Final Design Proposal

Snow Removal

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ME 140 - Inventive Design

Introduction

The project addresses the significant challenges associated with snow removal, focusing on individuals who experience physical limitations or lack access to effective tools. Traditional snow removal methods often require considerable physical effort, are costly, or occupy substantial storage space.

The aim is to develop an accessible, compact, and user-friendly solution that meets the needs of diverse users in snow-prone regions.

Setting and Context

Snow accumulation is a recurring issue in areas like the Northeastern U.S., Canada, and parts of Europe. Many residents face difficulties clearing snow due to their age, physical condition, or financial constraints.

Socially, ensuring that snow removal tools are affordable and accessible to all, especially vulnerable populations, is an equity issue. Economically, many existing tools are cost-prohibitive, and ethically, design must be inclusive and environmentally responsible.

Sources of Understanding

Our understanding stems from user surveys and interviews. These data sources offered insights into user pain points, current market gaps, and potential solutions. Additional perspectives were gained through classroom discussions and course readings.

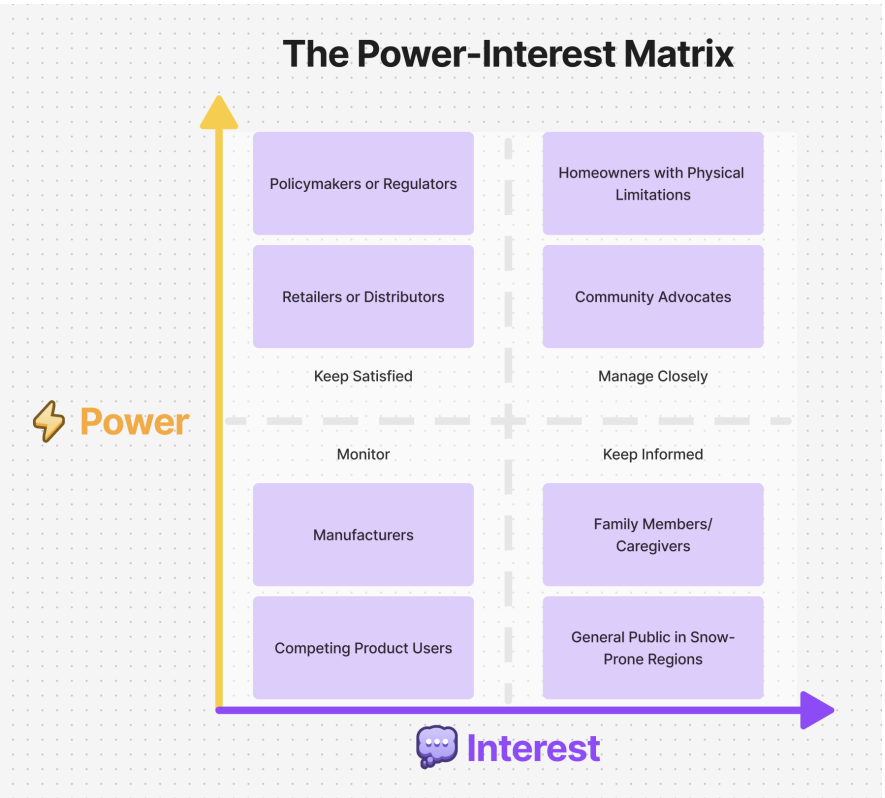
Stakeholders

Stakeholder Map:

- **Primary Users:** Individuals aged 40-80, particularly those with physical limitations such as arthritis or back issues.
- **Caregivers:** Family members or others who assist users with snow removal.
- **Community Organizations:** Advocates for accessible tools for elderly and disabled populations.
- **Manufacturers and Retailers:** Entities involved in the production and distribution of the tools.

Process for Stakeholder Understanding:

Stakeholders were identified through brainstorming sessions and interviews. Early assumptions evolved as new insights were gained, emphasizing the importance of inclusive design and sustainable materials.



