2H : Final Report

QuaLight

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Problem and Solution Overview

The average American spends a lot of time in their homes. According to the Environment Protection Agency, on average Americans spend 87% of their time indoors.[1] That is a lot of time that people may be exposed to indoor air pollutants, yet most are unaware of the air quality of their living spaces. Even if they do have concerns about air quality, people are usually unsure how to act on it. This is a big problem since the air we breathe in can have major effects on our health, especially for those with allergies triggered by air pollutants. Our goal is to educate people about the air quality of their living spaces while also helping them to take action in improving the air quality of their own home in order to foster a healthier living environment using QualLight.

QuaLight uses a strip of colored lights along the ceiling of a room to display an indication of the room's air quality. The color of the strip of lights will correspond to a state of the room's air quality: clear for good air quality, yellow for moderate air quality, red for poor air quality. Other colors are also customizable to desired air quality hazards. If there is a notification about the air quality in the room, a display will be projected onto the ceiling with more information about the alert and potential next steps. When asked questions about air quality, information is provided on the projection screen and suggestions to improve are given.

[1] Klepeis, Neil E, et al. "The National Human Activity Pattern Survey (NHAPS): a Resource for Assessing Exposure to Environmental Pollutants." *Nature News*, Nature Publishing Group, 24 July 2001, www.nature.com/articles/7500165.

Design Research Goals, Stakeholders, and Participants

Initially, we planned to conduct our research by having participants keep a diary for one full day, followed by an interview the following day. We interacted with one participant in this fashion, before deciding that it would be more effective to conduct research using a broad survey, and then interviewing a select few participants. We made this decision because we realized that the participants who will provide the most valuable insight into our design space would be those who already have some kind of air purification device in their home, since these participants are more likely to have opinions and experiences relevant to in-home air quality.

Our survey received 112 responses, and provided insight into people's experiences and opinions about in home air quality across many demographic groups such as age, income, gender, and living situation. This diversity of insight would prove to be extremely valuable in going forward in our design process.

In addition to the survey, we interviewed a total of three individuals to gather more in depth insight about in home air quality than our survey provided. Our interview participants were chosen based on them having notable experiences or insights relevant to indoor air quality. When selecting our participants, some qualities we were looking for in our participants were allergies, asthma, quality of living space, occupation, and pets. Two of our three participants, LD and ZM, are current Juniors at the University of Washington, who live in apartments near campus. LD lives without pets or roommates, but has occasional undiagnosed respiratory concerns that she treats with medication. LD also has a sophisticated air filter, that is primarily used as a fan during the summer. ZM lives with three roommates, two guinea pigs, and one rabbit. ZM has some allergies that affect their respiratory health, and has also experienced some health problems caused by mold in their living space. Our third participant, RN, is a middle-aged parent who lives in a suburban house with their spouse and child. RN experiences exercise induced asthma, and discussed concerns about how cooking, and outdoor air conditions can impact the air quality within their home.

Before conducting our research, we expected that key stakeholders in our design would be stay-at-home parents, and individuals with significant allergies or asthma. We felt that our research generally supported these expectations, and that it would be worthwhile to go forward designing with the needs of these specific groups of people in mind.

Design Research Results and Themes

Our most significant problem in conducting our design research arose when we realized that a diary study was much less effective than we had initially thought. When we created our design research plan, we decided to use a diary study paired with an interview because the diary study could show where in their living space our participants are spending most of their time, and whether any possible symptoms related to poor indoor air quality occured in certain rooms but not others. Unfortunately, after conducting our first diary study, we realized that the information we were getting included nothing relevant to air quality, instead focusing on the participant's daily routine. Additionally, at this point we were realizing that because most of the people who are accessible to us are University of Washington students and recent graduates, we were missing valuable perspectives from people of different age groups, geographic locations, and occupations. Out of these concerns and issues, we decided to replace our diary study with a survey, so that we could get information specific to indoor air quality, and across a wider variety of demographic groups. We found that our method of the survey combined with interviews was an effective research method.

