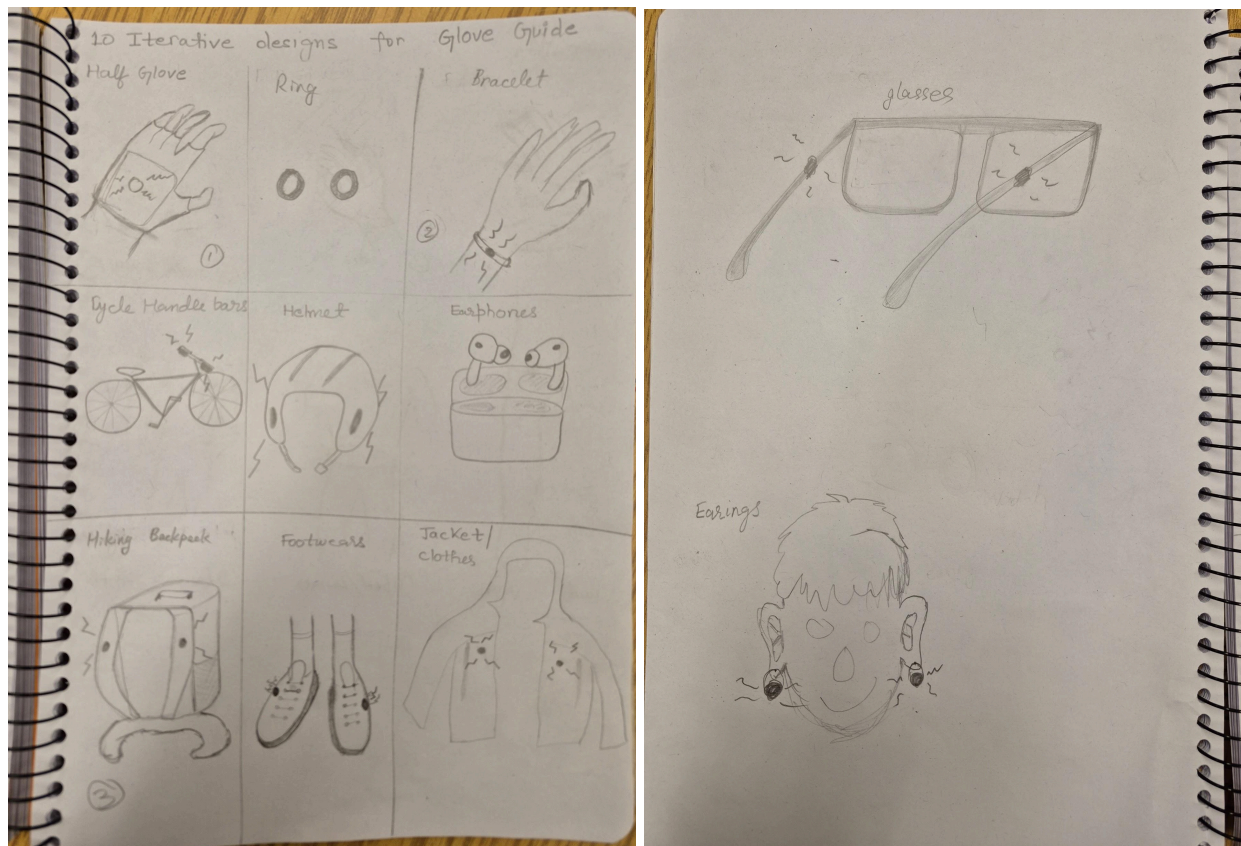


Low Fidelity Prototype

Design Concepts

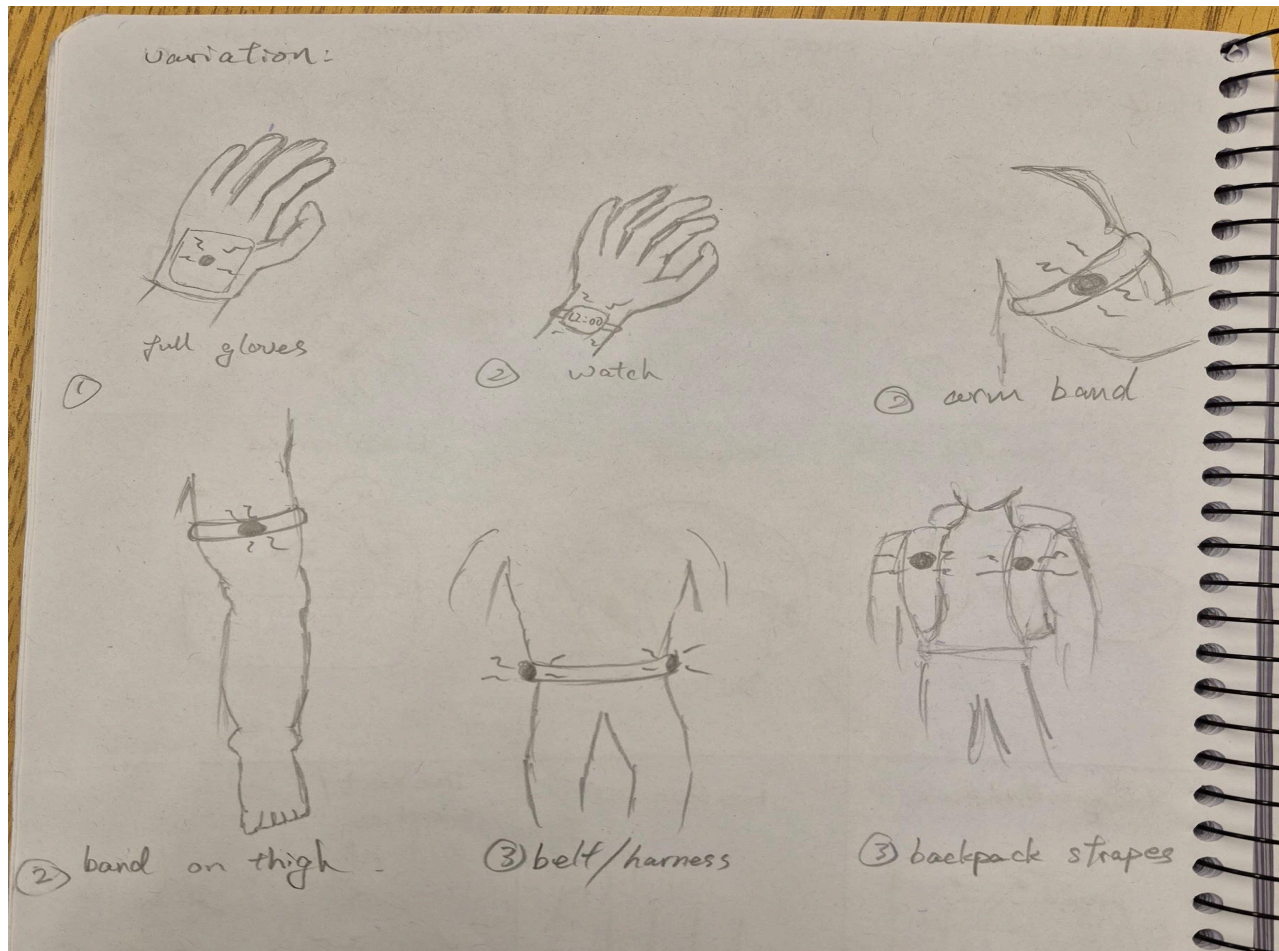
We employed the *10 plus 10* method to systematically generate a diverse range of design concepts for the **Glove Guide** project. The two figures below present sketches of 11 distinct concepts, each illustrating a different approach to user interaction and system integration.



From this initial set, the design team selected three primary directions for further development:

1. Half Glove
2. Bracelet
3. Hiking Backpack

6 refined variations derived from these three concepts are shown in the subsequent figure. Each variation is labeled with a number referencing its corresponding original concept.