Design Objectives & Priorities

Problem Definition:

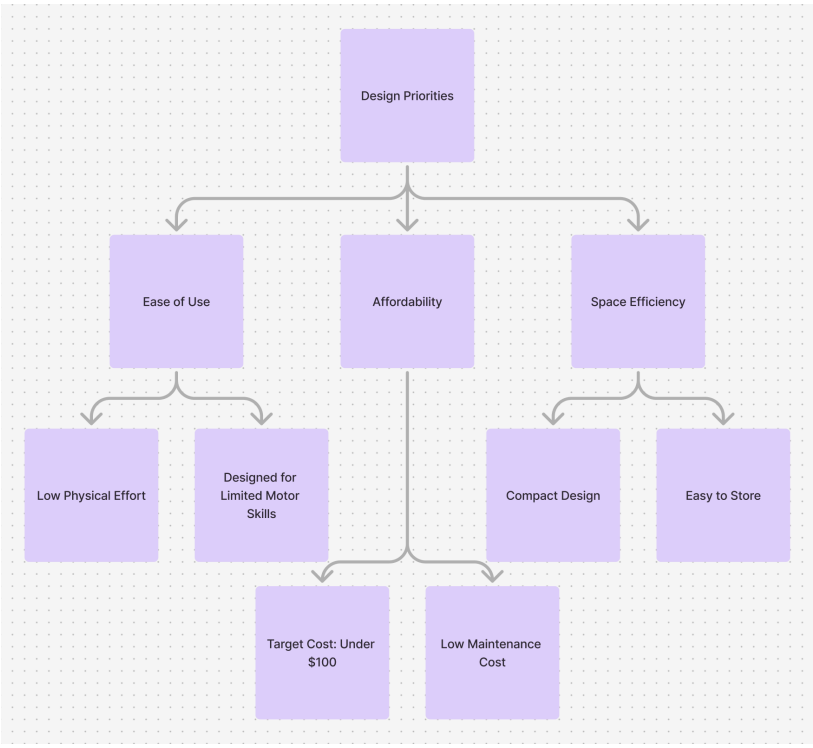
Clearing snow safely and efficiently is a challenge for users with physical or mobility limitations. Our design focuses on reducing manual effort, ensuring affordability, and optimizing for compact storage.

Initial Priorities:

1. **Ease of Use:** Ensure minimal physical effort is required.
2. **Affordability:** Keep the price under $100 with low maintenance costs.
3. **Space Efficiency:** Create a compact design suitable for small storage areas.

Evolved Priorities:

1. **Manual Operation:** Simplified design featuring a fulcrum and wheel system to ease physical strain.
2. **User-Focused Comfort:** Enhanced ergonomic handles for better grip and comfort.
3. **Versatility:** Adaptable to different snow conditions while remaining durable



Positionality Statement

Individual Positionality Statements:

Emma: Coming from a region with frequent snowfalls, Emma's personal experience with labor-intensive snow removal informed her understanding of user challenges. She has experience using gas-powered snow blowers and electric snow blowers as well as regular shovels. Her focus was on creating designs that reduce physical strain for users of all ages and abilities.

Ethan: With a background in mechanical engineering, Ethan brought a technical and manufacturing perspective to the team.

Tyler: Tyler's experience in mechanical engineering, specifically with mechanical design and modeling focused on the design of the final product. He focused on a modular design that is inexpensive, and compact, with the ability to be used by a variety of different users.

Will: Will's experience in user-centered design and accessibility helped him communicate with the team about the tripod to shovel connection and height variability. During the prototyping process, he learned new skills and perspectives on how to build a strong and accessible product.

Varun: Drawing from a design perspective, Varun prioritized ergonomic considerations and user-centric features. His background in user experience shaped the focus on comfort and ease of use.

Team Perspectives:

Our diverse backgrounds brought varied viewpoints to the project. Team members from snow-prone regions like Massachusetts, Connecticut, and New Jersey contributed practical insights. Exposure to community feedback refined our priorities, fostering a focus on inclusivity and practicality.

Evolution of Perspectives:

Initially prioritizing automation, feedback redirected the team's efforts toward simplified, manual designs that better address user trust and affordability concerns.

Team Thinking Overview

Strategies Employed: Our team employed the SCAMPER strategy to refine and clarify the design of the snow removal shovel. This approach allowed us to explore innovative ways to enhance functionality and usability while staying aligned with our design priorities.

