Understanding Analytics Needs of Video Game Streamers

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ABSTRACT

Live streaming is a rapidly growing industry, with millions of content creators using platforms like Twitch to share games, art, and other activities. However, with this rise in popularity, most streamers often fail to attract viewers and grow their platforms. Analytic tools—which have shown success in other business and learning contexts—may be one potential solution, but their use in streaming settings remains unexplored. In this study, we focused on game streaming and interviewed 18 game streamers on Twitch and Mixer about their information needs and current use of tools, supplemented by explorations into their Discord communities. We find that streamers have a range of content, marketing, and community information needs, many of which are not being met by available tools. We conclude with design implications for developing more streamer-centered analytics for video game streamers.

CCS CONCEPTS

• **Human-centered computing** → **Collaborative and social computing**.

KEYWORDS

live streaming, streamers, analytics, video games

1 INTRODUCTION

Live streaming is a form of social media where individuals simultaneously broadcast themselves and their activity to a live audience in real time. Unlike traditional streaming services, where content production and consumption is asynchronous [11], live streaming platforms boast real time interaction between the streamers and viewers. Aside from playing video games, live streaming is also popular for other content such as the creative arts, education, and food consumption [7, 12, 14]. The most popular streaming platform, Twitch, has reported an average viewership of 1.5million+

at any given moment with 4 million unique creators streaming each month [1]. Some estimates that livestreaming will be a 70 billion USD industry by 2021 [6]. Due to COVID, Live streaming has become more popular than ever before, boasting a 50% increase in hours watched [32].

To attract streamers and good content, platforms offer financial incentives. This could be in the form of donations or subscriptions from audiences, advertisements, or sponsorships. Ninja, arguably the most popular live streamer, had around 1.5 million subscribers on Twitch before switching to Mixer, and reportedly earned about 5.5 million USD per year [15]. However, while top streamers may receive millions of viewers and earn millions of dollars annually, most streamers struggle to grow and engage their community. In their work, Pellicone et al identified that in order to be successful, streamers need to have technical proficiency in streaming technology, need to apply different strategies to build and grow their community, and need to have the right gameplay attitude [29]. They found that new streamers particularly struggle to develop these skills, and hence struggle to grow their community. Hilvert-Bruce et al also found that streamers wanting to grow their community need to be able to properly address their viewers' needs, specifically social needs [18]. These prior works have emphasized the importance and challenges that streamers face around community growth and engagement.

One potential solution to help streamers host more successful streams is to provide them insight through analytics. This is akin to businesses or education institutions leveraging analytics to make more informed decisions [19, 31]. While existing stream platforms do offer analytics to their viewers, little is known around the validity and efficacy of these tools. This leads us to our research questions (1) How do streamers utilize the current information provided to them by their respective streaming platforms? (2) What additional information do streamers need and why? (3) What are some challenges and opportunities to support live streamers and their viewers?

To answer these questions, we first analyzed existing streaming analytics to identify key types of information made available to streamers. For scope, we focused on video game streamers, who represent the largest category of online streamers [34]. We conducted semi-structured interviews with 18 video game streamers from Twitch and Mixer to understand their current practices and needs. We also explored these streamers' respective Discord servers to understand the types of information they seek and solicit from their communities. Overall, we make the following contributions:

- We outline the current ecosystem of analytics and tools that video game streamers use for information seeking
- We describe key information types that address game streamer's identified marketing, content, and community needs.

- We show that there is need for developing human-centered analytics for live game streamers, given the current limitations of internal and external tools.

The goal of this work is to add to the existing knowledge of live streaming by focusing on the analytics aspect of their practices. This paper begins by discussing prior work on live streaming analytics and analytics in other contexts, followed by a qualitative method of interviewing 18 streamers and an exploration of their community, results and insights from these interviews, and a discussion of our findings with design implications.

2 RELATED WORK

To lay the foundation for our work, we turn to a literature review of live streaming, analytics in other contexts, and existing stream analytics.

2.1 Live Streaming

Live streaming refers to the broadcasting of audio and video to an audience in real time. Viewers are able to watch and listen to the streams, and can also interact with and respond to the streamers' actions through a text-based channel. This facilitates a two-way interaction where the streamers can directly respond to and acknowledge viewers, and viewers can participate and influence the contents of the broadcast [13, 26].

While there continues to be a high number of active streamers, becoming a successful streamer is not easy. As found in Johnson and Woodcock's study, professional live streamers generally use the number of viewers and subscribers to determine the success of a given stream [22]. This is not surprising as live stream platforms often have a minimum requirement with regards to viewers and followers for creators to be eligible to monetize their content, which is referred to as the affiliate status on Twitch and partnership status on Mixer. As of 2018, Twitch has reported only approximately 220,000 have reached affiliate status on their platform, which represents less than one percent of their then 3 million creators [5].

We should note that monetizing content, or having a large viewership, is not the only definition of success on streaming platforms. As explored in prior work, aside from those extrinsic factors, live streamer's motivation can also consist of intrinsic factors, such as joy and social interaction [18]. However, even these streamers' view of success are dependent on having a group of viewers (even if small), and unfortunately, many streamers end up broadcasting to no one [17]. Hernandez found that streamers often felt disheartened, exhausted, and found it hard to stay positive after streaming for hours with no social interaction .

In Pellicone and Ahn's work, they identified that streamers need to have (1) the technical proficiency in the hardware, software, and graphic design elements of a broadcast; (2) the right gameplay attitude in adopting a fun, casual, and naturalistic attitude to streaming; and (3) the skills to build a community to increase viewership and potential revenue, and also to retain a consistent group of regular viewers. [29]. However, they found that new streamers often lack the information to develop these skills and would retire soon before they hit their goals. They also found that streamers find streaming to be burdensome because of the unanticipated competition for

viewership. Similarly, Wohn and Freeman noted how streamers utilized internal and external tools to discover information about their audiences for management [35]. Similar work has also outlined other challenges that streamers face, such as knowing what content to prepare for their stream, or how to stand out amongst other streamers and attract specific viewers [12, 14]. All of this points to an opportunity to provide streamers with useful information and insights to help them improve their streams.

