StairWear Impressions:

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Initial Impression:

KS: This is a solid concept and well explained.

AS: This seems like a good idea and a valid problem to get excited about solving. It seems like a lot of good research has already been done on the subject so I may be restating some things but here are some thoughts I had:

AT: Very enthusiastic team and from a project structure and prototyping, and explanation point of view, I think you guys have an easy to follow well communicated, holistic project.

Comments in green are made by the StairWear team and show how we address the issues raised here.

Design/Look & Feel:

KS: Could use some development on material / color, etc - assuming these are not all bright orange - should have some consideration for the surrounding aesthetic, and therefore, probably variation in finish.

AS : I agree that high contrast is important to increasing safety for elderly eyes, but I would be careful about how “geriatric” and “old folks home” and “hospital” the final finish and colors end up looking.

Elderly people that are still living in their homes and are still active enough to handle stairs have a certain level of personal pride I wouldn't want to insult or infringe on. Are there ways to develop "lines" that have more architectural looks and feels and would fit into a home? An example would be a line that feels more "classic" and features some element of natural wood colors/tones as well as a higher contrast tread surface? Or a "contemporary" option with a white or a grey and a color? Based on what I've read about the project it seems like final finish and methods are TBD and aesthetics should be part of the equation.

I also think that durability and clean ability of these materials is going to be important. It's not going to be very cost effective if the tread surfaces wear down to slippery in a short time frame. Nor is it going to be appealing to have a design that gathers a lot of dirt and is difficult to clean off.

Document put together on best practices in interior design, grip design and how StairWear can incorporate and complement these.

User Interface:

AS: I like the idea of an app being the answer to ordering the components, but question how valid that is as a tool for the target demographic? My grandmother doesn't even own a cell phone, nor would she be able to enter information into an app. Is there a way to market this/spin this to family members of elderly people? Not to mention asking my grandma to accurately measure any staircase in her house would lead to a plethora of errors, and at this stage in her life she is living alone.

While elderly users are getting increasingly proficient at using internet technologies, we do plan to market this to the families/carers of elders, more so than the elders themselves. However, the website utilizes inclusive design principles, and so should be easy to use for anyone.

Install:

KS: You'll have to be particularly careful how these are attached to the existing stairs - and conditions both for wood and carpet. Also how the top tread attaches, so that it is not a tripping hazard at the top of the stairs.

AS: I do think offering a service for measuring/install would take away a lot of margin for error and remove some percentage of accidents caused by the product. This would be a challenging feature to implement, however.

AT: Stair are often the part of the house that moves the most. As the house expands and contracts with the season and changes to moisture in the air stair tend to creek and to get loose. Make sure your product can be secured very tightly. Currently stairs are nailed or better yet screwed through the top of

each tread. Hardwood stairs move the most, but any stair with wood parts will move by a few millimeter per step.

A combination of screws (which will be covered) and adhesive will be used to secure the product to stairs.

Legality:

KS: This would be worth a good look into codes. The International Building Code specifies a max 7" rise and min 11" run on all commercial stairs, with few exceptions. The Uniform Dwelling code specifies a max 8" rise and min 10" run for all single family residential dwellings. Many homes older than the 1970s have very steep stairs, including the majority of residences in the city of Milwaukee. While these existing stairs are largely exempted from the code, they aren't safe, especially for small children and the elderly. So, in a sense, your project has good merit, locally as well.

AS: You're going to want someone on the team of this project to get sharp on the building codes for the areas you are selling these in. This person should also have a good understanding of how these codes will be effecting the product. There is a standard minimum riser height if 4", but I know there are some funky tread width rules for curved and spiral staircases, etc. Working within these guidelines will not only be safer and make city officials happy, it will take away some grounds in the case of a lawsuit if an unfortunate accident of some sort happens and the victim is trying to blame the product. (they wouldn't have the easy "well it wasn't to code" card to play.

There is also a grading system for interior materials for how grippy/slippery a surface is. It might be worth looking into some other floor/stair tread materials and see which of these work really well already and how they do so? I imagine there's something to be learned from other's work and research in this area. Maybe there's a nosing piece already on the market that can be integrated somehow and increases durability over time.

