Walk Over Me

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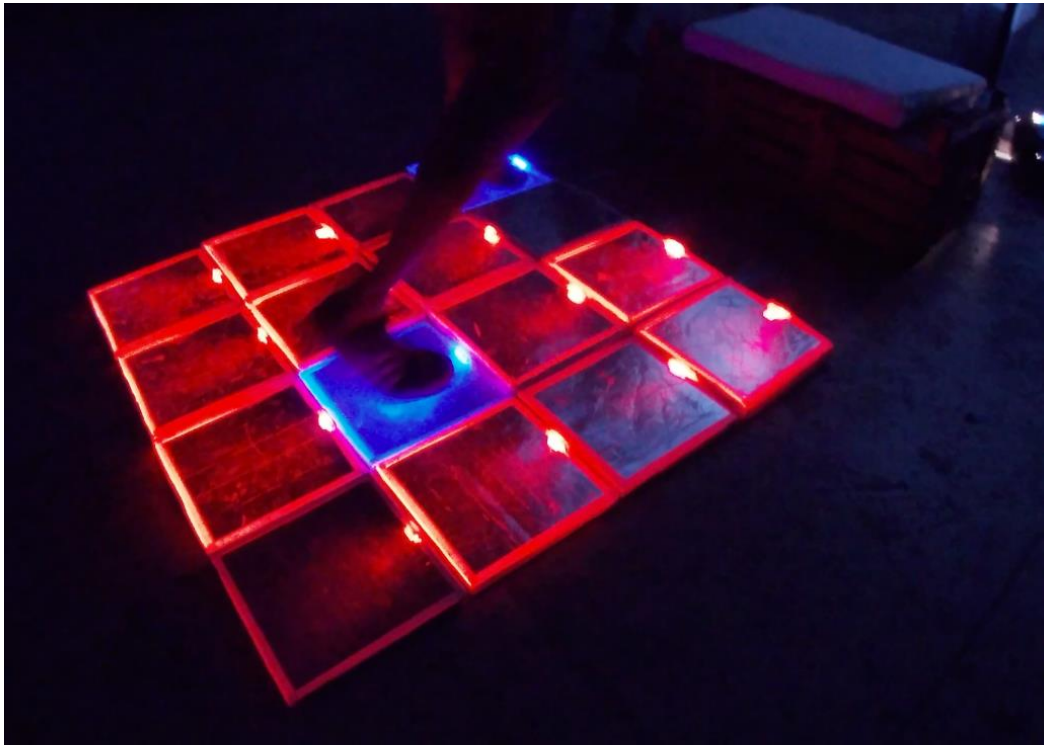

Abstract
Playgrounds are a source of great social value. In the winter months however, the darkness, low temperature, and slippery surfaces make playgrounds less appealing. Our team designed and created an artefact for playgrounds that maintain its appeal year round. Using several responsive pressure plates with interactive lights, we created a small board to encourage full body interaction and social engagement. Using an iterative design process we created an open ended design of the light board to enable children to create their own activities and games while playing. Our feedback so far has been overwhelmingly positive, and we believe further development and production of “Walk Over Me” would enhance playground utility, especially during the winter months.

Author Keywords
Playground; physical interaction; responsive lights; winter interaction; iterative design.

Introduction and Design Challenges
Winter in Sweden is tough; the days are short and dark, and the temperature hovers around zero degrees Celsius, often falling even below the freezing point.

During that time, playgrounds can become desolate. Occasionally, snow blankets the playground, but more frequently, the fluctuating near-zero temperatures cause the snow to oscillate between melting and freezing, thus covering much of the playground in cold and slippery ice. This presents a potential danger for children.

As interaction technologists, we made it our goal to find a way to make winter playgrounds more enticing for

Figure 1: Top: Rose structure at Ellen Keys Park, Östermalm, Stockholm, Sweden; Bottom: Swings at a playground, Södermalm, Stockholm, Sweden.

children even during the winter months. How can we enhance a playground to make it more appealing when the ground is covered in snow and those playing are covered in thick layers of clothing? Furthermore, is it possible to design such an interaction that also encourages social engagement with friends, families, or other members of the community? These are the questions that we aimed to answer in this product development project.