2.2 Research on Analytics in Other Contexts

Though minimal research exists on analytics for live streaming, analytics are increasingly used in fields such as business and learning to help develop actionable insights. Business analytics (BA) is primarily concerned with transforming different sets of data into creating useful insights for organizations [19]. Business analytics uses structured data from simple reporting to forecasting; uses unstructured data such as audio and video to support knowledge acquisition, insight generation, problem finding, and problem solving; and uses qualitative data to support decision making with methods such as cognitive mapping and robustness analysis. The overall goal of business analytics is to advance systems and mechanisms for acquiring, generating, assimilating, selecting, and producing knowledge relevant to making business decisions. Similarly, the field of learning analytics (LA) is primarily concerned with utilizing data about learners and their context in order to optimize learning and their environments [31]. Learning analytics can be applied and studied in different levels from the individual learner, the classroom, the institution, and more. These levels afford different sets of data for techniques and applications of learning analytics. Learning analytics techniques are reflective of machine learning and AI methodologies, while applications involve user modelling, knowledge domain modeling, personalization and adaptation [31].

While business and learning analytics focus on different contexts, these analytics have been broadly categorized into: descriptive, predictive, and prescriptive [27]. (1) Descriptive analytics uses data to figure out what happened in the past. Then, it uses and analyzes historical data to identify patterns from samples for reporting trends. Techniques that enable descriptive analytics include dashboards, scorecards, and data warehousing. (2) Predictive analytics uses data to figure out what could happen in the future. It uses a variety of models and techniques to predict future outcomes based on historical and current data. Predictive analytics is what translates big data into meaningful, usable information by allowing decision makers to learn from data how to predict the future behavior of individuals. Techniques that enable predictive analytics include data mining, text mining, and statistical time series forecasting. (3) Prescriptive analytics uses data to prescribe the best course of action to increase the chances of realizing the best outcome. These algorithms may rely solely on data, or expert knowledge, or both. The main outcome of prescriptive modeling is either the best course of action for a given situation, or a rich set of information and expert opinions to provide to a decision maker that could lead to the best possible course of action. Techniques that enable prescriptive analytics include optimization modeling, simulation modeling, expert systems, and group support systems.

However, despite the potential of these analytics, both business and learning analytics still face problems of adoption [25, 30]. Researchers and practitioners have noted that for these analytics to be useful, they need to be human-centered [8, 20]. Applying insights from human centered design, Shum et al. argues that designs of (learning) analytics "should therefore take into account the range of people who will engage with them (who?), what all those people will do with them (what?), the various occasions on which these interactions will take place (when?), the ways in which the analytics will form part of interaction and discourse (how?), and the meanings that these analytics, interactions, and discourse will have for stakeholders (why?)" [8].

Therefore, the goal of this work is to explore the use of analytics for streamers, and to explore their analytics needs. Specifically, we decided to focus on video game streaming. We do so for two key reasons: (1) video game streaming represent a large proportion of live streamers since key popular platforms, e.g. Twitch and Mixer, were initially designed specifically support live game streaming; (2) furthermore, analytics in this space remains underdeveloped and under explored, as an industry that's increasingly embedded in daily lives.

2.3 Twitch, Mixer, Discord and Existing Analytics

Twitch is the premiere and largest platform for live streaming [23]. It originally prioritized video game content, but its increasing popularity attracted content creators across different domains, generating new categories over time to support the content production on the platform [4]. A recent report shows that Just Chatting, a category dedicated to streamers talking with their community without any other content or gameplay shown on stream, continues to be the top category on Twitch with around 175 million hours watched in July 2020 followed by League of Legends and Fortnite [10]. As the dominant market leader in the live streaming industry, the streamers on this platform provide great insights about their experiences regarding community building, content creation, and media production.

Figure 2 shows a snippet of the current stream analytics provided by Twitch over the course of 30 days. This snippet is mostly centered on 4 key metrics regarding the streamer's viewers, followers, subscribers, and revenue. The stacked histogram also shows the breakdown of revenue sources such as from different types of subscribers. On the rest of channel analytics page, Twitch also offers further information such as (1) the breakdown of revenue streams (i.e. paid subscriptions, prime subscriptions, gifted subscriptions, ads, and more.), (2) breakdown of subscriber tiers (number of tier 1, tier 2, and tier 3 subscribers), (3) source of views within Twitch (i.e. views from other channels, views from followers or browse page), (4) channels with similar viewers, (5) reach of Twitch notifications, (6) breakdown of top clips in the channel, and (7) breakdown of tags used to find the channel.

Similarly, Mixer was a competitive and increasingly popular live streaming platform primarily focused on video game content. In 2019, Mixer acquired several large streamers from Twitch, including Ninja, which included reportedly around a $40 million contract over three to five years [15]. These partnerships signaled a large investment in streamers that potentially increased the platform's potential. During the process of interviewing streamers, we found value in the perspective of Mixer streamers with this resurgence and growth. However, not long after we completed our study, Mixer was unfortunately shut down and no longer exists as a live streaming platform.

Other large platforms in this space include Facebook Gaming and Youtube Gaming.In our work, we decided to focus on Twitch and Mixer because of their emphasis on video game live streaming, as opposed to YouTube that has an emphasis on video-on-demand service and less on live interaction, and Facebook, where user accounts are too closely associated with their personal information.

We inspected the analytics offered by Twitch and Mixer, and categorized them into metrics related to stream performance, viewer engagement, and revenue. Table 1 shows the current set of statistics available on either Twitch, Mixer, or both. These are a combination of information presented to streamers in real time, and also information presented to streamers as an after-stream summary. While we found that both platforms had overlapping metrics, we found that Twitch offers more insights regarding viewer engagement analytics. On the other hand, Mixer offers a platform level statistic, top games streamed, while Twitch does not offer any platform level insights to their creators. We also noted how both platforms provided a thorough account of revenue-related analytics.