Prototypes

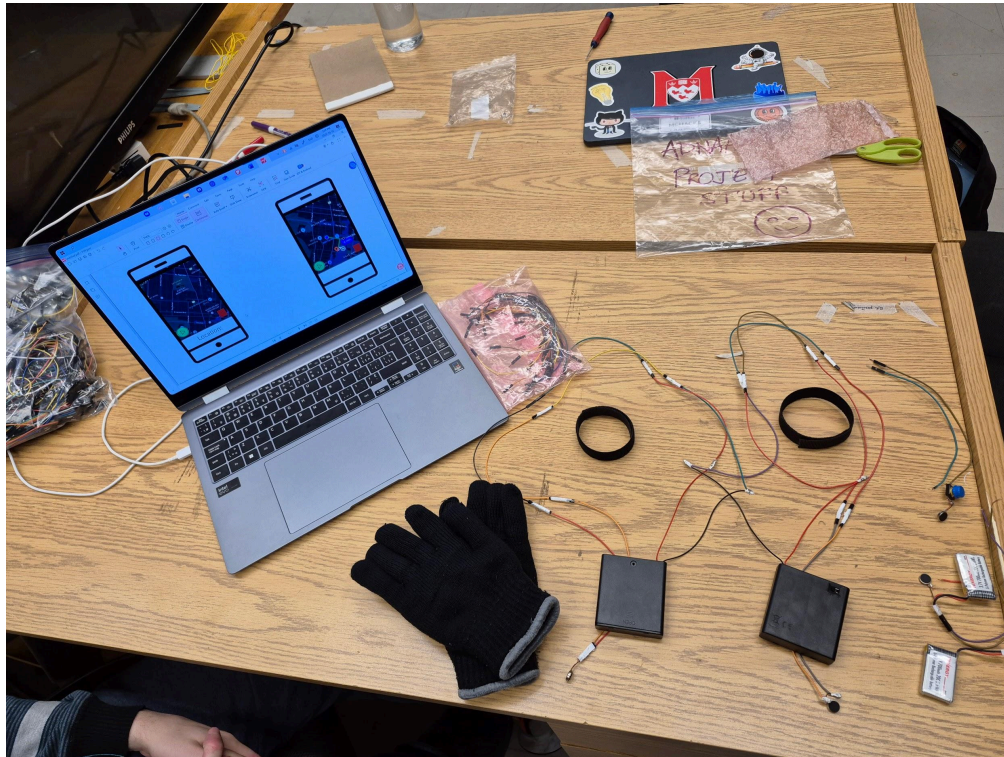
After several rounds of discussion, we selected two design directions to prototype: the **full-hand glove** and the **bracelet**. These two prototypes were developed to explore contrasting approaches to wearing and interacting with the Glove Guide system.

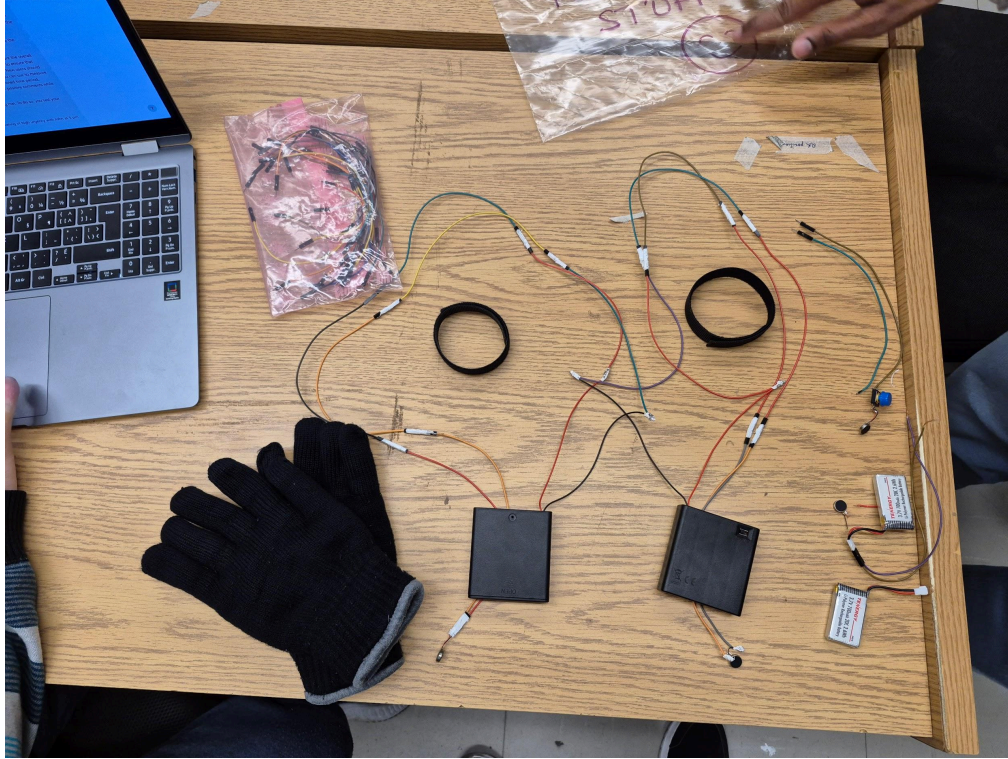
Each prototype consists of three components: **paper interfaces**, **electrical elements**, and **physical structures**.

