Interactive Visualization of a Robotic Music Ensemble

A Major Qualifying Project
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Abstract

The goal of this project was to identify features of both live performances and web-based platforms that can be applied to create engaging virtual concert experiences. To understand and test virtual concerts, we conducted research through the Music, Perception, and Robotics (MPR) lab at WPI. The MPR lab features an ensemble of robotic musical instruments that are difficult to showcase online due to their complex designs and small movements. Following the design thinking process, we identified key features that were then included in the design of a virtual concert platform aimed to best showcase the robots. A team of students then built the website including a live video stream integrating user-selectable camera views, a chat interface for audience communication, information about the robots, and a meter to visualize viewer reactions. We tested the website through two user studies to inform key design decisions and make future recommendations.

Acknowledgments

I would like to recognize and thank Professor Scott Barton and Professor Charles Roberts for their guidance and support throughout this project. I would also like to thank Ronit Banerjee, Nicholas Markou, and Emily Gorelik, our student team of developers, for their work building the virtual concert website. Additionally, I would like to thank everyone who helped with our interviews and user studies for their time and meaningful feedback.

Table of Contents

Introduction

For audiences, concerts provide entertainment, the discovery of new art, and a community of people with similar interests. With easy access to high-quality music recordings at home, it is important to understand why concert goers spend the time and money to go to concerts in-person. The anticipation of new sounds and the uniqueness of live music lures concert-goers into feeling involved as part of the performance. Research has shown that audience members are more engaged when listening to live music as opposed to pre-recorded music and have even higher engagement if they have pre-existing admiration for the performers (Swarbrick et al., 2018). This leads to the question, is it possible to mimic these effects and levels of engagement through virtual concert experiences?

Due to the COVID-19 pandemic, many entertainment industries have been forced to reimagine the ways they deliver their entertainment. The music industry specifically, which generated over 5.5 billion U.S. dollars in 2019 (Global Music Tour Revenues 2011-2020, n.d.), suffered significant financial loss in 2020 as it then only generated 1.2 billion U.S. dollars from live performances. On top of financial losses, live concerts are important for building support for artists through dedicated fan bases that are partially formed by audience-musician interactions. Many musicians have attempted to provide the live-music experience through virtual concerts during the COVID-19 pandemic and have created possibilities for more virtual concerts in the future. Aside from the health and safety benefits of virtual concerts as demonstrated in the last two years, virtual concerts also provide a more accessible viewing experience. Virtual concerts can be more cost-effective as they eliminate the cost of travel and can offer cheaper tickets. They also can provide a more comfortable environment for people who do not favor being in large crowds with limited space. This project will explore the design of virtual concerts with a focus on the experience of audience members.

To understand and test virtual concerts, we conducted research through the Music, Perception, and Robotics (MPR) lab at Worcester Polytechnic Institute (WPI). The MPR lab at WPI develops robots for live performance and composition as well as artistic tools to aid in creating musical works. Musical robots open doors for audience members to interact more with both the composers and the music performed. Live performances from the lab are typically done in-person. Some of the robots are heavy and difficult to move, making it hard for invited composers to collaborate with the robots without traveling to Worcester. The same difficulties apply to audiences, who must visit Worcester to see the robots in live performance or view a limited number of them in action when they do actually travel. Additionally, the movements of the robots are small and frequent and many movements happen at once making it hard for the audience to observe. Many performances also involve multiple robots playing simultaneously which makes it difficult for audience members to analyze how the instruments and sounds differentiate and how they work together. Developing and testing a platform for audience members to experience a live performance by the MPR lab is applicable to understanding the experience design of larger-scale virtual concerts.

Background

Live performances provide a unique experience for audience members and performers that makes the time and money spent worth it when people could listen to high-quality music recordings at home more easily and for free. Attending concerts in-person creates an opportunity for audience members to gain a sense of community and connection between each other and with the performers. The crowd experience is a vital part of developing a sense of unity and belonging among audience members.

For virtual concerts, there is an opportunity to create the same interactions that would typically happen during an in-person concert that make the concert worthwhile. It is important that the methods of the interactions don't distract or take away from the performance, but rather enhance it. Exploring the possibilities of virtual concerts provides unique opportunities for musical performances beyond human performers. In this section, we will explore virtual concert experiences that showcase robotic musical instruments as well.

Crowd Experience

The design of a concert focused on the audience perspective involves understanding both the individual and crowd experiences. The social influence presented in a large group environment, whether positive or negative, has an impact on the way people experience and review an event. There are three distinct qualities of crowd experience: imitation, emergence, and self-organization (Veerasawmy & Iversen, 2012). Imitation is central to the crowd social experience wherein joining a crowd, people are subconsciously prompted to participate in the emerging behavior of the crowd. Crowd behavior is contagious - the actions, feelings, and desires of a crowd are quickly spread among audiences at concerts. Imitation in crowds creates excitement and enthusiasm making it part of the foundation for creating a social dynamic in a crowd encounter (Möller, 2018). Through imitation, we are introduced to emergence as new and unexpected behaviors and feelings arise. Emerging patterns seen in crowds such as starting chants or "the wave" create a sense of unity and belonging among a crowd. These communal behaviors and feelings are typically not planned or governed by an institution, which is where self-organization comes into play. These three qualities: imitation, emergence, and self-organization are highly interrelated and should be considered as analytical tools for researching the interaction design of crowds (Veerasawmy & Iversen, 2012).

The collective experience of participating in a crowd is a key contributor to making live music worthwhile. According to Le Bon, "Group mind makes people feel, think and act in a manner quite different from that in which each individual would feel, think and act where he is in a state of isolation" (Le Bon, 1895). Crowds allow individuals to not have personal responsibilities, which encourages more irrational and emotional behaviors, such as yelling and dancing, that would not be seen individually (Möller, 2018). The communal aspect of attending a concert creates a sense of belonging that makes the concert experience worthwhile in comparison to watching a performance alone virtually. Another way this is achieved is through the communal movement to music. As explained before, individuals in large crowds may imitate those around them resulting in synchronously swaying back and forth, nodding their heads, tapping their feet, dancing, etc. One study that compared head movements of audience members during live performances vs. recorded playback of songs, found more frequent head movements during live performances which "represents greater arousal, increased anticipation, and increased connection with the artists and their music during the live concert" (Swarbrick et al., 2018). This is another reason why there is a benefit to attending live concerts as opposed to just listening to pre-recorded music as it increases the communal connection between audience members and performers. Replicating the benefits of the crowd experience in a virtual setting where there is no physical crowd is crucial in the design of the experience of virtual concerts.

Visual Experience

Another area that separates concerts from recordings is the visual component of a live performance. One reason people are more entertained during live performances is that there is a level of anticipation of not knowing what will happen next. In a live concert, there is no way to ensure that absolutely 100% of the performance will go as planned. Audience members must believe that what they are observing is actually happening live to preserve the anticipation of not being able to predict what will happen next. In order to believe a musical performance is live, viewers do not need to see every detail of what they are hearing. One study found that a concert-going audience will accept a performance as live as long as the music's core elements are represented on stage (Danielsen & Helseth, 2016). For example, an audience does not need to see the whole string section of an orchestra if they see a singular cello on stage. This means that in a virtual viewing of a concert it is important that there is a visual representation of each core sound played. Convincing the audience that the performance they are virtually watching is live, continues to entice and excite concert-goers.

Digital Channels of Connection

Exploring how the use of personal technology impacts in-person concerts is relevant as it can be translated for use in virtual concerts by individuals. Research is necessary to understand how to create the crowd experience virtually. In recent years, the use of technology has increasingly infiltrated every part of everyday life, including playing a large role in crowds at large-scale events such as concerts. Audience members use their phones to capture photos and videos, share on social media, and discuss and connect with other fans and performers. A study by Eventbrite, a popular platform in the music industry used for hosting and joining live events, explored cell phone usage at concerts. They found that 31% of adults ages 18-34 use their phones during half of the show or more. On top of that, 79% of Gen Z stated that they shared a photo, video, or update from the event to social media while at the event (Kershaw, 2019). The additional connections to others created through the use of phones and social media contribute to the unity and sense of belonging in crowds. When creating a virtual crowd experience, smartphones can be used as a channel of connection between audience members that would otherwise be lacking. Most people are already used to using their smartphones to connect with others, so the familiarity of this method of connection combined with the technological capabilities of a smartphone could lead to the possible contribution of creating a crowd experience.

Musical Robots

Digital channels of communication offer new opportunities to showcase musical robots, which have challenges when presented in traditional live settings. Musical robots are machines that compose and perform music pieces and are capable of more than what humans playing instruments are capable of. Robotic musical instruments can be programmed to produce sounds and rhythms that humans are not able to produce. Robotic musical instruments are created using mechanical parts, including motors, solenoids, and gears (Kapur, 2005). They are mechatronic systems, meaning that they are instruments with electronic elements that allow for computer control (Carvalho, P., Prihar, E., & Barton, S., 2017). The computer control of these instruments produces sounds and rhythms at exact times and pitches that humans are not able to produce. Additionally, these instruments are considered robotic because they include sensors that provide feedback and can therefore interact with their surrounding environment. (Carvalho, P., Prihar, E., & Barton, S., 2017). One example, Cyther, is a human-playable, self-tuning robotic zither. The self-tuning function of the instrument allows it to generate new tunings while operating or while a human interacts with it (Carvalho, P., Prihar, E., & Barton, S., 2017). The Music, Perception, and Robotics (MPR) lab on WPI's campus hosts an ensemble of musical robots including Cyther. The ensemble is shown in Figure 1 below, featuring Cyther in the bottom-center, can be showcased in in-person or online performances.

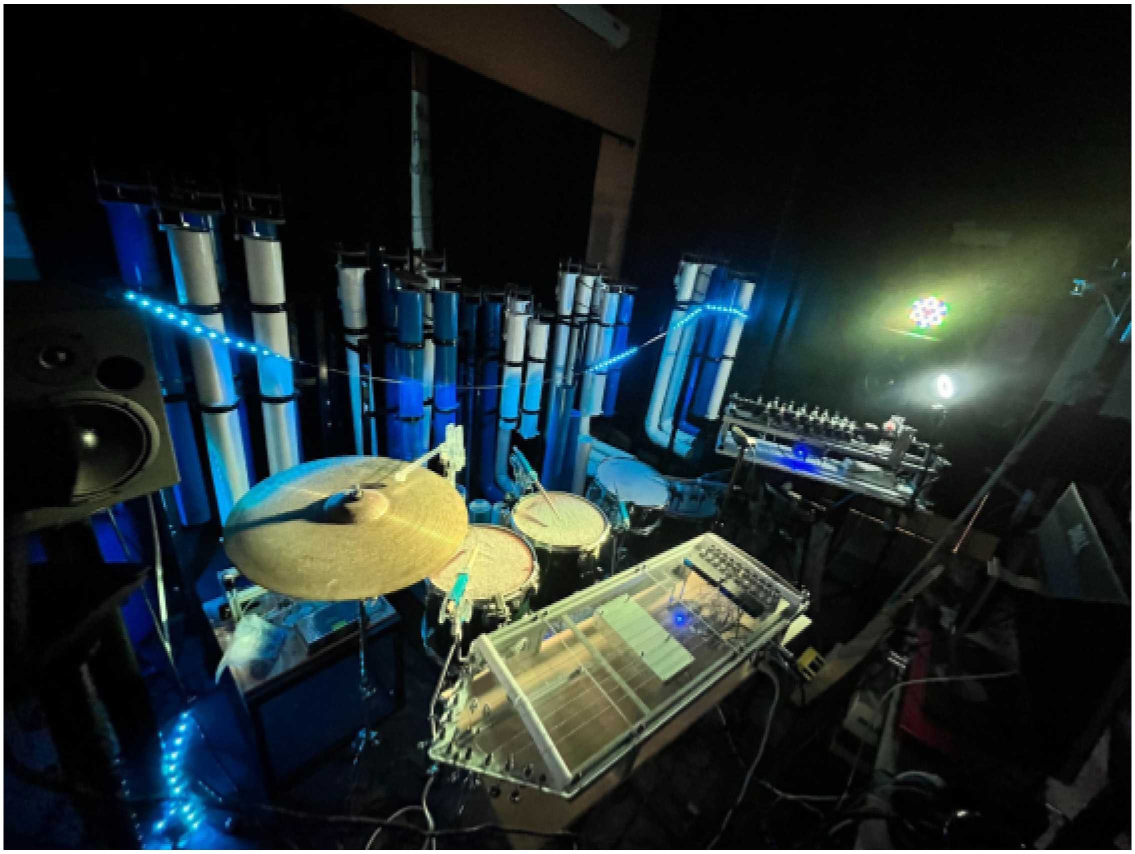


Figure 1: Robotic music ensemble in the MPR lab.