Another important tool that streamers may be using to communicate with and understand their audience's needs is Discord (Fig. [4]). Discord is a free VoIP, instant messaging, and a digital distribution cross-platform designed for creating and supporting communities in the form of servers [3]. Every user can create their own servers that range from the size of a small group of friends to larger communities with hundreds and thousands of members [21]. We will also examine the use of Discord by streamers in our work.

3 INTERVIEW STUDY

Below, we describe our interview study with streamers from Twitch and Mixer to have a better understanding of their practices and needs.

3.1 Methods

We recruited video game live streamers who regularly streamed on Twitch or Mixer with a range of experiences (6 months to 9 years) and community sizes (129 followers to 67,934 followers). The authors reached out through social media platforms and also through in-person streamer meetups. We informed the participants that this study is voluntary and that they would not be compensated for their participation. All interviews were semi-structured and conducted as a voice call on Discord, and all but one consented to being recorded. Each interview lasted from 30 to 60 minutes. We notified the participants that they would remain anonymous, and that they had the option to refuse to answer any question or leave the interview at any moment.

We began by asking interviewees to recall their most recent streaming experience on their respective platforms, and then asked questions around their general streaming experiences, including things such as their motivations and routine. Next, we asked them
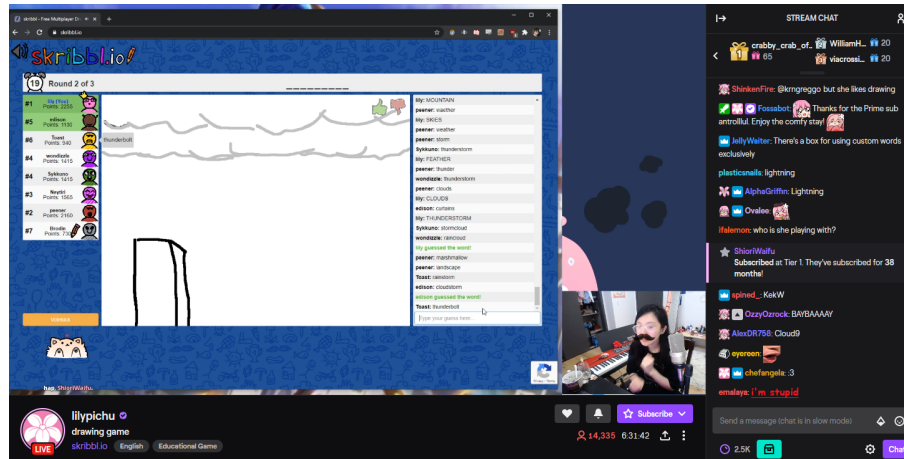
Figure 1: This figure shows the interface of Twitch.tv, specifically lilypichu's channel. The left panel consists of an image of skribbl.io, a multiplayer drawing and guessing game; a camera showing the streamer and her background; the title of the stream with its associated category and tags (english, educational game); viewer count (14, 3350; stream duration (6:31:42). The right panel shows the stream chat, which consists of the top 3 gifters in the community; a running text channel that shows usernames: messages, and stream activities such as a subscription event; and a text box to send a message.
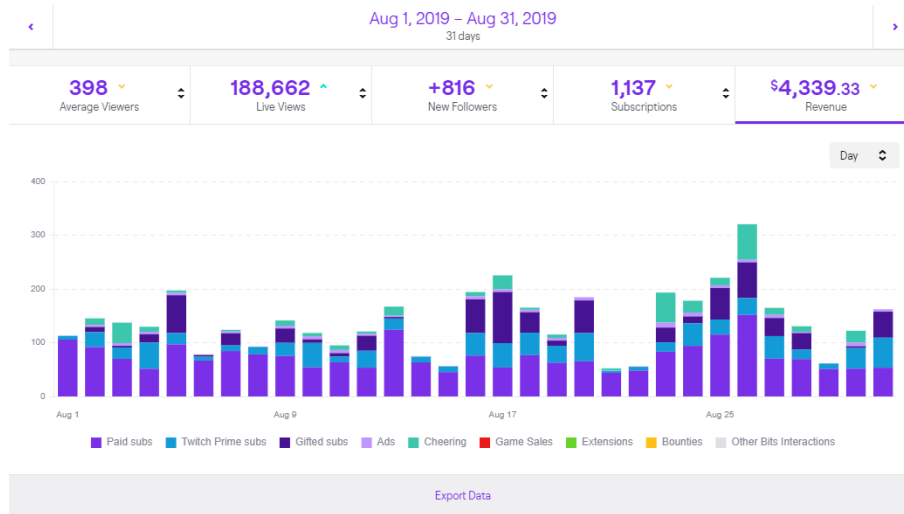

Figure 2: This figure shows a snippet of Twitch stream analytics. At the very top, it shows the duration of the statistics from Aug 1, 2019 - Aug 31- 2019. It also shows statistics on average viewers (398), live views (188, 662), new followers (816), subscriptions (1137), revenue ($4339)[2].

about their interaction and engagement practices with their viewers, and inquired about positive and negative experiences on the platform. Then, we asked about their current and desired information about their viewers. Lastly, we asked them if there was anything they wanted to share that we did not touch upon.

To gain a better picture of their practices, the authors also investigated and analyzed the messages in the participants' discord servers. All of our participants ran Discord servers as an auxiliary community platform for their streams. The primary goal of this analysis was to understand the types of questions that streamers

asked their community. This process was conducted after our interviews to supplement our initial findings regarding information seeking behavior of streamers.

