TECHNIORS

Making Graceful Aging Virtually Real

A project in collaboration with Center for Information Technology Research in the Interest of Society (CITRIS) and Center for Elderly Independence (CEI) to explore how traditional physical affordances play a new role in assisting telecommunication for older adults.

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Project Summary

With the advancement of technology, young generations are taking advantage of the technology offered to them in all aspects of their lives, whereas many seniors are left out, especially those without prior technology and living in affordable living communities. Additionally, due to social distancing policies to help slow the spread of COVID-19, most senior citizens are either home-bound or isolated within their senior living communities. Social isolation is now a necessity for the safety of seniors, but it can have a serious impact on their social, mental, and physical health. Though senior centers work to keep residents active and engaged during the pandemic, the current suspension of in-person activity operations is creating a challenge. Many senior centers and their activity directors are searching for solutions that keep members they serve socially engaged. We acknowledge this is a complicated and multi-dimensional issue that requires collaborations of various parties, but we want to offer our contribution with a physical tool that simplifies interactions required in virtual socialization and online wellness programs. Taking advantage of technology is necessary if senior centers want to continue their community experience with as little interruption as possible: **How might we lower the barrier for seniors to feel more comfortable and confident in using online video communication services?**

We have conducted in-depth interviews with senior centers in the bay area to understand the current role technology plays in seniors' lives. Spanning across our conversations with researchers, interviews with senior center staff and facilitators, and observations of various live Zoom sessions - these interviews and field studies helped us come up with a great range of initial hypotheses, approaches, including design proposals as well as potential solutions, vetted by more user research procedures. A major difficulty encountered in an effort to prove our hypotheses, however, is recruitment effort to find qualified seniors for our user interviews during a pandemic. Luckily, with the help of CEI, we conducted 14 in-person usability test sessions to evaluate our prototype and gather feedback. After many rounds of iteration, our final product is **a physical remote control** that allows users to control Zoom features faster and more easily.

This is an exciting and fun new project that combines learnings from tangible user interface design, user research, and product management courses at UC Berkeley's School of Information. While primarily aimed at lowering barriers for Zoom video communications, this project can have implications for developing accessible devices for seniors going forward to allow an alternative way to manage telehealth and beyond.

Problem Space

Problem Statement

Non-senior friendly digital interface prevents less tech-savvy seniors from taking the initiative to participate and engage in online video communication sessions on their tablets.

Our Goal - Bridging the Digital Gap for the Elderly

Online social and healthcare services are deemed as potential solutions for enhancing the autonomy and wellbeing of senior citizens, as well as safer alternatives for elderlies during the COVID-19 pandemic when in-person events are largely limited. Although efforts in offering such services are improving and available in place, lacking proper digital savviness is preventing seniors from the mentioned benefits. Empirical materials from caregivers and service providers also present that the target group of **seniors have low engagement with the technology and frequently report the experience is intimidating.** "Frustration appeared to be a significant barrier, which led to a lack of self-confidence and motivation to pursue using the technology"[1], also confirmed by researchers at UCSD.

We hypothesize that physical affordances that resemble something seniors are already familiar with combined with senior-friendly UX design can ease the anxiety and learning curve and eventually help target users obtain the confidence of using telecommunication services on their tablets, i.e. iPad, which will be further applied to other advanced telehealth, social, or learning applications. In this capstone project, we aim to provide additional user research studies on senior citizens to understand their pain points in this digital migration and help offer additional alternatives to make digital literacy training and technology adoption more effective.

[1] https://www.forbes.com/sites/robinseatonjefferson/2019/06/28/more-seniors-are-embracing-technology-but-can-they-use-it-ucsd-researchers-suggest-asking-them/?sh=882ba6c23233

Background Research

Seniors at Risk - Social Isolation

COVID-19 is a threat to everyone's health but can be especially devastating to older individuals. Social distancing magnified many challenges that current seniors are already facing - significantly less face-to-face interaction has been found to be particularly harmful to older adults given their existing levels of loneliness and isolation[2]. Report has shown that even prior to covid, "in the U.S., approximately **one-quarter** of community-dwelling older adults are considered to be **socially isolated**, and 43% of them report feeling lonely"[3]. Moreover, social isolation has been associated with an approximately 50% increased risk of developing dementia, a 29% increased risk of incident coronary heart disease and a 32% increased risk of stroke[4]. Therefore, it is important to develop innovative technology-based interventions to improve social connection for this population. Many researchers believe that the adoption of technology has the potential to have a profound impact from providing timely interventions to assist older adults in keeping healthy and facilitate independent living for longer[5].

Older Adults' Perceptions of Technology

Senior adults' deficiencies in digital skills and experience can come from a variety of sources. According to a research, a lot of them are actually related to attitudes: "older adults often feel skeptical of new technologies or perceive they will be difficult to use"[6] *before* even giving it a try. Another recent research conducted by scholars from UPenn has also revealed that **seniors rely heavily on their social network for support with Internet-related problems** and that "they avoid many online activities **as a consequence of their lack of digital confidence or concerns with exposure to risks"**.[7] Therefore, understanding older adults' perceptions of technology is instrumental before assisting with introducing effective digital literacy educational programs or tools to the older population. Only by first effectively locating the root cause, we can help guide them out of their fear and concerns, and then attract them with the right motivation,

[2] Geraedts et al., 2014 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5649151/#B12
[3] https://ghrp.biomedcentral.com/articles/10.1186/s41256-020-00154-3#ref-CR2
[4] Wu, B. Social isolation and loneliness among older adults in the context of COVID-19: a global challenge. glob health res policy 5, 27 (2020). https://doi.org/10.1186/s41256-020-00154-3
[5] Orpwood et al., 2010
[6] Hunsaker & Hargittai, 2018; Vaportzis et al., 2017
[7] Munteanu et al. 2015 Designing for Older Adults.
https://pensionresearchcouncil.wharton.upenn.edu/wp-content/uploads/2019/01/WP-2018-17-Munteanu-et-al.pdf

and ultimately develop tools to maximize the potential of technology to facilitate their online engagement and eventually independent living.

Additional Barriers to Interacting with Digital Interfaces

While the older population's perceptions of technology affect their willingness to try out new digital devices in the first place, there are more factors that are also preventing them from interacting with digital interfaces meaningfully *after their initiation*. We must also recognize and study these barriers before coming up with an effective solution that can last. A comprehensive study[8] done by a group of psychologists from University of Edinburgh on 18 focus groups with 113 community-dwelling older adults (mean age 73 years), further explored and summarized seniors' concerns and difficulties toward interacting tablets and technology in general. Combined with some previous research, below is a summary chart of their findings:

Themes	Subthemes
Barriers to using technologies and tablets	Lack of instructions and guidance
	Lack of knowledge and confidence
	Health-related barriers
	Cost
Disadvantages and concerns about using technologies and tablets	Too much and too complex technology
	Feeling of inadequacy and comparison with younger generations
	Lack of social interaction and communication
	Negative features of tablets
Advantages and potential of technologies and tablets	Positive features of tablets
	Accessing information
	Willingness to adopt technology
Skepticism and mixed feelings about technologies and tablets	

Indeed, the issue of digital marginalization that emerges from the combination of lack of access to support and the uneven technological literacy is further compounded by aspects of **usability (ease of use) and perceived utility of digital technologies**[9].

[8] Front Psychol. 2017; 8: 1687. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5649151/
[9] https://journals.sagepub.com/doi/full/10.1177/2056305120948162

Tablets and the Role of Zoom - "A Lifesaver", *Supposedly*

Compared to a normal computer, many tablets are much more senior-friendly as they can offer the same functionality at a smaller, more flexible size and weight, meanwhile they have a larger screen compared to mobile phones and can provide a better internet browsing experience. Older adults mostly prefer tablet technology due to the portability and usability they provide (e.g., adjustable font or icon size) vs. computer technology, especially to those who have a wide range of motor and visual abilities[10]. However, even though those devices are designed to lower the barrier for seniors, with an unprecedented shift to virtual interactions, many family gatherings, telehealth appointments with physicians are restricted to using a new communication app such as Zoom, where large numbers of seniors are unable to participate. While Zoom brings many benefits to our lives, the older population have a hard time using digital devices and such new apps designed without their needs in mind (small icons, difficult-to-read typefaces, inadequate captioning among the hurdles.)[11]. More than half of older adults with access to a device or a Zoom app are not adept at using technology and lack the assistance to learn[12]. The ability to use and navigate Zoom on a tablet is a crucial step to improving social isolation for seniors, therefore, we have narrowed our focus to removing friction of use in this particular problem space.