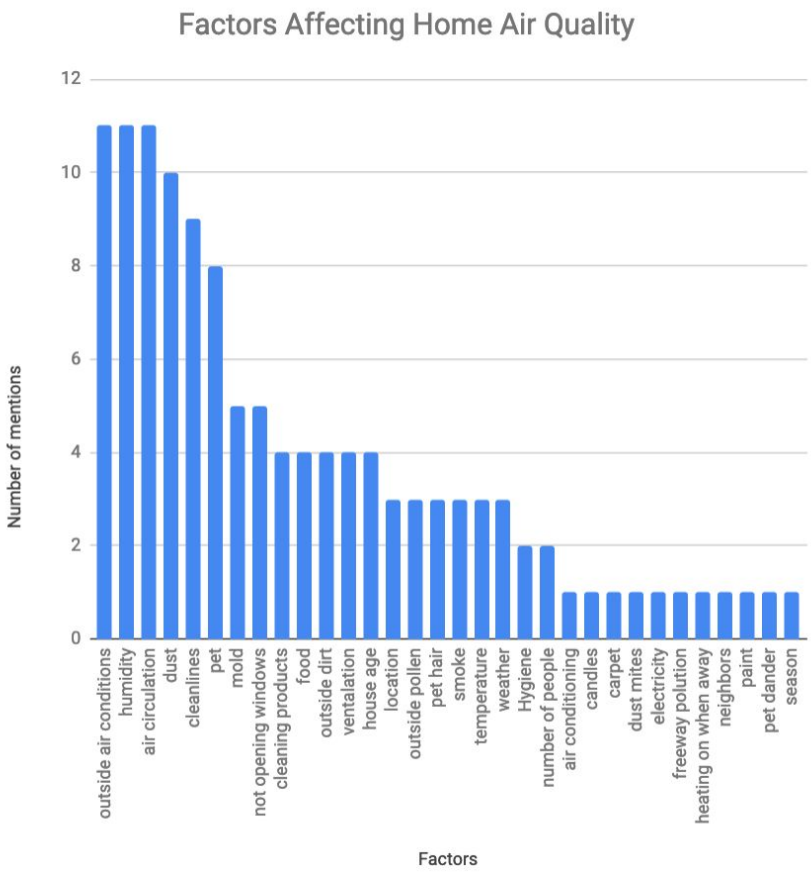

Figure 1: Graph representing factors that survey participants thought affected air quality.

Design Research Results and Themes (continued)

One of the most surprising and useful insights we gained from our participants is that many people are concerned about the impact of outdoor air conditions on indoor air quality. Because we had expected people's primary concern to be something along the lines of mold, pests, or allergies, the theme of outdoor air quality impacting indoor air quality, as shown in Figure 1, allowed us to significantly tailor our design to this need.

We also learned that many people are not aware of their indoor air quality, and how certain activities such as cooking, cleaning, or taking a shower can impact it[2]. As a result, we thought it would be effective to include something in our design that can educate people about indoor air quality and the everyday hazards to their health.

[2]*Factors Affecting Indoor Air Quality*. Environmental Protection Agency, www.epa.gov/sites/production/files/2014-08/documents/sec_2.pdf?fbclid=IwAR1xhuti9gj2fRIPwRyrN-Jk6kdJWWA-ODa_Btk2fUrR83BWWAvMasRRryE.

Answers to Task Analysis Questions

Who is going to use the design?

Our desired users are adults concerned about air quality in their home. It does not matter if they live in dorms, apartments, or houses since air quality in all three of these situations can affect the health of the individuals living there. Our design is not focused on interaction with children because although air quality affects adults and children's health equally, adults have more control over influencing factors in the home. Stay at home parents, and persons with asthma, allergies, or other respiratory problems will are desired users.

What tasks do they now perform?

According to the information gathered from our participants, people concerned about air quality in their home commonly install air filters in their homes or use air dehumidifiers to improve their air quality. For those who have allergies that may be affected by air quality, they regularly take allergy medication and use filtration systems to remove the irritants.

What tasks are desired?

Participants noted that they would like a way to learn more about what affects air quality in general. They would like a way to check the air quality in their homes at all times including a way to know whether the air quality in their home is at a level that they need to be concerned and should act on it.

How are the tasks learned?

Currently, an overwhelming majority of participants have little to no knowledge about air quality, and those who have air filters are uninformed on the best ways to use it or if their use increases the quality of the air in their home. We plan on integrating an educational aspect to our design that informs the user of various common tasks that affect indoor air quality to clear any misconceptions, how air quality is tracked, and what it means to have “bad” air quality and ways to fix those problems. This educational module would be implemented directly into our design so that users can refer to it any time.

Where are the tasks performed?

These tasks are generally performed at home, while the user is physically in their living space.

What other tools does the person have?