3.2 Participants

From November 2019 to February 2020, we recruited 18 participants with a range of experiences and audience sizes to have a broad understanding of their use of analytics.. The final sample included: one gender-fluid, three female and 14 male; age ranged 21 to 34 (broadly representative of Twitch streamer demographics [22]); 17

Figure 3: This figure shows the interface of Mixer, specifically showing Ninja's channel. The left panel consists of an image of Fortnite, a battle royale shooter game; a camera showing the streamer and his background; the title of the stream; and the number of viewers. The right panel shows the chat with the viewer's username and message.
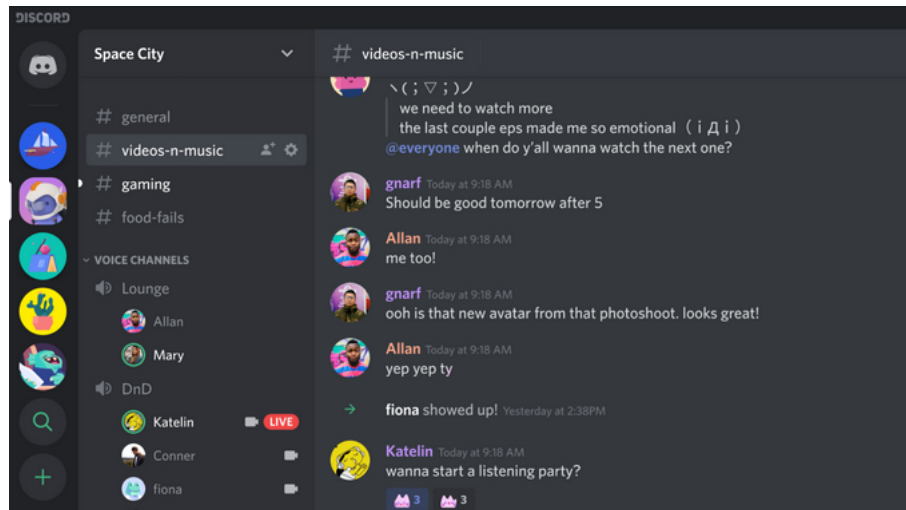

Figure 4: This figure shows a screenshot of Discord. The leftmost column shows the list of servers the user is a part of. The following section shows the list of channels in the specific server including both text and voice channels, and the rightmost section shows the exchange of messages in the "videos-n-music" channel.

streamers from USA and one from Germany; and 5 Mixer streamers and 13 Twitch streamers (see Table 2). These streamers primarily broadcasted video game content, from single-game streamers to variety streamers. While some of our interviewees considered live streaming as a full time job, most of our interviewees only considered live streaming as a part time occupation and had a different job as their main source of income.

3.3 Analyses

For our analyses, we followed the Grounded Theory Coding process discussed in Charmaz [9]. We collected two types of data, interviews and data from discord servers. For data from discord servers, we collected around 8000 streamers' messages from our participants' channels within the past 6 months, ranging from as little as 110 messages to 600 messages.

In analyzing the interview data, the first step was for each author to analyse a subset of the first six interviews, generating a set of open codes. After collating these into an initial set of codes, the authors then engaged in an iterative process of reviewing and labeling the data with emerging codes. During this process and prompted by the emerging themes, the authors reached out to the participants to follow up on the current usage of stream analytics and their perceptions on predictive and prescriptive analytics. The authors then repeated the process for reviewing and labeling the follow-up results based on the existing codes. Once the codes were established, similar codes were used for analyzing the messages collected from Discord servers, paying extra attention to messages that were pinned (messages that were particularly flagged as special) or messages that tagged everyone in the channel. The results were

Table 1: Twitch and Mixer Analytics

Category	Statistics	Twitch	Mixer
Stream Performance	Live views show the total number of views of all the channel's live streams	✓	✓
	Clip Views shows the total number of views from the clips created from the channel	✓	
	Minutes Watched shows the total time the live stream was viewed across all the viewers	✓	
	Average Viewers shows the concurrent viewers in a given stream	✓	
	Max Viewers shows the max number of viewers the channel received in a given time frame	✓	
	Unique Viewers shows the number of unique people who viewed the live stream in a given time frame	✓	
	Host/Raid Viewers shows the percentage of viewers that came from a host or raid. Hosting or raiding occurs when other streamers send their viewers and their community to a different channel	✓	
	Time streamed shows the total time that the streamers has broadcasted for	✓	
	Top Games shows the top games being streamed on Mixer at that moment		✓
	Platform shows a breakdown of which platforms the channel's viewers came from		✓
	Countries shows the countries where the channel's viewers are watching from		✓
Viewer Engagement	Subscriptions (or subs report) shows the number of subscriptions received in a given time frame	✓	✓
	Follows (or new followers) shows the number of follows the channel received in a given time frame	✓	✓
	Unique Chatters shows the number of unique viewers who chatted in a given time frame	✓	
	Chat messages shows the total number of chat messages sent in a given time frame	✓	
	Clips created shows the number of clips created from a stream. Clips are short videos from a live stream that enables users to share events about the broadcast.	✓	
Revenue	Revenue shows the total revenue gained	✓	✓
	Ad breaks shows the total duration of ad breaks ran by the streamer during a stream	✓	
	Ad time per hour shows the average amount of time per hour that ads were running during a stream	✓	
	Notification engagements shows the number of followers that engaged with the streamer's Twitch notification	✓	
	Promotion impressions shows the number of times a stream was viewed during promotions	✓	
	Promotion clicks shows the number of times a stream was clicked during promotions	✓	
	Leaderboards shows the top currency contributors on the channel		✓
	Plotlines shows the amount of sparks and embers spent on the channel over time		✓
	Milestone report shows the current state of sparks (mixer currency) milestone		✓
	Sparks from streaming shows the total number of sparks (mixer currency) earned from streaming during a specific time frame		✓

interpreted based on their relation to the current usage of analytics and the types of information needs.

4 VIDEO GAME LIVE STREAMER'S USES OF CURRENT ANALYTICS

In this section, we present findings about current practices of live streamers before, during, after, and outside of live streaming.