Historical Context: game-based learning for new affordances and user interface

Learning process mediated or simplified by games or other media can be traced back to the early days when household computers became widely available in the 90s. According to Windows developers, the built in games of Solitaire and Minesweeper were actually made to stimulate learning for users to use mouse "drag-n-drop" features and to perform left and right clicks in a natural manner[13]. After touchscreen devices became popular in the 21st century, researchers found games such as Angry Birds offer a simplified interaction model that is easy to learn because it allows the user to quickly develop a mental model of how hand gestures can interact with touchscreen devices.[14]

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[10] Chan et al., 2016

[11] https://www.washingtonpost.com/health/in-the-pandemic-technology-has-been-a-lifesaver-connecting-them-to-the-outside-world-but-others-dont-have-this-access/2020/07/31/8d46ddf2-d1ca-11ea-8d32-1ebf4e9d8e0d_story.html

[12] Washington Post

[13] "How Solitaire and Minesweeper Were Created in the 90s to 'trick' Users into Learning to Use a Mouse." DAILYMAIL.COM REPORTER, 2015,

[14] Chfp, Charles Mauro. "Why Angry Birds Is so Successful and Popular: A Cognitive Teardown of the User Experience." MAURO, 24 May 2019, www.mauronewmedia.com/blog/why-angry-birds-is-so-successful-a-cognitive-teardown-of-the-user-experience.

Target Community

CITRIS and the Lighthouse project

CITRIS

The Center for Information Technology Research in the Interest of Society (CITRIS) and the Banatao Institute leverage the research strengths of the University of California campuses at Berkeley, Davis, Merced, and Santa Cruz, and operate within the greater ecosystem of the University and the innovative and entrepreneurial spirit of Silicon Valley. We strengthen bridges between world-class laboratory research, state and national policymakers, and companies and startups creating new applications and reshaping entire industries. CITRIS and the Banatao Institute facilitate interdisciplinary work among hundreds of University of California faculty members, students, corporate partners, and international institutions. Together with these public and private partners, we are shaping the future of technology in ways that cross traditional boundaries.

Lighthouse project

The Lighthouse project supports low-income older adults living in affordable housing communities by providing access to internet and telehealth services in California. Older adults are at higher risk of contracting COVID-19, and those living in affordable housing communities are especially vulnerable due partly to limited access to information, connection, and health care services. Led by the CITRIS and University of California researchers, Lighthouse will introduce internet and telehealth technology and **provide digital literacy training for low-income older adults.** In partnership with affordable housing providers, technology distributors, and NGOs, Lighthouse will pilot its innovative program in two affordable housing communities in Northern and Southern California, with the goal of applying lessons learned and replicating the program statewide and nationally.
The three main levels of accessibility support for low-income senior community members are:

1. Basic Broadband infrastructure
2. Access to smart devices
3. **Access to digital literacy training**

Out of three main levels of accessibility issues, our project focuses on the last layer of bridging the gap of digital literacy.

Center for Elderly Independence (CEI)

Center for Elders' Independence PACE offers comprehensive community-based medical and social care all in one bundle. It serves East Bay seniors who are over 55 years of age and needs nursing home care living at home.

CEI's base digital literacy project was to educate 465 elderlies within a 2 year time frame. Supported by California Public Utilities Commission (CPUC), this project is for digital literacy and to educate elders to get Internet connection, which paves for further introduction of technology-aided services that support seniors to independently live at home.

The project is placing seniors (participants/patients) in cohorts of 8-12, and the training cohort is expected to go through 3 weekly sessions in a 8-week period. Training curriculums are designed and delivered by third party partners such as CTN (Community Tech Network). Free pre-configured iPads, CEI purchased devices, are distributed for training purposes. By the end of the training program, the training device will be recollected and seniors will be provided with donated smart tablets.

Background of Senior Participants in CEI program

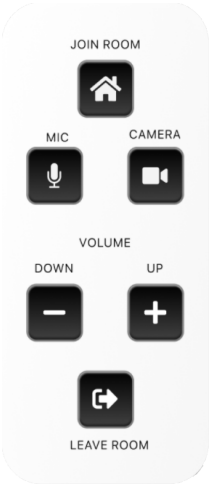
Typical background of senior community members with the CEI program are 55+ with multiple health conditions. Additionally, they are typically considered "low-income" as defined "household income is not more than 185% of the Federal Poverty Guidelines". All participants are eligible to live in an assisted living community but they choose to live in their own house/apartment. Most of these senior participants have limited experience with touch-screen tablet devices or smart devices in general.

Proposed Solution

Overview

To break this barrier, we envision building a physical remote control, where seniors can use just like their TV remote controls, to manage their Zoom sessions and access all the Zoom features at hand. This remote consists of mainly 6 features:

- Enter Zoom meeting
- Mute / un-mute
- Video on/off
- Volume up
- Volume down
- Leave Zoom meeting



(Figma Design)

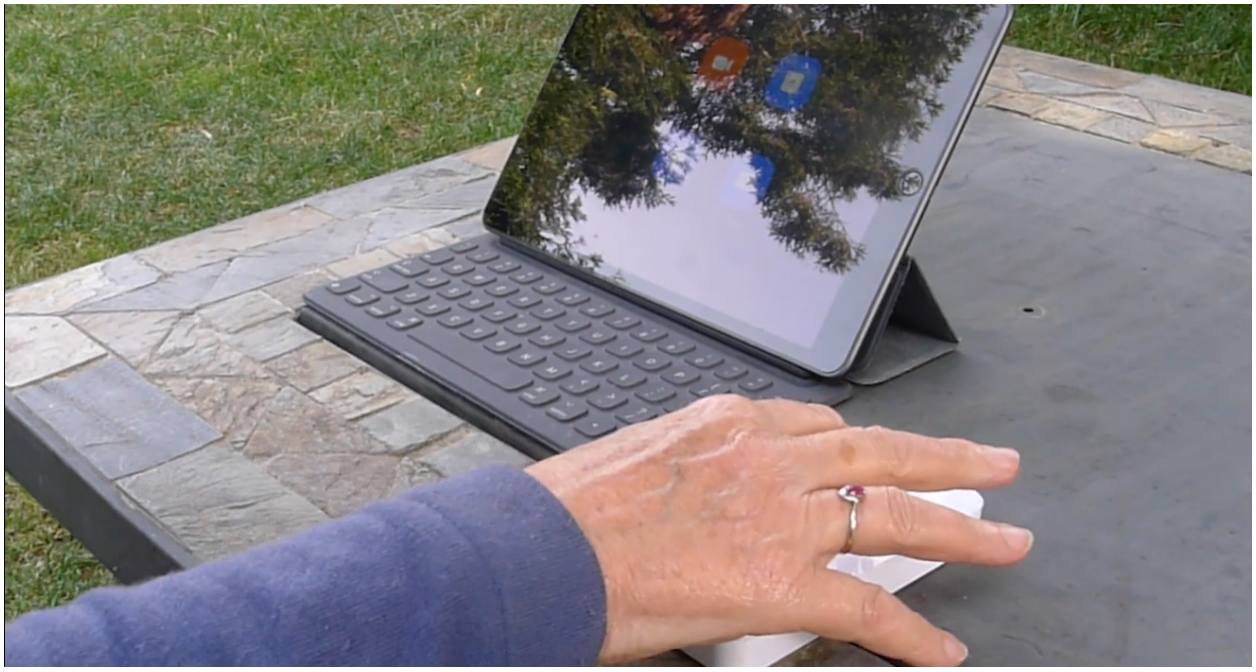
(Final Product)

Key Solution Benefits

- Familiarity - resembles a TV remote, easy and intuitive to use
- Less Friction - one step to join a Zoom meeting once the tablet is opened
- Faster Reaction - no need to look for button whereabouts on the screen
- Remote control - interact with Zoom even when you are away from the device
- Easy onboarding - the control can be pre-configured before sent to the senior user
- Language - the labels can be quickly modified to a different language
- Smoother learning curve - join the virtual classroom even before the user learn Zoom
- Adaptability - can be reconfigured to offer different features, not limited to Zoom

Demo Videos

Techniors: Making Graceful Aging Virtually Real (Video Link)



Demo of Techniors Wireless Control (Video Link)