You're also going to want to get serious about who's fault measuring errors are if customers are measuring for themselves? There are going to be a lot of older staircases that may not be level/square any longer and that may lead to some issues. Not to mention abnormal or strange staircases? Or if someone doesn't calculate for all the extra run they will need for the new stair slope and the final product doesn't fit. There are going to be people who just mess up measuring and parts get made incorrectly. This could become expensive/complicated if it is not clearly outlined.

The information I was giving doesn't really go into how these new stair pieces are anchored to the existing stair, but I think this is going to be the major safety issue. The last thing you want is for these pieces to be able to float away from the staircase and cause a fall, the very issue they are trying to solve.

Some sort of lawyer will need to help draft a contract to talk about liability, etc. I don't know much about this, but I wouldn't install any of these without getting a signature that offers you some sort of protection.

While many people we talked to believe that building codes should not interfere much with StairWear, we have put together a document outlining how this would work. As for the liability issue, we are discussing this with friends in Law, though we do not see how it should be any different to a failure in a different mobility aid, like a walking cane for example.

Logistics:

KS: In order to change the rise/run of the stairs, you would also need to modify the handrail to meet code (34-38" above the nosing of each riser, and must be consistent - must also extend 1'-0" past top and bottom risers)

AS: I do think logistics is where this project could get costly/complicated. I saw mentioned in the material that cnc is being considered as an option. This could get you a wider option of finishes (which I like) and just thinking about it for a few minutes I think this may be the easier way and cost less in materials and machining to fabricate (but an actual analysis of this may prove the opposite to be true).

It will require a lot of design time to custom fit and make each stair piece for a variety of staircases(see note above about not square and level). I'm guessing you've factored this in, but it is where a lot of cost will come in. Also, if you have to recut or print a bunch of times because people measure incorrectly that will add up as well.

The product will require a professional to carry out measurements of the customer's stairs, and each product will be customized to their exact needs and produced on demand. As for logistics, this is part of Michael's PhD research, and so we are confident in our plan (see attachment on logistics). While 3D printing/short batch production is likely best for Product 1 (Grip Strips) and Product 2 (StairWear Outdoor), we too believe that Product 3 (StairWear Indoor) would likely work best with CNC cutting. Material testing will be the first step following the challenge.

Other Thoughts:

AS : I've never really thought about it, but does the difference of going up stairs vs going down differ for elderly users? Are they more prone to vertigo or something going down? Which direction do most falls happen? Is there a way to factor any of this data in? Could the tread texture look or be colored one way

from the ascending direction and another from the descending? I'd also consider an angled riser, it helps with more "toe room" without adding as much overall length.

I do think illumination could be an interesting component. It helps in commercial spaces with step finding for the elderly in low light scenarios.

I know some elderly people prefer the look/softness of carpeted stairs. Is this a consideration at all? A softer edge would be better on an ascending fall if you fall forward into the stairs, but could be more logistically challenging.

This isn't part of the current scope, but eventually I think it could be a good idea to include some sort of base/housing to allow elderly people to add better/more railings to their stairs as part of this system. Especially as you are changing the slope with the new pieces the old railings may not be correct anymore. Maybe this could be as advanced as adding some sort of "rope" or "lead" they can hold that slides on a track as they traverse the stairs so they have a moving grab point to help keep them up. Or a bar that goes across the stairs and moves on a track to act similarly to the front of a walker or a barrier? (or maybe this is overkill?)

KS: My major hesitation is that this isn't a practical solution for every stair. In many cases, stairs have tall rises and shallow runs because of larger space limitations within the house. If the stairs are steep, the landing at the bottom of the stairs is likely to be very shallow - so there would be little room to alter the rise/run of the stair without having to move walls, etc.

KS: One other thought was that the idea is pretty solid just as building 3D printed applied stair surfaces, without needing to modify the stair rise/run. You could provide a product to retrofit existing wood or carpet stairs which can be slippery with socks or some shoes, by covering them with a PVC or other material that could be modified for great slip resistance - they could potentially also be easily removed / cleaned / replaced over time. These could be 3D printed, or more practically, CNC'd out of PVC, to be able to give the desired grip surface.