- **Paper interfaces:** Wireframes created digitally were printed and used to simulate the product's software interface during testing.
- **Electrical elements:** Both prototypes incorporated the same haptic actuator powered by a battery and controlled via a simple switch to trigger vibration feedback.
- **Physical structures:** The physical form differed based on how the prototype was worn — either as a glove or a bracelet.

Because our design exploration primarily focused on differences in **physical implementation** rather than variations in the software interface or circuitry, both prototypes shared the same electrical setup and paper interface mockups.

The figures below illustrate the components of both prototypes. During user testing, participants wore either the gloves or bracelets on both hands. Haptic actuators were attached using tape after, to ensure a comfortable fit. The moderator operated the switches to activate vibrations on the left or right side, signaling left or right turns respectively, while also using the paper interfaces to simulate interactions within the application.





Usability Goals

Calm Technology

- **Goal:** Users should be able to navigate without taking out their phones after completing the initial setup.
- **Rationale:** The *Glove Guide* is designed as a *calm technology*, meaning it should primarily occupy users' peripheral attention and only demand central attention when necessary (e.g., during destination setup). Users should not be distracted by haptic feedback or uncertainty about the navigation process.

Effectiveness

- **Goal:** Users should correctly interpret all haptic cues (left/right) without any errors.
- **Rationale:** The system's core functionality relies on accurate haptic communication for turn-by-turn navigation. Misinterpretation would render navigation unreliable or even unsafe. Because the cue mapping is straightforward—vibration on the left indicates a left turn and vice versa—users are expected to achieve complete accuracy.

Efficiency

- **Goal:** Users should respond to haptic cues within **2 seconds** without slowing down or pausing.

- **Rationale:** The Glove Guide must integrate seamlessly into real-world movement, particularly for pedestrians and cyclists. A short response time ensures that users can act on cues naturally without breaking their pace or focus.

Learnability

- **Goal:** New users should understand and adapt to all system functionalities on their first attempt and within **30 seconds**.
- **Rationale:** The design should be intuitive enough that users can immediately grasp how the haptic cues correspond to navigation actions without the need for instruction or repeated trials.

Satisfaction

- **Goal:** Users should report positive feedback and express confidence and comfort while using the system.
- **Rationale:** Beyond functional performance, long-term adoption depends on a pleasant and natural user experience. The system should feel unobtrusive, comfortable, and trustworthy during navigation.

Benchmark Tasks

Task 1: Choose Destination and Start a New Route

- **Description:** From the homepage, participants are asked to select a destination, start a navigation session, and put on the gloves or bracelets.
- **Purpose:** This task evaluates the **learnability** of the system interface and setup process.
- **Subtasks:** Glove fitting, destination selection, navigation initiation.

Task 2: Complete a Known Route with Multiple Turns

- **Description:** Participants follow a previously learned route using the Glove Guide system without referring to their phone or map.
- **Purpose:** This task examines all usability goals **except efficiency**. Since the route is familiar, quick reactions may result from prior knowledge rather than system responsiveness.
- **Subtasks:** Recognize left/right haptic cues with anticipation; maintain correct navigation along the route.

Task 3: Complete an Unknown Route with Multiple Turns

- **Description:** Participants follow an unfamiliar route using the Glove Guide system without any visual navigation aids.

- **Purpose:** This task evaluates all usability goals **except learnability**, with a particular focus on **efficiency**. Because the route is unknown, participants must rely entirely on haptic feedback, and their reaction times reflect true responsiveness rather than prior familiarity.
- **Subtasks:** Recognize and respond to haptic cues; maintain confidence throughout navigation.

Task 4: Navigate While Performing a Secondary Task

- **Description:** Participants are instructed to engage in a conversation while being guided by the *Glove Guide* system to a destination.
- **Purpose:** This task primarily assesses the **Calm Technology** goal. The system should operate within the user's peripheral attention, allowing them to stay focused on the secondary activity.
- **Subtasks:** Maintain attention on the secondary task; rely on peripheral perception to detect haptic cues.

Together, these benchmark tasks comprehensively evaluate the core usability goals of the *Glove Guide* system. They encompass all major aspects of the user experience—from initial setup and learning to real-time navigation and multitasking in dynamic environments. By observing task completion, response times, and error rates, as well as collecting post-task feedback through Likert-scale questionnaires, we can assess both the functional effectiveness and overall user satisfaction of the prototypes.