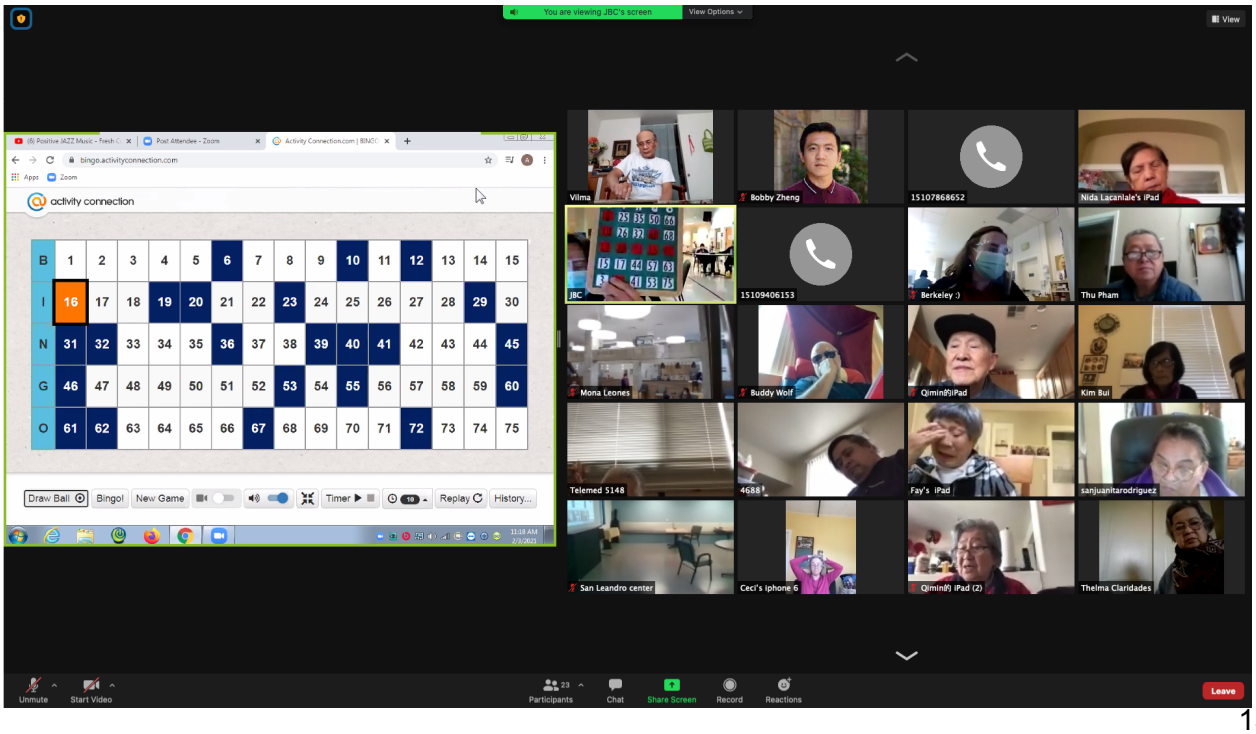
User Research

We started with a mission to help seniors smoothen their experience with technology. With such a serving user group in mind, we split our research into two phases: Generative and Evaluative. Each phase employed different research methods to understand the user and their problems. In the generative research phase, we tried to get a holistic understanding of some major pain points seniors are currently experiencing and develop solutions through interviews and field studies. The evaluative research phase was composed of semi-structured interviews to delve deeper into the problems faced by the seniors and assess the solution proposed by the team.

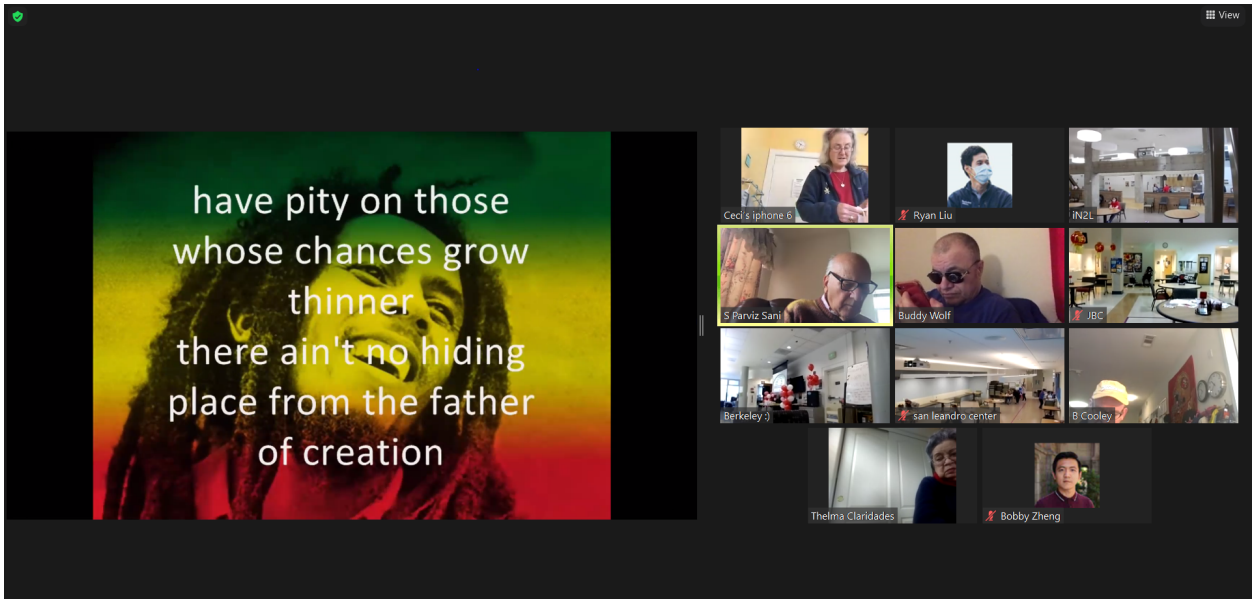
Stage 1 - Generative Research

After reaching out to CITRIS, we were introduced to various non-profit organizations focusing on bridging digital gaps for the elderly. In order to better understand the current landscape and the existing technology educational programs for the seniors, our team conducted in total of 7 interviews with senior nursing homes, HCI scholars and social workers in nonprofits, 4 interviews with CEI's staff, including their tech lead and event facilitators, 4 field observations in CEI's Zoom sessions, 1 onboarding session with CEI's tech team remotely support seniors to log in on Zoom.

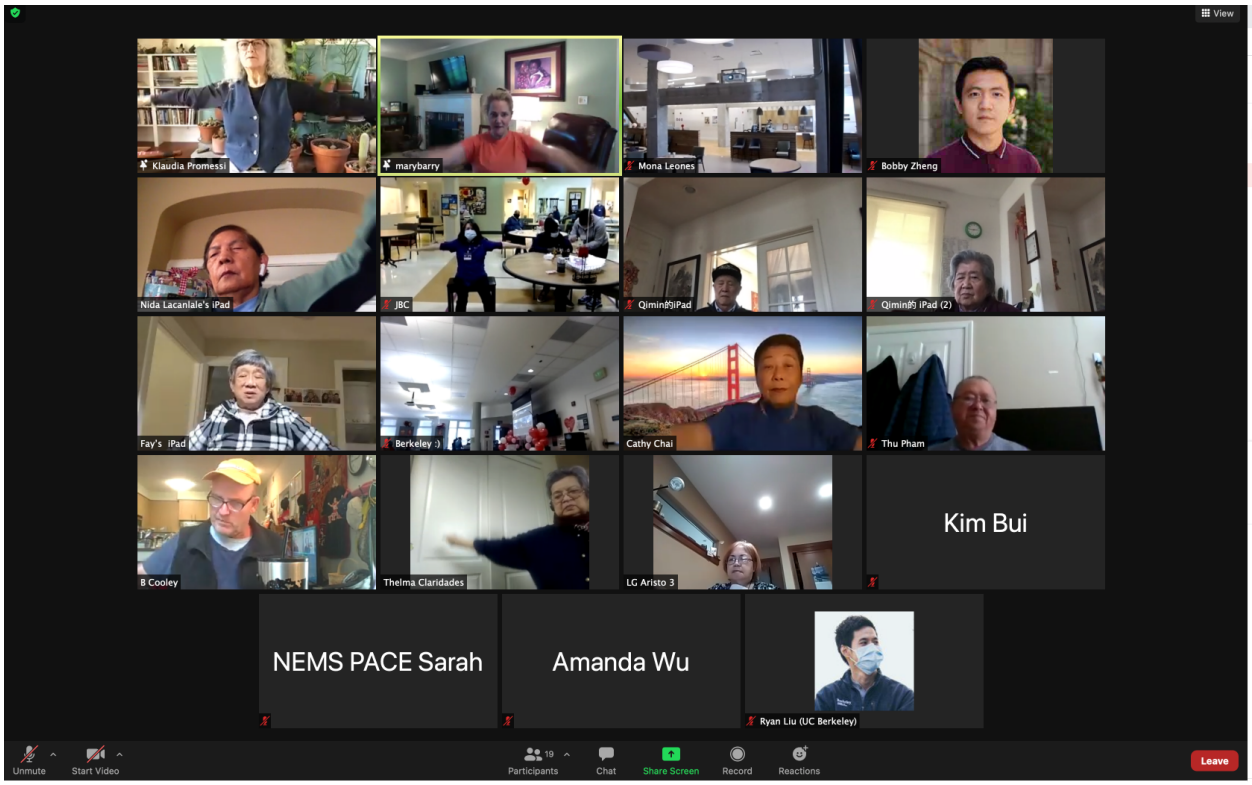
CEI Senior activity session - Bingo



CEI Senior activity session - Karaoke



CEI Senior activity session - Meditation



Exploratory session with CEI staff members (A schedule of senior participants daily social activities shown)