There are existing smart air purifying filters in the market and many single family homes already come with some built in air filtration systems. There are also existing sensors to detect hazardous indoor air quality, caused by particles such as Radon and Carbon Monoxide.

Answers to Task Analysis Questions (continued)

What is the relationship between the person and data?

From the data that we gathered from the survey, there did not seem to be a strong correlation between different demographics and the presence of an air filter or purification device. We are using the ownership of a air filtration or purification device as an indicator of the participant's significant interest in the impacts of air quality on their home. Overall, 24.1% of the the participants in the study had air purification devices, while 24.4% of people with allergies had a device. 25.7% of students had a purification device and 21.6% of single family homes. The one significant difference we found was with pet and non pet owners. Pet owners were more likely to have a filtration or purification device at 32% and non pet owners were significantly less likely to have a device at 18.2%.

How do people communicate with each other?

People currently do not communicate information about their air quality with other people. We do not have plans to have a way for people to communicate with each other due to the sensitive nature of the data we collect and show since the data relates to people's personal private living spaces.

How often are the tasks performed?

People can regularly check the status of the air quality in their home whenever they want so the frequency of this task depends on how often the user wants to check their air quality. When the air quality of a home is at a level that requires action, the user must act fairly quickly when that happens. Again, the frequency of this task varies since it depends on how bad the air quality of someone's living space is or what activities users do that may affect the air quality.

What are the time constraints on the tasks?

Since our design is more of a continuous tracking of air quality, there are no time constraints. The only time when there are time constraints for a task is when people have to change their air filters since air filters generally have to be changed after certain times, and also when they have to act upon emergencies due to their air quality such as gas leaks, etc.

What happens when things go wrong?

Things go wrong when people ignore warning of bad air quality and continue to live in the compromised space. Consequences of living in a space with poor air quality can vary drastically, from a person experiencing little or no symptoms, to a person contracting cancer, another serious disease, or even death. The typical case of someone not taking action against poor air quality in their home causes a person to experience, asthma, sinus irritation, minor to moderate respiratory problems, or general discomfort. Although particles like Radon and Carbon Monoxide rarely impact indoor air quality, failing to detect these particles can lead to the more serious consequences.

Proposed Design Sketches - "3x4"

Design 1: Air Quality Indicator Ring

This design consists of a ring, which interfaces with a smartphone application. The ring would be similar to a mood ring, in that a participant wears it throughout the day, and the ring changes colors throughout the day based on external conditions. Our ring would look like a solid, dark colored band, but depending on the air quality surrounding the person wearing the ring, the rims of the ring will change color. When the ring detects changes in air quality, the app will provide additional insight into what the ring has detected, so the wearer can understand their surrounding air quality. Also, if the ring detects exceptionally hazardous air, it will vibrate, in order to get the wearer's immediate attention so that they can proceed to safety.

This design would support four main tasks : educate self about potential air quality hazards/practices in home, know when immediate action is needed due to hazardous air quality, know when user specified irritants are affecting air quality, and opening windows when it is stuffy inside. For the first task, when there are no warnings about air quality, the app will display short facts and information that can assist the user in improving their overall air quality. For the second task, the ring will vibrate and turn red if there is a warning that requires immediate action. The vibration would make the notification more urgent, and once the user notices the ring, they can go to the app on their phone to see what immediate action they should take. For the third task, users can go on the app and customize the colors that the ring changes based on what they are most concerned about. For example, they can set the color to blue if there is high pollen concentration in the air which will remind them to take their pollen allergy medication. For the fourth task, the ring will turn a yellow color if it detects unhealthy levels of humidity in the air. The user will get a notification on their phone and they can click on that notification which will bring them to the app for next steps and more details. These functions and tasks are also illustrated in Figure 2.

Design 1: Air Quality Indicator Ring (continued)