Before a stream starts, streamers often announce to their followers and community members that they are about to go live through social media platforms such as Instagram, Discord, Twitter, and Facebook. When a streamer goes live, platforms also provide in-app notifications and pop-ups to their followers. Streamers utilize social media platforms to maximize the reach of current and potential viewers. Some streamers also tend to look at platform trends to

inform the type of content that they are about to broadcast. One of our interviewees who had experience with streaming on Twitch and Mixer shared:

> "I mostly use [Mixer analytics] to track trends rather than specific numbers [because] it's helpful for game to game comparison." (p2)

Per Table 1, Mixer offers information on the top games streamed on the platform that gives insights to streamers about the most popular game being streamed at a given moment.

Once the broadcast starts, streamers utilize the chat to receive information from their community such as various types of feedback, to converse with their community, and to view dialogue between community members. The chat feature also lets streamers know about new members of the stream whenever they come across a

Table 2: Participant Demographics

ID	Gender	Age-range	Country	Platform	Followers	Experience	Stream Employment	Occupation
P1	M	22-28	USA	Twitch	1,000-5,000	2 Y	Part-time	Digital Marketer
P2	M	29-38	USA	Mixer	10,000-50,000	3.5 Y	Full-time	Content Creator
P3	M	29-38	USA	Twitch	10,000-50,000	5 Y	Full-time	Content Creator
P4	M	22-28	USA	Twitch	0-1,000	2.5 Y	Part-time	Delivery Driver
P5	M	29-38	USA	Twitch	50,000+	9 Y	Part-time	Content Creator
P6	M	29-38	USA	Twitch	0-1,000	3 Y	Part-time	Webinar Producer
P7	M	18-21	USA	Twitch	10,000-50,000	1.5 Y	Full-time	Content Creator
P8	M	18-21	USA	Twitch	50,000+	1.5 Y	Part-time	College Student
P9	M	22-28	Germany	Twitch	50,000+	6 Y	Part-time	Esports Coach
P10	GF	29-38	USA	Twitch	0-1,000	6 M	Part-time	Voice Actor
P11	F	22-28	USA	Twitch	0-1,000	2 Y	Part-time	Veterinary Technician
P12	M	22-28	USA	Twitch	0-1,000	8 M	Part-time	Security Guard
P13	M	29-38	USA	Twitch	0-1,000	6 M	Part-time	Software Engineer
P14	M	18-21	USA	Twitch	5,000-10,000	6 Y	Part-time	Personal Trainer
P15	F	29-38	USA	Mixer	10,000-50,000	1 Y	Full-time	Content Creator
P16	M	22-28	USA	Mixer	50,000+	1.5 Y	Part-time	Software Engineer
P17	M	22-28	USA	Mixer	50,000+	2.5 Y	Full-time	Content Creator
P18	F	29-38	USA	Mixer	10,000-50,000	6 Y	Part-time	Community Manager

new or unfamiliar name. Additionally, streamers have an associated dashboard with their broadcast that shows them an activity feed and statistics for that specific broadcast. The activity feed informs the streamers about new followers, new subscribers, raids/hosts, and bits (twitch currency) donations. Some of these events could also have an associated message directed either to the streamer or fellow viewers. Moreover, streamers also have access to statistics such as length of stream, viewers, total views, followers, subscribers and bitrate (the speed of upload and download). These statistics allow streamers to view the progress of a given stream, such as seeing increase or decrease in followers and subscribers, or the progression of viewership throughout a broadcast.

> "[Twitch Analytics is] so much more easier to use for new streamers. I can basically find anything I need so fast from changing the stream name or game to checking my stats per stream or even checking how much income you've made that month." (p12)

Internal analytics are appealing to new streamers because of its accessibility and simplicity. It allows the streamers to manipulate various content features such as title and category very easily, and also presents analytics in a digestible manner.

Outside of internal analytics, streamers also utilize external analytics during a broadcast such as StreamElements, which is an all-in-one platform providing tools for stream production, monetization, engagement, marketing, and sponsorships [33]. Particularly, StreamElements enable streamers to receive donations from external payment platforms, such as PayPal, and allow viewers to send a message with the donation. Amongst other platforms, StreamElements also provides a chatbot that can blacklist keywords for moderation, and can occasionally post messages often used for promoting other social media links.

Immediately after a stream, streamers are provided with an after-stream summary of their progress, which includes statistics from Table 1. Streamers primarily utilize this to visualize the progress of a given stream, and also to compare their progression over a period of time. This aggregate view of statistics of one or multiple streams enable streamers to look at trends about their content and viewership. This also provides an in-depth analysis of their revenue statistics outside of subscriptions and donations, since streamers also receive monetization from ads, or partnerships with game developers.

Similar to their practice during a broadcast, streamers also utilize external platforms to track growth as a streamer and progress towards platform milestones immediately at the end of their stream. One of our interviewees identified Arsenal.gg as a platform that provides more details than the internal analytics.

> "[Arsenal] gives me stats about peak viewership for that stream or a couple of streams. It gives me very good analytics. That's actually what I used in order for me to get partner [status] because it let me know whether or not I should apply for partnership." (p15)

Arsenal provides viewership statistics that are broken down by the types of games, which is not currently offered by current existing internal platform analytics. These game-specific insights enable streamers to narrow down appealing features about their stream content and also enable streamers to track down self-defined game-specific goals. Additionally, Arsenal offers prescriptive analytics by recommending when streamers should apply for platform partnership from the set of statistics that they collect.

Outside of this time frame, streamers are primarily active on social media platforms and Discord servers to continue interaction with their community. This interaction allows them to solicit and receive direct feedback from their audience such as asking what

games should be played for the next stream, or insights about a new feature embedded on the stream. The time spent outside of streaming is mostly dedicated to community interaction to support stream production and community growth.