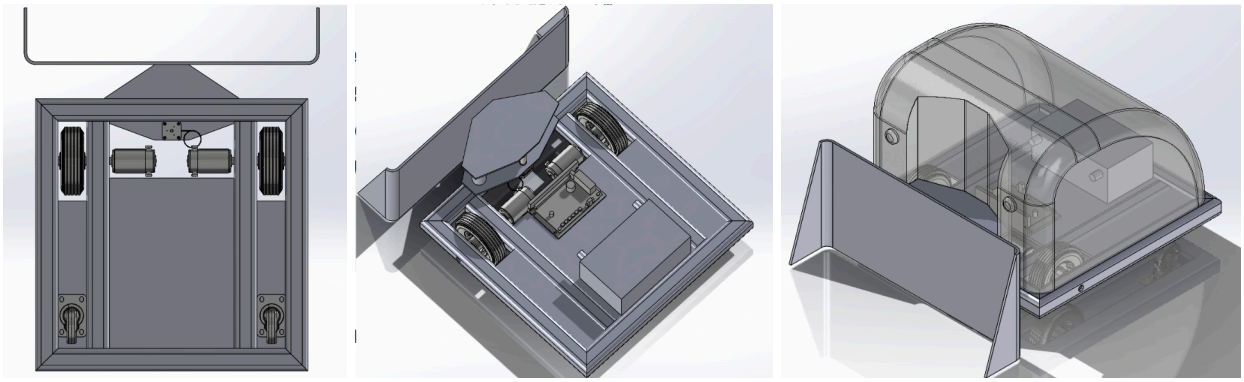
S	Substituted traditional lifting mechanisms with a fulcrum-based system to minimize physical strain.
C	Combined ergonomic handles and a wheel system to provide smooth maneuverability while maintaining the simplicity of a manual shovel.
A	Adapted the traditional shovel design by incorporating a fulcrum for a push-down motion, reducing the need for lifting snow.
M	Modified the shovel's handle design to enhance grip and comfort, ensuring usability for users with physical limitations.
P	Put wheels to another use, enabling users to push snow across larger areas more efficiently.
E	Eliminated reliance on automation and heavy components, making the product lightweight, affordable, and easy to use.
R	Replace the lifting motion of traditional shovels by introducing a downward push mechanism, leveraging gravity and reducing user effort.

Link to Priorities and Positionality: The SCAMPER strategy directly supported our design priorities by addressing ease of use, affordability, and compact storage. This systematic approach ensured that user needs, as reflected in our positionality and stakeholder insights, guided every stage of the design process.

Design Progression

Initial Concepts

The project began with brainstorming innovative snow-removal solutions such as automated or heated tools. However, these ideas were deprioritized due to their high costs, maintenance challenges, and reliance on external energy. The team shifted focus to developing a simple, user-friendly manual design, guided by the **Problem Definition framework** from the course. This framework emphasized designing solutions aligned with stakeholder needs while staying within practical constraints.



Feedback Integration

User interviews highlighted three critical priorities: simplicity, affordability, and physical accessibility. Elderly users and those with physical limitations emphasized the need for a tool that reduces physical strain without relying on energy sources. As one participant noted, *"I need*

something reliable that doesn't require charging or extra strength to use." This feedback directly shaped the shift toward a manual, ergonomic solution.

Development of the Final Design

Using Iterative Prototyping, the team refined their concepts to develop a fulcrum-based snow shovel.

- **Ergonomics**: Handles and hand grips were used to minimize wrist and back strain.
- **Fulcrum System**: A pivoting mechanism eliminates the lifting force, and replaces it with a pushing force, which is easier on the user.
- **Portability**: Compact dimensions, wheels, and lightweight materials ensure the tool is easy to store and transport.

Design Debates and Consensus

The team debated features like adjustable blade angles to enhance versatility. However, these were excluded to maintain simplicity and affordability. A Decision Matrix was used to evaluate user needs against feasibility, ensuring the final design met its primary objectives.

By integrating user feedback and prioritizing inclusivity, the final design successfully balances cost, efficiency, and ease of use.

Final Design Overview

Design Description

The final design is a fulcrum-based snow shovel tailored to reduce the physical effort required for snow removal. Its key components include:

1. **Ergonomic Handles:** Angled handles minimize wrist strain and back pressure.
2. **Fulcrum System:** A pivoting mechanism lowers the force needed to lift snow.
3. **Wheels:** Robust wheels enable smooth movement, reducing resistance while transporting snow.
4. **Shovel Blade:** A wide, durable blade scoops and moves significant amounts of snow efficiently.

Addressing Key Priorities

1. **Ease of Use**: The ergonomic design and fulcrum system reduce physical strain, particularly for elderly users and those with back pain.
2. **Affordability**: Cost-effective materials keep the design budget-friendly.
3. **Independence**: Manual operation ensures reliability in any conditions, free from energy dependencies.
4. **Portability**: Lightweight and compact, the shovel is easy to store without occupying excessive space.

