FLOWSAFE

FLOOD RISK SIMULATION DEVICE

SCAN HERE

ABSTRACT

Flooding, exacerbated by climate change, has become an increasingly severe threat to communities worldwide with over 140 countries affected and billions of dollars lost. Rising sea levels and melting glaciers, driven by global warming, significantly heighten the frequency and intensity of coastal flooding, particularly during storms and extreme weather events. Simultaneously, more frequent and intense rainfall in inland regions contributes to flash flooding, as urban and rural drainage systems struggle to handle sudden water surges. ***These challenges highlight the urgent need for innovative solutions to educate public, improve preparedness and reduce risks.***

The FLOWSAFE flood risk simulation device was designed to address this growing problem by combining real-time detection, intuitive feedback, and mobile connectivity. *The device features a compact, weather-resistant aluminum housing to simulate underwater environments. Integrated sensors detect key environmental parameters, including light levels, water flow velocity and acceleration. The device translates this data into actionable insights using a three-tiered LED color-coded alert system: green for normal conditions, yellow/orange for abnormal situations, and red for emergencies. Additionally, subtle buzzer alerts provide sound-based feedback for abnormal and dangerous conditions, enhancing usability in critical moments.*

To further improve the user experience, FLOWSAFE incorporates real-time signal transmission to mobile devices, enabling users to receive detailed status updates in three categories—NORMAL, ABNORMAL, and DANGER—accompanied by a flashing DANGER WARNING for high-risk scenarios. By integrating these features, ***FLOWSAFE provides an educational and interactive way for users to understand flood risks, respond effectively, and make informed decisions during emergencies.***

The development of FLOWSAFE was guided by a comprehensive design research process, including mindmapping, cultural probes, storyboard and GIF animations, interviews, morphological charts, and iterative prototyping to refine its core functionalities and aesthetics. Usability testing methods, such as UX surveys and System Usability Scale (SUS) evaluations, also provided valuable user feedback by highlighting areas of strength and opportunities for improvement. Role-play simulations were conducted to explore real-world scenarios, enabling the designer to assess user interactions and enhance the device's effectiveness in providing timely alerts and actionable insights. These methods ensured that the device meets the diverse needs of users across different contexts, making it a reliable tool for education, preparedness, and emergency response. ***With its versatile applications, FLOWSAFE has the potential to scale into schools, municipalities, and national disaster preparedness programs, empowering individuals and communities to better navigate the challenges posed by climate change-induced flooding.***

DESIGN PROCESS

1 Mindmapping

The concept of "Flood Risk" was explored using the mind mapping method: asking the questions of Where?, Why?, and How? floods are intensified by climate change. This process identified key factors like rising sea levels, extreme rainfall, and inadequate infrastructure, along with the existing solution space for flood preparedness and mitigation.

2 Cultural Probe

Conducting a thought-recording form and reflection exercises, I explored how participants perceive and engage with climate change over a 48-hour period. Participants recorded spontaneous thoughts about climate change, noting triggers, locations, and emotional responses. This approach captured real-time insights into their awareness and reflections on climate-related issues in various daily contexts.

3 Storyboard & GIF

Using a series of storyboard sketches and GIF animations, I illustrated the transition of device's status under different conditions and how it the device operates in real time, from detecting safe conditions with a green indicator to escalating alerts with yellow/orange and red warnings as the water flow velocity increases. This method effectively visualizes the device's response to changing flood scenarios, providing a clear understanding of its functionality and user interactions.

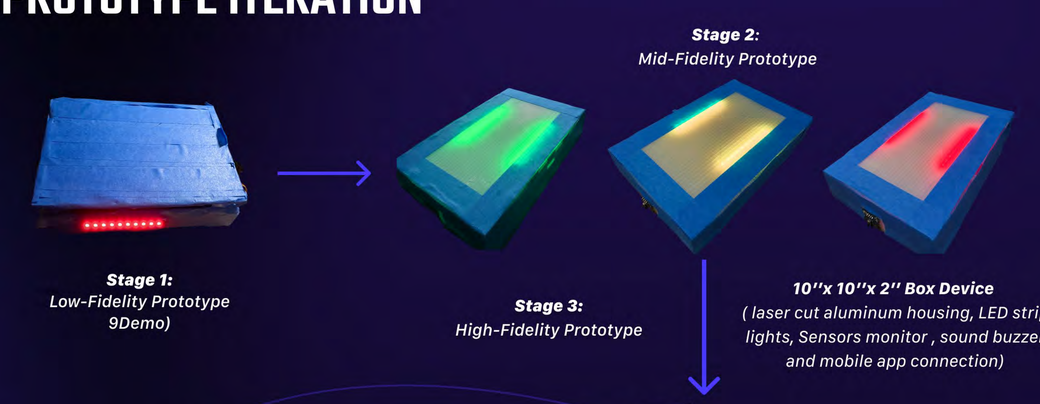
4 Interview

Through structured interviews, I gathered participants' perceptions of climate change and their feedback on the device prototype. I set 11 questions explored topics such as initial impressions, usability, and communication effectiveness, as well as 5 evaluations in personal relevance and suggestions for improvement. This method provided in-depth insights into user needs and expectations, guiding refinements in the design and functionality of the flood risk simulation device.