By having these initial rounds of interviews, we got ourselves much more familiar with this new domain. From our learnings, we were able to narrow down our focus. Some of the key takeaways from our interviews were as follows:

- Seniors from different age buckets have disparate interests and motivation for technology as well as their familiarity and skills for using technology
- There are many challenges the elderly are having with technology, some of the most prominent ones include: access to a digital device and education on how to navigate the device and software apps
- Seniors' access to digital device is mostly determined by their income bucket and the network around them
- The current educational programs on digital literacy for seniors are facing more challenges in the current remote learning environment
- Programs that offer iPads for seniors spent a lot of effort pre-configure the device so that it is intuitive to use when seniors receive it at home. However, a number of them still face many difficulties navigating the device even after the digital device educational programs
- Most older adults need assistance from their relatives or technical staff while they navigate a digital device, even after a few times of using it.
- We notice seniors participants rarely move the device in front of them and tend to treat the device as a "stationary portal"
- We also noticed and later validated with activity staff members and digital training onboarding specialist that joining and leaving online sessions are both extremely time consuming and difficult for senior participants and staff members

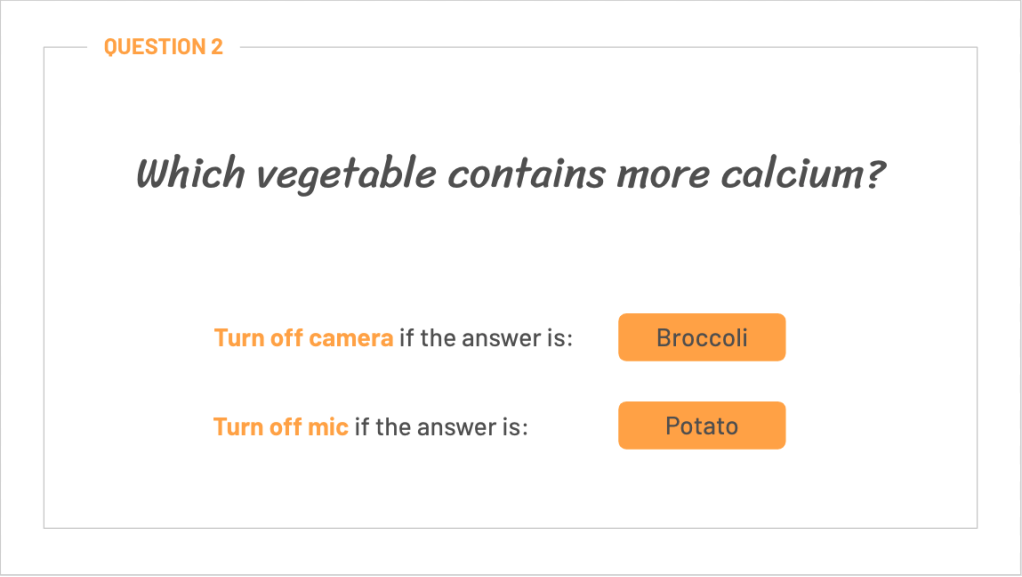
Stage 2 - Evaluative Research

Usability Interview Design

We conducted two rounds of in-person usability testing with two versions of physical prototypes. The format of the interviews consists of mainly three components: Online trivia session, Online Qualitative interview, and offline Quantitative survey. Questions and usability testing plans are attached in the appendix.

Trivia session

In order to access seniors' knowledge of how to use Zoom on a tablet with and without the assistance of our device, we need to ask them to perform some tasks with the Zoom features provided. Instead of directly asking them to intentionally perform those tasks, which might introduce some bias, we came up with a fun and engaging way to access their interaction with Zoom - through trivia questions. For each participant, we also switched the order we access them with or without device to account for the bias introduced by the learning effect.
Below is an example trivia that we asked during the interview:



Qualitative Interviews about technology usage

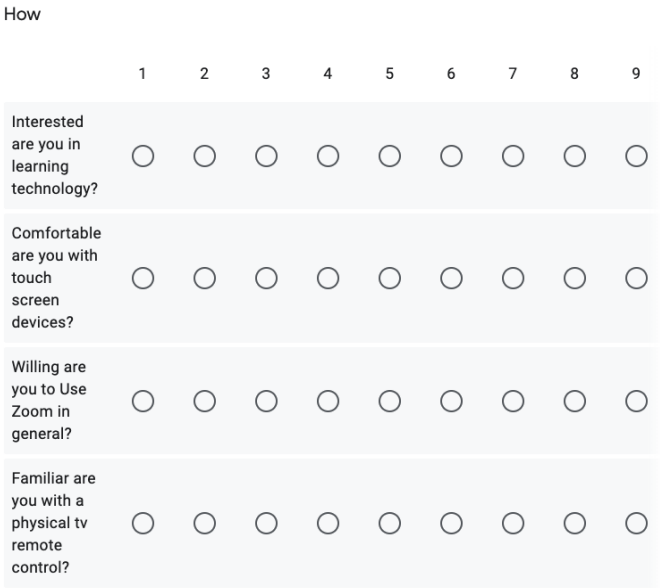
After the trivia questions, we follow up with some contextual questions to gauge their background and to test some of our key assumptions. Specifically, in addition to some basic background questions, we had 4 assumptions in total when asking those questions:

1. seniors are willing to learn how to use touchscreen devices for their own purposes
2. unfamiliarity with interactions with touchscreen devices is the key pain point that is keeping seniors at care centers from using those devices
3. once they know how to enter the Zoom room, they are willing to continue to use and engage
4. a physical remote device offers similar affordances that make seniors feel more confident interacting with zoom meeting

We divided up the questions into three main focus areas: motivation behind technology interaction, overall technology usage and frequency, roadblocks for meaningful digital engagement. Some of these assumptions were also assessed during the trivia section based on our observations of their interaction with Zoom and the tablet.

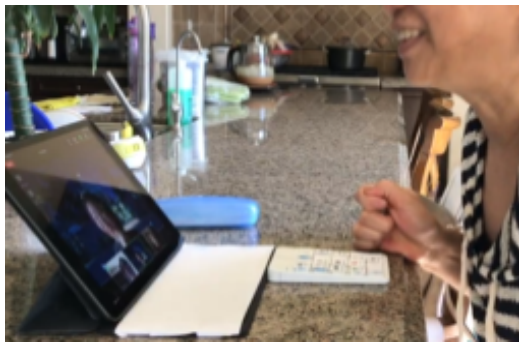
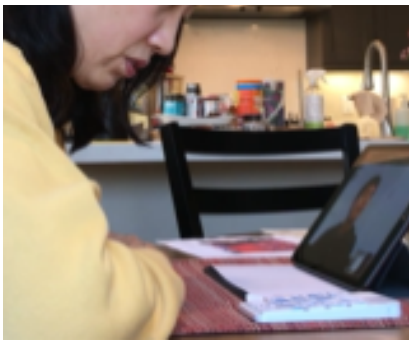
Quantitative survey

Lastly, we wrap up the interview section with a survey that focuses mainly on asking participants to rank questions based on a scale from 1 to 10. We designed the survey to keep the interview relatively short and minimum effort for older adults. The motivation for this survey was to get some quantitative data that could potentially back up our research. However, due to the limitation of interviews with older adults, some translation issues, and their limited attention span, we couldn't get a very consistent result from our participants. Some example questions we asked in the survey are shown as below:



Round 1: Low Fidelity Usability Testing

To assess our hypotheses, we used a low fidelity prototype which was basically a number keyboard for the first round of testing. We labeled all the functionalities that should be tested on the keyboard and assigned each button to do the task when the buttons were pressed. We conducted interviews with four 55-70 year-old Chinese immigrants about their experiences regarding technology and Zoom, with and without the help of our device, recording their general perceptions of online communication tools and their instant reactions to our device, though there might be some biases resulting from convenience sampling

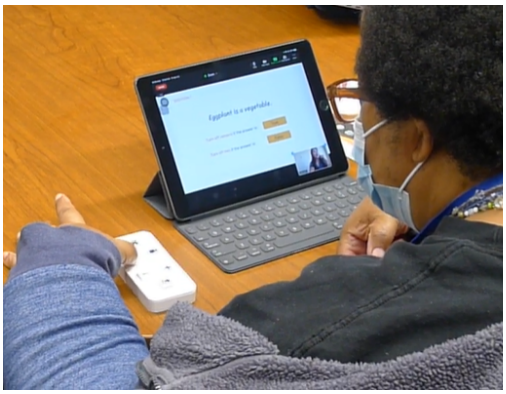
Below are the key takeaways:

- General positive feedback on the usability and usefulness of our device regardless of their familiarity with Zoom.
- Participants were able to describe the function of each button correctly on the device right after being asked to do and used the device to perform given tasks.
- One experienced user specifically pointed out the faster reaction time to use those basic Zoom features, as they are all now available by hand without the hassle of looking for them every time on the iPad.
- All participants had trouble logging into the Zoom session and needed guide from the facilitator regardless of given instructions (step by step with pictures)
- 3 out of 4 participants were not aware of the concept of “leave a Zoom meeting”; iInstead, they simply just walked away from the iPad.
- Raise hands, yes or no, and other supplementary zoom features have lower awareness among participants, they still focus only on the most used basic zoom features to interact with others.
- Fear of using technology is verbally mentioned or embodied in 3 out of 4. Quote from a participant -- “Once I realize I couldn’t break it (an iPad), I start to learn more”

Round 2: High Fidelity Usability Testing

Using the high-fidelity prototype, we conducted 8 in-person interviews with seniors aged from 70 to 91 years old at four CEI senior centers (Berkeley, Downtown Oakland, East Oakland, and San Leandro) about their experiences with technology and Zoom. Most of them are participants of CEI's digital literacy training program that teaches them how to use emails, watch videos on YouTube, and connect with people via Zoom. In this program, CEI targets giving away 450 iPads for their 850 seniors, where some of them do not even own a smartphone. Participants having taken CEI's iPad onboarding sessions have basic intuition on how to interact with iPad, but not necessarily how to use Zoom to attend their sessions; participants not being part of the training programs report and are observed having zero knowledge about Zoom.






With some key assumptions in mind, below are our key findings:

- Assumption #1: seniors are willing to learn how to use touchscreen devices for their own purposes.
    - Yes. Although none of the participants mentioned using tablets for self-organized social interactions, 7 out of 8 mention that they are willing to learn or are actively

using touchscreen devices to watch videos, listen to music, read news, or attend religious sessions.
    - However, 2 seniors also reported they are less interested in learning new things if it took too much time or effort.
    - Though loneliness was reported by all participants as the biggest challenge during the pandemic, we did not find active connection-seeking via video communication services (not limited to Zoom); instead, seniors tend to use Zoom to attend online events organized by CEI or churches.
    - Watching entertaining YouTube videos is the most reported use among (6 out of 8), followed by religious purposes and learning (both have 4 out of 8).

- Assumption #2: unfamiliarity with interactions with touchscreen devices is the key pain point that is keeping seniors at care centers from using those devices.
    - 3 out of 4 participants not using the device were not able to log into the given meeting room and would get stuck for about 4 mins on average (with step-by-step instructions at hand).
    - Confusion about location and functionality of features on the tablet are observable. For instance, participants would press answer boxes on the PowerPoint slides instead of Zoom's buttons such as "Mute" or "Camera On/Off".
    - 4 out of 8 reported that they were comfortable with using YouTube and it was easier to use than Zoom.

- Assumption #3: once they know how to enter the zoom room, they are willing to continue to use and engage.
    - This assumption is hard to validate because most participants simply don't completely understand the concept of Zoom room. This is also observed when participants were asked to describe the perceived functionality of features of the physical device. We observed most participants express confusion with "join zoom room" and "leave zoom room" buttons.
    - Only one participant used the "leave room" function on the device to end the session. Another two participants were able to leave the Zoom room via the tablet. The others were still confused about the concept of leaving a Zoom room, as we observed in the first round of interviews.

- Assumption #4: a physical remote device offers similar affordances that make seniors feel more confident interacting with zoom meeting
    - It's hard to measure the complete confidence level by observation, but one thing we noticed was that **senior participants are more assured of their action inputs** and instantly start seeking expected feedback after pressing physical buttons on the device. In contrast, when interacting with touch screen tablets for task completion, many participants would hover over the functionalities and seek assistance for confirmation.

- Device-related results:
    - The wireless connection between the physical device and the tablet may not be obvious to some participants without explanation.
    - Seniors spent less time (3 secs on average) to locate a certain button in comparison to using the tablet (>10 secs in general).
    - We observed they would place their fingers on the device and clicked the buttons if the facilitator asked them to perform some similar tasks.
    - Seniors also look up the device for hints when being asked to use the tablet to perform some tasks.
    - All participants can associate "camera on/off" and "mute/unmute" to the corresponding Zoom features.
    - All participants (including non-English speakers) believe the volume up/down, Camera, and Mic icons are intuitive for them when first receiving the device.
    - All participants believe the size of the device and buttons are about the right size for them to interact.
    - Seniors participants would press harder a second time if they didn't see any expected feedback from the tablet. In contrast, they showed hesitation to click the same place on the tablet if the expected result was not shown.

Prototyping

Tangible UI Design

Before diving into the design process, we did some research on different remote controls that were available in the market to see what are some of the designs that are working well. We wanted our remote control to be as simple as possible with intuitive buttons that are big enough for seniors to recognize and play around with easily. Furthermore, we wanted the physical buttons to provide a clear see-touch-feel clicking experience to the seniors as physical buttons generally appear to be clickable compared to that of a digital interface. This natural affordance will promote seniors' learning of the different features that each button serves.

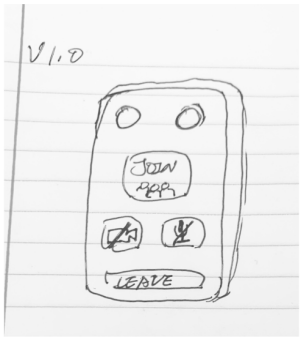
Ideation

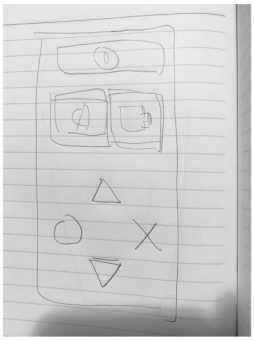
From our research we found out that the apple tv remote control can easily fit into one hand for most people and the design looked very simple and clear. This became the core inspiration for our final design.

Sketches

We started off by individually brainstorming ideas with sketches to visually identify the overall layouts and features that we wanted to include in our device. We came back as a group to look

over each sketch and discussed the core functionalities that seniors would use and removed the less important features that could cause more confusion to seniors.

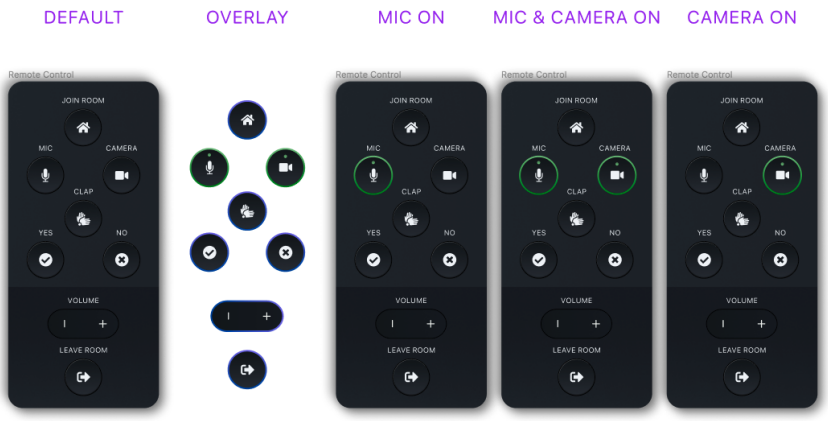




Low Fidelity Solution

After doing some market research and design exploration, we first designed our remote control prototype using Figma. We came out with some features that we think would be necessary to be included in the remote control and added some interactions on the prototype to see how it might feel when the buttons were pressed.

