

Mapping Design Spaces for Audience Participation in Game Live Streaming

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ABSTRACT

Live streaming sites such as Twitch offer new ways for remote audiences to engage with and affect gameplay. While research has considered how audiences interact with games, HCI lacks clear demarcations of the potential design spaces for audience participation. This paper introduces and validates a theme map of audience participation in game live streaming for student designers. This map is a lens that reveals relationships among themes and sub-themes of Agency, Pacing, and Community—to explore, reflect upon, describe, and make sense of emerging, complex design spaces. We are the first to articulate such a lens, and to provide a reflective tool to support future research and education. To create the map, we perform a thematic analysis of design process documents of a course on audience participation for Twitch, using this analysis to visually coordinate relationships between important themes. To help student designers analyze and reflect on existing experiences, we supplement the theme map with a set of mapping procedures. We validate the applicability of our map with a second set of student designers, who found the map useful as a comparative and reflective tool.

CCS CONCEPTS

• Human-centered computing → Social media.

KEYWORDS

Twitch; agency; pacing; community; live performance

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1 INTRODUCTION

In the social-distancing era of COVID-19, audiences are turning to live-streaming as a substitute for rich in-person experiences. Audience participation in live-streaming games offers new ways

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for audiences to engage with play, however the potential design spaces have not yet been adequately described in HCI.

Research suggests that deeply engaging viewers through audience participation has the power to create authentic social connections, turning “parasocial” (one-direction) interactions with streamers into bidirectional social experiences, akin to “seeing friends” [90]. Through interaction, live-streams can act as virtual “third places” [90], communities with a multidimensional ecosystem of relationships between streamer and viewers [89]. Such rich interaction has been shown to increase viewer attitudes toward live-streams, and enhance their perceived value [15].

On platforms like Twitch, research has considered new ways for audiences to directly participate in or affect streamer’s gameplay [69]. This includes influencing-in game challenges [66, 77], placing bets [60], giving hits [48], and even controlling gameplay [45, 47, 62]. In spite of the benefits of rich audience participation dynamics, many live streaming platforms primarily support classic participatory mechanics, such as commenting via a text chat, emoting with icons, and gifting money [35, 51, 81, 84]. One reason for this is that game live-streaming presently lacks an explicit representation of the design space in game live streaming.

In this paper, we present a theme map of an audience participation design space in game live streaming. Through this map, we identify key design themes that inform characteristics, affordances, and constraints of participatory live-streaming experiences. By defining a *potential* design space, this work offers value to student designers, educators, and researchers to design new experiences and identify research gaps. As research and design evolves in this domain, our map will likewise expand to consider new opportunities for participatory live-streaming.

This paper contributes the following:

- (1) A theme map diagramming a design space for audience participation in game live streaming
- (2) Step-by-step instructions on how to use our theme map for design analysis
- (3) Empirical findings that validate use of the theme map as a design analysis tool for students
- (4) Articulations of three sensitizing concepts for participatory live-streaming experiences

We construct this map by studying how designers create interactive audience experiences in an undergraduate course centered around Twitch, currently the most popular platform for game live streaming [27, 82]. First, we perform a bottom-up thematic analysis of student process documents. From this analysis, we identify three sensitizing concepts, *Agency*, *Pacing*, and *Community*. We use these

sensitizing concepts to spatially map related themes, employing background literature to inform spatial relationships on a three set Venn diagram. We validate the clarity, fit, and usefulness of the theme map with a second set of student designers, who used the map to reflect on their existing projects. Together, this paper lays the groundwork to help designers better understand audience participation spaces in game live streaming.

2 RELATED WORK

We situate our work in prior literature on audience participation in live streaming. First, we introduce live-streaming, and describe our focus on game-live streaming. Then, we describe audience participation dynamics, and present challenges for participatory live-streaming experiences.

2.1 Live-Streaming Platforms

Live streaming platforms, such as Twitch¹, are driving a new wave of live media experiences that give remote audiences greater participatory roles, such as voting on game mechanics that affect streamed gameplay. Broadly, live streaming comprises of performers or “streamers” broadcasting audiovisual content to remote audiences or “viewers.” Viewers typically react to the content, streamers, and one other through text-based communication channels, however an emerging trend in live streaming shifts emphasis of the medium from spectatorship to social interactions between streamers and their viewers [50]. For instance, viewers can respond to content, streamers, and one another via a text chat, emojis, and gifts [51, 81].

In recent years, live streaming has received increasing attention from the HCI community [32, 35, 51, 69]. In 2020, Stay-at-home mandates and quarantines related to the COVID-19 pandemic have further increased participation in online gaming [40]. For instance, the #PlayApartTogether initiative was developed as a coping strategy for people to socialize [40]. Due to the pandemic, main stream sports such as soccer [87] and darts [21] have likewise adapted spectatorship to live-streaming platforms.

Presently, many commercial live-streaming platforms exist. Founded in 2011, Twitch has on average 3.8 million broadcasters per month (as of March 2020), and 15 million daily Twitch viewers, watching on average 106 minutes per day over the course of a year [11, 83]. In competition with Twitch, Facebook and YouTube have launched game-streaming platforms, and several language-specific platforms have emerged, such as the Chinese platform, HUYA Live [25].

2.2 Game Live Streaming

We focus on game live streaming due to the interactive nature of games, and the benefits of engagement with play. Participation provides many positive benefits for games; it can increase engagement [31] and experience involvement [29]. Through immersive “deep play” [10, 19, 24] games can also increase emotional investment [76, 79]. Game experiences can even lead to *flow*, a state of total immersion and optimal performance [18, 23, 71].

Twitch has gained widespread popularity in online streaming communities for a range of game content [72]; individual streamers use Twitch to play through games and comment on their experience [28], channels broadcast professional commentaries of

massively-multiplayer role playing competitive games (MMORPGs) like *Fortnite* and *League of Legends* [7, 74]. Small groups even use Twitch to stream tabletop role-playing games (RPGs) [28].

2.3 Designing for Audience Participation

The capacity to alter experiences has empowered audiences beyond traditional roles, and has led to a dissolution of traditional audience-hood [76]. A growing trend in live streaming shifts focus away from passive spectatorship towards active participation [73, 81]. For this reason, the HCI community has a strong interest in how technology can support audience participation in live streaming [13, 32, 35, 64, 69, 76, 81, 86].

Audience participation is affected not only by the immersiveness of content, but by the immediacy of interactions with the streamer, and the sociality of the experience [34]. Reviewing theater, theme park, and game literature, Striner [76] defines audience interactivity as a range of experiences and roles that may allow audiences to participate or interact, and describes a *spectrum* of audience interactivity in entertainment. Cerratto-Pargman [13] further explains these interactions are not simply social; they can become integral elements of a play experience.

We find game live streaming particularly well-suited for crafting engaging audience participation experiences. Game live streaming enables viewers not only to interact socially, but to affect gameplay in meaningful ways [32, 62, 64, 66, 69, 77]. The popularity of game live streaming platforms has driven researchers and designers to consider new ways for viewers to engage with play experiences. For instance, *Choice Chamber* [77] and *Legend of Dungeon: Masters* [66] allowed audiences to influence in-game challenges, and *Streamote* empowered audiences to place bets using virtual currency [60]. Likewise, *Helpstone* provided contextual information about a game, letting “audience participants” suggest hints for the streamer [48]. Further, *Twitch Plays Pokémon* parsed audience commands in a Twitch chat stream to control games from the Nintendo series [45, 62], and *CrowdChess* aggregated audience input in a chess game [47].