Related Work

In the midst of the COVID-19 pandemic, many musicians held virtual concerts on a variety of different platforms. The most common method for hosting virtual live performances was live streaming through social media. Through these live streams on platforms such as TikTok or Instagram, artists can perform live while audience members can post comments to a communal chat and send “likes” to the artist. In Figure 2 below, you can see an image of a live performance by John Legend at the beginning of the pandemic on Instagram live. Viewers had the option to send messages in a live chat and react with emojis that would then fly up the right side of the screen.

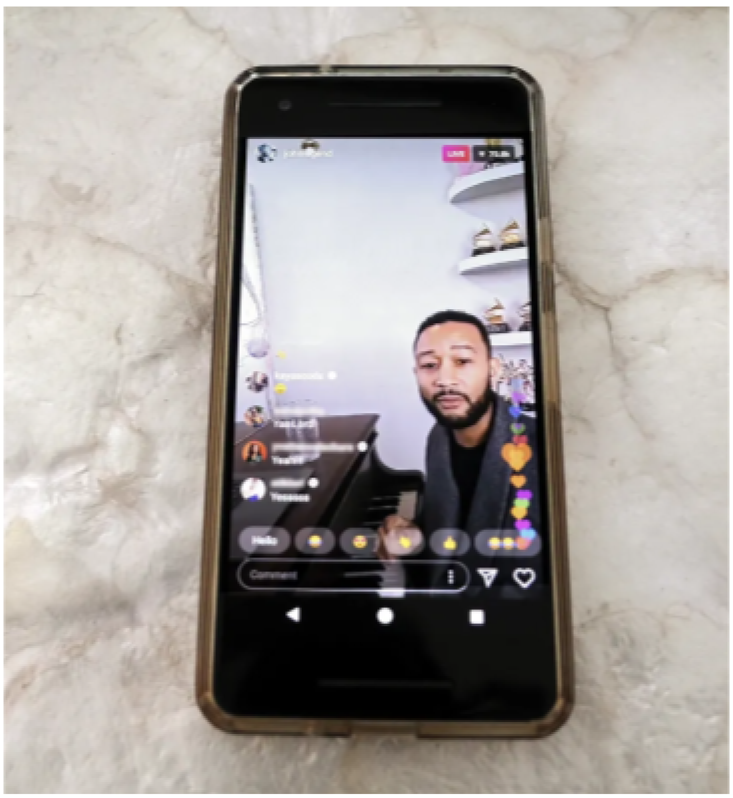


Figure 2: John Legend hosting a virtual concert on Instagram live in March 2020 (Frank, 2020).

Many artists hosted live performances on more traditional platforms for live streaming such as Youtube and Twitch as well. The audience interactions in these are also limited to live chat and the use of different reaction buttons. Travis Scott, a rapper and producer, held a virtual concert through the popular video game, Fortnite, as seen below in Figure 3. The short ten-minute concert featured a set of prerecorded songs and only allowed limited audience interaction. Audience members could only see an animated avatar of the performer. The use of gaming engines to host live performances introduces opportunities for different visual elements, like the animations in Travis Scott's performance, that are only available in online settings.

Figure 3: Screenshot from Travis Scott's Concert on Fortnite (Webster, 2020).

BTS, a popular South-Korean boy band, live-streamed a concert in June of 2020, as seen in Figure 4, that set the Guinness World Record for most viewers for a music concert live stream (Punt, 2020). The live stream was hosted on Weverse, a South Korean platform, that allows fans options to pay different amounts of money for tickets that will allow them to see more camera views and have better audio with more expensive tickets. The benefit of platforms like Weverse is that fans get an exclusive show that can not be seen for free in other places on the internet. Additionally, fans are connected to the performers through the platform outside of the concert where they have direct access to merchandise and content posted on the platform by the artists themselves.

Figure 4: BTS performing a virtual concert on the Weverse platform.

There are many applications developed for online group interaction that are not directly intended for concerts. One mobile application developed for crowd interaction is Mentimeter, which can be seen in Figure 5 below. According to the Mentimeter website, “Mentimeter is a free-to-use interactive presentation platform for hosting Live Q&A sessions, polling and much more” (Mentimeter, n.d.). Something like this could be used to build connections and a sense of unity between audience members and performers.

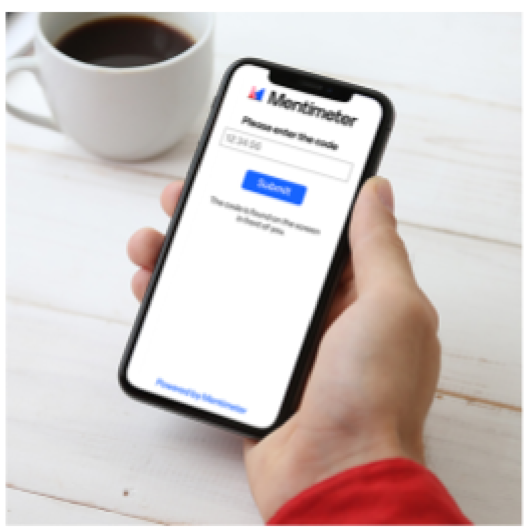


Figure 5: A poll hosted on the Mentimeter platform.

Many applications have been built to enhance the spectator experience at large-scale sporting events. An app called TuVista provides a system that deploys "live multimedia content to spectators' mobile phones" during sports games (Bentley & Groble, n.d.). The unique part of an application like TuVista is that it uses a phone as a tool to enhance the experience, not just as a viewing platform. Using the technological devices around us as tools to make an experience enhanced rather than just channels to view a performance opens a unique gap in the virtual live-music industry.

Many of the features described in this section such as live chat and audience reaction buttons that are frequently used in online live streaming platforms may continue to add value in a virtual concert platform. Additionally, because these features are frequently used, users will most likely be familiar with them and they can serve as guiding tools to set the standard for audience participation in a new virtual concert platform. For example, if a user of a new virtual concert platform sees a familiar chat feature they may feel encouraged to provide feedback and connect with others through the chat since they understand the function of it. What a lot of the platforms mentioned above in this section are missing, is unique features that set the event apart from in-person or prerecorded performances. There is an opportunity for a platform that combines the features such as live chat and audience reaction buttons that are familiar to users with new features unique to the platform. This combination of features could result in a platform that makes attending virtual concerts worthwhile.

Methodology & Design

The goal of our project was to identify features of both live performances and web-based performances that can be applied to create engaging virtual concert experiences. Through developing an interactive virtual platform for MPR lab performances that would be hosted as a page of the MPR lab website, we tested versions of the identified features and created recommendations for future directions of the website. Our objectives are as follows:

1. Define the Means of the Product
2. Understand the User
3. Develop a Prototype
4. Develop the Minimum Viable Product (MVP)
5. Test the Prototype to Inform Key Design Decisions
6. Test the MVP and Gather Future Recommendations

We followed the five-step design thinking process, as outlined below in Figure 6, which includes a cycle of empathizing with users, defining the product, ideating, prototyping, and testing, to ensure that the product was developed centered around the user's experience (Design Thinking, n.d.).

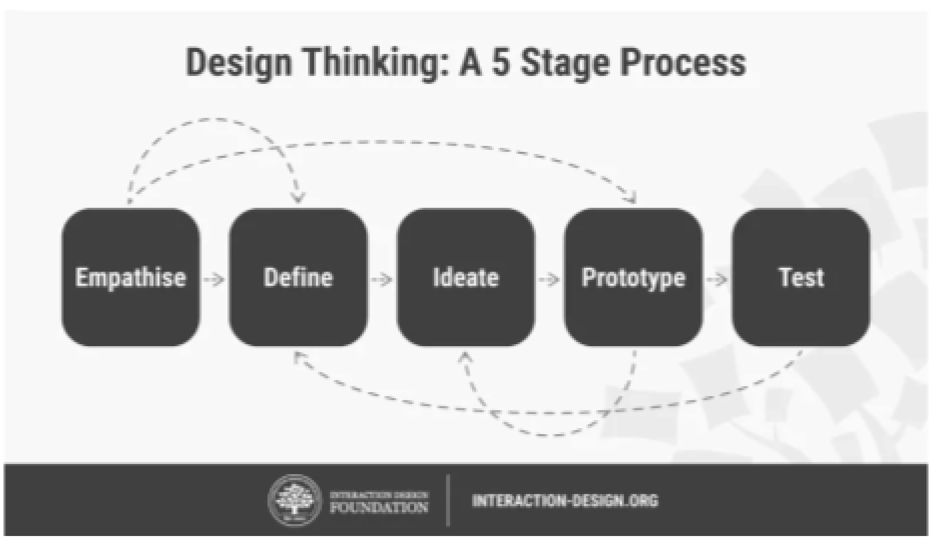


Figure 6: The design thinking process outlined by the Interaction Design Foundation.

In the following sections, we examine our objectives and methods and demonstrate how they supported our project goal.

Objective 1: Define the Means of the Product

The first step was to understand the space for a solution based on the given problem. As explained before in the background, the MPR lab performances struggle to convey the movements of the instruments and the dynamic of an in-person live performance through existing virtual concert platforms. Understanding a space for a solution meant defining what type of product to produce in an attempt to ease the problem at hand. In order to do this, we needed to engage with key stakeholders who can be defined as composers, performers, and audience members of concerts. To learn from the stakeholders we aimed to complete a series of informational interviews. The informal atmosphere of informational interviews allows for casual conversation regarding the topic of focus which can result in a better understanding of a solution space. Additionally, with easy access to potential stakeholders in the local community and through online meeting platforms, informational interviews were the most appropriate method to engage with stakeholders. Through these interviews, we were looking to understand what key stakeholders are seeking to find and expect in a virtual concert. Although we were designing for a virtual experience, it was necessary to conduct interviews with composers, performers, and audience members of both virtual and in-person concerts to understand which aspects of a live in-person experience to aim to satisfy virtually. In the end, the goal of these interviews was to define the product to create based on insights from key stakeholders.

We conducted a total of six informational interviews. The participants were recruited through email based on recommendations from my advisors and via word of mouth with peers. These interviews were semi-structured and followed a loose script that allowed for open-ended discussion (see Appendix A). The topics we aimed to gain insights into included platforms used for virtual concerts, reasons for attending concerts, things to avoid in virtual concert settings, things to include in virtual concert settings, and methods of audience interactions with other audience members and performers.

Objective 2: Understanding the User

After completing the informational interviews with stakeholders, the next objective was to understand how users interact with existing products and how they may interact with a potential future product. A user's interaction with a product includes their motivations, frustrations, and emotions which are valuable to understand for multiple reasons. First, understanding a user's interactions creates a clear vision of the project goal for all team members working on the project. Second, understanding a user's interaction pinpoints problem areas that may not be clear to developers. User personas and journey maps are commonly used by UX professionals to understand their users (Junior & Filgueiras, 2005). User personas are fictional users created by designers to represent a larger group of users. The first step in creating proto personas is defining spectrums. Here researchers brainstorm to identify a set of spectrums (non-binary user attributes), that they think would impact whether people would use the system they are designing. An example of a spectrum for this project could be “tech-savviness”, where there is a scale that determines a potential user's likelihood to feel comfortable using a smartphone or navigating a website. Next, researchers begin developing personas for potential users. A persona is a fake user profile that can represent a larger group of users. Personas typically include a specific user's demographics (ex. gender, age, job), biography (ex. Responsibilities, schedule, technology usage), challenges and feelings, and the wants, needs and goals of the person (see example below in Figure 7).