Test Materials

To evaluate the usability of the *Glove Guide* prototypes, a complete set of test materials was prepared. These materials ensure consistency across sessions and provide both the moderator and observer with clear procedures to follow. They include an observer briefing, moderator guide, user introduction script, pre-test questionnaire, user documentation, benchmark task descriptions, data collection sheet, and post-test questionnaire. Together, these documents support a structured yet flexible usability evaluation, allowing the team to collect both quantitative and qualitative insights on the system's performance and user experience.

1. Observer Briefing

Overview:

This usability test evaluates *Glove Guide*, a wearable haptic navigation system designed to assist users in navigating through haptic feedback. The goal is to allow users to maintain focus on their surroundings rather than relying on visual cues or screens.

Observer Role:

Observers are responsible for monitoring participant behavior throughout the testing session. They should:

- Remain silent and unobtrusive during all test activities.
- Take detailed notes on user actions, confusion points, reaction times, and observable expressions or gestures.
- Record task completion times, number of errors, and any participant requests for clarification or assistance.

Prohibited Actions:

- Do not provide assistance or guidance unless there is a clear safety concern.
- Do not answer user questions during the tasks; instead, redirect participants to the task instructions if necessary.

Key Observation Focus:

- Reaction time to haptic cues.
- Misinterpretation or hesitation in responding to signals.
- Verbal or physical indicators of confusion or frustration.
- Posture or head movements suggesting distraction or divided attention.

2. Moderator Guide

Purpose:

This guide outlines the moderator's responsibilities and actions during the usability testing session. The moderator facilitates the test procedure, ensures consistency across participants, and controls the simulated system feedback while avoiding any verbal influence on user behavior.

Instructions:

- Present **Interface 1** to the participant at the start of the test.
- After the participant selects a destination and presses the **Start** button, present **Interface 2**.
- When the participant presses the **Stop** button, return to **Interface 1**.

- Remove the interface to indicate that the phone is no longer in use during navigation.
- Activate the **left-side vibration** when a left turn is required, and deactivate it once the turn is completed.
- Activate the **right-side vibration** when a right turn is required, and deactivate it once the turn is completed.
- Guide the participant through the route using only haptic cues for turn-by-turn navigation.
- **Do not provide any verbal instructions or feedback** during the task, except in cases where participant safety is at risk.

3. User Introduction Script

Hi, welcome — and thank you for taking part in our usability test for the Glove Guide system.

Before we start, I want to emphasize that we're testing the system, not you. There are no right or wrong answers here. What matters most is seeing how easy and effective the glove is to use, and hearing your honest impressions along the way.

Here's how it will work:

You'll go through a few short tasks that simulate real-world walking routes. The glove will give haptic cues — vibrations — to let you know when to turn left or right. Please try to complete each task as naturally as possible, just as you would if you were using it on your own.

Everything you do today will stay confidential. Your data will be anonymized, and participation is completely voluntary. You can stop the session at any time if you wish.

Before we begin, do you have any questions about what we'll be doing or about the equipment?

4. Pre-Test Questionnaire

Pre-Test Questionnaire – Glove Guide

Section A: Demographics

1. **Age:** _____
2. **Gender:** _____
3. **Occupation:** _____

Section B: Technology Use

4. How often do you use navigation apps?
- ☐ Never ☐ Rarely ☐ Sometimes ☐ Often ☐ Always
5. Which navigation apps do you currently use?
- _____
6. Are you familiar with wearable technology (e.g., smartwatches, fitness bands)?
- ☐ Yes ☐ No

Section C: Experience with Haptics

7. Have you used a device that provides haptic feedback (e.g., smartwatch, game controller)?
☐ Yes ☐ No
8. How confident are you in interpreting vibration cues for navigation?
- | | | | | |
|-----------------|---|---|---|--------------------|
| 1 | 2 | 3 | 4 | 5 |
| (Not confident) | | | | (Highly confident) |

5. Documentation

Glove Guide Quick Start

1. Setup

- Open the *Glove Guide* app and select your destination.
- Ensure the glove fits snugly and comfortably on your hand.
- The glove has already been paired with the mobile app for this test—no additional setup is required.