2.4 Design Challenges

As game live streaming has become popular, researchers have begun to identify interaction design challenges for audience agency, time, and viewer-streamer relationships [32]. A primary challenge in participatory streaming experiences is how to give agency to multiple audience-participants. Lu [51] suggests that streamers and viewers both desire interactions that are more substantial and consequential than commenting and gifting, however it is difficult to do this without compromising the overall experience [32]. For instance, a public text chat is effective at enabling audience participation, however participation begins to break down when the number of viewers chatting gets too large [35].

In complement to agency, temporal challenges in live-streaming include latency, stream schedules, and viewer attention [32]. For instance, viewers might attempt to simultaneously participate in multiple streams that are broadcasting an event [36]. Another temporal challenge is conveying the feeling of liveness. In sports, Davis (2020) [21] suggests that it is difficult to recreate physical liveness online; they explain that an integral part of the experience are

¹<https://www.twitch.tv>

the “dancing cheerleaders, gregarious announcers and an inebriated audience roaring bawdily along.” Weed (2020) [87] elaborates, describing the importance of recreating the drama of fans in the stadium.

Designing effective viewer-streamer relationships is also a challenge. Via text chat, viewers can comment on the action in a stream, talk amongst themselves, or direct questions and discussions at the streamer [4, 35, 51]. In response, streamers can reply to questions in the chat, comment on chat dynamics, participate in informal conversations, and conduct formal polls [4, 35, 46, 68, 81]. Glickman [32] explains that these dynamic become complicated as viewers compete for limited streamer attention, a form of validation for viewers.

3 METHOD: IDENTIFYING THEMES, SENSITIZING CONCEPTS AND DEVELOPING THEME MAP

The following section describes our method for developing the theme map. First, we performed a bottom-up thematic analysis of student process documents from an undergraduate game design course for audience participation on Twitch. From this analysis, we identified three sensitizing concepts, Agency, Pacing, and Community. We used these sensitizing concepts to spatially map related themes, using background literature to inform spatial relationships.

3.1 “Design for Crowd and Cloud” Course

“Design for Crowd and Cloud (Twitch Plays Game Design)” was an undergraduate course at Carnegie Mellon University that taught game design for audience participation in live-streaming games on Twitch. During the course, students studied existing game design techniques, and designed Twitch play experiences for viewer participation, considering symmetric and asymmetric multiplayer experiences, and issues of stream latency and scale. In the final project, student teams were instructed to develop either an original game that took advantage of “crowd and cloud” play dynamics, or a Twitch modification that addressed a problem identified by the class. Preceding the final project, students learned about live streaming, game design, and audience participation dynamics. The syllabus of course content is located here: <https://bit.ly/3bq6Qet>.

3.2 Students and Teams

Thirty (30) students participated in the course. Of these students, one was a graduate student. For the final project, students formed eight teams; six teams designed original games for Twitch-based experiences, and two teams designed Twitch interfaces to address streamer and audience interaction needs.

We chose to use these student projects instead of analyzing existing audience participation tools and extensions for several reasons. Our goal was to develop a theme map of the *potential* design space for this domain, however, we found that popular live-streaming sites use limited viewer engagement tools (e.g. the chat feature on Twitch). Further, game developers create content for a variety of reasons, and have a range of experience.

In contrast to professionals, students were pursuing a degree in game design, had a background in technical development, and had considerable exposure to audience participation streaming games over the semester long course. Further, students were not limited

by professional goals of success (e.g. a visually polished product), experimenting with the design space rather than developing a scalable experience. By using student projects, we also gained access to their process documents, which would have been more difficult to obtain from industry professionals.

3.3 Summary of Team Projects

The following section summarizes the goals and challenges of the eight final projects from the course (Table 1). Screenshots of a subset of these projects are shown in Figure 1.

Together, these projects comprised a range of goals, designs, and challenges. Six of the eight teams designed games for Twitch, ranging from a rhythm matching game for blind streamers (*Duet Master*), an idle kingdom building game (*Kingdom Builders*) and a live-action library call number game (*Twitch Plays Undergrad*). The other two teams designed extensions to cultivate streamer-viewer relationships (*Twitch Meets*) and to improve the Twitch donation platform (*Rainbow Sunshine*).

Outlined in Table 1, teams also faced a range of challenges. *Duet Master*, *Always Present*, and *Rainbow Sunshine* had trouble scoping their experience for consequential audience participation. Similarly, *Kingdom Builders*, *Oh The Horror*, and *Twitch Plays Undergrad*, had trouble balancing game pacing and player choice with team dynamics. Likewise, *Typing of the Dead* and *Twitch Meets* struggled to balance gameplay with viewer and streamer relationships.

These course projects gave us (1) a consistent context to consider audience participation design in live streaming, and (2) unique access to design process documents that experts may not have been willing to share.

3.4 Formatting Process Documents

Process Documents: Each group produced a set of process documents as part of the final project submission. As described by Bardzell [2], these process documents embodied “action-notes,” the goal of which was to support design ideation, and to trace the emerging rationale of a project. The actual process documents varied between teams, however each team produced on average 5.5 documents, with one team that chose to produce one long process document. Each team produced on average 4382.5 words across their process documents. Types of documents included a “*Concept Document*,” “*Design Iteration*,” “*Trial and Error*,” “*Prototyping*,” “*Playtest Report*,” “*Notes*,” “*Process Book*,” “*Feature List*,” “*Interim Milestones*,” “*Research Interview*,” and “*Final Project Pitch*.”

Formatting Documents: Process documents from all teams were compiled into one Excel sheet for coding. Each process document was segmented by natural breaks in the text; some lines in the sheet contained paragraphs (if the document was a more formal description), while others contained single words or phrases that were part of a short description or set of bullet points. This format made it easier to code lines separately, but in the context of the larger document. The full document contained 2042 lines.

3.5 Thematic Analysis

The following section describes our thematic analysis procedure, a qualitative method for identifying, analysing, and reporting themes that is more flexible than traditional grounded theory [9]. Two

Table 1: A summary of the eight team projects. The table outlines whether each project was a game or extension, and presents the team’s audience participation goals. The table also overviews each final design and design challenges each team faced.