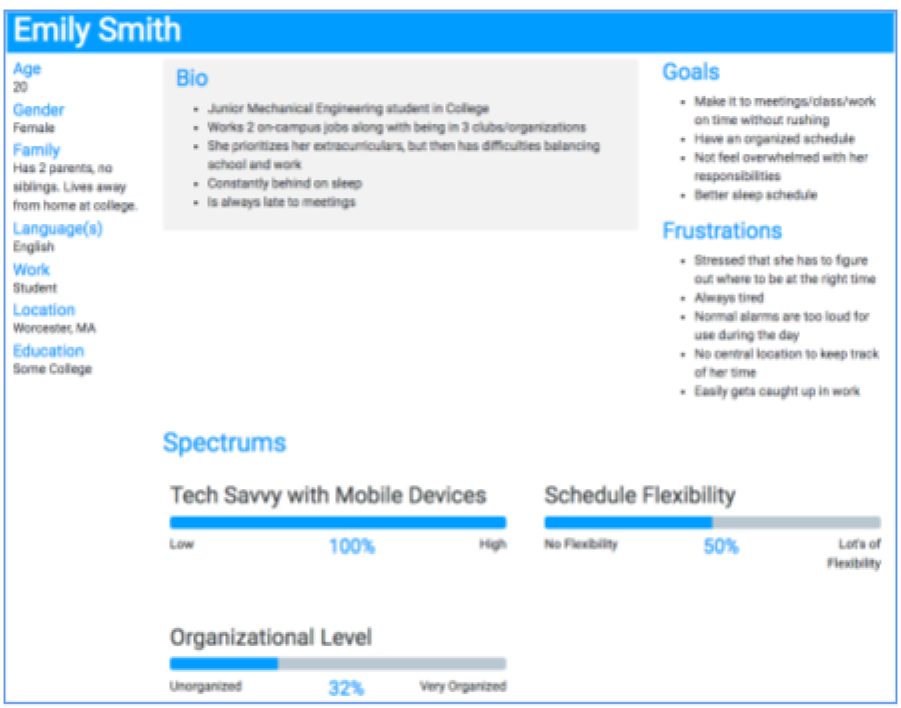


Figure 7: A sample user persona.

Personas are used to identify the priority features of a solution. In this phase, we created three user personas representing different potential user groups. The three groups represented were college students with no musical background or interest in robotic music, people with strong technological backgrounds interested in music technology, and people without much technical background that are just interested in music. These three groups were chosen based on the informational interviews completed in the first objective.

The next step was to create journey maps for each of the user personas. Journey maps in the user experience design process are used to visualize the process a user goes through in using a product or service (Babich, 2020). A journey map is a visualization of the steps a person takes in completing a task (Journey Maps & Personas, n.d.). A template of a journey map outlined by WPI's User Experience and Decision Making lab can be seen below in Figure 8.

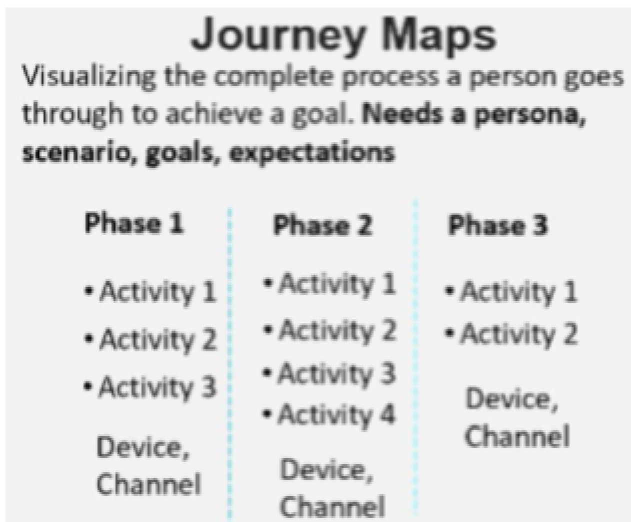


Figure 8: A template of a journey map.

Journey maps are valuable because they identify ways the existing experience can be enhanced. In this case, we created journey maps that detailed each step of the experience that each of our user personas would have in attending a virtual concert. Each of the three journey maps visualized the actions of the user in three phases: 1) Deciding to attend a virtual concert, 2) Attending the performance, and 3) The end of the performance. For this project, we used these tools to help us understand core problem areas with current systems used to experience live music virtually and spaces for innovation. As discussed in the next objective, brainstorming solutions to the frustrations discovered in this user analysis was the next step in developing a solution.

Objective 3: Develop a Prototype

The insights from the user analysis were used to design a functioning prototype of a potential platform for an interactive virtual concert. The goal was to design a prototype of an online platform for virtual concerts that catered to the problem areas identified in the user analysis. We brainstormed potential solutions to each of the problems and then selected the features that seemed the most feasible for the scope of this project. The first step in developing a prototype was designing a low-fidelity user flow that detailed each step a user would take in the process of using a virtual concert platform. The user flow was created using a tablet note-taking application called Notability. These sketches indicated how different user actions would lead to different pages on the virtual concert website. This step is important to ensure that there is an intuitive and logical way to navigate the website.

The next step was creating a high-fidelity wireframe in Adobe XD. Adobe XD is a vector-based tool used to create and test realistic-looking prototypes. This wireframe created was used to visualize the layout of the site and the features included in the virtual concert experience. The wireframe would also serve as a library of all of the visual design decisions such as colors and fonts that developers could use when coding a website. In Adobe XD, we connected different pages of the prototype to test the prototype as a website. Feedback collected from different project advisors and peers who used the prototype was then incorporated into the final design decisions.

Objective 4: Develop the Minimum Viable Product (MVP)

The next step was to develop a minimum viable product (MVP) that could be used for testing and future implementation. To create the MVP, we recruited a team of three undergraduate students to work on the project as an independent study. While we intended for this team of students to work together, we aimed to recruit three different students to each to have a separate role with different goals. The first role was focused on backend development which sought students with experience in Node.js, WebSockets, and servers. The second role focused on front-end development and sought students with HTML, JavaScript, and CSS experience. The final role was focused on video streaming and production and sought students with experience in OBS studio and audio/video hardware knowledge. Students were recruited through a series of email advertisements and after interviews with everyone interested we selected a team made of the three best-fitting candidates.

To organize the teamwork for this project it was critical to select a project management framework that focused on productivity, collaboration, and task execution. Agile methodologies can be described as “a group of incremental and iterative methods that are more effective and have been used in project management”(Lei et al., 2017). Implementing an agile management style would help keep the project on track and allow for changes in development along the way. In comparing agile management frameworks, the Kanban and Scrum methods seemed the most appropriate. After research into both methods, one study found that the Kanban method is more effective than scrum in managing project schedules (Lei et al., 2017). Due to this finding and the nature of our limited seven-week time frame for this website's development, we decided to go forth with the Kanban method. The Kanban method emphasizes “just-in-time” delivery where the main focus is to define tasks that immediately need to be done and their due dates (Lei et al., 2017). This method reduces incomplete tasks because it highlights the most critical work that needs to be done in order to move on with the project workflow. To implement the Kanban method we used an online platform called Miro that had a collaborative card wall as seen in the template below in Figure 9.

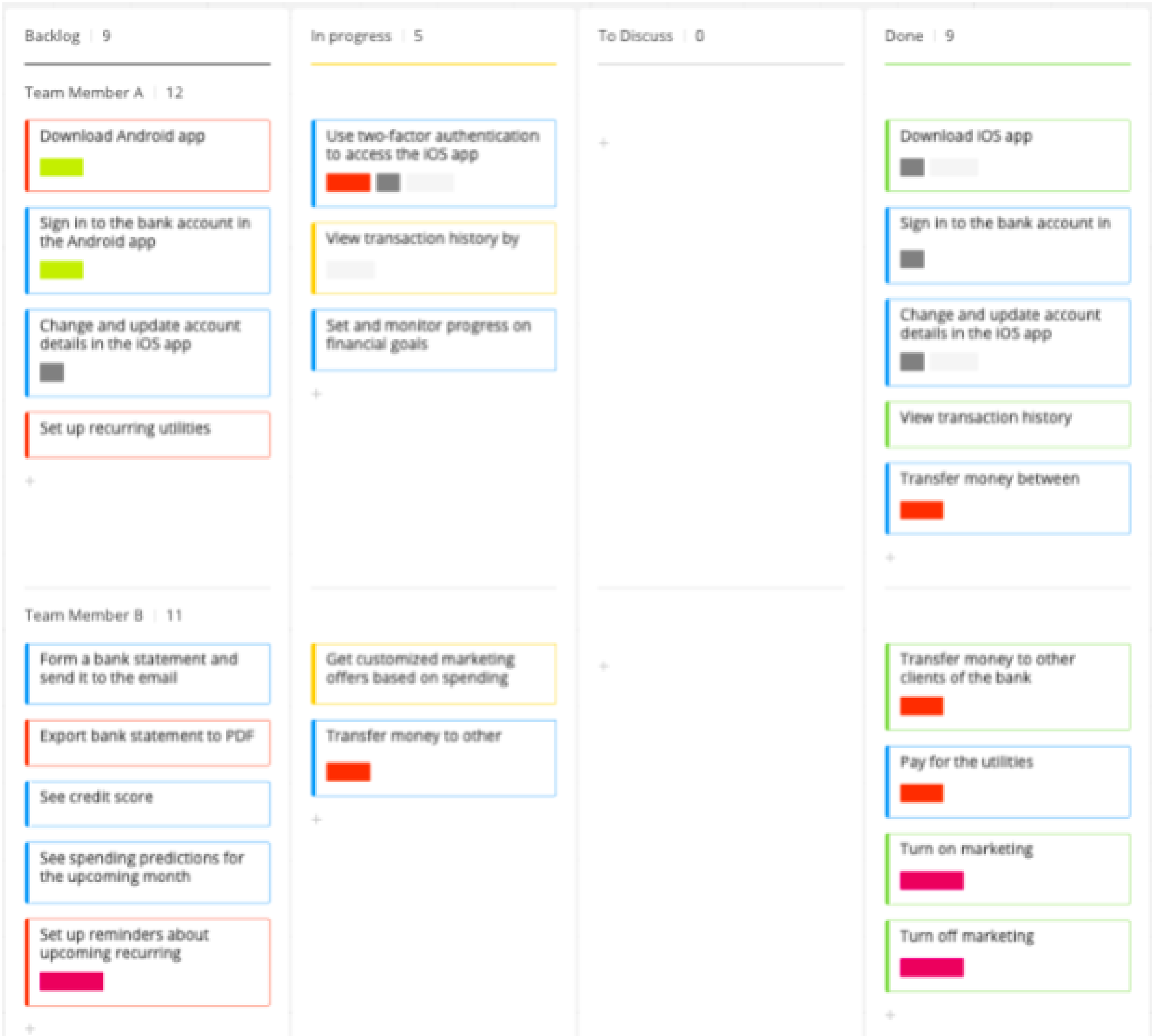


Figure 9: Kanban board template in Miro.

The card wall featured four columns: Backlog, In Progress, To Discuss, and Done. All team members and project advisors had complete access to this card wall so that they could move card tasks into different columns as progress was made. This card wall allowed each team member to see their immediate tasks for the upcoming week and to track their progress before the next meeting. The Miro board served as a visualization for our weekly team meetings that were held over Zoom. Any cards placed in the “To Discuss” column were discussed at a weekly team meeting and often led to key decisions being made. Additionally, on the Miro board, we had a visualization of the overall project timeline that was updated over the seven weeks of the project to keep overall project development on track.