5 Morphological Chart

I constructed a morphological chart to analyze and combine design elements for FLOWSAFE, focusing on six key sub-functions: color, form, material, mechanism, effect, and connectivity. Feedback from participants during a simulation exercise helped rank and refine three alternative design models for guiding the optimal features of final prototypes.

PROTOTYPE ITERATION



SYSTEM USABILITY SCALE STUDY

SUS SCORES: 73

SUS Range : 68-85

Feedback from users:

- *Color-Coded Light System: "The LED indicators are very intuitive and make it easy to assess flood risk level at a glance."*
- *Sensors Integration: "The sound and light alerts work well together, providing immediate and clear feedback of status on changing conditions."*
- *Mobile Interface: "The mobile connection is straightforward and provides useful, detailed updates."*
- *Sound Alerts: "The sound alerts are a bit too loud for less critical conditions. Softer tones in the normal and abnormal states would be better."*
- *Visual Appeal: "The wave-like texture on surface could enhance the aesthetic, making it look modern and professional."*

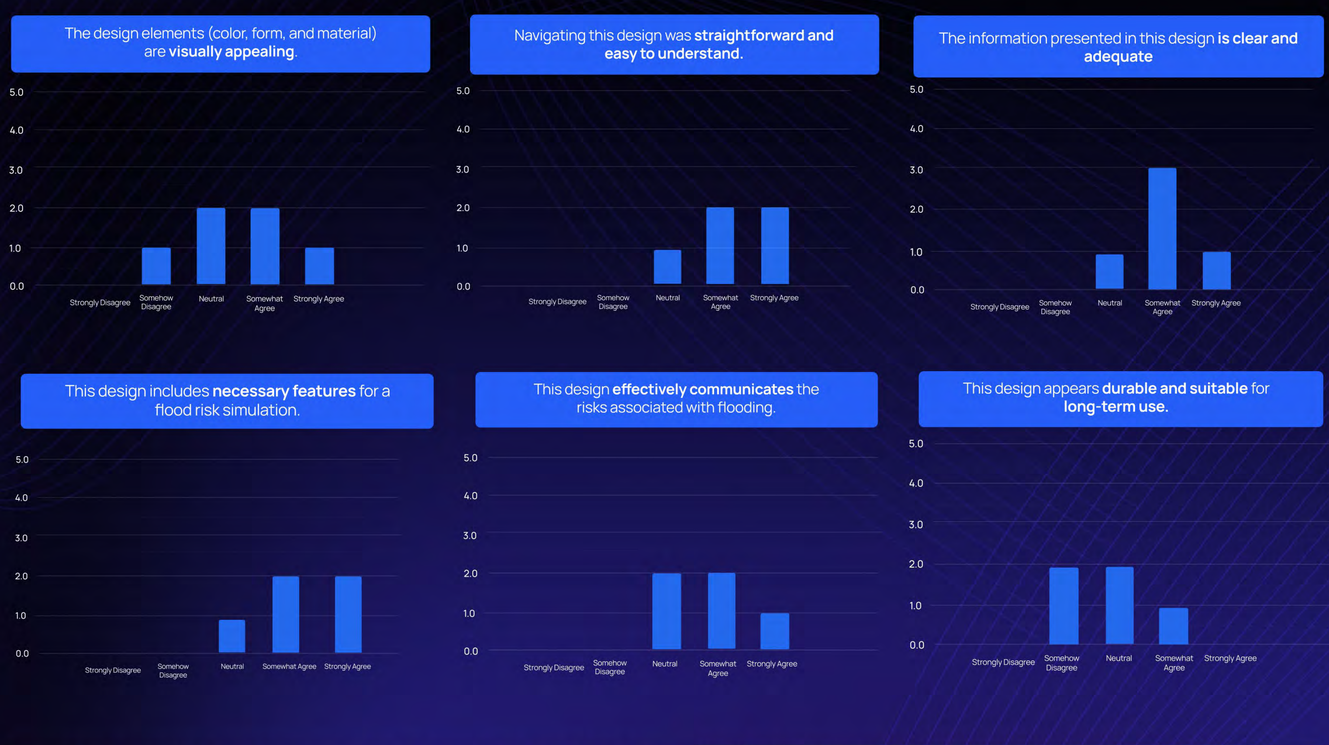
ERRORS IDENTIFIED

1. *The motion sensor occasionally failed to detect subtle changes and show status very accurately.*
2. *The exterior design was considered too simplistic, without refined textures, shapes, or decorative elements.*

CONCLUSION

The SUS score is 73, which is not bad. Both errors suggested by users are addressed to enhance the overall functionality and aesthetic appearance as shown finally.

UX SURVEY *(2 males & 3 females; aged 19-21)*



THINK ALOUD

1 *Sophomore, Applied Economics & Management*

"The green light feels peaceful, like a reassuring friend letting me know everything is fine right now."