Project	Type	Goals	Overview of Final Design	Challenges
<i>Duet Master</i>	Game	Allow blind streamers to interact with sighted streamers	Rhythm matching call-and-response game. As blind players matched song rhythms, emojis produced in the Twitch chat turned into emotional sound effects for the streamer to hear.	The team had trouble effectively scoping the game, identifying player needs, and designing for system affordances.
<i>Typing of the Dead</i>	Game	Address streamer public speaking anxiety	VR storytelling zombie game where viewers generate zombies by typing words (associated with those zombies) into the Twitch chat. Streamers kill zombies by weaving the words into a larger narrative, continuing the story until time runs out to stay alive.	Streamers wanted explicit feedback on the impact of their voting, the correctness of their chat commands, and their contribution to the narrative. Streamers found the game could be “intense” and “stressful.”
<i>Kingdom Builders</i>	Game	Strengthen Twitch channel communities	Idle game intended to be played passively by stream viewers. During the game, viewers select a role-based character, and passively help build a kingdom by allowing their character to gather resources and build structures.	Designers struggled to balance the passive nature of idle gaming with customization and player choice. Players also had trouble understanding the impact of different roles of the game, and the effects of game events.
<i>Always Present</i>	Game	Design entertaining game that includes an audience	2D puzzle-platformer based around a robot with a wacky aesthetic and unexpected abilities. The robot could launch their head and reach high places with a magnetic arm.	The team had trouble meaningfully incorporating the Twitch chat into the game, and on evolving the functions of the robot’s abilities.
<i>Oh the Horror</i>	Game	Create feeling of experiential ownership	Body modification game where body mutations were controlled by voting in the Twitch chat. Played in a surreal third person views, viewers modified the body of a grotesque creature to help the Twitch player navigate a 3D maze.	The team was challenged to balance the value of viewer trolling; too much trolling could slow down gameplay, whereas too much solidarity resulted in limited streamer and viewer interaction and play.
<i>Twitch Meets</i>	Extension	Cultivate streamer and viewer relationships	Designed to operate during waiting periods between live streams, the extension directly connected individual streamers and viewers, allowing them to play mini games together.	The team had to conceptualize how low-commitment experiences fit into larger game dynamics, and to consider streamer control and viewer anxiety issues.
<i>Twitch Plays Undergrad</i>	Game	Design a game taking advantage of the physical world	A Live-action Role Playing (LARP) game where a streamer deciphers a generated essay topic by finding books related to that topic in a college library. Viewers input library call numbers in the Twitch chat to communicate with the streamer, which the streamer printed out on a wireless printer as they hunted for the associated books.	The physicality of the game lead to technical difficulties, such as accounting for lag between the video and Twitch stream. The team had to give users a concrete way to select a book topic, and to account for game trolls.
<i>Rainbow Sunshine</i>	Extension	Improve Twitch’s fundraising platform	Twitch extension that helps streamers communicate fundraising progress while enhancing the larger stream viewer experience.	The team had trouble making effective overlays that differentiated between moderator and stakeholder views, communicated donation goals, and motivated users.

authors conducted the thematic analysis and developed the theme map together. One author participated and observed the course over the semester. The other author was not involved in the course, but was an expert in online gaming streaming.

We employ the six-phase framework developed by Braun and Clarke (2006) [8, 52] to identify important themes and sub-themes in the data. We borrow the notion of *sensitizing concepts* from grounded theory to visually organize the theme map. Sensitizing concepts are interpretive devices that offer ways of seeing, organizing, and understanding an experience, “drawing attention to important features of social interaction.” [6].

3.5.1 Open Coding. The first two steps of thematic analysis are becoming familiar with the data, and generating initial codes. The authors first read and reread the dataset, and made notes of their

first impressions. In the second step, the authors iteratively open-coded the dataset. First, they independently produced open codes for two of the eight projects. The authors discussed the codes they observed in this sample, and created an initial set of open-codes. After this, they coded the remaining six projects using these set, discussed additional codes they observed, and added them to the set. Then they did a final pass through the dataset, making sure they had not missed any codes.

3.5.2 Identifying Thematic Relationships and Sensitizing Concepts. After open-coding the data, the authors searched for themes (step 3), reviewed them (step 4), and defined them in a codebook (step 5). Before writing up the analysis (step 6), the authors further organized the themes by three high-level sensitizing concepts, borrowed from grounded theory [6].

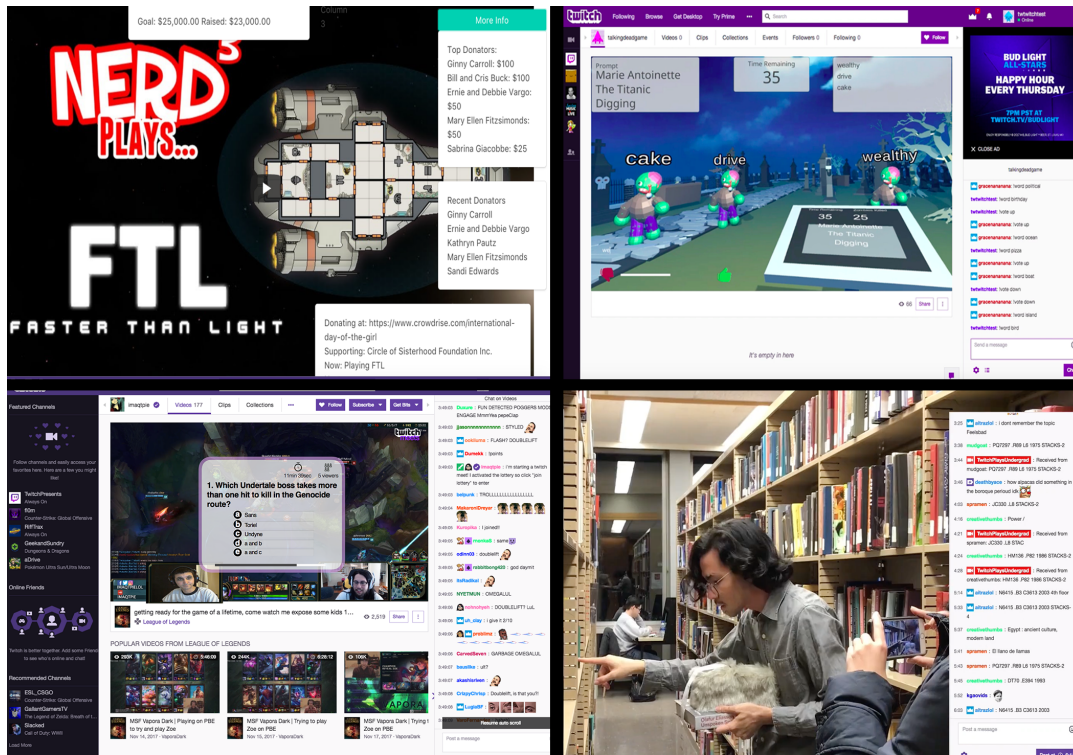


Figure 1: Screenshots from four final projects, *Rainbow Sunshine Donation Extension* (Top Left), *Typing of the Dead* (Top Right), *Twitch Meets* (Bottom Left), and *Twitch Plays Undergrad* (Bottom Right).

The authors identified themes by first examining the open codes, and grouping clearly related codes together in a Google sheet. After grouping the related codes, the authors discussed the broader themes that each code grouping could represent, and created an initial codebook with a theme name and description. After this, the authors reviewed the themes. They considered whether the data supported the themes, whether there were clear distinctions between themes, and whether they had missed any important themes. The final product was a set of 19 themes divided into 58 sub-themes. We found that the large number of sub-themes were necessary to fully describe the complex dataset. The authors also identified three sensitizing concepts, *Agency*, *Pacing*, and *Community* that encapsulated the themes and sub-themes. These sensitizing concepts were reflected in the literature, and were used to organize the theme map.

3.6 Constructing Theme Map

The authors constructed the theme map by diagramming semantic relationships between sensitizing concepts, themes, and sub-themes onto a three set Venn diagram. This theme map was based on concept mapping, which allows students to understand relationships between concepts and related domains; manipulating a complex set of relationships in a diagram helps them remember and analyze component parts [20].

To construct the map, the authors first organized the sensitizing concepts along three edges of an equilateral triangle. Then, they used background literature to spatially organize related themes;

strongly related themes (e.g. *Power* and *Control*) were mapped closer to one another than weaker themes (e.g. *Attention* and *Privacy*). Sub-themes were similarly organized in relation to themes and each other.