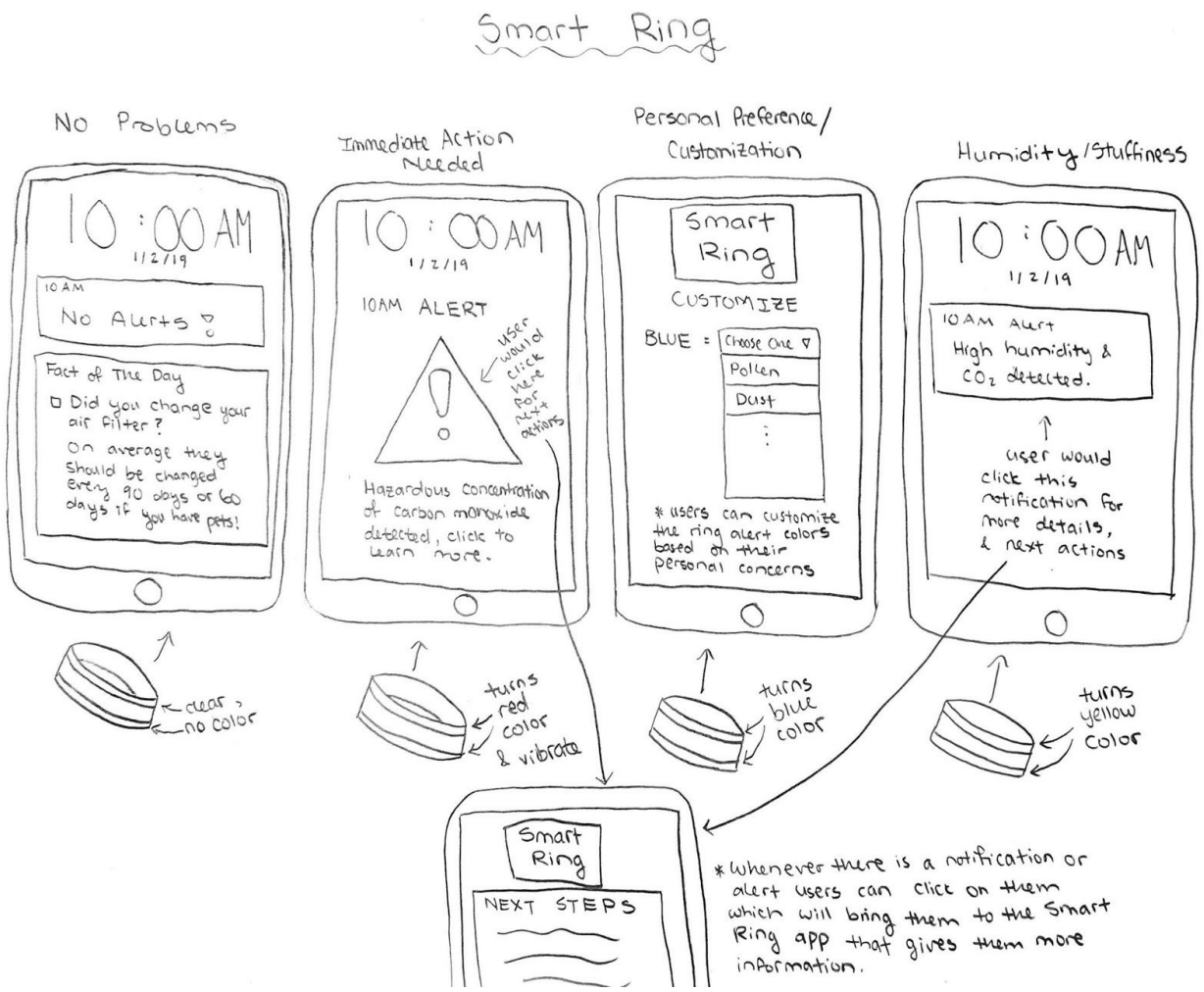

Figure 2. Smart Ring and app functionality sketch. Note how the ring changes color based on what notifications there are, and how the app displays the appropriate information for each scenario.

Design 2: Ceiling Light Strip with Projection to Indicate Room's Air Quality

This solution uses a strip of lights along the ceiling of a room to display an indication of the room's air quality. The color of the strip of lights will correspond to a state of the room's air quality: clear for good air quality, yellow for moderate air quality, red for poor air quality, and blue for a customizable air quality alert such as high pollen concentration, or air that could trigger asthma. If there is a notification about the air quality in the room, a display will be projected onto the ceiling with more information about the alert.

This design would support four main tasks : to educate oneself about potential air quality hazards/practices in home, to know when immediate action is needed due to hazardous air quality, to know when custom irritants are affecting air quality, and to know when to open windows when it is stuffy inside. For the first task, the design will display on the ceiling if there are hazards in the air, or if the participant's customizable irritant is detected in the air. The projection shows facts along with the information about the hazard itself. This is seen in figure 3. For the second task, the light strips will turn red and the ceiling display will come on if there is an immediate hazard in the room's air quality. This is demonstrated in figure four. For the third task, the light strips will turn blue when the irritant specified by the participant is detected in the air in concentrations that could cause adverse symptoms. This allows the user to program the lights for their specific air quality concerns. For the fourth task, the lights will turn yellow if it is stuffy inside, indicating that the participant should open their windows. Tasks three and four are demonstrated in figure 3.