To summarize, we found that streamers utilize a variety of tools to support the growth of their stream and their community. During a stream, we found that streamers primarily have access to viewer engagement through chat and viewer statistics, and also have access to revenue information through internal and external donation channels. After a stream, we found that streamers primarily look at visualizations of analytics to see their progression towards milestones and growth as a streamer. Outside of stream, we found that streamers prioritize community interaction and management through external communication channels.

5 INFORMATION TYPES TO SUPPORT ANALYTICS NEEDS

Through our interviews, streamers defined information needs around improving their content, improving their marketing tactics, and supporting their community. The set of information types we found often addressed multiple needs, such as viewer age addressing content and community needs.

5.1 Content Production

Live streaming content production encompasses many things such as the main content (i.e. the game being played), the technical features (whether the stream has high resolution or a crisp camera), and the personality and conversations carried by the streamer. Our interviewees have noted that they are lacking information that can support and improve this area. They noted viewer demographics and shared interest as information types that can help address this space. Through our interviews, streamers noted that viewers' shared interests serve as conversation starters that allow streamers to spark interactions with community members. Personalized interactions are an important aspect of live streaming. They fulfill a social need from the viewer and streamers' perspective. However, current interaction practices are limited because there is a lack of information for streamers to initialize these conversations. Several interviewees noted that having this shared interest is helpful in establishing intimate relationships and interactions. For example, one participant talked about how a shared interest in a similar game such as Super Smash Bros or the genre of retro games helps him start conversations with his viewers.

> "So if they join and they're interested in Smash [game], that's helpful. If they join in and they're interested in retro games, that's helpful. Helps me establish conversation pieces with them. And it would be a good way to find shared crossover audiences I hadn't anticipated" (p1)

Similarly, another interviewee mentioned that shared interests in the game of Half Life, or the genre of shooters, or esports in general enables them to have a dialogue with the audience. For live streaming, a large part of their content is their personality, with a large emphasis on conversations.

> "If I knew that you're playing half life and love shooters and love esports. Those are things that I can pop off like, 'which games do you like? which teams do you like? and so on" (p5)

When streamers are aware of their shared interests with their viewers, they will utilize that information to interact and constantly engage their viewers with their content. It is a way for streamers to fill in the empty air, but also shifting the conversation away from themselves and the gameplay and towards their community.

Similarly, streamers also want to be able to tailor their content not just individually, but to a subset of their viewers. Different viewers can be attracted to a channel for different reasons, such as the streamer's music, personality, or gameplay. Through our interviews, streamers identified that viewer demographic information such as viewer age-range, timezone, and location will enable them to tailor their content. In particular, age-range enables streamers to broadcast age-appropriate content, whether that means narrowing their content to a family friendly community or to a mature community. One of our interviewees only streams family-friendly content and also manages a team of family-friendly streamers. For them, family-friendly means "avoid using profanity both on-stream and in chats, avoid engaging in vulgar or explicit discussions, all while promoting general positivity and good vibes." This streamer and their community value creating content that is open to a younger audience and their family.

Moreover, viewers' location and timezone information enables streamers to target their content based on language or regional preferences. For example, P10 noted that their East Coast friends have tuned in to their Sunday streams and have attracted more European viewers to watch their weekday streams because "it's a very good time for them to be watching then." In this instance, our interviewee noted that different streaming times have attracted different audiences based on their location. In a different instance, P6 noted that his viewers have been predominantly international recently, and his Latin American viewers have preferred interacting with him in both Spanish And English. Being able to know content preferences of viewers' timezone and location enables streamers to tailor specific gameplay or persona to their audiences.

In our exploration of Discord servers, we also found that streamers ask for content-specific feedback from their community. An example includes P16 sharing designs of potential subscriber badges and asking for his community to vote on a design and give specific feedback. Other questions include opinions on adding a specific overlay, or game suggestions for content and viewer engagement. However, it is worth noting that this is not a practical way to interact with community members live, given the already cognitively overwhelming ecosystem streamers have during a stream.

5.2 Marketing Strategies

Another area that our interviewees noted struggling in was the lack of information to support their marketing strategies. Marketing strategies refers to identifying information within and outside of their streaming platform that enables them measure and optimize their return on investment. We found that several information types address this need such as platform-specific trends (i.e. top games on

Table 3: Key Information Types across Areas of Analytics Needs

Content Production	Marketing Strategies	Community Management
Viewer Age	Viewer Income	Viewer Age
Viewer Timezone	Viewer Timezone	Platform-level Viewer History
Viewer Location	Viewer Location	
Shared Interest with Streamer	Viewer Stream Interest	
Content-specific Feedback	Viewer Referral Source	
	Platform-specific Trends	
	Platform-level Category Saturation	
	Platform-level Time Saturation	

Mixer), viewer referral source, viewer stream interest, and viewer demographics including income, timezone, and location.

While stream analytics offer some data around where viewers are coming from, this data is limited within the platform and streamers are unable to identify the efficacy of their other social media efforts. Streamers often promote their streams on Twitter, Facebook, and Discord; however, there is no way for them to see how much those promotions have translated into actual viewership. This information would enable them to allocate resources appropriately, whether they should increase advertisement on a specific channel or whether they should give up on a different channel. One of our interviewees shared a current limitation of internal analytics:

> "Where [did] these people [viewers] came from? Did they click a Discord link? If so, from what server? Probably would be hard to get that info but it would be very nice to have." (p6)

Additionally, streamers want to be able to compare their stream content and performance against other channels to help inform their marketing strategies. However, there is little information available to them to make these assessments. Specifically, they noted that the lack of information around category and time saturation prevents some streamers from achieving their maximum viewership potential, and also limits them from potential stream collaborations. Category saturation informs streamers about categories that are populated with the most viewers and streamers, which can allow streamers to strategize around the content that they are about to broadcast. Similarly, time saturation refers to the distribution of content production and consumption on the platform for a given time, which can inform a streamer's broadcast schedule and optimal time to promote their content on social media. While streamers already receive plenty of information during their broadcast, they still lack integral information about their viewers outside of broadcast. The lack of platform level information is not only detrimental to the streamers' potential but also to the streamers' community.