The literature expressed more complex relationships between sensitizing concepts and themes than we anticipated. For instance, the theme *Engagement* was affected by both *Agency* and *Pacing*, *Streamer-Viewer Relationships* were affected by *Pacing* and *Community*, and *Power* was affected by all three sensitizing concepts. To represent the complex nature of these relationships, the authors reconstructed the map as a Venn diagram. After constructing the initial map, the authors iterated on the placement of the themes and sub-themes through several discussions.²

4 THEMES

In this section, we describe our thematic findings. These consist of 19 themes grouped by three sensitizing concepts, which offer a lens through which to study, organize, and understand relationships between themes [14]. First, we contextualize the sensitizing concepts and related themes in literature. Then, we use student projects to demonstrate the complex relationships between sensitizing concepts and themes.

²We considered quantitatively estimating thematic relationships, e.g. by the number of search results that appear with paired words on Google Scholar, however, due to the sheer volume of themes and sub-themes, we chose to use a qualitative approach, similar to that described by Butler (2010) [12].

Table 2: Example quotes of each theme for Agency.

Theme	Quote
Live Streaming Agency	<i>Mutations will take place every x seconds, with whatever parts having the most votes winning and the player mutating into that. Chat would have to continue to vote to keep him in that state lest dissenters change the character into a less desirable form. (Oh the Horror)</i>
Choice	<i>The winning pair will be awarded with the profiles of the other players involved—it is up to them whether they choose to match with each other or with another player in the game. (Twitch Meets)</i>
Interaction	<i>Streamers can end the interaction whenever they want, while non-selected viewers are free to watch or provide input through chat. (Twitch Meets)</i>
Control	<i>This game was inspired by the concept of taking chat interaction a step forward. Kind of on the lines of having the chat control an important aspect of the game except, instead of a technical or atmospheric change, they can actually give the game a lot more direction. (Oh the Horror)</i>

Table 3: Example quotes of each theme for Pacing.

Theme	Quote
Temporality	<i>We also changed our game to be call-and-response instead of instantaneous matching, which required the player to play the notes one bar later than the computer played them. (Duet Master)</i>
Progression	<i>Our team made a Twitch extension that provides philanthropic streamers with the tools necessary to effectively communicate the progress of their fundraising to their audience while enhancing the overall viewing experience for the viewers of the stream. (Rainbow Sunshine)</i>
Attention	<i>Although there are UI elements for the streamer to adjust the lottery timer and see how many people have joined the lottery, we didn't want to put too many degrees of control as it would give the streamer too much to think about and take away from the casual aspect of the extension. (Twitch Meets)</i>
Distraction	<i>The playtesters indicated that they forgot about our game because the video was interesting, and they believed that this reflected positively on the game and said that they would probably check back on it very occasionally. They echoed the sentiment that they valued low commitment and minimizing distraction from the stream the most. (Kingdom Builders)</i>
Engagement	<i>Our extension, although not a game, utilizes the concept of reward to engage viewers through the "lottery" system – viewers who win the lottery not only gain the opportunity to interact with their favorite streamer, but also make public their own Twitch handle/presence to the rest of the community. (Twitch Meets)</i>
Gametime/ Downtime	<i>Many streamers play games that suffer from downtimes in-between matches – these include queue timers, load screens, and just game fatigue in general. They don't have many options to entertain viewers when these downtimes occur. Some streamers respond to the Twitch chat, while others opt to play side games instead. (Twitch Meets)</i>
Stream Schedule	<i>If I could, I would want to stream everyday, all day (Laughs)...however, grades, health, & friends are important too...That being said, I try and stream for a couple hours every other day; this gives me some sort of schedule which is good for my viewers and my academics. (Twitch Plays Undergrad)</i>

4.1 Agency

Murray [57] describes agency as “the satisfying power to take meaningful action and see the results of our decisions and choices.” In complement, Smith [73] contends that agency is “the most interesting part of ...live streaming...broadcaster and spectator – phenomenon...the malleability of activity and passivity.”

We found four themes common to the Agency sensitizing concept: *live-streaming agency*, *interaction*, *choice*, and *control*. This category describes the range of *agency* that exists between streamers and viewers, and their ability to *impact* different game states. Viewer and streamer agency is affected by the *interactions* and *choices* available to *individuals and groups*, and by the control they afford over *different states*, and over one another.

Agency through interaction is a common theme in audience participation game literature [1, 3, 53, 76]. In live-stream contexts, audiences value their ability to affect the outcome of live-streamed

games [32, 69], and feel control and ownership over actions [17]. Literature even suggests that agency considerably affects how people experience technology [17, 57]. This is supported by Glickman [32] and Seering [69], who describe a range of audience roles in live streaming; helpers, power seekers, collaborators, solipsists, and trolls. For instance, Yonezawa [91] suggests that non-verbal communication and interaction can promote camaraderie amongst audiences and performers [91]. Conversely, audience agency through control can clash with the goals of an experience, creating tension between a performer's authorship and the audience's desire to interact [16]. For example, pranking behaviors by viewers intended for observable fun can interrupt play and social aspects of game live streaming [44]. Thus, striking an appropriate balance between streamer and viewer control is essential to designing enjoyable experiences for all participants.

However, agency is more complex than control. In games literature, Tanenbaum [80] proposes a nuanced definition of agency as

commitment to meaning, describing the rich space between player choice and authorial intent. For instance, Recktenwald [63] explains that live-streaming audiences can create “local meaning” through bursts of short utterances and messages. Likewise, Gupta [33] suggests that audiences can experience agency through meaningful control of ambiance, rather than direct control over choice in the narrative of a game story. Viewers can even exhibit agency through “peripheral performances,” such as sending gifts to streamers [49]. Thus, a key design consideration in game live streaming is how to provide varying degrees of agency [76] to streamers and viewers without compromising the overall experience [32].

4.2 Pacing

In game live streams, streamers shift between two temporal frames: an interview frame involving conversations with viewers, and a play frame where they engage in gameplay [44]. Pacing—the interplay between audience participation and temporality—impacts game live streaming experiences for both streamers and viewers [32].

The seven themes common to Pacing are *temporality*, *progression*, *attention*, *distraction*, *engagement*, *gametime/downtime*, and *stream schedule*. *Temporality* describes the time-state of an experience; considering how much *progression* is based on time, whether and how much *time pressure* exists, and whether there is a *time delay* (latency) between streamers and viewers. The pacing theme interrelates with viewer and streamer *attention* to, and *distraction* from different parts of the interface, and with stream *scheduling* and *game time*. In turn, these themes affect viewer and streamer *engagement* and *progression* through an experience.

Li [49] suggests that viewer attention affects the pacing experience because it is not evenly distributed across live streams; simultaneous use of different media scatters attention, and intensifies distraction [75]. In games, there also exists a duality between play-time (the time the player takes to play) and event time (the time taken in the game world) [43]. Jacucci [39] describes these rhythmic shifts in attention and social interaction; periods of intense attention towards the performance interspersed with periods of downtime.

Liveness is also integral to streamer and viewer experiences. Glickman [32] highlights the importance of liveness and co-presence, and suggests that liveness affects streamers’ actions and choices. For instance, streamers want “immediate” interaction with viewers to get valuable input on their work, such as trying out topics for a radio show or discussing ideas for an upcoming book [81]. However, Gerber [30] also cites the value of asynchronous engagement, explaining that streaming services allow gamers to “peer review” past content and provide constructive feedback to other players.

Many factors affect this experience of liveness. During live performances, audiences subjectively experience time [26], and in live-streaming, streamers and their audiences subjectively experience liveness. One reason is that streamers and audiences operate on different schedules. Streamers often commit to a regular streaming schedule, whereas audience may drop in and out of gameplay during a single streaming session. Webb [86] suggests that the lack of physical co-presence adversely influences perceptions of liveness. For instance, stream latency can create pacing problems as streamers wait for audiences to respond [32, 61].

