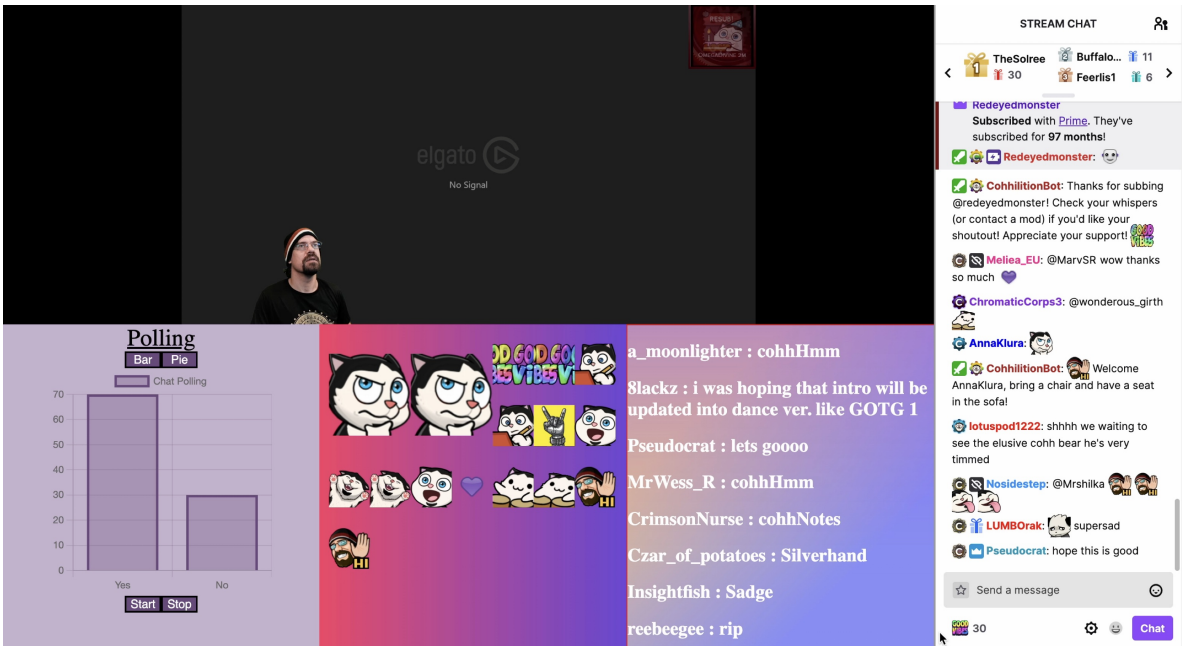

Figure L.2: Stream Assistant after extracting and displaying chat information.

chatbox space to cover the entire screen and were able to successfully display emote images and chat messages in real time.(see figure L.2)

Next, we were able to extract words from messages and show them in a word cloud. (see figure L.3)

In the next step, we decided to integrate the time slider across all three sections in order to convey the idea that it affects all features. Moreover, we removed the pie graph and moved the start and stop buttons if the users prefer not to utilize the slider. We also introduced an update speed slider to provide streamers with the option to have less frequent updates, addressing potential distractions.(see figure L.4)

Based on the feedback we received, we made several adjustments to the prototype during the implementation process. We eliminated the background coloring from the features and restricted the quantity of emotes and words visible in the Emotes and Word Cloud features. Regarding the Polling feature, we set the default mode to show the statistics of the top four frequent words. We also replaced the start and stop buttons in the slider section with preset buttons for setting the range of the slider. (see figure L.5)

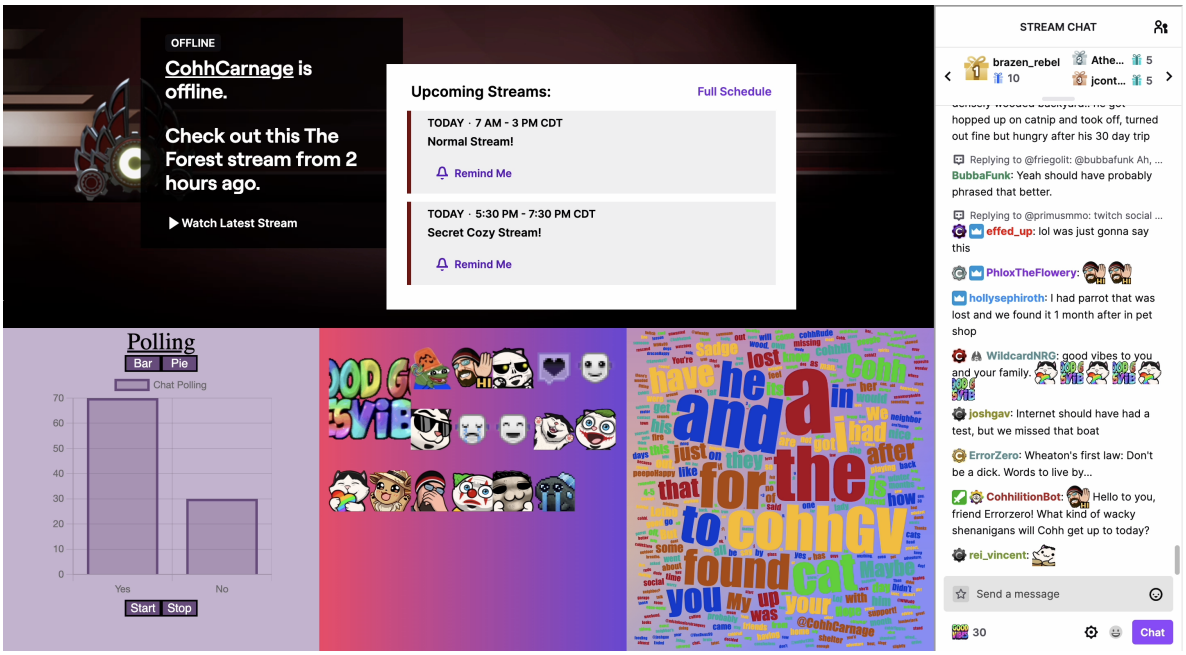

Figure L.3: Stream Assistant after adding the word cloud.