We had more options like “Clap”, “Yes”, and “No” initially, but after going through the first round of low-fidelity usability testing with the number keyboard, we noticed that seniors were confused with more options, so we decided to focus more on the core functionalities that needed to be taken into consideration.

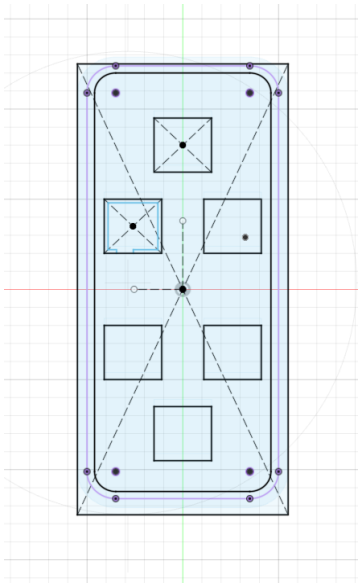


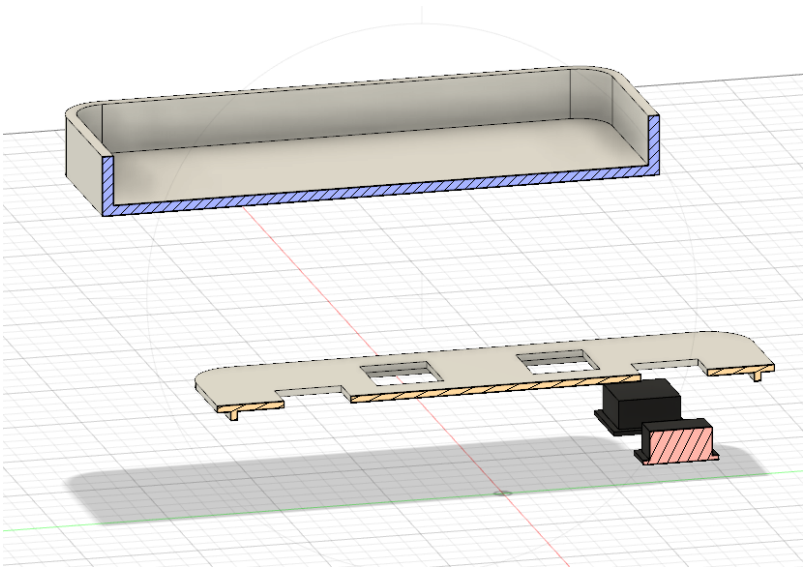
USER TESTING MANUAL

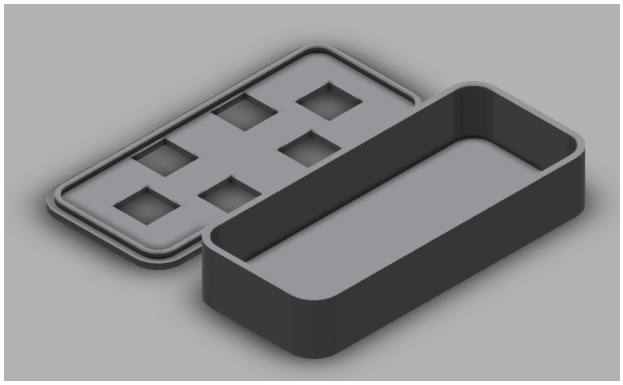
1. Join room
2. Turn on Mic
3. Turn on Video
4. Clap
5. Yes
6. No
7. Volume
8. Turn off Mic
9. Turn off Video
10. Leave Room

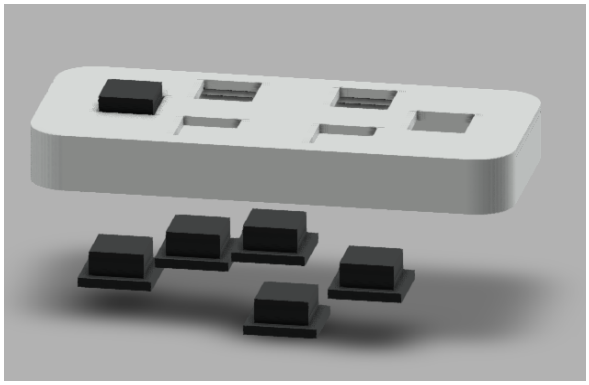
Final Solution

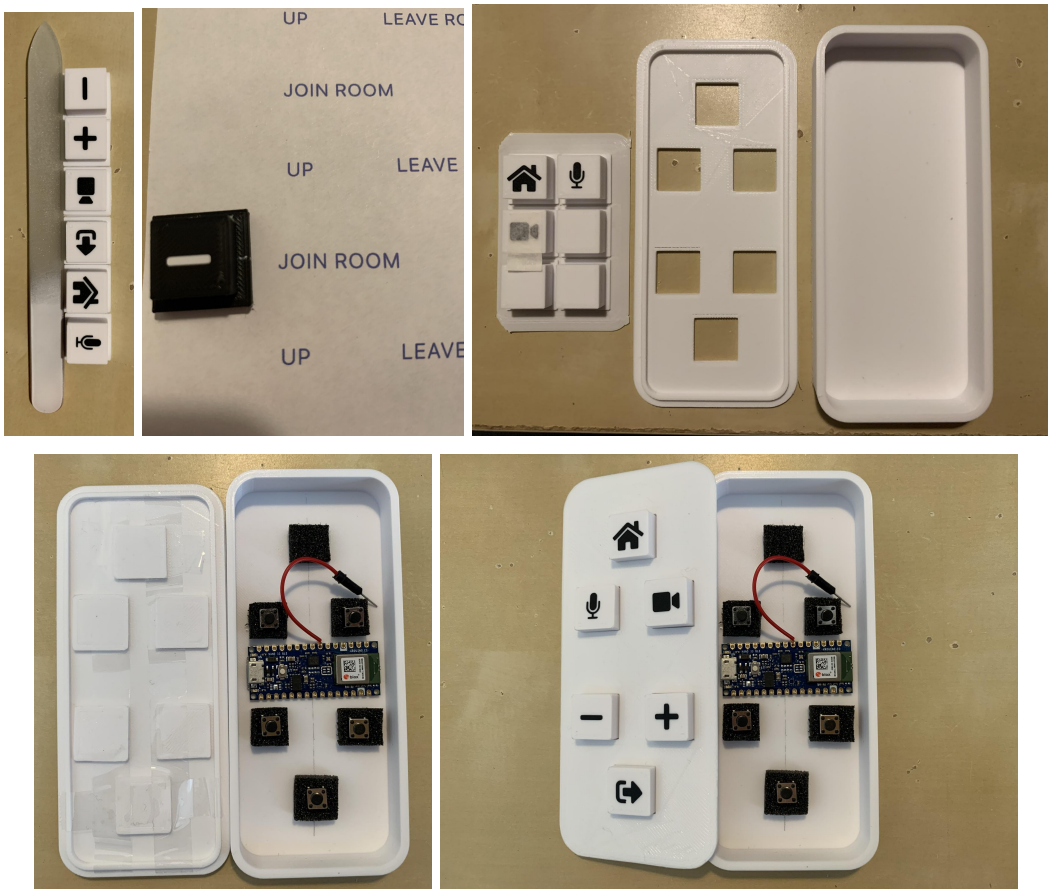
With some help from a design specialist at the Jacobs Project Support Service, we were able to transfer our 2D prototype into 3D designs. We used the Autodesk Fusion 360 to sketch and design the 3D elements of the remote control cover and buttons as shown below. Our first 3D printing was not fully successful, so we had to adjust the length and width of our designs and reprinted it. We were hoping to add some background light that could give visual cues of a successful interaction when an user presses a button, but due to time constraints, we were not able to put it into function eventually.