4.3 Community

Community is a synthesis of roles and identities, emotional connection, influence, and reinforcement and fulfillment of needs among group members [55]. Hamilton [35] and Hu [38] suggest that live streaming platforms often support group identification in participatory communities; streams become “third places” [59], regular informal gatherings beyond the space of homes and work.

The nine themes common to Community are *streaming community*, *cooperation/competition*, *roles/identity*, *communication*, *privacy trade-offs*, *balance*, *streamer/viewer relationships*, *moderation*, and *power*. The Community category characterizes viewer and streamer abilities to build and support communities around themes such as *culture* and *pride*. Community integrates within a complex network of thematic relationships; it considers the interplay and *moderation of streamer and viewer communication*, the *balance of streamer and viewer benefits with privacy*, and its effect on *identity, roles, communication, and power*.

A large body of research emphasizes the importance of shared or common identity through communication within online communities [5, 65, 78]. Taylor [82] suggests that engagement with audiences animates the channel, allowing streamers to “feel the vibe of the chat.” In turn, this heightens the performativity of the experience, creates intimate feelings and dialogues between viewers and performers [13], and even promotes acts of loyalty, such as donation [38]. This dynamic is dependent on comment volume, content, and relationships between viewers and streamers [34]. Viewership size likewise shapes stream content; streamers are more willing to do mundane things when fewer people are watching [82], and viewers motivated by social engagement often prefer smaller channels (<500 viewers) [37]. In complement, Ren [65] finds that there is a high turnover of viewers for large streaming communities.

Providing and supporting different viewer roles (e.g. helpers vs. power seekers) in participatory games can further shape community identity [69]. Thoughtfully designing for these roles is particularly important because streamers and viewers favor different relationship dynamics; content creators often focus on their individual skills, whereas viewers appreciate team dynamics [41]. Moderators enjoy a special role in the streaming community, and are highly valued by both streamers and viewers [69]. Notably, not every viewer can become a moderator; expressing desire to become one is considered taboo unless asked first by the streamer [88].

4.4 Themes Across Projects

Themes in the three sensitizing categories were reflected across the eight projects. For instance, designers had to consider *Community and Pacing* in the *Kingdom Builders* idle game. During the game, viewers build a kingdom by allowing their character to gather resources and build structures (Table 1). Game designers likewise had to consider the *Roles/Identity* theme: how to give players ownership and identity over objects in the game world, and how to balance different roles within the game. Since the game was intended to be played passively by viewers, designers also had to consider elements of *Temporality*: whether progression through the game should be based on viewer decisions or time, whether viewers should be under time pressure to make decisions, and whether idle gameplay should be persistent across other active gameplay.

Table 4: Example quotes of each theme for Community.

Theme	Quote
Streaming Community	<i>Streamers felt disconnected to chat in VR, wanted feedback on their story and humor. Both parties wanted chat presence in game through chat log, emojis, etc. (Typing of the Dead)</i>
Cooperation/ Competition	<i>Each puzzle has many solutions and many traps that seem like solutions. It's up to the player and the Twitch chat to determine the best solution. Will you grow wings to fly to the ceiling? A rhino horn to knock over a wall? (Oh the Horror)</i>
Roles / Identity	<i>[Our idea] also pushes the identity of the player beyond just an entity owned by someone playing the game in real time and explores the idea of shared identity. (Oh the Horror)</i>
Communication	<i>Twitch chat itself is text-based, and would likely be the main point of communication between the streamer and the viewer. However, because the streamer would be physically moving around, we expected them to be unlikely to want to read through an entire chat transcript as it came in. (Twitch Plays Undergrad)</i>
Privacy Tradeoffs	<i>If people put their numbers, how could we protect big streamers who give their numbers to matches from going public? Looks like Twitch has rolled out Whispers, which are direct. (Twitch Meets)</i>
Balance	<i>Is our game design balanced and intriguing enough for player to get enough fun? Are the puzzles hard enough? Are game mechanics and rules easy for players to understand versus are they too frustrating? (Always Present)</i>
Streamer/Viewer Relationships	<i>Our Twitch extension provides philanthropic streamers with the tools necessary to effectively communicate the progress of their fundraising to their audience while enhancing the overall viewing experience for the viewers of the stream. (Rainbow Sunshine)</i>
Moderation	<i>Our audience feedback mechanism allows for the visually impaired to get a general sense of audience sentiment, without having to rely on a screen reader. Additionally, it insulates them from possibly verbal harassment or abuse - the mapping from emoji to sounds played is controlled from the game, making it very difficult to harass people. The throttling of feedback to once every 10 seconds also helps in this regard. (Duet Master)</i>
Power	<i>The fun comes from trying to correctly optimize user distribution...Streamer should have enough godpowers to influence the kingdom, but not enough such that the game can't progress without them/they can unlimitedly spam powers. (Kingdom Builders)</i>

Similarly, the *Twitch Plays Undergrad* physical library game reflected elements of all three sensitizing categories. During the game, viewers input library call numbers in the Twitch chat, which streamers hunted for in a college library. This dynamic reflected the *Agency* category, since streamers and viewers had to respond to each others actions, creating a balance between streamer and viewer agency. This game likewise reflected *Temporality* themes; in the call-and-response dynamic, streamers received printed notifications of viewer call numbers; in this way, viewer engagement affected the streamer's ability to progress. This interaction further affected *Community* themes, forming a bi-directional relationship between streamers and viewers. Further, the natural library and printed setting affected the connectedness of the streamers and viewers, since walking through a physical space changed the responsiveness of the Twitch live-stream and Bluetooth printer connections.

5 DESIGN SPACE THEME MAP

Shown in Figure 2, the primary contribution of our work is a theme map diagramming a *potential* design space for audience participation in game live streaming. The full theme map shows topological relationships between sensitizing concepts, high-level themes, and related sub-themes. For visual clarity, Figure 2 presents only the high-level themes, highlighting each sub-theme space, and uses weighted text sizing to represent the relative number of sub-themes. The full theme map is attached in the supplemental materials.

The map is organized by Agency, Pacing, and Community sensitizing concepts, each of which corresponds to one edge of the theme space. Between these concepts, the map shows distance relationships between the themes and sub-themes; themes closer to one another have stronger bidirectional relationships, whereas themes

further from one another have weaker relationships. The topology of the theme map is also organized from outside-in; “primitive” themes common to a variety of interaction experiences (e.g. *attention, identity*) are organized around the periphery of the map, whereas “applied” or interconnected themes (e.g. *stream schedule, control*) appear toward the middle of map.

5.1 Using the Theme Map

Our theme map enables designers to analyze existing live-streaming experiences, and we envision multiple uses in education and research. The map will help student designers analyze and reflect on existing participatory live-streaming experiences by breaking down concepts into component parts, allowing them to consider the impact of interconnected themes [20]. The map will also support educators teaching participatory live-streaming design. Educators could use the theme map as part of a larger design process, or integrate it into their personal teaching methods.

The theme map may likewise be used by researchers to consider new directions for participatory live-streaming. We posit that analyzing existing experiences will allow designers to better understand both recurring and uncommon gameplay and audience participation dynamics. Doing so will help the HCI community identify gaps in current literature.