Initial Exploration

Playground Exploration

Since the project was carried out in early autumn when the weather was still warm and bright, creative use of our imaginations was crucial. For this, each designer visited a different playground in Stockholm, such as those in Humlegården, Södermalm, Ellen Keys Park, and also in the city of Uppsala. The visits were done after sunset to get a more accurate feeling of winter lighting settings.

Each playground had unique characteristics that were worthy of studying (see **Figure 1**). Main takeaways were as follows:

- Some playgrounds are badly lit and relatively dark.
- Contrastingly, playgrounds which did utilise light had a more powerful effect at night.
- Most playgrounds have basic playground equipment such as slides, swings, and climbing nets.
- However, most playgrounds do not have any roof-covered areas where children are protected from rain or snow.
- Children mostly play outside in the early evening (outside kindergarten recess).

Bodystorming at Turbo Sportzone

For a bodystorming [1] session, we went to an indoor playground called Turbo Sportzone in the town of Uppsala, Sweden. Turbo Sportzone has trampolines (see **Figure 2**), climbing walls, parkour, obstacle courses, and several other facilities on an indoor area of 4.400 square meters. It is divided into sections based on different activities and age groups. We hypothesised that this experience would give us ideas and insights into the type of play we want to offer children. In particular, we aimed to question employees about how children behave on the playground.

Upon questioning the owner, we learned that parents express a want for the kids to be active instead of remaining stationary before a screen; the owner added that this is especially difficult in winter.

Our main takeaways from this experience are as follows:

- Very few written rules; only on safety issues.
- The affordances are discovered by yourself.
- The affordances give the constraints to play, but you may come up with several different games within the constraints.
- Few games have digital interactivity, e.g. timing (start-button on one end, stop-button on the other end).

Initial Literature Research

In addition to the bodystorming session, we developed our design concept based on two papers which are presented in the following section.

Figure 2: Turbo Sportzone trampolines.

First, Sturm et al (2008) present in their paper, “Key Issues For The Successful Design Of An Intelligent, Interactive Playground” [2], five key dimensions of designing interactive installations for children:

- Social interaction
- Simplicity
- Challenge
- Goals
- Feedback

According to this paper, our interactive system should allow children to play with or against each other, be intuitive enough so that they can start playing immediately, and present an appropriate level of challenge to keep children entertained but not frustrated or bored. Furthermore, well-designed installations should provide goals or allow players to set their own goals. Finally, our system should give immediate, encouraging, and multisensory feedback.

We decided to incorporate these five principles into our design, which we describe in the following section. This paper also inspired us to design for open-ended play, to promote children creating their own games and goals.

The second paper, “Playware Technology for Physically Active Play” by Lund, Klitbo, & Jessen (2005) [3], inspired our concrete design idea. Lund created a reconfigurable playing field out of individual tiles which can be combined in different shapes to allow for different rule-based games (see **Figure 3**).

Figure 3: Children exploring the reconfigurable playing field.

Of all these principles, the most valuable for our purposes was that our playground installations should be flexible. By enabling children to play different games with the same construction avoids constraining them, and it is possible to avoid boredom and entice them to play for longer.

After pondering the results of our chosen related works, we concluded that our main challenge would be to create interesting play while using simple interactions. Additionally, our installation should be suitable for weather conditions in winter, encourage sustained play and be suitable for children of different ages and abilities.

Design Proposal

Our solution for these challenges is to create an interactive floor made up of individual pressure-sensitive light-up tiles. The intended interaction is to step on a tile and then have the tile light up some colour or switch to a new colour. For much of the design and development, we weighed two possibilities against each other:

- The colour changes when the tile is pressed down for a longer time span;
- The colour changes every time the tile is pressed.