Design 2: Ceiling Light Strip (continued)

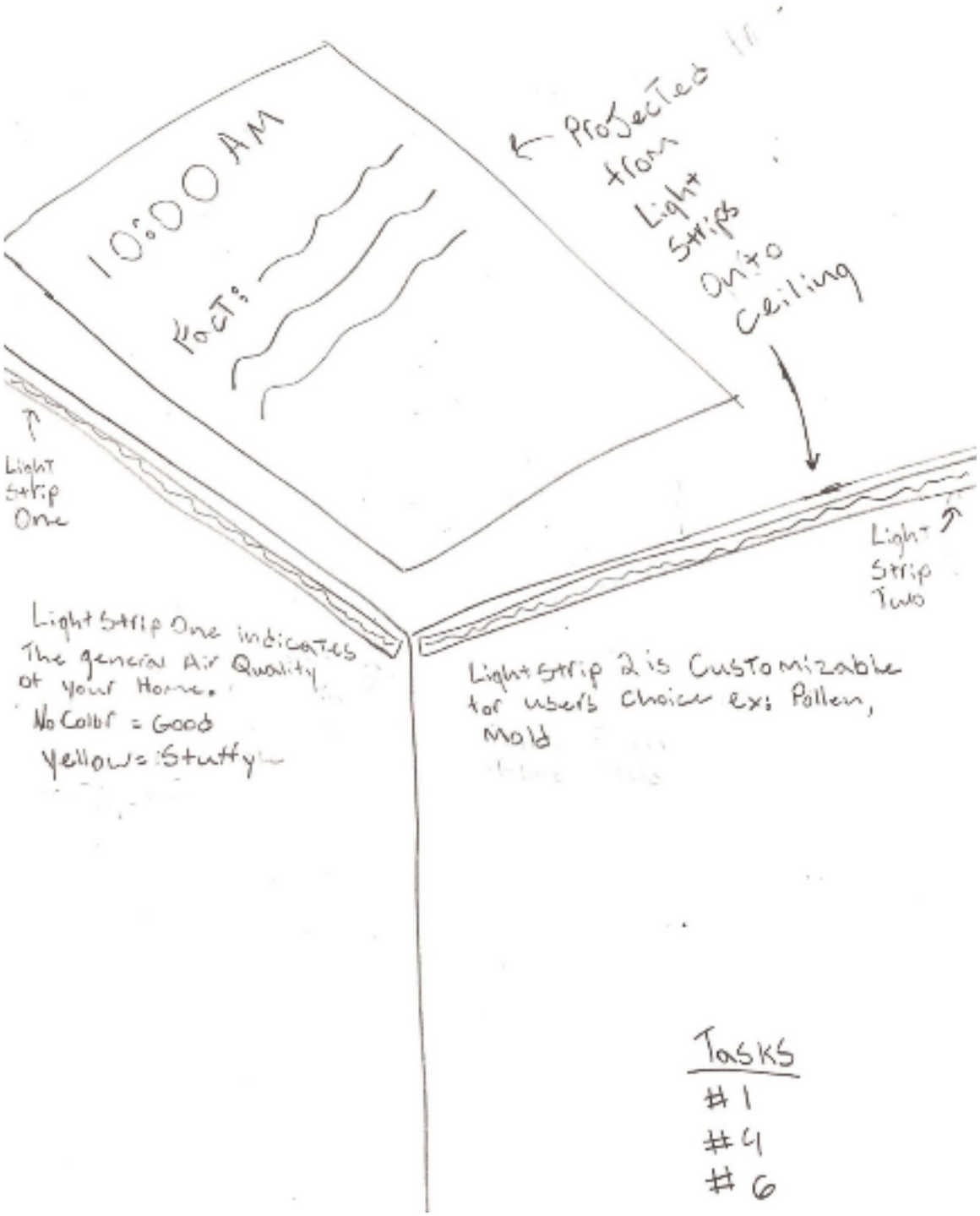

Figure 3. Ceiling Light Strip functionality sketch. Note how the light strips light up based on what notifications there are and the projection on the ceiling projects useful information when needed.