Potential Shortcomings

The fulcrum mechanism may require some initial familiarization, and the tool may not perform as effectively on hard-packed snow or ice compared to automated systems.

Proposed Materials and Budget

- **Shovel Blade**: Aluminum (durable and lightweight)
- **Handles**: High-strength plastic with rubber grips for comfort
- **Fulcrum System**: Stainless steel for structural strength
- **Wheels**: Polyurethane with steel axles for durability

Approximate Dimensions

- Shovel Blade: 22 inches wide x 12 inches tall
- Total Height: 70 inches
- Wheel Diameter: 6 inches

Budget Estimate

- Materials: $50
- Assembly: $20
- Miscellaneous (testing and adjustments): $10

  Total: $80

Visual Model

The CAD model showcases the ergonomic handles, fulcrum mechanism, and wheel placement in a compact, user-friendly design. It represents a practical and inclusive solution, embodying the principles of human-centered design to address the needs of snow-prone communities.

Evaluation Strategy

Testing and Evaluation Efforts:

To assess the design solution, members of our group tested the ability of the final prototype to both pickup objects and lift a 9lb weight, simulating a big scoop of snow. We also evaluated the final cost and size of the prototype to evaluate how well they met our goals of developing a product with low cost and a small footprint.

Methods Employed:

- **Weight Test:** We placed a 9lb weight on the end of the shovel and tried raising and lowering the shovel. We were able to get qualitative feedback from this test as we were able to evaluate our own levels of comfort raising and lowering the weight with the shovel and we were able to determine which parts of our bodies we used to perform that action.

  We determined that the majority of the lifting action was performed with the arms rather than with the back. One of our group members, Varun Nair, said “I didn’t feel anything at all - there was no stress on my back.”

- **Snow Pickup Ability Test:** We placed pieces of balled paper on the ground by a way (the wall simulating a snowbank and the pieces of paper representing snow. We attempted to pick up the pieces of paper and move them to a different location.

  We were able to successfully pick up and move the paper.

- **Cost and Space:** We evaluated how well our final prototype did in minimizing its cost and the space it takes up. Overall we are pleased with the outcome of this first prototype as the total cost is estimated to be less than $100 and with its modular design, the snow removal device could easily fit in a closet.

Link to Priorities:

The evaluation methods directly addressed our design priorities by focusing on reducing strain on the user’s back, ease of use, and affordability. For example, testing the push-down motion ensured minimal physical effort, aligning with our goal of making the tool accessible to users with limited strength.

Limitations

Challenges Faced:

One of the key limitations in our design process was the absence of real-world testing under varying snow conditions. While simulated trials provided valuable insights, they could not replicate the unpredictability of actual snow removal tasks. Additionally, perspectives from people in our target user group were not incorporated due to time constraints, which might have provided further technical insights.

Unaddressed Goals:

The device is heavier than we initially anticipated due to the weight of the wheels that we chose for the device. While the large weight of the wheels ensures a steady platform on which to maneuver the shovel over snow, it also makes it difficult for someone to carry the device where it cannot be wheeled (i.e. on stairs).

Efforts to Address Limitations:

Despite our testing challenges, we feel that our user testing is extensive enough to prove proof of concept for the device. Future iterations will incorporate broader perspectives and enhanced real-world testing to address these gaps. We also would ideally either make custom wheels or find wheels that are both lightweight and able to maneuver over snowy conditions.




Feedback & Future Work

Key Feedback:

More extensive testing with the target user groups needs to be performed in order to get more optimized feedback. However, based on our limited testing, the key feedback that we got was that while the device was a little too heavy to carry by hand we were able to minimize back strain with the device which made users happy overall.

Future Work:

To address feedback, we plan to:

1. Test the design in real-world conditions to validate durability and functionality.
2. Explore a redesign of the wheels (the heaviest part of the device) that optimizes both sturdiness and a lightweight design.

Further testing would then need to be conducted in order to determine if that redesign had been successful.

Conclusion

Our final design addresses the challenges of snow removal for individuals with physical limitations by focusing on simplicity, affordability, and ease of use. By replacing traditional manual lifting mechanisms with a fulcrum and wheel system, the design effectively reduces physical strain and caters to a broad user base.

The iterative design process, driven by user feedback and practical testing, ensured that the solution remained aligned with user needs. While limitations such as the weight of the device remain, these areas present opportunities for future improvement. With additional testing and refinement, this design has the potential to provide a highly accessible and effective snow removal tool for diverse users.

Appendices

References:

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