The tile colours rotate through the three primary colours: red, green and blue (RGB). After stepping off the tile, the light slowly fades out. When comparing to the playing field created by Lund et al [3], the main difference between our project is the lack of any sort of rules. To support open ended play, we did not implement any rules.

Our vision included a grid of tiles four by four in size (16 total) to allow for several children to play simultaneously (see **Figure 4**). Each tile was designed with a dimension of 25x25 cm to fit most shoe sizes.

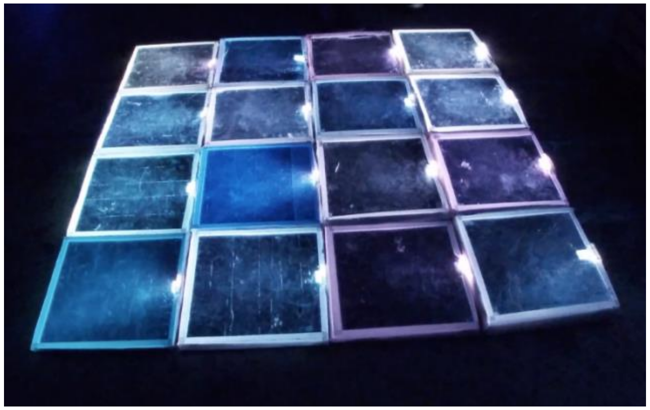

Figure 4: A grid of sixteen interactive tiles.

After receiving feedback from the testing sessions conducted with children, we decided to have the colours alternate for each activation of the tile. The alternative mode required more patience and individuals needed to wait for the colour change. Thus, children often didn't stay on a tile long enough to even notice that there were multiple colours. The most important aspect, we believe, is to maintain the idea that the tiles provide immediate, clear feedback through the changing colours.

The implemented system of open-ended design allows users to create their own rules and goals. The most

Figure 5: The bottom layer of the tiles is made of cardboard.

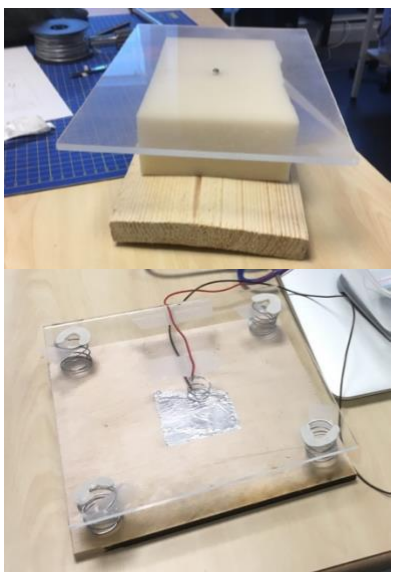

Figure 6: Two different tile prototypes from the user testing session with coursemates.

common example was the task of causing all tiles to light up in the same colour.

Iterative Prototyping and User Testing

Our implementation for the physical realisation of an interactive light-up floor is relatively simple (see **Figure 5** and **Figure 7**). No special sensors are used. The tiles themselves are, in essence, large buttons. When a tile is pressed, electrical wires separated by some amount of space connect. This completes the electrical circuit. Information about this press is sent to the microcontroller (Arduino UNO) that in response, powers a corresponding LED-light.

Throughout the design process, our prototype went through four different versions. We tested each version with users and adjusted the further development based on the feedback. In the following, we describe the changes to each version and our results from the user tests.

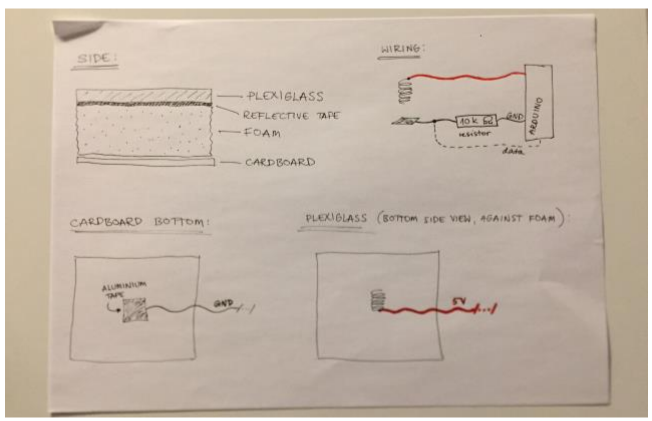

Figure 7: Physical design sketches.