5.1.1 Instructions. We offer the following step-by-step instructions:

- (1) Circle three themes that you identify as representative of the experience. If you identify more than three themes, circle the themes furthest from one another on the map
- (2) For each theme, circle any relevant sub-themes

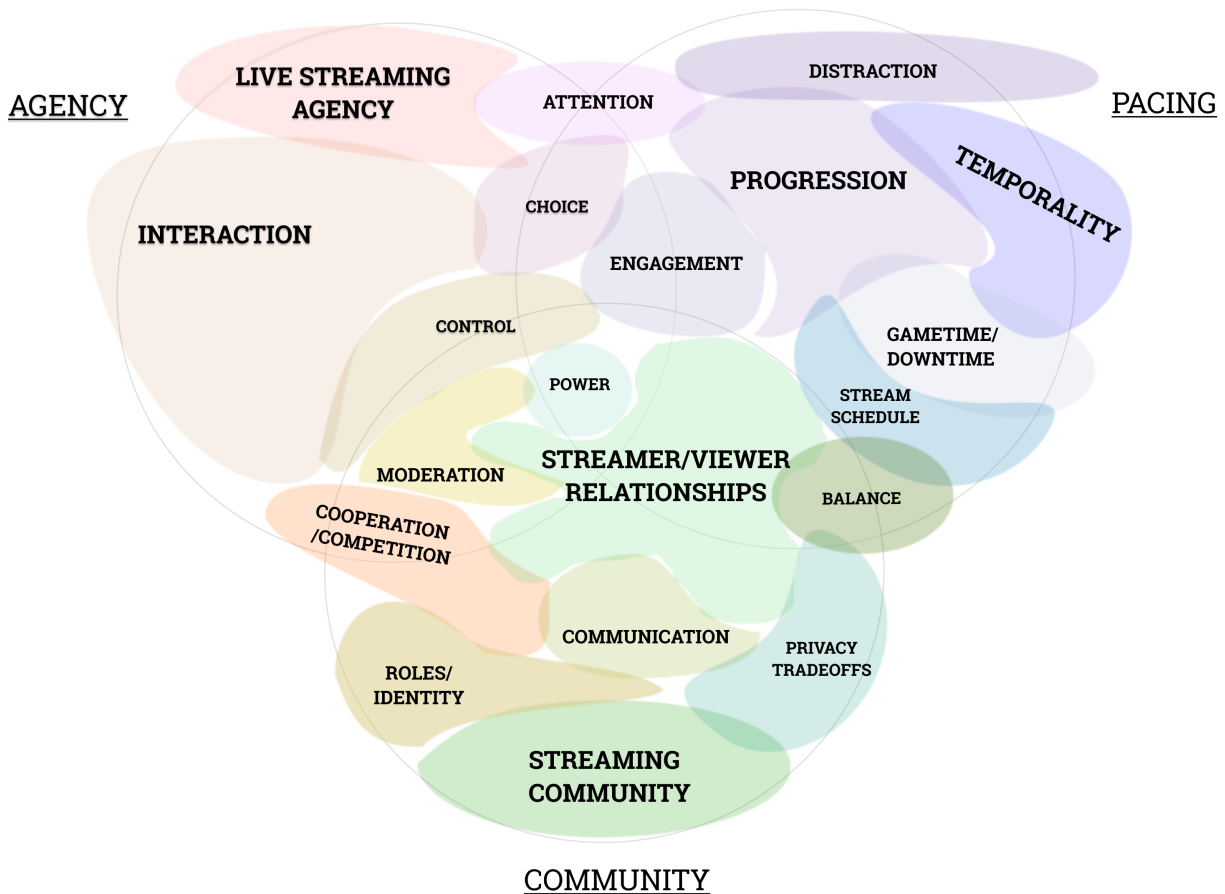


Figure 2: High-level Twitch Audience Participation Theme Map. Each theme is represented by a colored region and a corresponding label. Sub-themes, which occupy the colored region for a theme, are not shown to reduce complexity and improve legibility (see the more detailed version in the supplementary materials for sub-themes). More “primitive” themes appear near the periphery, while more interconnected themes appear towards the middle. Each sensitizing concept—Agency, Pacing, and Community—corresponds to a corner of the thematic map. Concept boundaries are depicted by lightly-stroked circles that slightly overlap, forming a Venn diagram. Themes related to two sensitizing concepts reside at the intersections of two circles. Themes common to Agency are *live-streaming agency*, *interaction*, *choice* and *control*. Themes common to the Pacing concept are *temporality*, *progression*, *attention*, *distraction*, *engagement*, *gametime/downtime*, and *stream schedule*. Themes common to the Community concept are *streaming community*, *cooperation/competition*, *roles/identity*, *communication*, *privacy trade-offs*, *balance*, *streamer/viewer relationships*, *moderation*, and *power*. *Attention*, *choice*, *control*, and *engagement* consider aspects of both Agency and Pacing. *Engagement*, *streamer/viewer relationships*, and *balance* consider aspects of Pacing and Community. *Cooperation/competition*, *moderation*, *control*, *power*, and *streamer/viewer relationships* consider aspects of Community and Agency. No theme considers all three concepts. The full theme map showing the topological relationship between high-level themes and related sub-themes is located in the supplemental materials ©Alina Striner

- (3) Draw a line connecting the circled themes, noting any themes that fall in between
- (4) Circle relevant themes or sub-themes along the line
- (5) Repeat steps 1–4 for any new themes identified
- (6) After several iterations, scan the map for any essential themes that were missed
- (7) Repeat steps 1–6 if missed themes are identified

These steps aim to reduce the information overload of the complex theme map. The steps also replicate the iterative nature of the

design process. For example, in the *Twitch Meets* extension, streamers and viewers got to know each other while playing mini games during waiting periods. Over the course of the project, the extension evolved from a “virtual dating” experience that matched streamers and viewers on personality and location, to one that was based on a lottery system and included other viewers using game show features like “phone a friend.” Although this evolution happened through feedback, having a visual map of themes and relationships during design could help avoid local design maximums [58].

6 VALIDATION OF APPLICABILITY BEYOND COURSE

We validate our theme map with a second set of student designers, using it to analyze two existing audience participation projects. Our goal was to show that the concept map could be applied beyond the course, in order to understand (1) how clearly and consistently project designers mapped project design spaces using our theme map and (2) how useful and valuable designers found the map.

We investigated two projects, *Commit to the Bits* and *Echoes*, asking team members to map out their respective projects using our theme map and step-by-step instructions, and to respond to questions about the exercise and map. *Commit to the Bits* had a wide scope because it included several improv games, whereas “*Echoes*” had a narrow scope because it focused on one type of audience interaction.

6.1 Overview of Projects

Commit to the Bits was an improvisation live streaming experience on Twitch. The project explored concepts of dramatic agency, viewer understanding, and intra-audience interaction through a series of games. One game, for example, explored how to employ submitted content in live streams on Twitch. Performers received viewer submitted images, and acted them out during gameplay. In contrast, another game brought music to the improvisation stage, exploring how audience members with authority could affect the performance and crowd.

Echoes was a data collection game for Twitch. In this game, streamers asked their viewers to donate sounds. Viewers used a mobile app to collect sounds and share them with the streamer and other audience members. Streamers rewarded viewer participation with attention on-stream, including playing games that incorporate donated sounds.

6.2 Participants

We recruited seven participants that worked on one of the two projects as either a designer or developer. Five participants contributed to the *Commit to the Bits* project, and two participants contributed to *Echoes*.