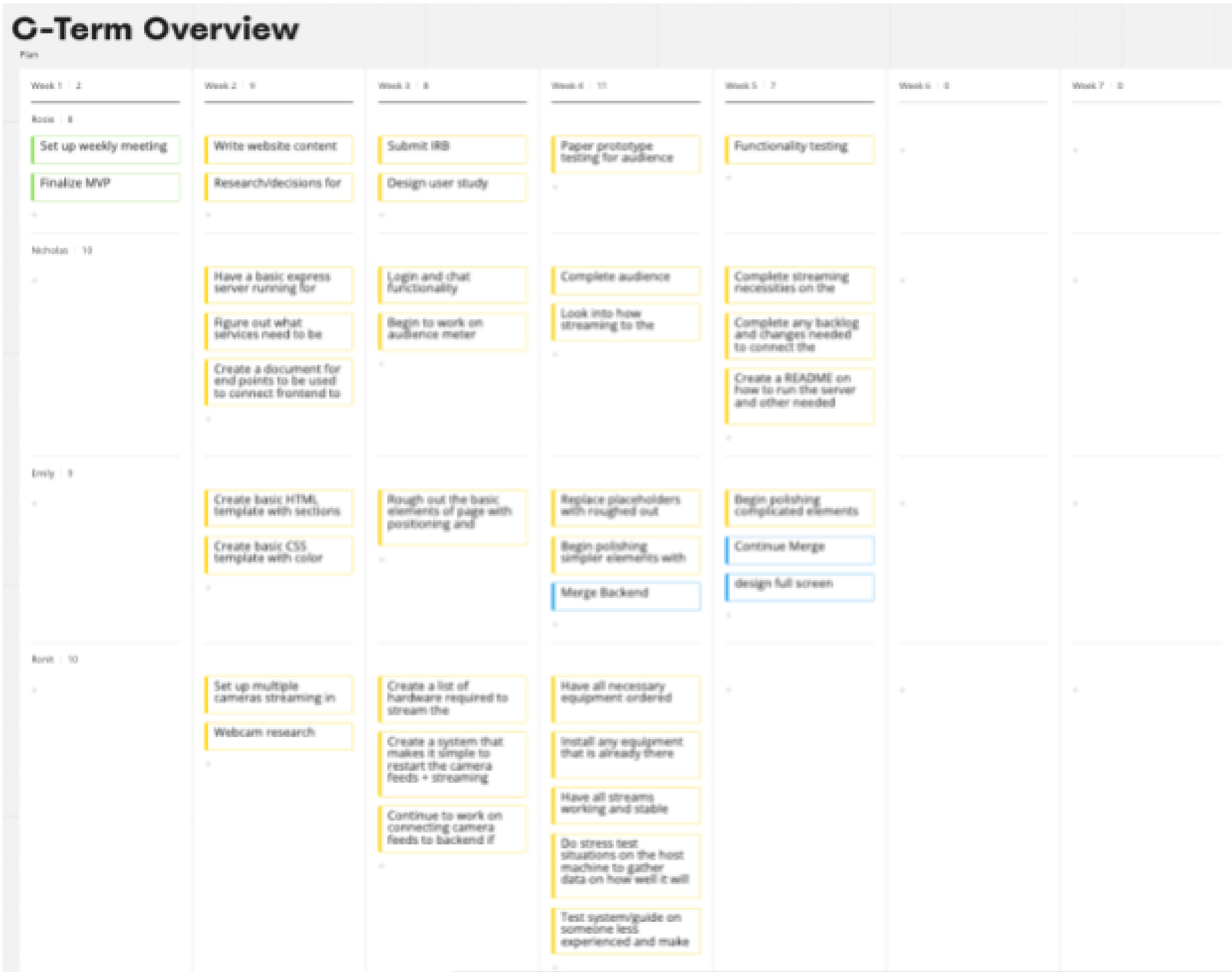


Figure 10: C-Term project timeline.

As you can see in Figure 10 above, we initially only planned for tasks up through week five to leave room for development taking longer than expected, unforeseen problems, and revisions.

The wireframes created in Objective 3 were used to guide the team members throughout the development process. However, the wireframes depicted the ultimate project goal so it was important to define the MVP for the team to produce as a base product. The necessary features to include in the MVP are as follows:

1. Live Video Stream
2. Viewer Login & Registration

3. Live Chat
4. Audience Reaction Meter
5. Information on the Robotic Instruments

The first feature of the MVP is a live video stream of all of the robots. After all, the point of this project was to create a virtual concert platform so it was most important that we create a platform that can stream a live performance at the bare minimum. The second feature of the MVP is a viewer login. It was necessary to create a viewer login so that each audience member would have an individualized experience similar to an in-person concert. On top of that, a viewer login is necessary for the third feature of the MVP, a live chat, so that each viewer would be able to participate in the chat. A live chat was included in the MVP because it was the easiest way for audience members to interact with each other. The fourth feature of the MVP was the audience reaction meter because this meter would visualize the presence of other viewers which would contribute to recreating the crowd aspect of an in-person concert. The final feature of the MVP would be access to information on the robotic instruments themselves. This feature was included in the MVP because most viewers would not have prior experience with robotic musical instruments, so it's important that they have an outlet to understand what they are viewing. Understanding the instruments is also part of the reason we made the decision to include the concert platform as part of the WPI Music, Perception, and Robotics website as a separate tab. This way, viewers can navigate outside of the performance onto the website to learn more information about the instruments and work of the lab.

Objective 5: Test the Prototype to Inform Key Design Decisions

While the MVP was being built, the next objective was to conduct a user study to inform key design decisions for the virtual platform. This user study aimed to gain insights into two components of the MVP. The first component we were testing was the icon used in the audience meter. The audience meter is one of the key contributors to creating relationships between audience members. Audience members had the opportunity to select an icon to demonstrate a positive reaction to the performance. The meter would then visualize the percentage of viewers pressing the reaction button within the same time period. This visualization indicated to viewers that other members of the audience were reacting to the performance, therefore creating a relationship between viewers through familiarity. This is why it was important to understand which icon button was most natural for viewers to press to indicate a positive reaction. This study used a within-subjects design, meaning that all participants were given the same independent variables. The study was designed to collect both quantitative and quantitative data in order to compare the effectiveness of different reaction buttons. There were four levels of the independent variable with four different icon buttons being tested. The four icons chosen, shown below in Figure 11, were chosen because they are commonly used icons for reaction on the internet as seen below.

Figure 11: The 4 icons tested in Study 1.

The dependent variable (ordinal) for this part of the study was the number of times each reaction was selected by each participant. To account for the fact that participants would react at different frequencies, the reactions were ranked from 1(most reacted) to 4 (least reacted) by each participant. The rankings were then compared between participants. We hypothesized that one icon would be more popular than the others indicating that it was the most appropriate icon to serve as a reaction button on the virtual concert platform.

The second component we were testing in this study was different camera views. We wanted to understand which camera views of each instrument resulted in the best viewer experience. I worked closely with the student on my team focused on cameras and streaming to decide on two or three views for each instrument. We then composed two 30-second pieces involving all of the instruments and recorded them from each of the selected camera views. We made sure to record the same views for each of the two pieces so that in testing the views the angles would remain the same. In order to test both the camera views and the reaction icons at the same time, we created a series of ten videos to show each participant. There were two videos for each instrument showing one of the two musical pieces, and within each video, all of the camera views were shown for the same amount of time but in different orders to eliminate order bias. The best camera views would be revealed by a count of how many reactions occurred during each view.

As a solo researcher, it would have been difficult to manually record which icons were reacted with along with the time of the reaction. Due to this, we used an online platform called Mindstamp to show all of the videos. All of the videos were edited with the same audio recording on iMovie. The ten edited videos were then uploaded to Mindstamp where they were edited further for the testing. In Mindstamp, we added each of the reaction icons as image buttons on a banner at the top of the video. Mindstamp was chosen for its ability to record timestamps of clicks on different image buttons. This way when participants viewed a video, it would record their viewer IDs, which buttons were pressed, and when each of those buttons was pressed which can be seen in Figure 12 below. The data recorded in Mindstamp can then easily be exported as a .csv file for analysis.

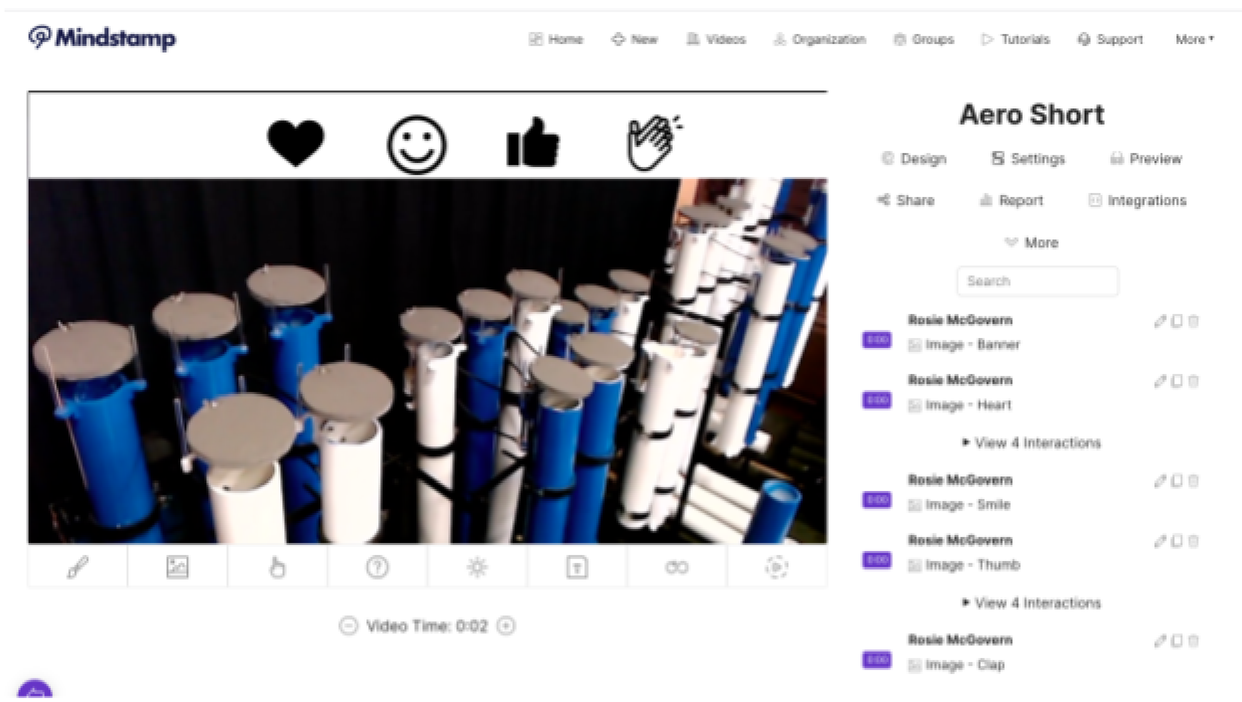


Figure 12: Reactions recorded within Mindstamp

We aimed to recruit 10-20 participants for this study through email advertisements and word-of-mouth with our peers. For the purposes of the study and based on limitations due to COVID-19, all participants were members of the WPI community. This study was hybrid where participants could participate either in-person on WPI's campus or online over Zoom. We started the study by welcoming participants and verbally reciting our IRB-approved introduction. Once the nature of the study was established through the introduction, participants read and agreed to an informed consent form. Next, participants were read instructions (see Appendix B) and then sent a series of ten links leading to each of the videos. The links were grouped into two cohorts, one group for each musical piece with five videos for each instrument inside. The order of the five links within each group was randomized for each participant to once again eliminate order bias. After all ten links were viewed, the participants were given two follow-up discussion questions to help them understand their decisions and thoughts on what they viewed. At the end of the study, the participants were thanked for their time and asked if they had any final thoughts or questions.

As mentioned before the results from this study would inform key design decisions to be implemented in the MVP. After all data was collected, it was downloaded from Mindstamp and imported into excel. In excel the data was organized, cleaned, and analyzed to determine the most appropriate icon and most favorable camera views.

Objective 6: Test the MVP and Gather Future Recommendations

At the end of the term, the work the team of students completed resulted in an MVP of the virtual concert website. The next step was to test the MVP to produce recommendations for future teams working on this project. To test the MVP we completed one final usability test. The purpose of this study was to find problems in the website, see if the audience understood what they were watching via a performance on the website, gain general feedback on the visual design and layout of the site, and identify spaces for improvements. For this study, it was necessary to have participants use the actual website even though it was not fully functioning. We planned to have a group of around 5-10 participants who would view a short performance on the site and provide feedback in a focus group afterward. We were aiming to collect qualitative data to evaluate the current state of the site and provide suggestions for future directions of the virtual concert platform. Due to the nature of this data, it was most logical to do a focus group over a survey to gain as much qualitative feedback as possible. Additionally, because we had limited time to complete this study, a focus group allowed us to gather all of the data at once. Participants joined the study virtually over Zoom where they were immediately welcomed and read and agreed to the IRB-approved introduction. Next, the participants were all sent a link to the concert where members of my team and my project advisors had set up a performance for the time of the study. The participants were instructed to watch the performance and interact with the site for the duration of the performance. At the end of the performance, participants returned to the zoom call where we read the discussion guidelines and then began the group discussion. The group followed a series of guided questions (see Appendix C). After the questions had all been answered, participants were thanked for their time. The discussion responses were then recorded and organized in a findings document to be used by future teams working on the website.

Results

This chapter discusses findings from the informational interviews with stakeholders, the personas and journey maps created as part of our user analysis, the prototypes, the process of building the website, and the results of both of the user studies that tested different necessary features of the website along with the website's functionality. Additionally, we will define recommendations for future directions of this project based on feedback and data collected during each step in the design process.