First Prototype

For the initial prototype, two different tiles were made. The first had four springs separating the plexiglass top and wooden bottom at each corner (see **Figure 6** - bottom). The circuit was completed by pressing a fifth spring against a patch of aluminium tape. Springs gave this construction a lot of flexibility and made the build sturdy. If pressed hard, the springs would simply contract. Therefore, no additional blocking elements were needed to restrict the movement of the top plate.

The second tile had foam with a hole in the middle to separate the top and bottom layers, aluminium tape on the bottom, and a nail attached to the top panel of plexiglass (see **Figure 6** - top). This design incited concern because the nail would pop out of the plexiglass if the tile was pushed hard enough. Fortunately, however, the foam was thick and restricted movement enough to avoid this.

Testing with Coursemates

We tested the two designs in class by putting them both on the floor and inviting our coursemates to try them out. Our main take-aways were as follows:

- Most Classmates liked the open-ended design.
- The foam model felt more secure to press down. However, the spring model wiggled around when pressed down, which was fun for some users but frightening for others.
- When people failed to activate the light, they lost interest and moved on to another project.
- Having the tiles change between different colours would make the play more interesting and allow users to come up with more varied rules and games.
- Some thought that standing on the tile to change the colour was not very intuitive. They would have preferred pressing the button repeatedly to make the light burn longer.

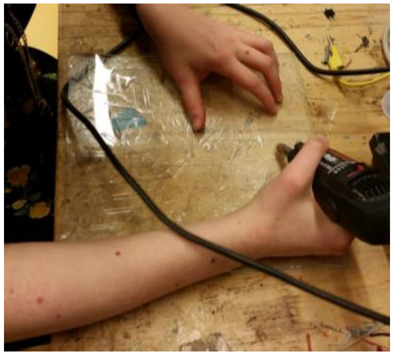

Figure 8: Dremeling the snowflake engravings by hand.

Second Prototype

Based on the feedback from the first test, we decided to combine both prototypes. As before, we cut a hole in the middle of each piece of foam. But instead of the nail, we used a spring to connect the top to the aluminium tape on the bottom. We soldered wire directly to the spring, which connected the springs to the power source.

For the second version of the prototype, we made 4 tiles with the above design and engraved snowflakes in the plexiglass (see **Figure 8**). The LEDs changed colour after standing on the tiles for 5 seconds. After leaving the tile, the LED faded out. If someone stepped on the tile before the LED had faded out completely, the light went back to full brightness.

Testing with Coursemates

As before, we tested the prototype in class. We placed our tiles in a 2x2 grid in a corner of the room (see **Figure 9**) and invited people to test them, without giving any information about the interaction design.

Figure 9: Setup for the user testing.

The main takeaways from this test were as follows:

- The engravings didn't add any major user benefit.
- It took a while before the peers discovered the additional colours.
- Adults are cautious and take more of an observer role than that of an actor. Our classmates seemed hesitant to fully commit to the interaction.

Third Prototype

We found during the previous user tests that the snowflake engravings did not add any major benefits and were very time-consuming, thus we decided to leave the plexiglass smooth. Furthermore, since one of the tiles broke during the user tests, we swapped all of the plexiglass pieces with new materials. Additionally, we cut the foam in half height-wise to facilitate easier interaction with the tiles in hopes that users would not need as much balance as before. As before, the LEDs were programmed to change colour when pressed for a prolonged amount of time.