2. Navigation

- During navigation, the glove will vibrate to indicate turns:
 - **Left-hand vibration** → Turn left
 - **Right-hand vibration** → Turn right

- Vibrations begin approximately **10 meters** before each turn.
- No screen interaction is required once navigation has started. Simply follow the haptic cues to reach your destination.

6. Test-Task Description

Test Tasks Description

Task 1: Choose Destination and Start a New Route

Description: "The app has been opened and you are now on the homepage. Start a route navigation to a destination of your choice. Then put on the gloves or bracelets."

Task 2: Complete a Known Route with Multiple Turns

Description: "Follow the pre-defined route with multiple turns using the Glove Guide system. You may look at the app before departure to remember the route. After departure, complete the route without looking at your phone or a map."

Task 3: Complete an Unknown Route with Multiple Turns

Description: "Follow the route with multiple turns using the Glove Guide system. You will not know the route in advance. You may start whenever you are ready. After departure, complete the route without looking at your phone or a map."

Task 4: Navigate While Performing a Second Task

Description: "While walking, carry on a conversation and follow the haptic navigation cues."

7. Data Collection Sheet

Glove Guide – Data Collection Sheet

Participant ID: _____ Prototype: ☐ Glove ☐ Bracelet

Date: _____ Observer: _____

Task Summary

Task	Completed (Y/N)	Errors / Misinterpretations	Reaction (Fast / Slow)	Phone Checks	Comments
1. Start Route					
2. Known Route					
3. Unknown Route					
4. Dual Task					

Observation Checklist

- ☐ Recognized haptic cues correctly
- ☐ Responded promptly to cues
- ☐ Appeared confused or uncertain
- ☐ Needed verbal help
- ☐ Checked phone during navigation
- ☐ Seemed distracted during dual task
- ☐ Reported comfort with glove/bracelet

Overall Notes

Ease of use: _____

Main difficulties observed: _____

Body language / facial reactions: _____

Observer's general impression (1–5): ☐1 ☐2 ☐3 ☐4 ☐5

Post-Session User Feedback

Comfort level (1–5): ☐1 ☐2 ☐3 ☐4 ☐5

Confidence in cues (1–5): ☐1 ☐2 ☐3 ☐4 ☐5

Would you use this system again? ☐ Yes ☐ No

8. Post-Test Questionnaire

Post-Test Questionnaire – Glove Guide

Purpose:

To gather participant feedback on usability, satisfaction, and overall experience with the Glove Guide prototype.

Please rate the following statements from 1 (Strongly Disagree) to 5 (Strongly Agree):

1. The glove/bracelet was easy to understand and use.
2. I could navigate confidently without checking my phone.
3. I correctly interpreted the vibration cues.
4. The system did not distract me from walking or cycling.
5. The haptic feedback felt comfortable and natural.
6. I would consider using this system regularly for navigation.

Open-Ended Questions:

1. What did you like most about using the Glove Guide?
2. What did you find confusing, frustrating, or uncomfortable?
3. What features or improvements would you suggest?
4. Would you recommend this system to others? Why or why not?

Overall, the assembled test materials provide a coherent framework for evaluating the Glove Guide prototypes. They ensure that each participant receives consistent instructions and that observations are recorded systematically. By combining structured tasks, standardized

questionnaires, and open-ended feedback, the evaluation captures both measurable performance data and user perceptions, forming a solid foundation for analyzing usability outcomes in the following section.