Design 2: Ceiling Light Strip (continued)

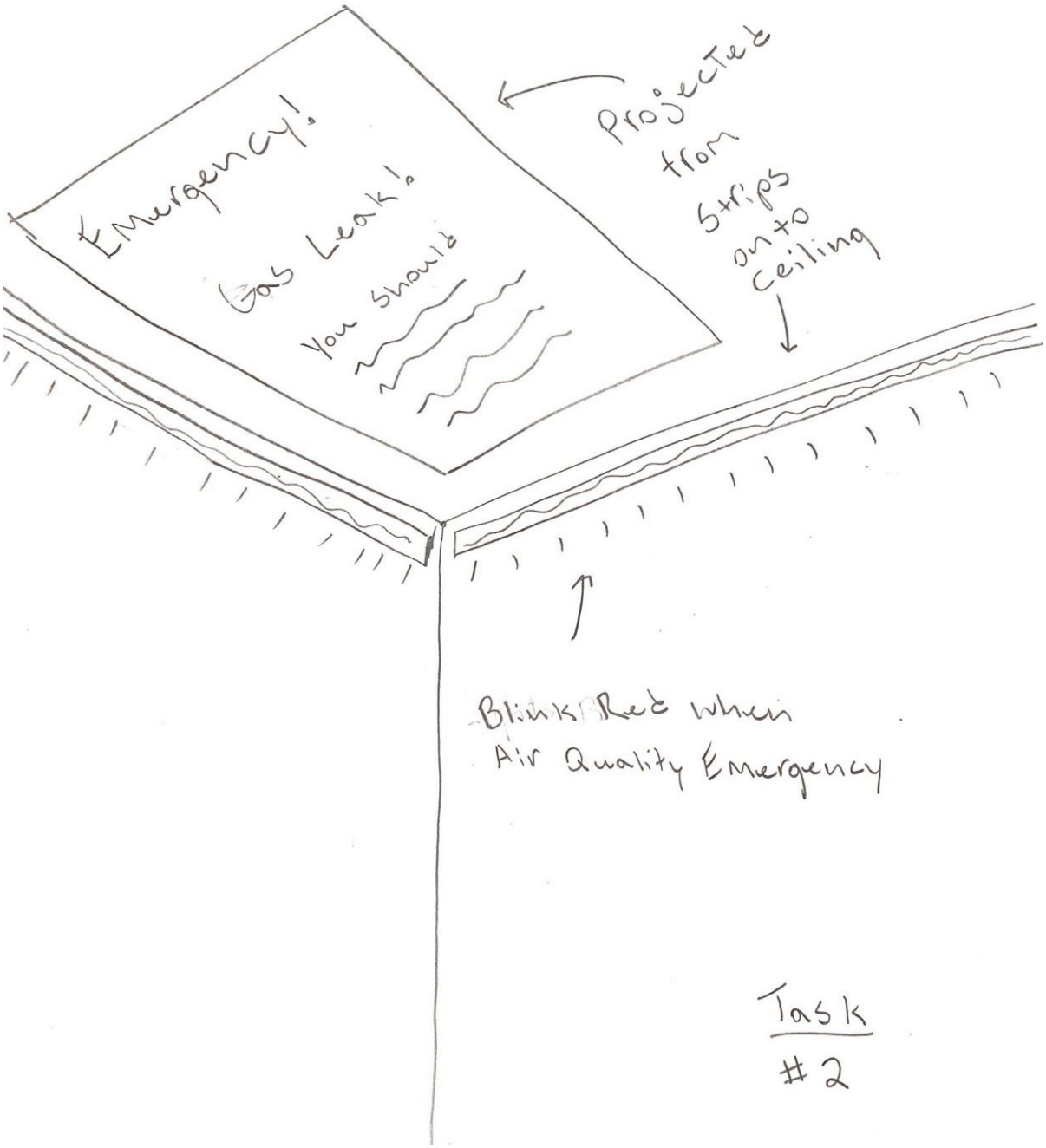

Figure 4. This figure demonstrates the emergency notification functionality in the light strip design.

Design 3: Smart Home Device

In this design, a participant will place air quality sensors in each room of their house. Each of these sensors will communicate with a primary hub that tracks each of the sensors' data and can be interacted with using voice commands, similar to Amazon's Alexa. With this design, participants can pinpoint exactly where in their house particulate air quality problems arise, such as mold in a bathroom due to humidity from frequent showering without using a fan. For especially hazardous air quality, this device will "speak" to notify the residence's inhabitants of the hazard. Otherwise, participants can ask the device about their residence's current air quality, ways to improve their residence's air quality, and program it to track particular irritants in their air.