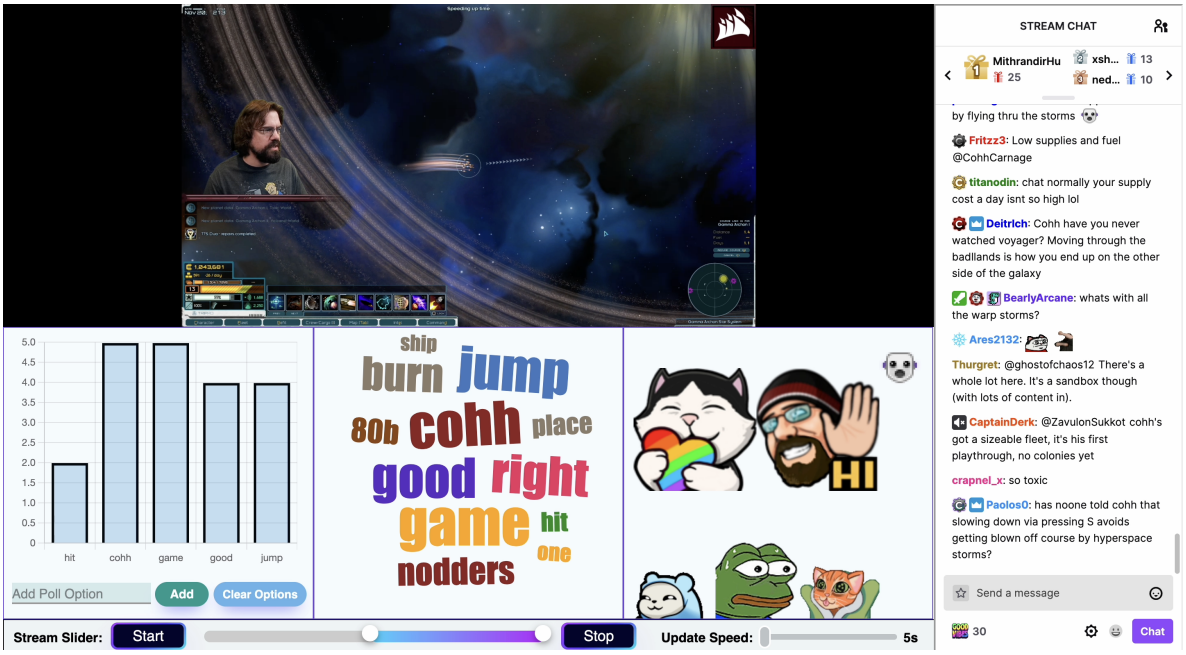

Figure L.4: Stream Assistant after adding sliders.

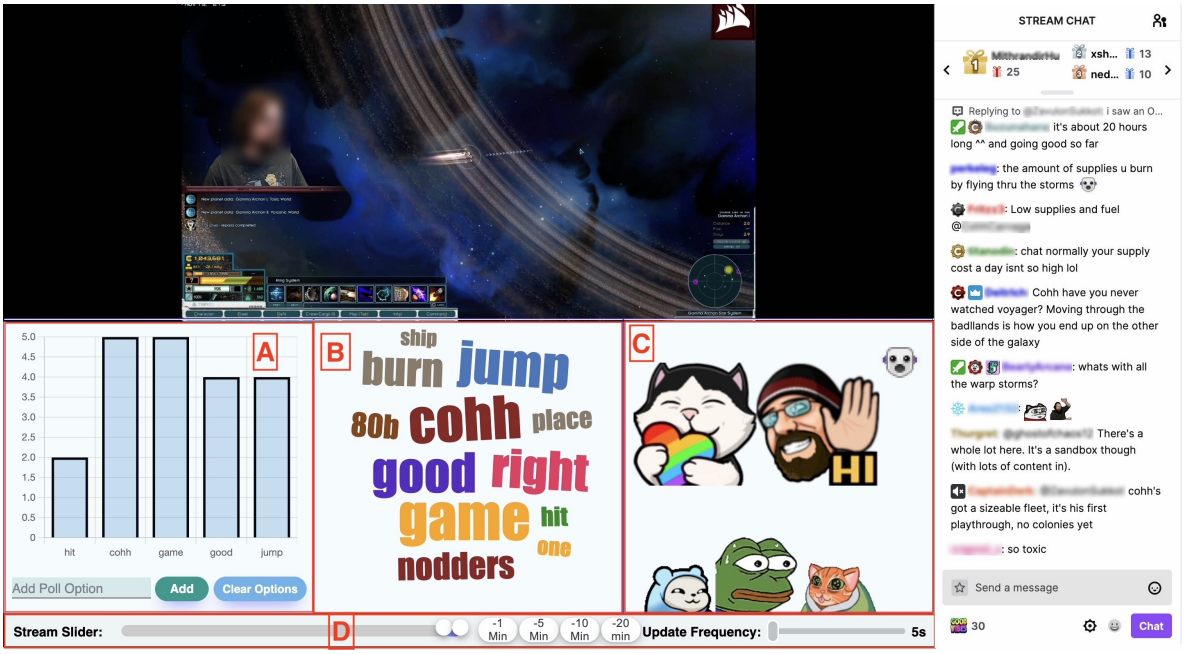

Figure L.5: Stream Assistant after fine-tuning the features.