> "Am I streaming at an effective time? Am I streaming where people can actually see me or am I streaming too late or too early? Am I playing the game that people tend to like watching me play or not?" (p14)

Finally, similar to how viewer demographics of timezone and location allows streamers to tailor their live broadcasted content,

viewer demographics also enable streamers to send target marketing notifications to different subsets of viewers. As one our interviewees mentioned,

> "It would be nice to send out like targeted notifications to people. Because I don't always just want to spam everyone that I'm playing a game because then they'll just unfollow and then they won't get notified the next time I play a game that they actually care about." (p12)

In this instance, the streamer noted that spamming notifications to everybody can lead to losing community members, thus being able to target subsets of audiences is more advantageous from a marketing perspective.

Streamers have identified a set of needs that can help them make decisions around optimal resource allocation regarding promotions, and to help them maximize return on investment of their streams.

5.3 Community Management

Community building and management is a key skill in being a successful streamer [29]. This was reflected in our findings, when our interviewees identified several information types related to community building. First, streamers identified that viewers' history or prior behavior and viewers' age are useful information types that can support community management.

> "A general community idea of upvoting people for being helpful in chat, or [information] that this person has participated in polls in this chat X amount of time. I think that it could be really cool to not just have bits, which are entirely money based, but like citizen scores." (p10)

In this instance, the streamer p10 was asked about their opinions on having more information regarding a user's prior behavior. They are describing the need for information around a user's history to have an indicator of their potential to contribute within a community. Similarly, streamers also take note of viewers who often donate of gift subscriptions to a channel because of how well they foster growth within that community.

We also found that streamers asked questions about their community on their Discord servers. One of our interviewees asked about their community's opinion on potential platform transitions, given that Mixer was shutting down. Additionally, streamers also use this space to post about applications for stream moderators,

who are community members that ensure that chat is behaving according to community norms.

Another key theme related to community is the topic of safety, with regard to having younger viewers. Streamers are concerned in being able to foster a safe space for kids in their channel, such as being wary of toxic or not safe for work (nsfw) messages. This also allows streamers to help shape moderation practices and community norms within their channel. One streamer in particular notes,

> "If I knew for example that every one of my viewers was like 13 maximum, in terms of age, I will not swear on stream anymore. I'll be a bit nicer and would probably not swing ban hammers as quickly." (p9)

Here the streamer is noting that knowing viewers' ages enables him to cater his actions and also cater his moderation practices so as not to push away this group viewers. In a sense, this enables him to craft his community space to cater to his community's actions and attitudes. Similarly, streamers are also interested in having a better understanding of their viewers' prior behavior in other channels. While most streamers welcome any new viewers to their channel, it is not unusual to attract negative viewers, or "trolls". Knowing viewers' prior history can equip streamers and their moderators to be prepared with deleting messages or immediately banning that member from their community. As our interviewees noted:

> "Their [viewers'] history on a banned list, like knowing if they're banned from a channel and what their ban is for, because sometimes you don't want toxic viewers. But if that viewer is like really good at hosting or donating or following. That's good to know too" (p16)
>
> "Okay, this guy's been banned 45 from other people's channels that would be really useful for me to be aware of that. Okay, this guy is being nice to my chat right now there's a possibility there's ulterior motives, right? need to keep an eye on them"(p18)

6 ADDITIONAL INSIGHTS

Across these analytics needs, we describe a couple of high-level insights that persists through streamer's content, marketing, and community needs.

6.1 The Current Lack of Predictive and Prescriptive Analytics

Through our analyses, we noted that current analytics generally focus on providing descriptive data. These platforms offer similar and repetitive time series visualizations for various statistics. However, data analytics can be more than just descriptive, as suggested by business analytics that have found success in applying these in their systems and applications [19, 31]. Our interviewees also noted the value and potential for predictive and prescriptive analytics across their needs for content production, marketing strategies, and community growth. For example:

> "Getting an idea of when my audience tends to be on Twitch would be helpful" (p5) "It would very useful if there was analytics on predictive patterns … and

> have a tool stating like 'around this time people usually start leaving the stream' to enable us to figure out a way to change things to somehow keep people involved." (p12)

P5 reported wanting information about viewer behaviors to help him figure out a future stream schedule that could maximize viewership. Similarly, P12 wants information around viewer behavior to be able to update his content to keep viewers interested and engaged during a stream. In both scenarios, predictive analytics can help. Having predictions of viewer behaviors before and during their streams can enable advertising at the optimal time, and changing contents appropriately.

> "Things like what games caused you to earn the most viewers versus the amount of viewers who are returning per stream. Those kind of things I'm looking for because it tells me where and what things I'm doing right and wrong for my channel. Being able to evaluate your moves like it was a chess board can allow you greater success while only guessing can get you to success but only on a whim." (p14)

P14 is hinting at the desire for prescriptive analytics that can help him inform his content and marketing strategies to achieve greater success as a streamer. In particular, he is hoping for analytics to provide actionable insights that is grounded in his historical data.

6.2 The Desire for Qualitative Feedback

We found that streamers value feedback from their community. However, there are challenges with the receipt, storage and organization of feedback because of how live streaming platforms are designed. While streamers have tried to mitigate this by using external communication tools, there is valuable feedback that is shared and lost during the broadcast. Current analytics fall short on capturing this type of insight.

Our participant shares his thoughts on being able to provide feedback to other streamers. As a streamer and a viewer, he finds value in being able to share his opinion about the current stream content. This could then inform both the streamer's future content production and also marketing strategies, by being able to target and identify groups of viewers who prefer one content over another, and to help inform promotion strategies.

> "Let's say I tune in to a stream I frequent, and I'm not interested in the game they're playing. If I could submit a feedback about why I'm choosing not to watch, that would be interesting." (p13)

Others also just enjoy hearing about how their streams have affected their viewers. This provides positive reinforcement for their current efforts.