This design supports four main tasks : educate self about potential air quality hazards/practices in home, know when immediate action is needed due to hazardous air quality, know when user specified irritants are affecting air quality, and opening windows when it is stuffy inside. For the first task, users can request information about how to improve the air quality of specific rooms in the home. The smart home device will respond with suggestions based on the particular problems of the given room. For the second task, the smart home device will speak without prompting and warn the occupants that there is an immediate danger and suggested advice. Users can ask to repeat information if needed. For the third task, the user can prompt the smart home device to give information about specific irritants. The smart home device will then respond with the requested information. For the fourth task, the smart home device will chime to indicate that it is too stuffy inside, and the user can then interact with it to find out what specific rooms are affected and then take action.

Design 3: Smart Home Device (continued)

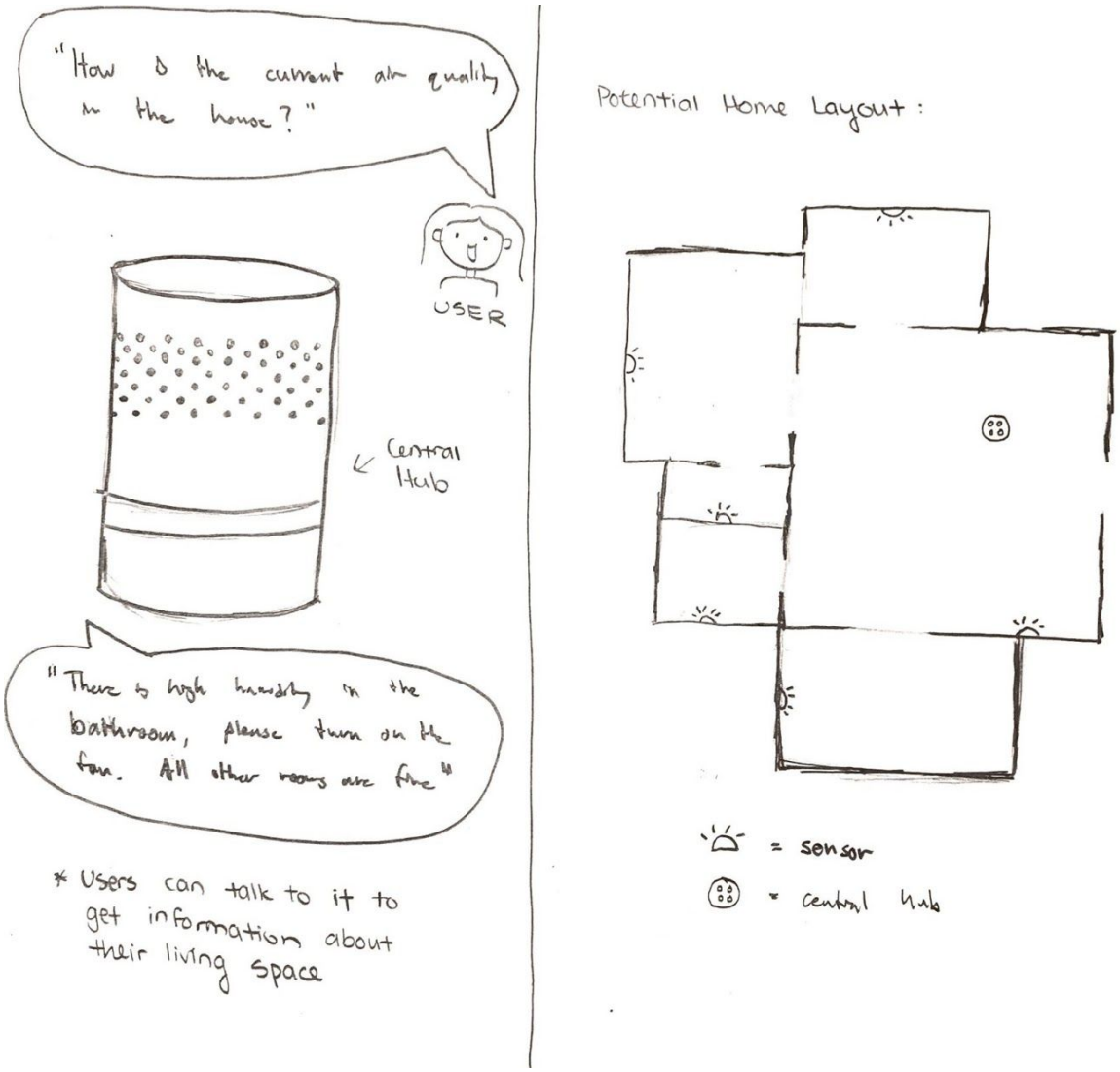

Figure 5. Smart Home Device functionality sketch. Note how users can place various sensors in each room of their home which connects to the central Smart Home Device hub. Users can also speak to the hub to get information.