AT: When measuring each step it will be very important to measure all four sides of the step. As every step is custom cut and fit to each level since nothing in a home is every plum or square. Each step can be more or a rhombus or trapezoid shape. This makes each step cut a carpenter had to make when initially installing.

The need for careful measurement of the step became evident when building our final cardboard model. It would be interesting to test 3D scanning equipment and apps as, if done correctly, would ensure a perfect fit. As for CNC cutting PVC, this is definitely something that could be tested, particularly for StairWear Indoor.

Input from Building Permit Inspectors:

JP: **Tread depth and riser height requirements:**

R311.7.4 Stair treads and risers. Stair treads and risers shall meet the requirements of this section. For the purposes of this section all dimensions and dimensioned surfaces shall be exclusive of carpets, rugs or runners.

R311.7.4.1 Riser height. The maximum riser height shall be 8 inches (203 mm). The riser shall be measured vertically between leading edges of the adjacent treads. The greatest riser height within any flight of stairs shall not exceed the smallest by more than $^3/_8$ inch (9.5 mm).

R311.7.4.2 Tread depth. The minimum tread depth shall be 9 inches (229 mm). The tread depth shall be measured horizontally between the vertical planes of the foremost projection of adjacent treads and at a right angle to the tread's leading edge. The greatest tread depth within any flight of stairs shall not exceed the smallest by more than $^3/_8$ inch (9.5 mm). Consistently shaped winders at the walkline shall be allowed within the same flight of stairs as rectangular treads and do not have to be within $^3/_8$ inch (9.5 mm) of the rectangular tread depth.

The effect of the new stairs on handrail and guard heights:

R311.7.7 Handrails. Handrails shall be provided on at least one side of each continuous run of treads or flight with four or more risers. The continuous handrail required for winders shall be located on the side where the tread is narrower.

R311.7.7.1 Height. Handrail height, measured vertically from the sloped plane adjoining the tread nosing, or finish surface of ramp slope, shall be not less than 30 inches (762 mm) and not more than 38 inches (965 mm).

Profile and nosing requirements:

TABLE R301.5
MINIMUM UNIFORMLY DISTRIBUTED LIVE LOADS
(in pounds per square foot)

USE	LIVE LOAD
Attics without storage[b]	10
Attics with limited storage[b, g]	20
Attics served with fixed stairs	30
Balconies (exterior) and decks[e]	40
Fire escapes	40
Guardrails and handrails[d]	200[h]
Guardrail in-fill components[f]	50[h]
Passenger vehicle garages[a]	50[a]
Rooms other than sleeping room	40
Sleeping rooms	30
Stairs	40[c]

For SI: 1 pound per square foot = 0.0479 kPa, 1 square inch = 645 mm^2, 1 pound = 4.45 N.

a. Elevated garage floors shall be capable of supporting a 2,000-pound load applied over a 6-inch square-area anywhere when on the floor and shall be capable of supporting two 2000-pound loads each applied over 6-inch-square areas centered 5 feet apart perpendicular to the direction of vehicle entry and a second pair of 2000-pound loads 9 feet from and aligned with the first pair of 2000-pound loads. These loads shall be applied anywhere on the floor but need not be applied closer than 2 feet from the interior end wall nor closer than 1 foot from interior sidewalls.

b. No storage with roof not over 3 units in 12 units.

c. Individual stair treads shall be designed for the uniformly distributed live load or a 300-pound concentrated load acting over an area of 4 square inches, whichever produces the greater stresses.

d. A single concentrated load applied in any direction at any point along the top.

e. See Section R502.2.2 for decks attached to exterior walls.

f. Guard in-fill components (all those except the handrail), balusters and panel

Riser height and tread depth are considered in our document on Building Codes and we note where StairWear Indoor may be limited for some. As for handrails, this appears to be an issue primarily for StairWear Indoor, though it is already highly recommended that elderly users get new handrails installed. Perhaps new handrails or handrail attachments are even a future product for the StairWear brand.