2 *Junior, Information Science*

"The yellow light and gentle buzzing feel like a quiet heads-up, like someone softly saying, 'Hey, just keep an eye out.'"

3 *Sophomore, Mechanical Engineering*

"When the red light came on with the loud alarm, it felt like an urgent shout from someone who really cared about my safety."

Question: How did the design simulation prototype affect your perception of the dangers of flooding?

- **Participant 1:** "It made me realize how important quick notifications can be. Seeing how each design offered different ways of alerting users highlighted the urgency and need for reliable flood warning systems."
- **Participant 2:** "Honestly, it was eye-opening. I hadn't thought much about flood risk before, but after interacting with the prototype, I saw how valuable a dedicated device could be in dangerous situations. The simulation helped me understand the potential impacts better."
- **Participant 3:** "The simulation definitely emphasized the risks. Alternative 3's sound alert was especially impactful – I could imagine it being useful in a real emergency. It made me more aware of how immediate and intense flood risks can be."
- **Participant 4:** "It didn't change my perception that much, but it did reinforce the importance of preparedness. I think it would be a helpful tool for communities prone to flooding, but I wish the simulation included more scenarios to show the range of risks."
- **Participant 5:** "Interacting with the prototype made the dangers of flooding feel more real to me. I realized how important it is to have an alert system that's accessible and easy to understand. I think the designs were effective in conveying urgency."

Question: What would you add or modify to increase engagement with the simulation?

- **Participant 1:** "Adding more interactive elements would help, like a feature where users could simulate different flood scenarios. This would keep it engaging and provide a hands-on experience."
- **Participant 2:** "Maybe a tutorial at the beginning? I think that would help users understand each feature better. The simulation could also have more visuals, like color changes, to indicate different alert levels."
- **Participant 3:** "I'd love to see more personalization options, like selecting your preferred alert style (sound, visual, or both). Also, having a quick quiz or interactive flowchart on how to respond in different flood levels would make it more engaging."
- **Participant 4:** "For me, a scoring system that provides feedback on how well you responded to alerts could add an element of gamification. It might also be helpful to add visual aids that explain what each feature does."
- **Participant 5:** "If there were more levels of simulation – like mild, moderate, and severe flood scenarios – it would help users understand how the device would function in real-life situations. It would add depth and keep people interested."

OBSERVATION

- *Color Coding Reinforces Risk Awareness*
- *Auditory Cues Effectively Amplify Urgency*
- *The Yellow State Could Benefit from Enhanced Clarity*
- *Non-Intrusive Design for Low-Risk States Is Appreciated*
- *Volume Control Could Improve User Comfort*
- *Intuitive Design Reinforces Immediate Action in Emergencies*

4 *Junior, Design Environmental Analysis*

"I like how the device isn't overbearing when things are normal—it's like it respects your space until it really needs your attention."

5 *Junior, Fiber Science and Apparel Design*

"It's a thoughtful design; I feel like it's guiding me, not just alarming me, and that makes it feel more like a helpful companion."

KEY TAKEAWAY

Participants appreciated the intuitive integration of LED indicators, sound alerts, and the mobile interface, which effectively communicated flood risks in real-time.

However, several areas for improvement were identified. Many suggested enhancing the realism of the alerts by making LED lights flicker dynamically and improving the durability and aesthetic appeal of the device, such as using darker colors, textured finishes, or a water-resistant coating. These insights informed the final design refinements to make FLOWSAFE more functional, durable and visually engaging for diverse use cases.

(Driving in the Wild) SCENARIO / ROLE PLAY

Kevin, an outdoor adventurer, is ready for his trip to the wild. Before leaving, he was introduced with the interactive device called FLOWSAFE, which can help simulate and give feedback in different levels regarding the change in weather conditions that lead to flood risks.

Kevin, , starts driving through a scenic mountainous region to explore . On the way, his FLOWSAFE device and the app are connected well and are showing a steady green light status , indicating normal conditions of safe environment outside.

As Kevin drives deeper into the area, dark clouds gather, and light rain begins to fall. The FLOWSAFE device switches to an orange light with a soft buzzing sound. Kevin checks his phone, which displays the ABNORMAL status, prompting him to stay cautious all the time.

Reaching the narrow valley bridge, the rain intensifies, and the device escalates to a flashing red light with a loud warning alarm. Kevin's phone displays a critical flashing DANGER notification.

Kevin quickly reacts and turn around to leave the dangerous place, deciding to avoid the bridge and rerouting his journey. The FLOWSAFE device provides real-time guidance as Kevin safely navigates away from the flood-prone area.

Having avoided danger and driving back safely, Kevin reflects on how FLOWSAFE's timely alerts and immediate information helped him steer clear of potential harm, ensuring his adventure continues without incident.

EXPERIENCE SAFETY AND LEARN PREPAREDNESS IN REAL-TIME.

2024 FALL DEA 2730 (PROF. GREEN) YICHEN TONG