Informational Interview Findings

In order to define the product to create in this project, we conducted informational interviews to understand what key stakeholders expect, need, want, and are frustrated with in regards to in-person and virtual concerts. After six interviews with students, music professionals, frequent concert-goers, composers, etc., we gained several insights. The most common online platforms already used for virtual concerts reported by interviewees included Zoom, Youtube, Facebook, and Instagram live streams. When discussing the motives for attending a concert, in-person or virtual, many participants noted that they sought a unique experience that could only be offered with an online concert that would set it apart from other experiences. An example of this includes the opportunity to use the browser as an instrument. This would mean showing the inner workings of the music composition and robots alongside the video streams. This is an example of a feature that would differentiate a virtual concert on our developed platform from a basic live stream. Additionally, many of the people interviewed described how the energy of a live performance created from the vibrations of the sound and the vulnerability of leaning into crowd imitation, were key motivators for attending concerts. Based on experiences using online meeting platforms or from watching live streams, many participants verified a need for connecting with other audience members. These connections are often formed by reacting to the performance in the same way as others and through conversation about the performance. This insight demonstrates the importance of a chat feature and a visualization of audience reactions as a feature in a virtual concert experience. The takeaways from these interviews led to visualizing the possibilities for virtual concert experiences and understanding our target users and their goals and frustrations.

User Analysis

Our goal was to empathize and understand our users in order to pinpoint features of the website that would be a priority to include based on problems we discovered. To do this we created user personas and journey maps (see Appendix D). The user personas were created first and then based on each persona a journey map was created. The findings from the informational interviews about different user groups influenced the personas we created. For instance, the first persona created shown in Figure 13 below, was based on conversations with college-aged students who frequently attended concerts but had no prior knowledge of musical robots This persona describes a Clark University Graduate student named Gabriella who has limited background in musical technology.

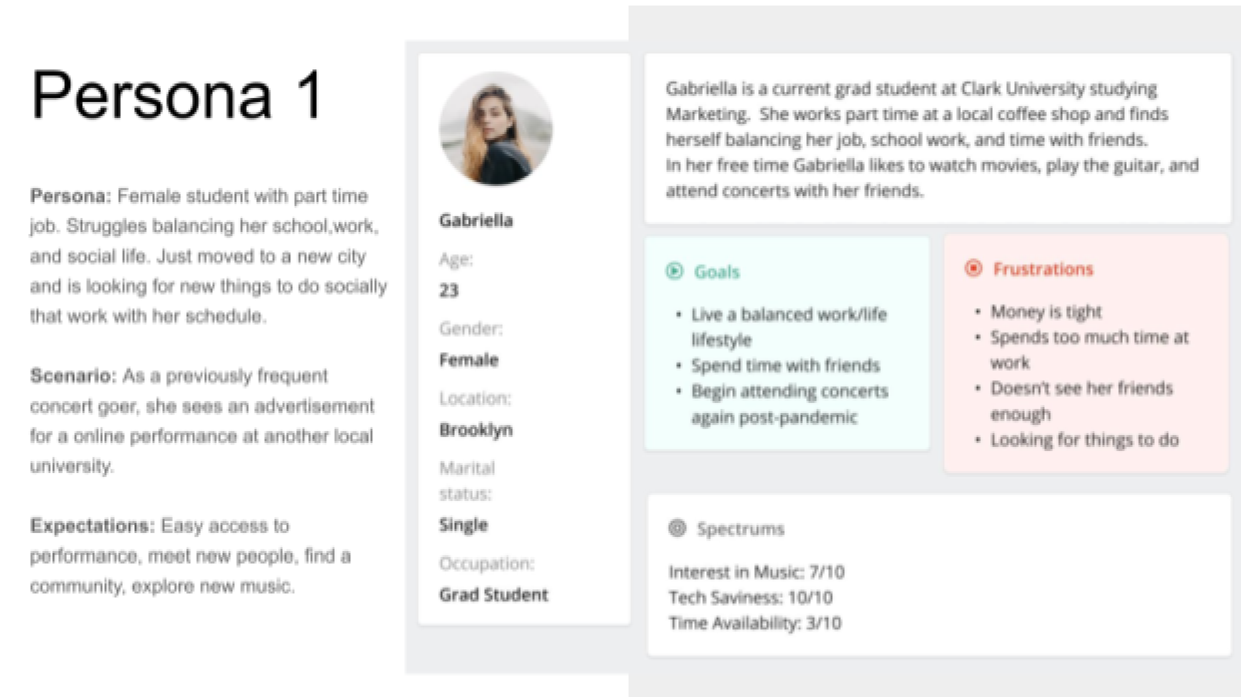


Figure 13: User Persona 1, Gabriella.

The personas were created using a template on Figma, a web-based platform to create vector graphics on. The journey map created for Persona 1, Gabriella, is shown below in Figure 14.

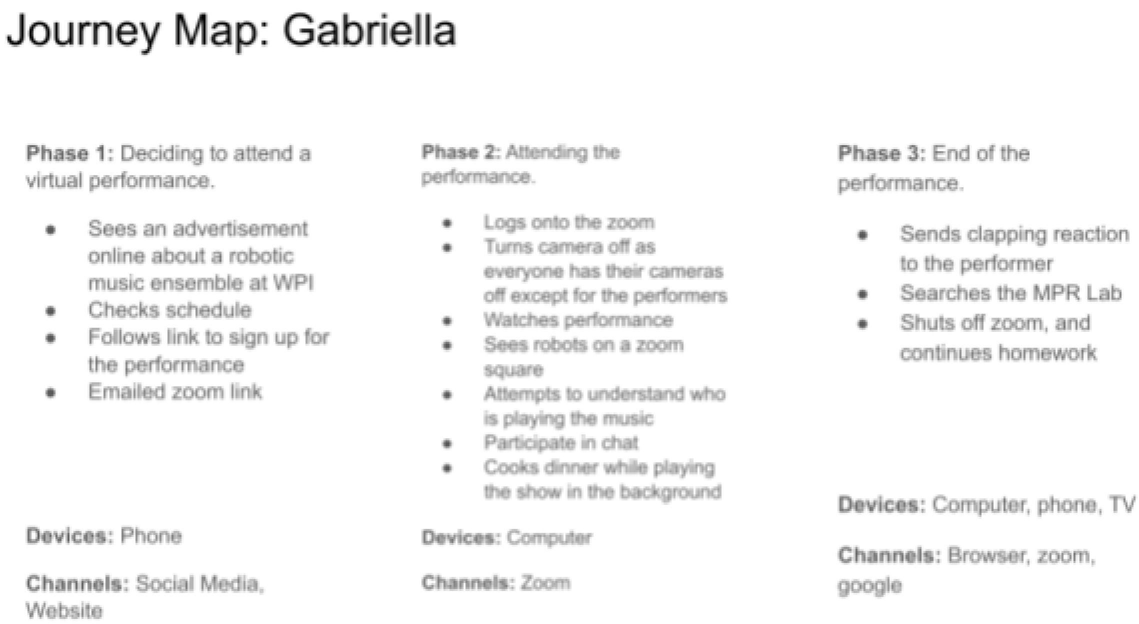


Figure 14: Journey map for User Persona 1.

Each phase shown in this journey map details what Persona 1, Gabriella, would do and feel during each phase. One example of a takeaway from Persona 1 is that users may follow the actions of their peers which may result in the lack of use of some features. In this case, Gabriella did not want to turn her camera on since no one else in the audience had their camera on, even though there was a camera feature. We reviewed each persona and journey map and found common themes and identified problems which are described below.

From this analysis, we found three problem areas in attending a virtual concert. The first problem area is the lack of a communal experience. In a virtual setting, audience members miss the interactions between audience members and the experience of communal reactions to the same performance. The second problem area is the lack of event excitement. There is nothing special about viewing a performance online considering there is unlimited access to pre-recorded performances on the internet already. An online concert needs to have unique features that can only be experienced online and set the online performance apart from in-person and pre-recorded performances. The third problem area is with maintaining audience focus. Audiences have no responsibility to participate when watching an online performance, whereas when watching an in-person performance audience members are encouraged to respond and interact with the performance. The lack of participation along with often distracting home environments where virtual concerts may be watched may make audience focus an issue with online performances. In the next step of the design process, prototyping, we identify potential fixes to these problems and visualize those solutions in prototypes.

Final Prototype

Before creating prototypes, we selected potential solutions to aid each of the problems detailed in the section above. To combat the lack of a communal experience in a virtual concert, we used insights from the informational interviews and decided it was important to include a live chat feature for audience members to communicate with each other on. Additionally, we decided to include an audience reaction meter that would allow viewers to react to the performance by pressing a button and then provide a visualization of the communal responses. This meter was intended to combat the lack of a social bond that is formed through relating to the responses of the people around you. To make online performances unique, we wanted to include a feature that allows viewers to explore and learn more about what they were viewing. This included options for multiple camera views that were controlled by the viewers and accessible information about the performances and instruments they were looking at. All of these features also address the third problem area, lack of audience focus, as they encourage more audience participation.

To begin visualizing these proposed features, we created a user flow that included sketches of each screen and arrows indicating how different user decisions impacted the website. The user flow can be seen below in Figure 15. Creating this flow revealed possible layouts for different screens and ensured there was a logical flow at all parts of a user's interactions with the site.

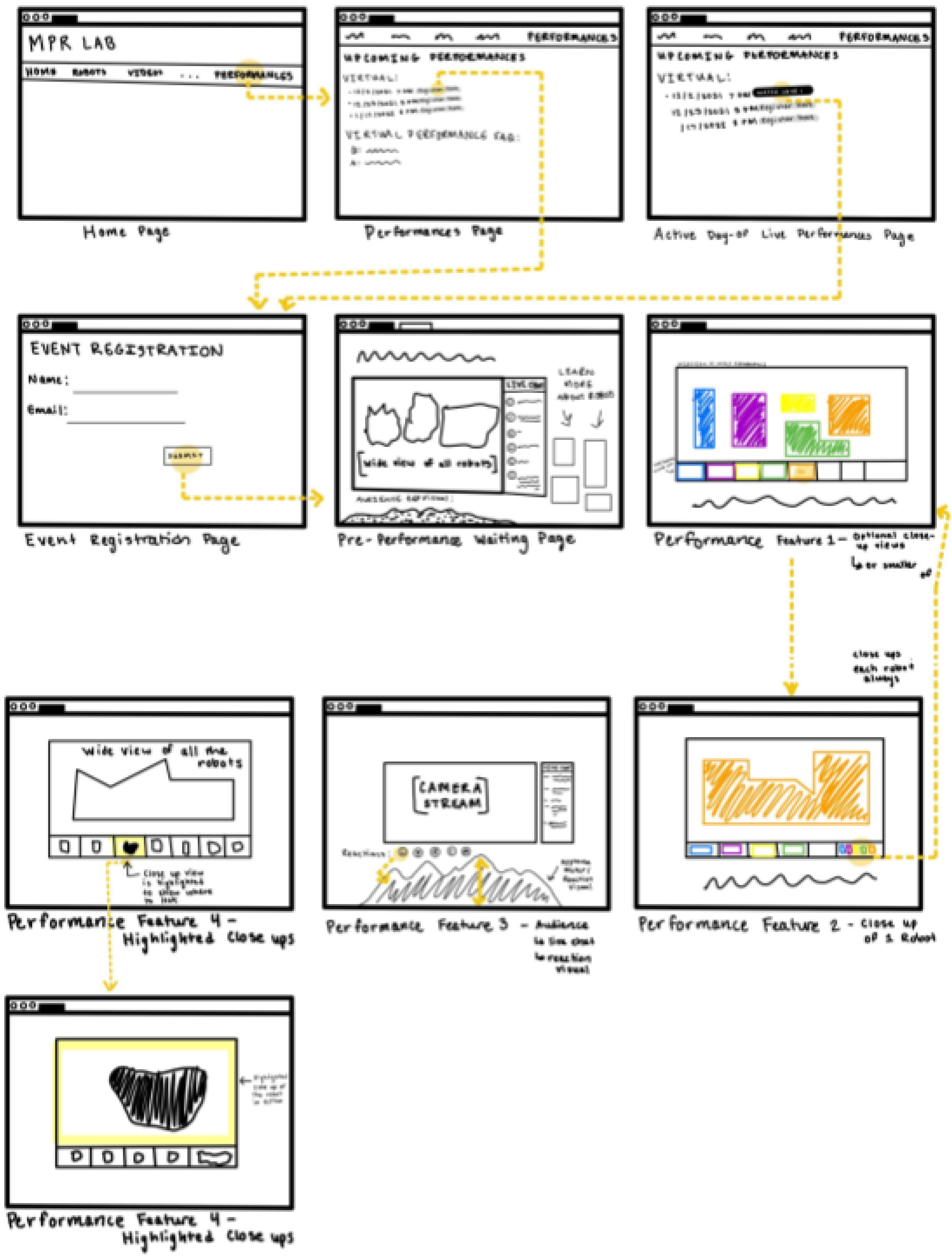


Figure 15: Low-fidelity user flow detailing the website.