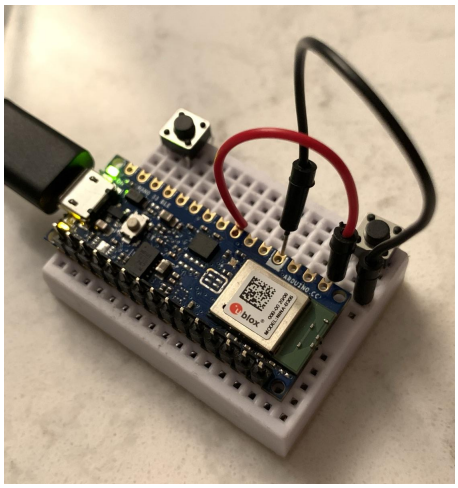
Prototype Implementation

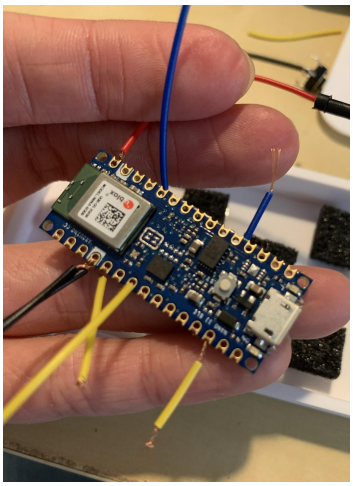
Based on our first round usability testing, this high fidelity prototype is designed to offer affordances that seniors can simply click on a few buttons on a light, portable device to log in and leave Zoom meetings, mute and unmute themselves, turn their camera on and off, and adjust the volume of the iPad they use for Zoom. After our survey over potential hardware solutions, we decided to adopt Arduino's electronic development platform for its resourceful ecosystem; and to use Bluetooth Low Energy (BLE) Standard as the wireless communication standard for its low cost, low power consumption, and easy-to-use pairing feature.

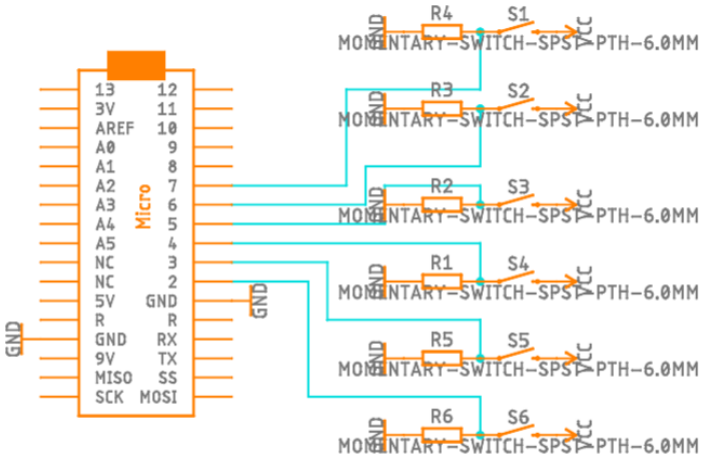
Physical Hardwares

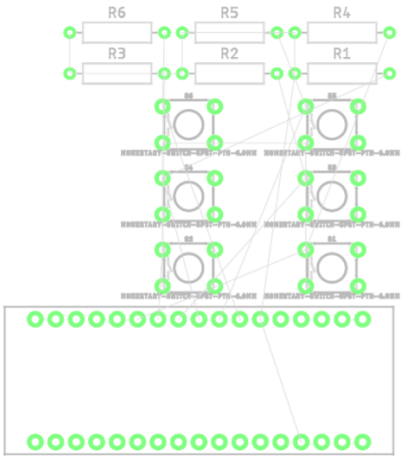
To engineer these features, we chose Arduino's Nano 33 BLE (Nano33) as the central microcontroller for its lightweight (<5g) and small size (45x18mm) that fits well in the 3D-printed device case. Nano33 supports the latest BLE Standard, ideal for wearable devices and

short-distance wireless communication; its lower power consumption also enables a longer battery life. Since Nano33 is geared with an internal power regulator, it can be simply powered by two CR2032 (or any similar sub-types of) button batteries in series offering a 6v or a single A27 battery for a 12v input voltage. The physical, clickable buttons are the integral results of the Arduino default tactile switches, connected to the microcontroller with breadboard jumper wires, and the 3D-printed buttons caps. The final product is only 70g and guarantees all functions with a stable connection to the iPad in a 5-meter distance (theoretically up to 10 meters), when the power source is secured. We also planned to implement the final prototype on a Printed Circuit Board (PCB), which guarantees a stabler connection between the microcontroller, power source, and the buttons and further reduces the space overhead. However, we did not have enough turn-around time for the third iteration on PCB after our second usability testing.









Software Connectivity

To bridge the hardware and iPad, we write a program to form the client-server connection on top of an Arduino open-source library, which allows Nano33 to emulate a Human Interface Device (HID) Profile. Nano33 will broadcast itself as an HID keyboard over the BLE Generic Attribute Profile Profile (GATT), on its ARM Mbed OS Stack, and pair with the iPad (or any other Bluetooth Device). When a user clicks a button, Nano33 will accordingly send a pre-configured macro to the iPad, which will be mapped to the wanted features such as joining Zoom meetings or adjustmenting the volume. This mapping is achieved through a series of existing accessibility and automation tools iOS currently offers. In the first round of low-fidelity prototyping we mainly leveraged Accessibility Switch Control functions embedded in the iOS system while we leveraged mainly Full Keyboard Access, Zoom's hotkeys for iPadOS, and Apple's Shortcuts for the second round of high-fidelity prototyping.

Accessibility Switch Control

In this method, "Switches" can be defined with associated actions (e.g. "tab", "invoke siri", "open control center" etc.) and mapped by a key from an external bluetooth paired device. Furthermore, a "tab" switch action can be further re-defined by a series of hand gestures, movements, or touches. Lastly, a group of switches can be packed into a "recipe" as a solution for our low-fidelity prototype.

Limitation of this approach is also obvious and hard to overcome. The main disadvantage is the fact that the approach leverages the "front end" user interface to perform preconfigured actions regardless of user current interface. For instance, the camera on/off button would still work in the main home screen but would simply press the top center area and launch associated apps located in that region. This approach is also not reliable if Zoom relocates some of their features in any future updates. Lastly, when a switch control recipe is enabled, preconfigured volume adjustment switches will be disabled and thus require constant switching between different switch control modes.

Full Keyboard Access

Differently, Full Keyboard Access allows us to define a series of actions in accordance to the signals sent from our microcontroller. Paired with iOS shortcut functions and full keyboard access capabilities we can specify a wide variety of actions with a click of button. For example, we can define "⌘+J" as the hotkey with one single click to join Zoom meeting and associate it with iOS predefined script as "go back to home screen, open Chrome, paste the url of the Zoom meeting, and hit the return button". Additionally, we can also send multiple keyboard commands with a click of a button. For instance, Nano33 can pack a series of commands as " send '⌘+Tab' twice, hold the '⌘' button, and then send an '⌘+Q'" into one signal. In this particular instance, the iPad will populate all working tasks, select the current focus app, and close the app, which ends up terminating the Zoom app and serves as the "leave meeting" feature.

With iOS enabled macros and flexibility of command signals, a preconfigured iPad can map and automate virtually all existing functionalities into a single button. This flexibility essentially ensures that our device can be used to simplify for any potential tasks on the iOS device.

Conclusion & Final Impact

This 6-month project presents insights to make telecommunication technology more accessible to senior users, specifically for those in lower socioeconomic positions. We first explored the problem space by conducting 7 initial interviews with caregivers in senior nursing homes, HCI and medical scholars, and social workers in nonprofits; 4 interviews with CEI's staff, including their tech lead and event facilitators; 4 field observations in CEI's Zoom sessions; and 1 onboarding session with CEI's tech team remotely support seniors to log in on Zoom. From these initial explorations, we identified the pain points were closely related to the mental and practical barrier, and further hypothesized that physical affordances resembling experiences seniors are already familiar with, combined with senior-friendly UX design, can lower the barrier. To test that hypothesis, we prototyped one low-fidelity and one high-fidelity wireless device that offers 6 common Zoom features and conducted two rounds, 12 usability testings on them.

UX Research Findings and Implications

We first conclude from our interviews and usability testings that most seniors (11 out of 12) are willing to use or learn how to use the tablet for a wide range of purposes. However, even though most of them were provided with a tablet at home to join Zoom activity sessions, our field observation and CEI staff suggest that the attendance of their Zoom sessions dropped by 80% compared to their in-person onsite events before the COVID-19 pandemic. All respondents highlighted that staying at home alone has been the biggest challenge during the pandemic, and half of them reported they would like to learn and use the tablet and Zoom (or other telecommunication services) if the services were easy enough.