Why We Chose QuaLight

From our three proposed designs, we chose QuaLight, previously referred to as the Light Strip design. Our design is primarily targeted towards people who are already aware of or interested in how the air quality in their living space impacts their health. Furthermore, people who have allergies or respiratory concerns are the most likely to be aware of and interested in monitoring the air quality in their living spaces. This makes them more likely to be open to installing light strips around their home so that their whole living space can be integrated into their desire for air quality tracking. Our design is also very hands free which is suitable for people who may not be very comfortable with using mobile apps or technology or for busy people who just want quick live feedback with zero fuss. By having light strips around the walls and a projector displaying information, we can accomplish the main tasks participants were concerned about as mentioned in Design Scenarios, while occupying minimal space in homes. The light strips design makes it so that it can easily integrate into people's homes without intruding or requiring multiple devices in each room of their house. Having information or alerts be projected on walls is a good way to get people's attention but also take up little to no space since once a notification has been addressed, the projection will just go away by itself.

From the data collected from interviews and surveys we conducted with our participants, we also noticed that one of the main concerns was being able to understand how outdoor air quality can affect indoor air quality. To address this concern, QuaLight was designed to adjust its recommendations for certain tasks and scenarios based on doing an evaluation of outdoor air quality data taken from local news and weather outlets, and indoor air quality data taken from the QuaLight sensors in the light strips. If outdoor air quality is poor for example, QuaLight can notify the user to keep windows closed to maintain indoor air quality.

Design Scenarios

Scenario 1: Casey Monitors Her Home Air Quality (Figure 6)

Casey is stuck inside all weekend because of the snowstorm outside. To pass the time, she reads in her room. Because of the cold, all the windows in Casey's apartment are closed and her heat is turned up. She doesn't realize that the air quality in her small apartment has worsened dramatically during the day. However, her QuaLight device detects the decrease and when it determines that the air quality has degraded past a certain point, it notifies Casey by changing colors and projecting an alert onto the ceiling. The alert states that the air quality in the room has changed from good to moderate, and it recommends opening up windows. Casey looks outside and sees that it is no longer snowing. She opens up the window to let in fresh air, and QuaLight device soon indicates that the air quality is back to being good.

Figure 6. A storyboard detailing the light strips informing Casey that the air quality in her home is poor and providing her with recommendations on the best actions. Using news and weather outlets' data on outdoor air quality, QuaLight was able to determine that it is safe for Casey to open her windows and let in fresh air from outdoors in order to improve her indoor air quality.

Design Scenarios (continued)

Scenario 2: Joel Learns About Air Quality and How it Affects His Health (Figure 7)

Joel goes to the store to buy some cleaning supplies for his home office. One of the things he picks up is an aerosol cleaner. Joel has asthma, so he has some concerns about the potential negative effects of using the cleaner. When Joel returns home, he asks his QuaLight how the cleaner he purchased might affect air quality. QuaLight projects onto the ceiling that the cleaner Joel purchased does have potential contaminants and based on Joel's asthma triggers, these contaminants may be hazardous to Joel.QuaLight then provides recommendations for using the cleaner, which Joel follows.

Figure 7: This storyboard portrays Joel as he uses QuaLight to learn about products that could affect his air quality. The projection explains to Joel what the product is and the potential hazards involved, then gives him advice on how to proceed with using the product safely.

Contribution Statement

Joy Clark (25%) : Design Research Goals Stakeholders and Participants, Design Research Results and Themes
Bailee Barrick (25%) : Task Analysis Questions, Significant formatting work, Captioned images, general revisions and proofreading
Daniel Shen (25%) : Wrote Design scenarios 1x2 and drew second storyboard
Pei Lee Yap (25%) : revised Proposed Design Sketches - "3x4", wrote Problem and Solution Overview, set up template for report, Why We Chose This Design paragraph