We collected feedback on the user flow from project advisors and peers and then created a functioning prototype in Adobe XD. Adobe XD was a successful platform to build this wireframe on because it was capable of creating a realistic-looking prototype that could be run to mimic the real experience of using the site. In Adobe XD we created multiple different screen layouts and selected the two below seen in Figures 16 and 17 to use as guides in the website development.

Figure 16: High-Fidelity full screen wireframe.

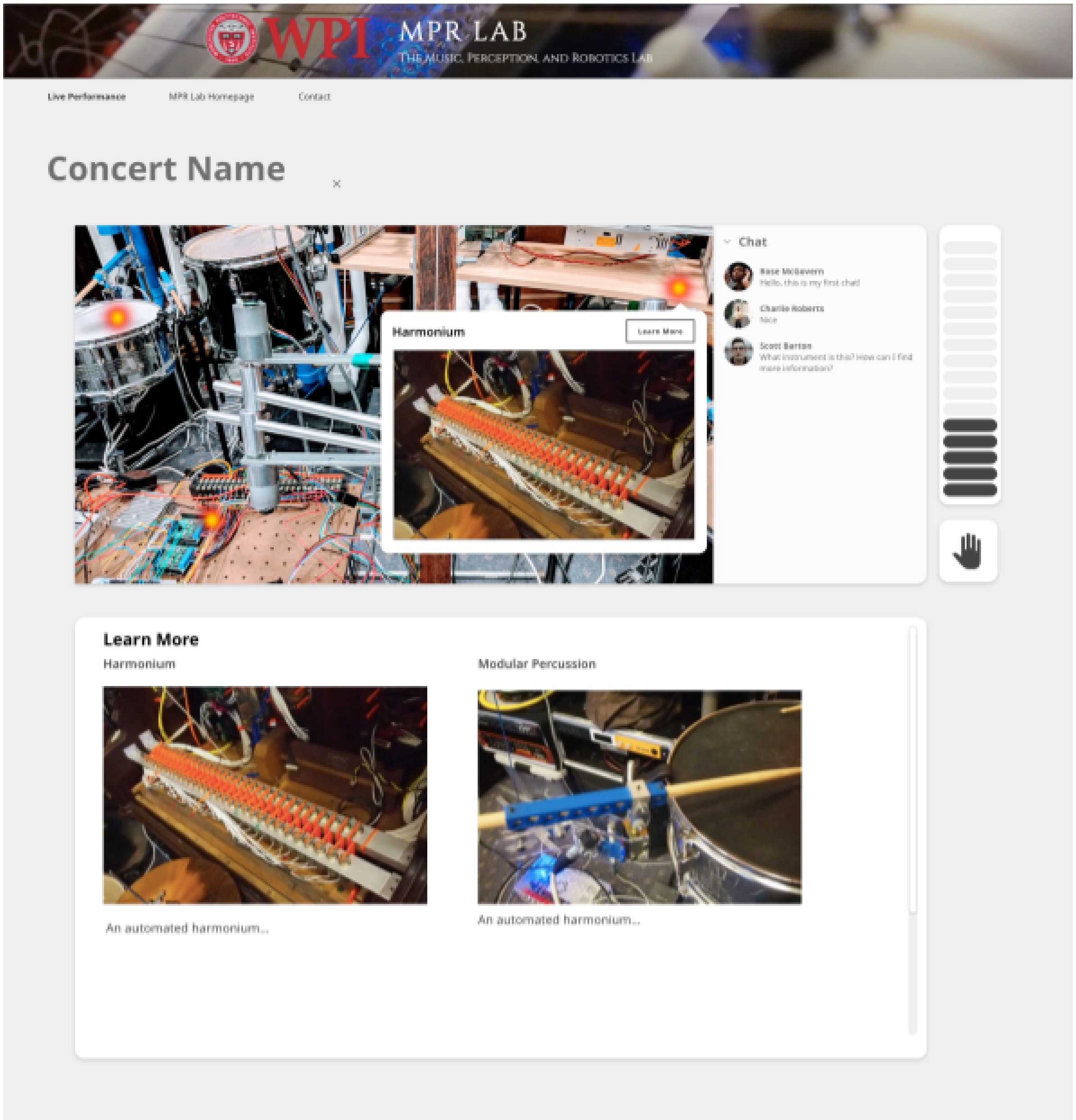


Figure 17: High-fidelity landing page wireframe.

The connections of the wireframe that made the prototype clickable can be seen below in Figure 18.

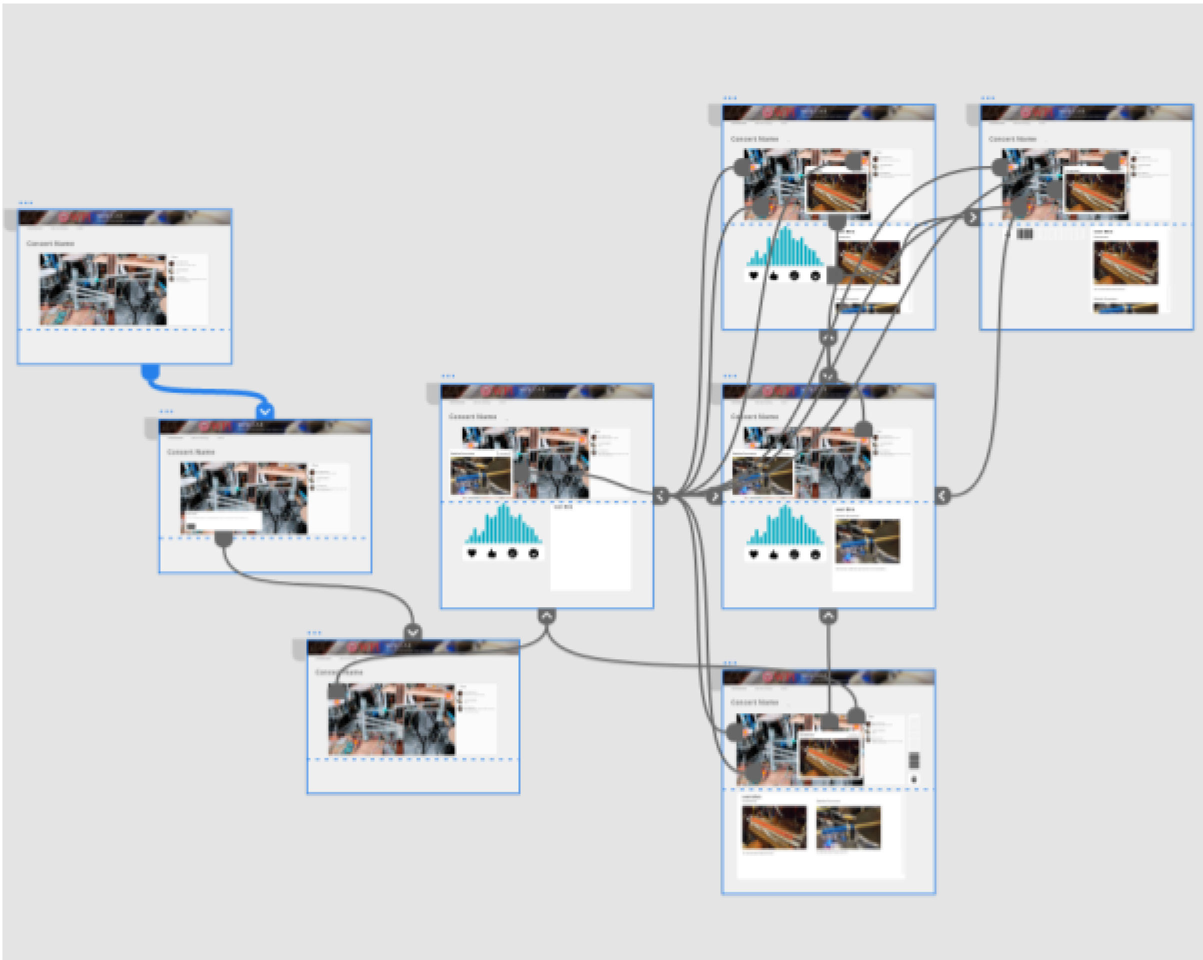


Figure 18: Connections made between pages in the wireframe to make the prototype interactive.

Project Management Findings

To manage the development of the website, we followed the Kanban method which is an agile framework that focuses on completing tasks that immediately need to be done (Lei et al., 2017). We organized the tasks using a collaborative online Kanban board on the Miro website. The Kanban method was effective in keeping track of tasks. During team meetings, team members were able to quickly update their task lists with new tasks that arose in discussion. This was helpful as it ensured that no tasks were forgotten and that there was always someone assigned to a task. The ability to move task cards between four columns (backlog, in-progress, to discuss, and done) created fluidity in team meetings as well since we could easily visualize progress. Additionally, the Kanban method limits the amount of tasks that are in progress which made it easy to see areas we were overworking if the in-progress limit was reached. The online Kanban board also made preparing for meetings more efficient since it eliminated the need for meeting agendas. During meetings, all notes were taken on accessible sticky notes on the board that all members could see.

There were challenges in managing the development of the website. Most of the issues arose surrounding the limited seven-week time frame.The team spent a lot of time dwelling on key decisions such as which cameras to purchase and how to approach the technical development of the website. Without these decisions made progress was delayed causing us to focus only on completing the minimum viable product.

Study 1 Results: Informing Key Design Decisions

We ran two different tests in the first user study to test 1) which icon was the most appropriate to indicate a positive reaction as part of the audience meter feature, and 2) which camera views prompted more positive reactions from the audience. We had a total of 12 participants in the first study.

Icon Test Results

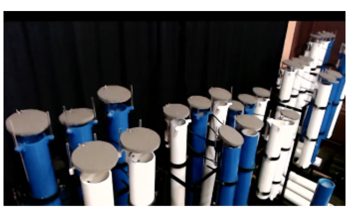
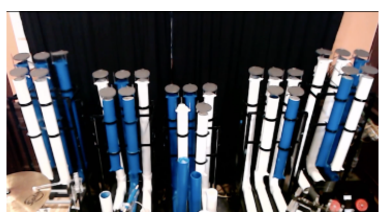
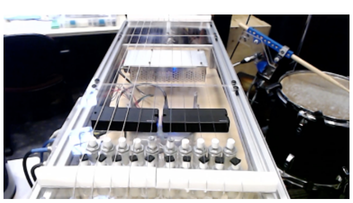
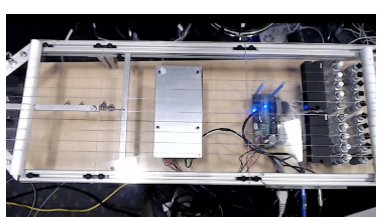
The number of times each icon was selected by each participant was recorded, then the icons were ranked from 1(most used) to 4 (least used) per participant. If a participant selected multiple icons the same amount of times, each of those icons was given the higher rating. For example, if a participant selected the heart icon 6 times, the thumb icon 4 times, the clap icon 4 times, and the smile icon once the icon rankings for that participant was 1 = heart, 2 = thumb & clap, 3 = smile. After each participant's responses were coded to the ranking system, the rankings for each icon were added up where the lowest sum indicated the most used icon. The results were as follows:

	Total	Final Rankings (Most used to least used)
Heart	33	1) Thumb
Thumb	26	2) Clap
Smile	35	2) Heart
Clap	32	4) Smile

These results indicate that the thumb icon was the most intuitive choice across participants.