6.3 Mapping Procedure

Interviews lasted 30 minutes, beginning with a brief introduction of the research and our theme map, followed by a think-aloud analysis exercise, and a set of reflective questions. We introduced the theme map by explaining how it represents a design space for audience participation in game live streaming. Then, we described how the sensitizing concepts, themes, and sub-themes were visually represented on the map.

During the mapping exercise, participants analyzed their project using our theme map; they identified relevant themes and sub-themes, then drew connections among them. First, we asked participants to take five minutes to look over high level themes, and to identify themes that best represented their project. Then, we asked them to follow the steps listed in the *Design Space Theme Map* section above.

After completing the mapping exercise, participants responded to the following statements about the mapping session on a five

point Likert scale (strongly agree-agree-neutral-disagree-strongly disagree). After rating each statement, participants were asked to explain their responses.

- (1) The session went smoothly
- (2) The design space was clear
- (3) The design space was easy to map to my project
- (4) The design space fit my project
- (5) The design space would be useful to the design process of my project
- (6) It would be useful to compare my project map to other project mappings

We conducted interviews using Google Hangouts. Participants used Aww,³ an online, collaborative whiteboard, to perform the analysis exercise. Aww provides a zoomable canvas for participants to circle and draw lines on top of the theme map.

6.4 Results

In this section, we present the results of the theme mapping exercise, and describe differences in themes and sub-theme mappings between participants across the two projects. Then, we consider participant responses to the clarity, fit, and usefulness of the map and corresponding design space.

6.4.1 Mapping. Figure 3 shows contours of each participant’s mapping for their respective projects onto the design space. Participant mappings are represented through different colors. More saturated areas represent regions of overlap where common themes and sub-themes reside.

The two projects differed greatly in scope. *Commit to the Bits* was a broad project that designed five improvisation games for audience participation. As shown in Table 5, in *Commit to the Bits*, participants mapped 16 themes and 21 sub-themes. Out of those, a majority of participants (at least 3 of 5) agreed on 68.8% of themes and 66.7% of sub-themes. Although there was a wide range of themes participants selected, study participants agreed on an appreciable number of themes. In contrast, *Echoes* had a narrow scope, focusing on audiences collecting and donating sounds. For this project, participants mapped 8 themes and 23 sub-themes. Of those, both participants agreed on 7 themes (87.5%) and 6 sub-themes (26.1%). Although participants chose different sub-themes, they closely agreed on the larger themes.

Table 5: Participant majority agreement on themes and sub-themes for the two projects.

Project	Themes	Agreement	Sub-Themes	Agreement
Commit	16	11 (68.8%)	21	14 (66.7%)
Echoes	8	7 (87.5%)	23	6 (26.1%)

Notably, our findings show differences in sub-theme agreement: designers worked on different parts of the project, and thus reflected on different sub-themes. The quantitative comparison showed that designers were thinking about the project similarly in a high-level way, but differently in a low-level way, based on their own involvement.

³<https://awwapp.com>

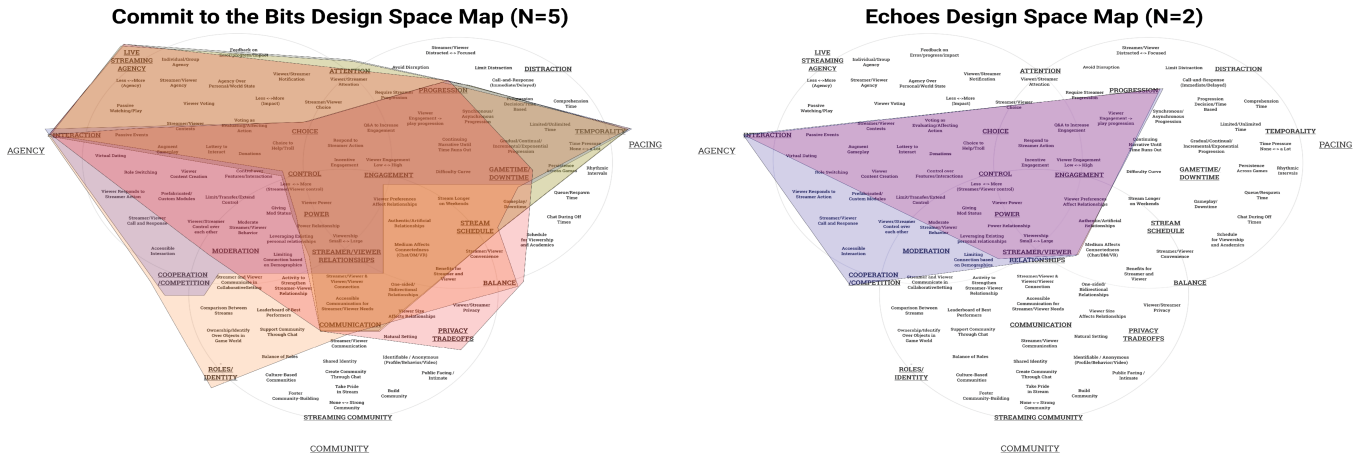


Figure 3: Design Space theme maps for Commit to the Bits (left) and Echoes projects (right) used in the validation.

6.4.2 *Clarity.* Participants across both projects agreed that the map was clear ($\mu=4.14$) and that it was easy to map their project onto the design space ($\mu=4.43$). Participants described the map as visually clear (P1, P2) and explained that they “could immediately relate to examples of what [was] going in the sub themes, even those that don’t apply to my project” (P6). Participants also thought that it was easy to understand how to map their project to the design space. For instance, P2 said that the “sub-themes are very relevant...very articulated what I am doing.” Participants likewise said that the map covered their project well. Several participants commented on the intuitive clarity of the visual map, such as that “roles and identities...was placed near communication...placement on the map made sense” (P3). Further, P7 was surprised that the map covered their “weird technical complaints, about temporarily and stream schedule.”

Although the map was easy to understand, participants asked for clarity about some aspects of the map. Two participants had questions about the meaning of the sub themes (P5, P6), and P2 “felt like some themes were similar...[such as] viewer voting vs. voting impact.” One participant observed that a challenge of mapping was that “some things are much easier to map directly, [whereas in] some things I had to dig a bit deeper to find the connection...like viewer power is a bit more abstract...whereas rhythmic intervals, call and response are easier to connect” (P4).

6.4.3 *Fit.* Participants agreed that the mapping instructions and theme map fit their projects well. Participants agreed that their mapping session went smoothly ($\mu=4.43$), and strongly agreed that the map was a good fit for their respective project ($\mu=5$). P4 “clearly understood what I was supposed to do,” and P6 found that “line drawing was helpful,” explaining that “purposely picking ones far apart made drawing lines make sense.” P2 and P3 clarified that “connecting the dots was really impressive” (P2) because “almost all the things that [we] have touched upon in the project...is in my front of my face” (P3). Further, P5 explained that “most of the themes were related to Twitch and community experience in Twitch...[I] felt that themes were all something that we considered during the project.” Similarly, P4

and P6 felt that the themes were “related to things that we did... was fitting for our project” (P6) and that nothing felt weird (P4).

Participants also pointed to areas for improvement. P7 felt the map was “missing [the] idea of co-creation,” explaining that “cooperation/competition implies balance, but shared creation has a bit longer lifespan, vs. temporary creation in the minds of viewers.” Similarly, P3 wanted a range of sub-themes for scheduling, telling viewers “what you’re going through...schedule of games, how to play, when will play, what sequence will play.” While most participants found the online mapping intuitive, P5 noted that the task “was a bit difficult because it was virtual...[physical] drawing is easier.”