Test Results

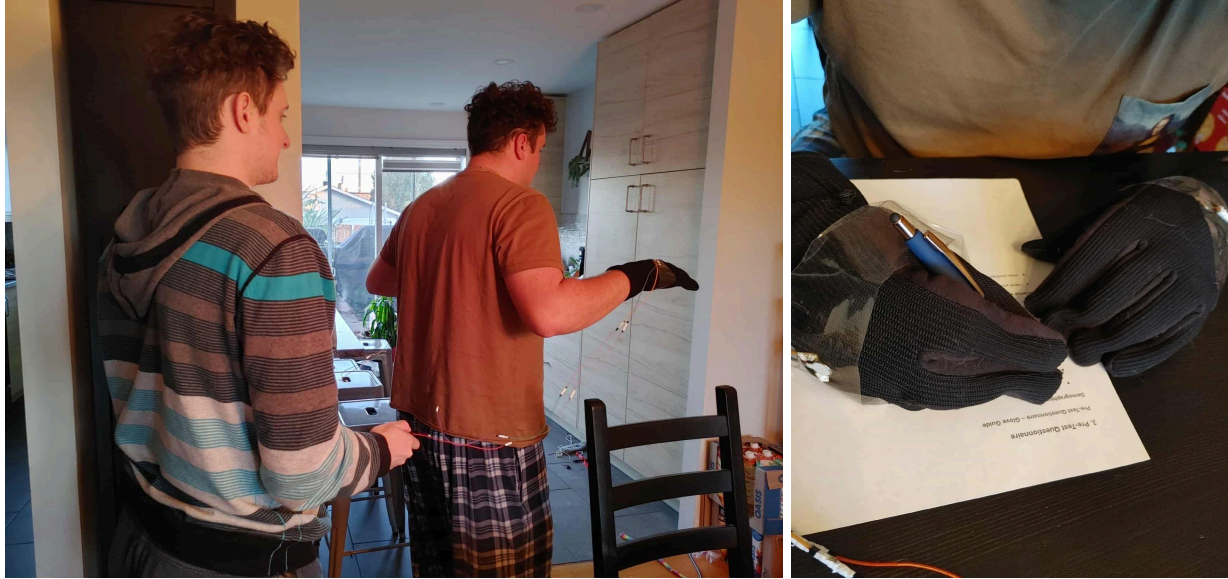
Overview

Two participants, both within the target user group (pedestrians familiar with navigation and wearable devices), completed usability testing for the Glove Guide system. Each participant performed all four benchmark tasks using both prototype variants — a glove and a bracelet form factor.

The test aimed to evaluate the usability goals: ease of understanding, accuracy of haptic interpretation, distraction minimization, and confidence in navigation.

The following pictures provide photographic documentation of key moments in the main test procedure, including the pre-test questionnaire, the usability testing process, and the post-test questionnaire with Participant 1 (P1).





Test Results Summary

Participant	Prototype	Task 1: Start Route	Task 2: Known Route	Task 3: Unknown Route	Task 4: Dual Task	Key Observations
P1 (Indoor)	Glove	Smooth start	1 missed cue	Accurate	Slight hesitation	Reliable vibration feedback; minor confusion at one turn.
	Bracelet	Smooth start	2 missed cues	Accurate	Needed reassurance	Feedback weaker, slight lag in perception during turns.
P2 (Outdoor)	Bracelet	Fast setup	1 missed cue	Accurate	No distraction	Vibration too subtle when arm moved freely.
	Glove	Fast setup	Accurate	Accurate	No distraction	Clear directional cues, confident navigation.

Post-Test Averages (1–5 Likert Scale)

Metric	Glove	Bracelet
Ease of use	4.5	4.0
Confidence without phone	5.0	4.5
Accuracy interpreting cues	4.5	3.5
Non-distracting operation	5.0	4.5
Overall satisfaction	4.5	4.0

Observer Notes Summary

- Both participants maintained natural walking behavior, rarely looked at their phones, and quickly adapted to the vibration cues.
- The glove prototype consistently produced clearer directional feedback and stronger vibrations.
- The bracelet prototype, while conceptually appealing for flexibility, occasionally produced weak or inconsistent feedback, especially when worn loosely or when the wrist moved dynamically.
- Both participants expressed that the system was intuitive, non-distracting, and promising for hands-free navigation.

Analysis

Overall, both prototypes met the primary usability goals, demonstrating effective and intuitive haptic-based navigation without requiring visual attention.

However, the glove prototype achieved more consistent performance across tasks and participants. A tentative explanation is that both prototypes use the same vibration components, yet the bracelet's looser fit and greater motion of the wrist may have dampened the perceived vibration strength. This difference suggests that physical fit and surface contact significantly influence haptic clarity, warranting further exploration in future iterations.

Both users provided positive feedback and indicated they would use the system regularly, particularly appreciating its simplicity and non-distracting nature.

Conclusion

The usability testing demonstrated that the Glove Guide system successfully supports calm, intuitive navigation through haptic feedback. Both prototypes enabled participants to navigate effectively without relying on visual cues, confirming that the core interaction concept is sound. However, the glove prototype consistently provided clearer and more reliable feedback than the bracelet, likely due to tighter skin contact and reduced motion at the hand compared to the wrist.

Future iterations could address this by introducing **adjustable straps**, **variable vibration intensity**, or **sensor calibration features** to ensure consistent feedback across different users and movement conditions. Overall, both participants expressed satisfaction and confidence using the system, indicating strong potential for further development and real-world application.