Camera Views

To determine which camera views initiated the most reactions from viewers, the total number of icons selected at each view was totaled to make a comparison. Each view was shown for the same amount of time and in different orders between the two videos to decrease variability due to different exposure lengths and times. The results are as follows:

	PVC Aerophone		
			
Total:	15	**16**	
	Cyther		
			
Total:	23	**24**	
	Modular Percussion 1		

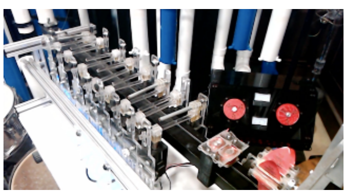
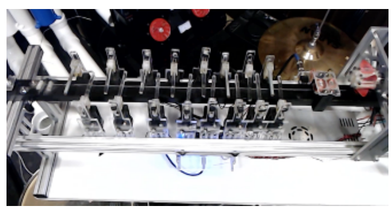
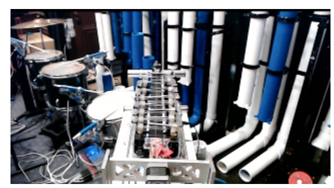
			
Total:	**13**	12	
	Modular Percussion 2		
			
Total:	**9**	3	8
	PAM		
			
Total:	10	**16**	15

Figure 19: Camera view reaction counts by instrument.

The bolded totals highlight the camera view that was most reacted to in this study. It is important to note that all of the results had only a one-point difference between at least two of the views. This indicates that of the camera views tested, there was not a significant difference between them.

Discussion Questions

At the end of the study participants were asked two optional questions. The first question was, "Was there a specific icon that you felt more inclined to select than the others and why?" and the second question was, "do you have any other thoughts, opinions, or questions based on what you watched?" to provide additional feedback. The responses to the first question provided explanations for why participants reacted the way they did, but the responses varied across participants. Multiple participants noted that the clapping icon was the most intuitive choice since they were watching a musical performance and were used to reacting with clapping for in-person musical performances. Others stated that the thumbs-up icon seemed the most appropriate because that is the most common indicator of a positive response in online spaces.

The responses to the second question also varied among participants but provided key insights on which instruments and views were most visually appealing. Multiple participants noted that out of all the robotic instruments, they found that PAM and the PVC Aerophone were the most exciting to look at. One participant noted that when they could visually connect the sounds they were hearing to what they were seeing they were more intrigued.

Study 2 Findings: Focus Group Feedback

The goal of the second user study was to test the usability of the website developed and to receive feedback regarding design decisions on the site. The focus group in Study 2 resulted in feedback that will be used to guide future directions of the project. After the focus group participants viewed the performance on the website, they returned to the Zoom call where we began the discussion. There were limitations with the study due to technical issues that may have impacted the responses. The chat, learn more, and concert information features were not functioning at the time of the performance. The key findings from the discussion are listed below:

- The purpose and functions of the audience meter feature were unclear. Participants could not tell if the meter only visualized their own reactions or if it was visualizing an accumulation of all of the viewer's reactions.
- There was no full-screen viewing option that viewers wished for as they watched the performance. When first landing on the live stream viewing page the video indicates that it can support a full-screen view because it is presented as a Youtube video.
- There is too much white space in the margins of the website. This made the proportions of the video and informational text look off. Additionally, participants noted that the video was too small to see the details and the additional white space in the margins could have been used better to expand the video.

- Participants liked the ability to click between different camera views. However, this feature was not explicitly clear without instructions.

Conclusion & Future Recommendations

We began by understanding our potential users and speaking with key stakeholders to identify features of live concerts and online entertainment platforms that create engaging experiences for audience members. Using these insights we developed high-fidelity mockups of a virtual concert website that included the identified features. These mockups served as a clickable prototype used to demonstrate to our team of developers the product we aimed to create. Our team of developers then worked together to create the minimum viable product. We defined the minimum viable product as a website that includes live video streams, multiple camera views, an audience reaction meter, live chat, viewer login or registration, and access to information on the robotic instruments in the ensemble. With the developed website, we ran two user studies. The first user study aimed to inform key design decisions including which icon to use for the reaction meter button and which camera views were better. We found that the "thumbs-up" icon was the most appropriate image for a reaction button. For camera views, we found that there were not any views that were favored significantly more than others as long as viewers were able to clearly see the movements of the instrument. The second user study aimed to test the usability of the website and gain feedback to inform future recommendations. From this focus group, we gained key insights on the visual design of the website, information on parts of the website that were confusing or not working properly, and validation of some of the features on the website.

While our design provided a sufficient platform for testing some of the key features we identified as a priority for a virtual concert website, there are a lot of opportunities for future directions with this project. As outlined in the Results section, many of the future recommendations come from the focus group discussion. In the future, we recommend that the further development of the website be continued first. The website's code is located in a Github repository (https://github.com/MPRlab/interactive-website.git). The README file includes instructions on how to run and edit the website. Existing features that are not fully functioning and need to be further developed include:

1. The live chat feature which expands when messages are longer than the width of the chat box. This then impacts the size of the video stream, as it gets smaller as the width of the chat box expands.

2. The “learn more” section of the website that is supposed to update when a camera view is clicked on. The information on the instruments does not consistently update when their respective camera views are selected.

Future developers should focus on developing a full-screen view of performances. For the visual design of the website, we recommend that the proportions of the video, margins, and text are fixed to focus on the video stream. Additionally, there is an opportunity to make the overall design more exciting to reflect the nature of the robotic musical performances in the lab. This may include changing the color scheme to match the neon LED lights in the lab. We also recommend exploring different possible visualizations of the audience reaction meter. This could include visualizations that are included more in the view of the video stream or reflect more of the nature of the music. Additional wireframes of the website created in the prototyping phase that may be useful in future development can be seen in Appendix E.

We also recommend exploring how spatial audio can contribute to the virtual concert experience. Many of our interviewees noted the importance of being able to connect what they are hearing with what they are seeing. Multiple participants recommended having the volume levels of certain instruments increase when their video is focused. Manipulating the audio to reflect the visuals of the performance may create a more engaging experience for viewers. With all of these recommendations and potential future directions, we are confident that the continuation of this work will be valuable in enhancing virtual concert experiences.

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Appendix

Appendix A: Informational Interview Scripts

Professional Interviews:

"I am working with the Music, Perception, and Robotics lab on campus and we are exploring the experience design of virtual concerts through performances and interactions in the lab. There are many different stakeholders in a virtual music performance including the composers, the performers, and the audience, so right now I am working to gain an understanding of what each stakeholder is looking for in virtual performance. The end goal of this project is to create an online platform for virtual concerts that hopefully has some level of interaction between performers and audience members."

1. **Could you tell me a little bit about your background in composing and/or performing?**
2. **What Different contexts have you performed in?**
3. **First, Scott Barton, my advisor, recommended that I reach out to talk with you. Do you have any experience with the MPR lab or robotic musical performances?**
4. **What it's like working with live musicians, different interfaces and how does that affect the audience experience from their perspective.**
5. **Have you performed or viewed any virtual concerts? What parts of the experience do you find are missing with virtual concerts?**
6. **As a performer, what role does the audience play to you?**

7. **What are your feelings or emotions in the process of attending or performing at a concert from start to finish?**

Student Interviews for Virtual Concerts:

"I am working with the Music, Perception, and Robotics lab on campus and we are exploring the experience design of virtual concerts through performances and interactions in the lab. There are many different stakeholders in a virtual music performance including the composers, the performers, and the audience, so right now I am working to gain an understanding of what each stakeholder is looking for in virtual performance. The end goal of this project is to create an online platform for virtual concerts that hopefully has some level of interaction between performers and audience members. "

1. **Could you tell me about your experience attending a virtual concert? (Genre, location, channel, duration)**

2. **What encouraged you to attend the performance online?**

3. **What did you particularly like or dislike about the online performance?**

4. **Did you feel connected to the performers or any other audience members?**

5. **What devices would you feel most comfortable viewing a virtual concert on?**

Student Interviews for In-person Concerts:

"I am working with the Music, Perception, and Robotics lab on campus and we are exploring the experience design of virtual concerts through performances and interactions in the lab. There are many different stakeholders in a virtual music performance including the composers, the performers, and the audience, so right now I am working to gain an understanding of what each stakeholder is looking for in virtual performance. The end goal of this project is to create an online platform for virtual concerts that hopefully has some level of interaction between performers and audience members."

1. **What drives you to attend concerts?**

2. **How do you feel connected to other audience members or performers during concerts?**

3. **What aspects of an in-person concert would you find missing in a virtual or prerecorded concert?**

4. **What feelings do you have from start to finish in the process of attending a concert?**

Appendix B: User Study 1 Script

Introduction

"Hello, thank you so much for coming in today. Feel free to take a seat here. My name is _______________. I will be your experimenter today. "

"Before we get started, I need for you to look over this informed consent document and indicate if you agree to participate. If you agree, please state that you agree and you will start the study. If you do not agree, please state that you do not and the study will end now."

For Zoom Participants:

"Thank you for agreeing to participate! In today's study, you will view a series of robotic musical performances from the Music, Perception, and Robotics lab. As you watch the performances, please react if you feel inclined to do so by clicking on one of the 4 reaction icons at the top of the video. I will be sending you links to the different videos in the chat. Please share your screen so that I can observe that everything is working. You may be asked to enter your name at the beginning of a video, if that happens please type your name. You are going to watch a total of 10 videos, the first five will each be a different instrument from the first musical piece, and the second five will be a different instrument from a second musical piece. We are testing different camera angles, music, and viewer reaction buttons so please select the buttons at the top of the screen when you feel appropriate while watching the videos."

For In-Person Participants:

"Thank you for agreeing to participate! In today's study, you will view a series of robotic musical performances from the Music, Perception, and Robotics lab. As you watch the performances, please react if you feel inclined to do so by clicking on one of the 4 reaction icons at the top of the video. I have just emailed you a series of links to the videos, please watch them in the order they were sent. I will be here observing to make sure that everything is working. You may be asked to enter your name at the beginning of a video, if that happens please type P1."

At the end of the videos:

That concludes all of the videos that you have to watch. I just have 2 follow-up questions:

1. Do you have any thoughts, opinions, or suggestions on viewing those performances that would have made it easier to understand or more enjoyable to watch?
2. Were there any other reaction buttons that you wished you could have had?

"That concludes the study. Thank you for participating!"

Appendix C: Focus Group Script

Pre-Performance

1) Start zoom call and have the concert site URL copied on the experimenter's computer.
2) Once all participants have joined the call, review informed consent and explain the study.
    a) "Before we get started, I need for you to look over this informed consent document and indicate if you agree to participate. If you agree, please state that you agree and you will start the study. If you do not agree, please state that you do not and the study will end now.
        i) *If they do NOT agree: thank them for coming and show them out.*
    b) *If they agree:* "Thank you for agreeing to participate! In today's study, you will be viewing a virtual concert done by the Music, Perception, and Robotics lab on WPI's campus. Here there are robotic musical instruments that will be performing each piece. The platform you will view the concert on has been created specifically for testing. If you feel inclined to do so, please navigate around the website and interact with its different features as you see appropriate. After the performance is finished, please return to this call where we will have a group discussion and you will be asked a few questions regarding your experience. I'm placing the link to the concert's website in the chat. Once you receive it, feel free to minimize this zoom call window and head to the website where the performance will begin shortly. Please hold any thoughts or questions until after the performance."
3) *Send the link to the concert site in the zoom chat.*

Wait in the zoom call after participants have finished watching the performance.

Post-Performance

1) Once all of the participants have returned to the call, read the discussion guidelines:
    a) We want you to do the talking. We would like everyone to participate. I may call on you if I haven't heard from you in a while.
    b) There are no right or wrong answers. Every person's experiences and opinions are important. Speak up whether you agree or disagree. We expect and want to hear a wide range of opinions and we do not anticipate consensus, just sharing.

c) We emphasize that what is said in this room should remain here. You should be comfortable sharing anything if sensitive issues come up. Please don't disparage another participant's remarks and let's have just one speaker at a time.
d) The discussion will last about ______ minutes. If we have not ended by that time, I will begin wrapping up the discussion.
e) We will record this session as we want to capture everything you have to say. We don't identify anyone by name in our findings. When you respond, be sure to not mention your name. You will remain anonymous and the recording will be deleted after the findings are recorded.
f) Are there any other questions?