6.4.4 *Usefulness.* Participants in both projects thought the theme map would be useful, both as a comparison and reflection tool ($\mu=4.57$), and as part of a larger design process ($\mu=4.86$). P1 explained that a strength of the design space map was seeing “detail in categorized interactions, and actions [because] understanding what action fits under which theme would make the project way stronger.” They further added that “connecting these themes and sub themes, [helped us] understand the strengths of our project...[we] thought it was about temporality, but really [it was] about agency and community.” P6 further explained that the map would help clearly present the main themes of a project to an audience as well. “if there’s another continuation of the project,” they explained that a map of the project space “would help explain [better] than a wall of text...how a project has evolved from beginning to end.” P4 elaborated that since there is “potential for very large variety [of mappings that] could look at things that people are focusing on,” and P5 added that comparing maps would allow them to “see differences and compare between [projects].”

Finally, participants wanted to use the map during the design process. P3, P5, and P6 explained that if they would have gotten this theme map at the start of the project, it would have been easier to consider and explore design options. For instance, P6 explained that “some things in the design map align with the future goals of the project... communication and streaming community... and eventually moderation and privacy.” Participants also highlighted the value of the map as helping scope and balance the project. P2 thought the

map could help them “*focus on what we want to take care of, really good way of keeping the project...consistent.*” Likewise, P7 indicated that during design, it is “*very hard to balance of [things] that happen in a live-stream,*” explaining that it was useful to “*have points to triangulate around...see what segment of the triangle you are moving towards, [and] what [you] need to balance out more.*”

7 DISCUSSION

This work presents a theme map of an audience participation design space in game live streaming. We developed this map by studying how designers create interactive audience experiences in an undergraduate course centered around Twitch, using a bottom-up thematic analysis of student process documents to identify themes, sub-themes and three sensitizing concepts, *Agency*, *Pacing*, and *Community*. We spatially mapped related themes to the sensitizing concepts, employing background literature to inform spatial relationships on a three set Venn diagram. We conducted a preliminary validation of the theme map with a second set of student designers, considering its clarity, fit, and usefulness.

The following section discusses the value of the theme map as a reflection tool for student designers. First, we discuss the value of the map in context of reflection literature in HCI, both supporting reflection-on-action, and reflection-in-actions goals. Then, we discuss the validation results in contexts of these goals, finding that the theme map and instructions allowed student designers to reflect on current participatory live-streaming experiences through the process of mapping and reflection. At the end of the discussion, we present our research limitations.

7.1 Reflection in Design

In the last fifteen years, HCI research has increasingly turned its attention towards reflection, “a mental process...in which manipulation of meaning is applied to relatively complicated or unstructured ideas...to problems for which there is no obvious solution” [56]. In design, Dewey [22] suggests that reflection is “critical to the thought process” [22], supporting and reinforcing learning [56]. In education, Jonassen [42] further describes learning as a “constructivist” experience; effective when learners create a personally meaningful artifact using a flexible and playful process.

A primary goal of the theme map was to allow student designers to map existing participatory live-streaming experiences. Through the process of mapping, students became familiar with themes relevant to the domain. Students could also reflect on differences between live-streaming experiences by comparing their theme maps. These two goals are echoed in reflection literature; *reflection-in-action* that arises in the process of doing design actions, and *reflection-on-action*, which evaluates those actions afterwards [67].

7.1.1 Supporting Reflection-in-Action. The validation study supported the *reflection-in-action* goals. Participants agreed that the theme map was intuitive (P1, P2, P6), and that themes were relevant to their projects, helping them articulate their goals more easily (P2). Reflecting on the fit of the map, P2, P3, and P6 even responded that the process of drawing lines and connecting the dots between themes was valuable, because it allowed them to triangulate the primary contributions of their projects. Since reflection-in-action is affected by how ideas are represented and what tools are used [85],

this suggests that the representation of the design space was valuable to designers.

Notably, the differences in sub-theme agreement described in the results highlight the value of the map: as described by participants in section 6.4.4, these differences support group reflection, helping group members come to a cohesive understanding about project goals. It is for this reason that the validation questions about smoothness, clarity and fit are valuable: they demonstrate that participants found the map easy to use, and thus differences in themes came from their perspectives of their project, rather than from the construction of the map.

7.1.2 Supporting Reflection-on-Action. The validation also supported *reflection-on-action* goals of the theme map, helping designers critically reflect by “bringing unconscious aspects of experience to conscious awareness” [70]. After reflecting on the theme map, P1 said they understood the strength of their project. “[We] thought it was about temporality, but really [it was] about agency and community.” Likewise, P5 wanted an opportunity to compare mappings of different projects to see differences between them. This is supported by Mateas [54], who notes that a primary goal of game studies is to analyze existing games by understanding their form, features, and organization.

Notably, several validation participants expressed a desire to use the theme map during their design process. P2 and P7 believed mapping their ideas during design would allow them to scope and balance their projects. Since teams often include students with a range of experiences, participants felt the map could help different members communicate the focus of their project. P6 even suggested the theme map would be useful as a presentation tool, to show audiences the evolution of a design process from the beginning to the end of a project.

7.2 Limitations

We analyzed eight student projects implemented over a semester long course. The students were novice designers with limited time to design and implement their projects, and limited technical and financial resources. The final project assignment was open-ended, so teams created divergent experiences based on their interests, ranging from VR and physical games to donation overlays. The diversity of these experiences impacted the type of background research, play-testing, and reflection the teams performed.

For instance, the *Twitch Meets* project conducted interviews with Twitch streamers to understand group dynamics, whereas *Twitch Plays Undergrad* focused on iteratively designing and playtesting physical game mechanics. This made it difficult to compare the design process of the different interfaces. Likewise, since the process documents were free-form, the teams presented their design process and final design documents differently. As described in the method, we found differences in both the types of process documents and in their lengths. This resulted in an incredibly rich dataset that does not lend itself to comparison across projects.

The curriculum also affected the types of games and extensions students developed. While many forms of spectatorship exist in this domain, these projects reflect the new wave of live streaming [81] that emphasizes active audience participation through personal devices. Our resulting theme map is representative of one design

space situated in student projects, however the validation shows that it can be applied to other contexts.

Finally, The validation study was also limited by the availability of student participants. Only a subset of students were available from the two design teams, creating an imbalance in the number of respondents for the two projects. Further, since the *Commit to the Bits* project included several improvisation games, it was difficult to compare the mappings of the five team members.

8 CONCLUSION

In this paper, we present a theme map of a potential audience participation design space in game live streaming. The map is derived from thematic analysis of student's process documents, and is framed by three sensitizing concepts: *Agency*, *Pacing*, and *Community*. Through this map, we identify key design themes that inform characteristics, affordances, and constraints of participatory live-streaming experiences. We supplement the map with step-by-step instructions on how to use our theme map for design analysis, and conduct a preliminary validation of the map with student designers.

By defining this design space, this work offers value to student designers and educators. We envision it being used as both a teaching tool to help students understand the space of possibilities, and as a design ideation tool to help student designers map out novel experiences. The map may also help researchers in HCI identify gaps in participatory live-streaming.

Future work will validate our theme map with professional designers, and employ the map as a design ideation tool. We encourage others to employ our methodology to map a range of participatory live-streaming experiences; in doing so, researchers can begin to construct more holistic perspectives of audience participation affordances in live-streaming. As research and design evolves in this domain, our map will likewise expand to consider new opportunities for participatory live-streaming.

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