> "I have some viewers that literally, they sit there and they lurk. And then they come on and they say something like, I was having one of the worst days and I found your stream by accident. I'm so happy that I came here because it made me feel better." (p15)

But dealing with this data is not easy. Aside from the fact that it is hard to capture, not all feedback is constructive. This introduces a

challenge regarding the balance between different types of feedback received from the community.

> "What will qualify that person to give feedback in the first place? Are they a streamer? Do they know what they're doing? What are their credentials to give that type of feedback?" (p15)

7 DISCUSSION

Live streaming has become an important part of our everyday media. Many individuals turn to live streaming for entertainment, information, and socialization [16, 18, 34]. With the COVID pandemic, the demand and broadcast of live streams is higher than ever before [32].

Unlike traditional streaming services, a critical part of live streaming is the real time interaction between the streamers and viewers. This means that like other similar online communities, having user participation is extremely important. And like these communities, growing a successful stream is hard [24]. Thus, in this paper, we sought to understand how streamers may utilize insights about their viewers to improve their streams. We present our findings from our analyses of existing live streaming analytics and interviews with 18 live game streamers. Using a grounded approach in our data analyses, we describe the ecology of tools being employed before, during, and post streaming.

However, while these tools are being used, we also found that streamers have multiple unmet needs from current analytics. Perhaps the best way to characterize the problem is that existing analytics are performance centric. Our analyses of existing analytics offered by Twitch and Mixer shows that they focus on key streaming metrics of views, followers, and revenues – in some ways, metrics that are most critical for assessing success based on the platforms' definition of success. However, while these types of information are used and useful, they fall short in providing streamers real actionable insights to help them improve. For analytics to really help, they need to help explain what factors can result in changes to these performance metrics.

Based on our data, we classify the needs of streamers into three key categories: to help them improve on their stream content, to help them improve their marketing efforts, and to help them build up their communities. In terms of content needs, streamers expressed desires to gain more insights about their viewers (e.g. demographics and shared interests) so they may better tailor and personalize the stream content. Both in terms of tailoring what they say during streams, as well as what content (i.e. games) to stream. In terms of marketing needs, streamers discussed needing to know how their viewers arrived at their streams so they can better track the efficacy of their marketing efforts. They also wish to gain more insights about how they compare to similar streams to develop their marketing strategies. Finally, our interviewees talked about the need for additional insights about their stream community. This both includes information to help them increase community members' engagement and sense of belonging, but also to ensure the safety of their communities to their viewers.

In addition to advancing our overall understanding of live streaming, our findings also contribute to the research on data analytics. Perhaps most critically, our findings further highlight the need for human-centered design in developing analytics [8]. Through our study with users, we demonstrated that we can gain a better understanding of when, how, and why they use analytics. This can then ensure the value of these tools to users.

Prior work has found that effective socialization and participation of newcomers has been an inherent challenge in social systems [28], and our work contributes to research on supporting community building on attracting participation in these social systems. The findings of our work further demonstrates the challenges in these areas through the problems we identified in community management and growth of live streamers. Then, we outlined recommendations to help live streamers manage and attract further participation within their respective communities in our design implication section below.

7.1 Design Implications

Most immediately, our findings call for additional analytics to support video game streamers' needs relating to content, marketing, and community building. Some of this information may be fairly easily implementable. Information such as timezone and location of the viewers could be inferred through the users' IP address. Though not 100% accurate, it could at least provide some preliminary demographic insights. Streaming platforms should also be able to provide some more data about referrals so streamers can track where their audiences are coming from (external to their platform) or even where viewers go after the stream.

There are also opportunities to develop and utilize inference models about viewers. Based on viewers' behavioral patterns, streaming platforms may provide insights on how viewers' engagement changes during streams, allowing streamers to explore how changing their content or how community-level factors affect viewers' engagement. This also relates to our findings about developing prescriptive and predictive analytics. With these inference models, the analytics can do more than just show users what is going on, but actually highlight opportunities to improve and make suggestions.

But as we noted in our findings, not all valuable insights need to be in the form of quantitative data. Streamers do see value in qualitative feedback. However, most of qualitative feedback exchange occurs outside the streaming platform and outside of broadcast times. Not only is it hard for streamers to receive qualitative feedback during broadcast, but it is also hard for them to store and recall feedback amongst all the interactions and messages during their stream. A potential solution is to be able to extract and store helpful and impactful messages during a stream, and be able to present it to the streamer during or after their stream to help their streams.

But this last point also highlights the importance of considering the optimal time and optimal way of presenting this information to streamers. Not all of the data should be shown to the streamers at all times. For instance, individual viewer demographic information really enables streamers to have an intimate conversation with their viewers, but may not always be helpful to streamers for an after-stream summary. On the other hand, while referral source could be a useful thing to know during a stream, it is most useful to a streamer outside of stream to help them prepare strategies and techniques to grow their community. In addition, even if the same data is useful before, during and after streams, there are significant

design considerations to be made in order to meet the attentional demands of the streamer.

7.2 Limitations

While Twitch and Mixer are considered large streaming platforms for video game streamers, this study did not include the experiences and practices of streamers from Facebook Gaming and Youtube Gaming, both of which are competitive and growing platforms in the industry. While we found significant results regarding video game streamers analytical needs, they may not necessarily translate to streamers on other platforms such as Facebook and Youtube, given that they may provide some of the missing analytics mentioned here and that they provide more utility to their users outside of live streaming.

8 CONCLUSION

This study makes contributions to the live streaming literature by providing a view into how streamers utilize and gather information about their performance and their community. Extending prior work on the experiences of live streamers, we outline the uses and limitations of current analytics tools of streaming platforms, which allows us to capture the set of information needs of this community. Our findings allow us to develop some insights around usage and potential of analytics, and implications for developing human-centered analytics.

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