2) "Next I have a series of guiding questions for the group, don't be afraid to stray from the questions or to continue the discussion, we want to hear all you have to say."
   a) What are your general opinions on the experience?
   b) What did you initially expect before you navigated to the concert page and how did that differ from what you saw in the experience?
   c) What do you think about the visual design of the website?
   d) What challenges did you encounter and/or when were you confused?
   e) Did you click on different instruments to view different camera views? What do you think about this feature?
   f) What did you particularly like and dislike?
   g) Do you have any suggestions, comments, or other opinions that haven't been discussed?

3) *Thank the participants.* "That concludes this study. Thank you for your participation today. If you need playtesting credit, you should be able to forward the confirmation email from earlier but if you need anything else please let me know. If anyone would like to see the results of this research or would be interested in working on this research please let me know and I can help you get in contact with the project advisors. Thank you!"

Appendix D: User Personas and Journey Maps

Persona 2

Persona: Adult male software engineer with a strong background in composing and deep interest in music technology. Attends the NIME conference yearly and works on side projects that combine composing and tech.

Scenario: Tom is interested in musical interfaces and decides to view the MPR lab concert to learn more about the robots and see them in action.

Expectations: Learn more about the robots, understand how they work and are able to play music, entertaining performance

Tom

Age:
40

Gender:
Male

Location:
Boston

Marital status:
Married

Occupation:
Software Engineer

Tom is a software engineer working for a start up in Boston. He has a long history of composing classical music ever since he was a teenager. As a trained software engineer, Tom is interested in the intersection of technology and music. He frequently composes digital pieces in his free time. Tom annually attends the NIME conference which explores musical interfaces. He designs new interfaces for playing classical music in his free time.

Goals

- Explore new musical interfaces
- Be inspired for new side projects
- Stay up to date with latest NIME findings

Frustrations

- Limited availability to travel
- Wants more opportunities to show his projects
- Tired of online performances

Spectrums

Interest in Music: 10/10
Tech Saviness: 10/10
Time Availability: 5/10

Journey Map: Tom

Phase 1: Deciding to attend a virtual performance.

- Is on a mailing list for musical-tech performances
- Receives an email about the performance
- Puts the performance time and date on his calendar
- Locates the link to the performance on a website

Devices: Computer, paper calendar

Channels: Website

Phase 2: Attending the performance.

- Joins the livestream concert through the MPR website
- Explores other parts of the website in another tab
- Reads about the robots/lab as the performance is playing
- Zooms in on video stream to see more detail
- Screenshots performance

Devices: Computer

Channels: Browser, live stream

Phase 3: End of the performance.

- Has questions for the performer
- Emails the lab
- Does research online

Devices: Computer

Channels: Browser, google

Persona 3

Persona: Adult male church organist who has played music his entire life in different venues and as a part of different groups. Is passionate about the music community and is lacking a sense of community with the pandemic.

Scenario: Peter is exploring using the digital world to make new connections and to try new experiences. He comes across a the MPR lab and decides to watch a performance.

Expectations: Meet other musicians, explore new music, connect with others online, watch an entertaining performance

Peter

Age:
65

Gender:
Male

Location:
Seattle, WA

Marital status:
Married

Occupation:
Church Organist

Peter is a lifelong resident of Seattle, WA. He has worked as a church organist at his local church for the past 30 years. He has a passion for music and loves composing in his free time. Peter performs as an organist at other venues in his free time. He grew up playing musical instruments and in his life has been apart of many different music groups.

Goals

- Attend musical performances
- Talk about his work and learn from others
- Connect with other musicians

Frustrations

- Can't travel due to his work schedule and family
- Lacking a sense of community post pandemic
- Not tech savvy

Spectrums

Interest in Music: 10/10
Tech Saviness: 3/10
Time Availability: 7/10

Journey Map: Peter

Phase 1: Deciding to attend a virtual performance.

- Searches on the internet about online music groups/performances
- Discovers the MPR Lab facebook and explore the website
- Notices an announcement for a virtual concert in the near future

Devices: Computer

Channels: Website, google, facebook

Phase 2: Attending the performance.

- Joins the livestream concert through the MPR website
- Submits comments in the live chat, no one responds directly
- Zooms in on video stream to see more detail
- Feels confused about what he is looking at

Devices: Computer

Channels: Browser, live stream

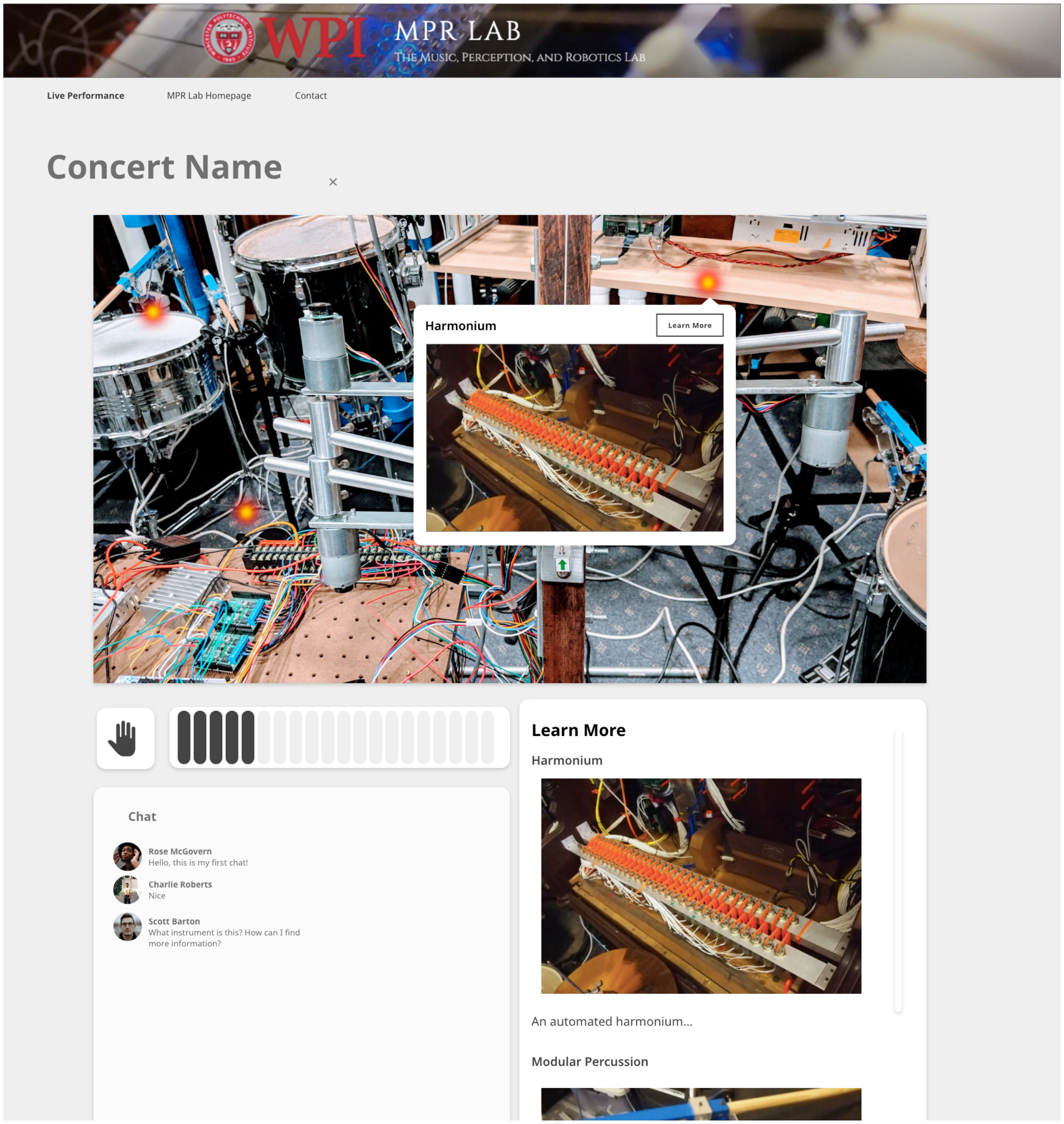
Phase 3: End of the performance.

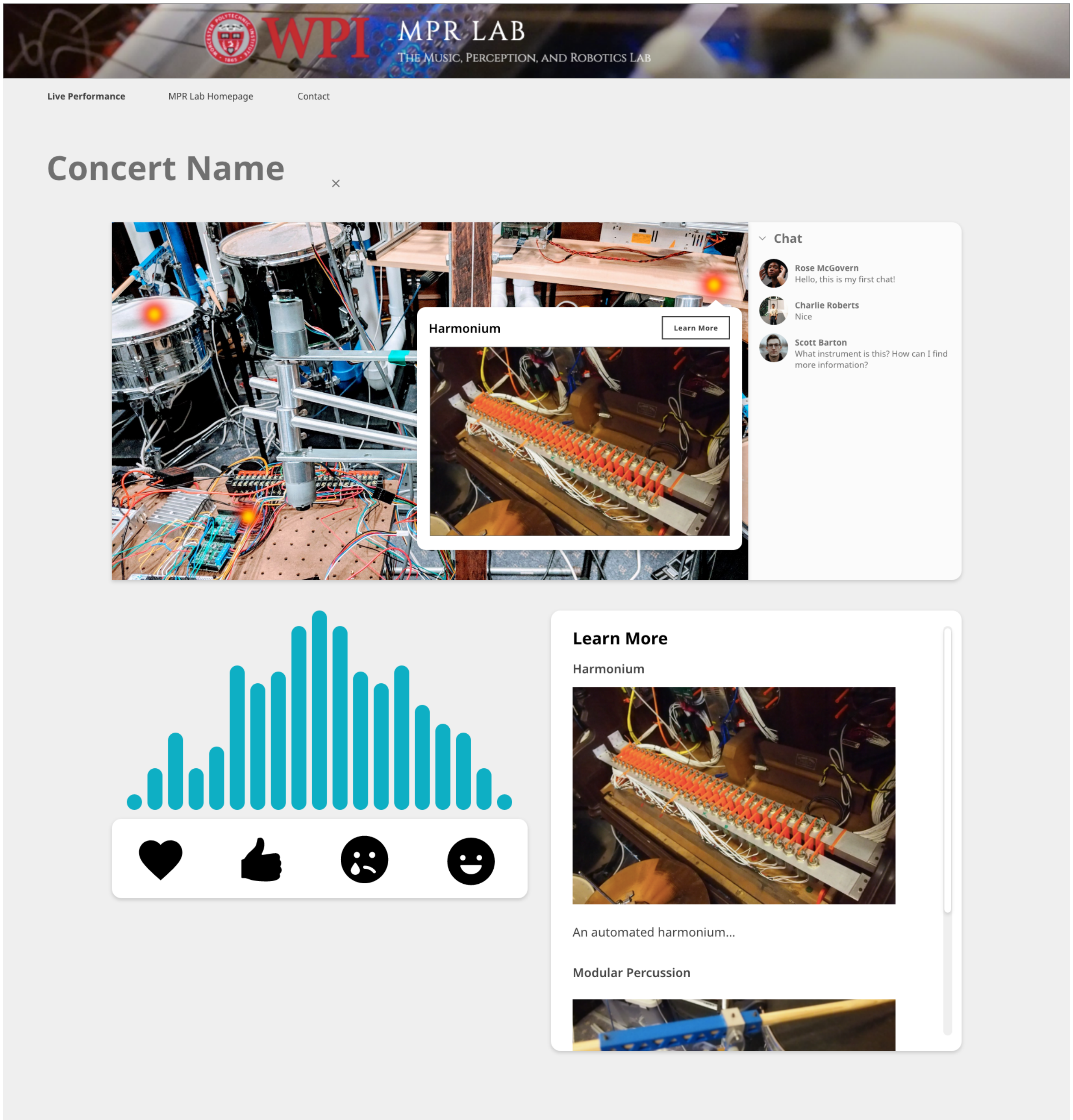
- Sends thanks in the live chat
- Remains on the live stream until it is shut off
- Goes to sleep

Devices: Computer

Channels: Browser, google

Appendix E: Additional Website Mockups




WPI
MPR LAB
THE MUSIC, PERCEPTION, AND ROBOTICS LAB
Live Performance
MPR Lab Homepage
Contact
Concert Name
Harmonium
Learn More
Chat
Rose McGovern
Hello, this is my first chat!
Charlie Roberts
Nice
Scott Barton
What instrument is this? How can I find more information?
Learn More
Harmonium
An automated harmonium...
Modular Percussion