Our usability testings further revealed that the steep learning curve and non-senior friendly design practices prevailing in current Zoom's UI prevent seniors from using it. For example, without the use of our device, 80% of respondents could not join a Zoom meeting on their tablet without help, and nearly all of them frequently showed hesitation, doing nothing over 10 seconds staring at the screen. We also noticed that only 25% of participants showed a clear understanding of the concept "leave the meeting", while the others sometimes were even not able to perceive if they had turned on/off camera successfully, showing that **Zoom failed to provide clear visual indications to seniors when they clicked on its UI** nor what

affordances it can offer. The icon changes, especially on a mobile device like an iPad, are not likely discernible to them. 10 participants had difficulty reading the labels on Zoom; 7 verbally admitted they were not familiar with Zoom even after the relevant training offered by CEI; and 4 directly shared that they tried Zoom before but felt it was too difficult, so they stopped using it. The friction is an issue for the caregiver as well. In the onboarding session we sat in, CEI's onboarding facilitator spent 30 minutes over the phone to help one senior navigate through the basic settings; CEI's event facilitators also reported that seniors frequently called in to seek their support in logging to Zoom. The empirical feedback we collected suggests that more efforts are needed to make telecommunication services like Zoom more accessible to seniors.

The physical device in our interviews is observed to possess qualities that lower the barrier of using Zoom. When using the device, respondents had a higher success rate of joining the Zoom meeting and spent less time locating a button associated with a feature they had learned from a prior task. Participants also showed confidence in trying the device, by clicking more firmly on the device and re-clicking the buttons to try out different functions when they did not receive the wanted feedback on the tablet. 3 seniors even placed their fingers on a button and clicked it right away when they wanted to use Zoom features, naturally without even looking at the device. Most seniors could click the right button within 3 seconds when asked to perform a similar or identical task. In contrast, seniors sometimes still spent more than 10 seconds looking for a button they tried in a prior task on Zoom's UI. Furthermore, participants deem it no ambiguity when an instruction asks them to click a specific button. Without the device, 6 respondents tried to click icons on the shared Zoom screen, showing that they could not differentiate them from real buttons.

Our hypothesis derived from our UX research findings is that a physical button naturally indicates it is clickable and returns mechanical feedback when clicked, produces a more pronounced and straightforward signal, which consistently "communicates" to the respondent to let them know they have performed something. As long as the respondents receive affirmative feedback, the association is effectively built and deepened. On the other hand, some may argue putting all the commonly-used features in an app or simplifying Zoom's UI can have a similar effect; Yet, the Zoom UI on iPadOS has only 6 icons, and 4 participants misclicked or failed to click on the right button at least once and were completely unaware of it. Moreover, in our study, even given a clear instruction with a picture of the tablet's home screen with a Zoom icon circled, participants were still hesitant to click on the icon and needed confirmations many times.

They constantly refer to nearby assistance and hover over the icons on the tablet instead of clicking on it. Thus, we believe a physical device provides better intuition for seniors, especially with all the noises in the digital environment, where seniors also have to deal with “surprising” pop-up messages. Senior-assisting tools do not necessarily have to be physical, but for our target group, physical devices appear to carry more affordances that make themselves easier to be learned and used. More usability testings are still needed to further inspect these ideas.

Finally, our usability testing on the physical prototype suggests that two factors are helpful for designing a more accessible video communication service for seniors. First, the UI should be low-friction, meaning that the device should be easily recognizable or even familiar to other physical devices that they already own or trust. Note the low fiction here refers to fewer steps to achieve their wanted effects instead of the simplicity of graphic or visual design; the device needs not to be frictionless, but must be simple enough to be learned. Second, the UI should give consistent and noticeable feedback. That is, seniors will be instantly “confirmed” or “green-lighted” when a certain task is successfully performed. Though our usability testing did not show that a physical device is inherently intuitive to the seniors in terms of what it can control on Zoom, however, we found that as long as a respondent had successfully performed a task with one physical button, all of them could repeat the task. In contrast, without the physical device, some respondents still mixed up the microphone and camera buttons on Zoom for a similar or identical task. This result implies a design needs not to be completely intuitive (without a learning process) to be accessible. Once seniors learn how to use the physical device, reproducing the result requires less mental processing, simpler than the current digital UI, they show more confidence in trying the device. A few respondents even reached out to the device when they could not find the buttons on the tablet when asked to only use the tablet for the task. The affordances of a physical, tangible UI can be helpful if a senior learner is not able to receive in-person training as well, since it will be easier to verbally navigate by clicking a physical button with a specific icon or color.

To answer our initial question: how might we lower the barrier for seniors to feel more comfortable and confident in using online video communication services? Our project presents with a tool that takes less mental effort and gives consistent feedback can encourage seniors to learn and finally get to use Zoom. More importantly, showing seniors the possibility that they can use technology independently is empowering. This belief motivates seniors to try, and once they overcome the initial barrier, they are more likely to keep learning and using technology.

Going Beyond

During our usability testings with seniors, we noticed areas of future improvement for our remote control design. Some of our participants were non-native English speakers, which made it challenging for them to read the label under each icon. A few of them were unsure what each icon meant even though they could read the label as they were unfamiliar with icons in general. This made us revisit the importance of keeping the diversity and uniqueness of each senior in mind when we approach design decisions.

To get a step closer to our ultimate goal in bridging the gap between individuals who are straying from the average in some facet of their needs or goals, we would like to improve our design with more consideration of senior diversity in respect of their age, language and culture. More research could be done to find better icons that could help seniors understand the function of each button regardless of their familiarity with digital icons or cultural background. Given more time, we would also explore more options to give a clearer message when an interaction was successful by enabling sounds (e.g. Your camera is now on) to be provided upon a press of the button. This will help the majority of the seniors who are having a hard time noticing some changes when they are interacting with the device and furthermore, benefit those who have poor eyesights or disability too. We would also love to add Braille alphabets on the buttons for non-sighted seniors to make it easier for them to use our device and get a step closer in communicating with others using technology.

Additionally, our proposed solution can be somewhat a reactive method to handle a complex user interface. With more nuanced needs of everyday users on smart devices and faster iterations, task completion on smart tablet devices may require multiple levels of complex interactions that implicitly exclude certain user groups from using the application and/or device. We encourage future designers and industrial practitioners to keep inclusive design principles in mind, and make this approach more proactive than reactive.

Challenges in Affordable Senior living community

We acknowledge the issues we are tackling in this capstone project are multidimensional and no single study/solution would solve it all. Furthermore, as we approach further into the process and conduct more detailed in-person interviews, we are becoming more aware of the different kinds of challenges senior participants and the affordable living community are facing in general.

At the individual level, most participants we interviewed heavily relied on family members for their daily activities. Completing simple tasks such as grocery shopping would require a significant amount of time and effort. Let alone the difficult tasks such as doctor appointments and oversea family member visa applications.

Non-profit organizations that support seniors living in affordable living communities are in general short-staffed. There are hundreds of permanently Medicare funded institutions such as CEI nation-wide that offer the Program of All-inclusive Care (PACE), which supports medical, social, emotional and nutritional needs for these vulnerable groups. However, it's our understanding that qualification for programs such as this is extremely difficult and they are only serving roughly 10% or the potential population of need. Equally important we should be aware of other non-profit organizations such as Oakland at risk that solely depend on volunteer work to operate.

We encourage policy makers and corporate decision makers to be more aware of these vulnerable groups and associated nonprofit organizations and provide incentived volunteering programs to help alleviate burdens on their shoulders.

Appendix

First Round Usability Testing Plan & Interview Questions
Second Round Usability Testing Plan & Interview Questions
Low Fidelity Prototype on Figma

Literature Review & Background Research links:

- Designing for Older Adults: Overcoming Barriers to a Supportive, Safe, and Healthy Retirement
- Older Adults Perceptions of Technology and Barriers to Interacting with Tablet Computers: A Focus Group Study
- Technology Use by Older Adults and Barriers to Using Technology | Request PDF
- Older Adults, Social Technologies, and the Coronavirus Pandemic: Challenges, Strengths, and Strategies for Support - Ryan C. Moore, Jeffrey T. Hancock, 2020
- 'A lifesaver': US seniors turn to Zoom to connect with friends and family
- As Life Moves Online, an Older Generation Faces a Digital Divide (Published 2020)
- 4 Tips for Zooming with Seniors
- In the pandemic technology has been a lifesaver - connecting them to the outside world
- More Seniors Are Embracing Technology. But Can They Use It? UCSD Researchers Suggest Asking Them.