Testing with Individual Children

This user test was carried out in MIDDLA and involved four tiles placed again in a 2x2 grid (see **Figure 11**). Participants were two children accompanied by their parents.

Immediately we saw a difference between adult testers and the children. While the older users were conscious of breaking our product, the children had no such consideration.

From this test we also realized that the tiles were not sensitive enough to be pressed comfortably by children. This lack of feedback that confused or frustrated the participant. This motivated our decision to increase the tile sensitivity for the next generation of tiles. Furthermore, we also hypothesised that this missed input was caused by the child pressing on the corner of a tile instead of the centre.

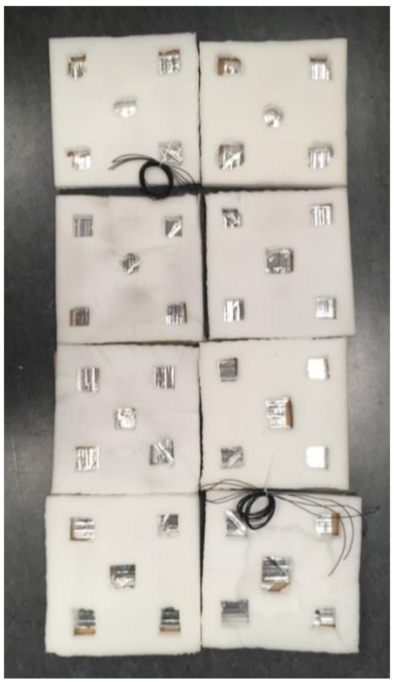

Figure 10: Layout of eight tiles.

Figure 11: User testing with individual children.

While the tiles were easier to balance on than the previous prototype, the children still had occasional difficulties balancing themselves on the tiles. However, the children did not see the uneven surfaces as a problem.

Unfortunately, the interaction with the tiles was not very intuitive, as the children did not figure it out on their own. The main problem was that the children did not remain stationary long enough for the colour to change. Child testers were unable to get all of the tiles to show the same colour.

With four tiles and only one player it was difficult for the child to invent a good game. They pointed out that they would like to play there with friends.

The main criticism towards the design was the anaesthetic look of the tiles. There were a lot of exposed wires and the tiles were not secured together well. This criticism was shared by one of the older test subjects.

The user test did not accurately reveal how multiple children would play with the tiles. We also acknowledge that the laboratory setting influenced how children behaved during play. They approached with caution and seemed hesitant to engage in actual play.

Fourth Prototype

Since children had difficulties to press the tiles down, we hypothesised that this missed input was caused by the child pressing on the corner of a tile instead of the centre. Therefore, we decided to cut four additional holes in the foam, one in each corner, and add four more springs. In this way, pressing down one corner would also complete the electrical circuit and activate the LEDs.

To accommodate the children's wish to play on the tiles with friends, we made four more tiles. We hypothesised that the total of eight tiles (see **Figure 10**) would allow several children to play simultaneously and encourage social interaction and various forms of gameplay.

Furthermore, we redesigned our interaction with the tiles. Previously, the LED colours changed upon a prolonged input. In the new version, the colours changed after each subsequent press. Since the former version was not intuitively understood by children, we hoped that the latter version would improve the interaction experience.

Testing with a Group of Children

Our next iteration of tiles, placed in a 2x4 grid, was tested on a larger group of children. The test participants were a group of 5th grade children studying design, and the test was conducted indoors.

We did A/B testing with the two different light activation modes as described above, switching the mode approximately in the middle of the test. Additionally, we hid the wires and the Arduino hidden, and had secured the tiles to the floor with tape. This was done to make the tiles look more inviting, and to avoid any inhibiting effects caused by the exposed wires.

The children started testing the tiles immediately, sometimes playing with eight children simultaneously (see **Figure 12**). At first, they stepped on each tile individually to test them out. In the first mode, they did not discover colours other than red until we prompted them to try to activate other colours. We found that the children preferred the second mode, during which colours changed after each press. This method was decidedly more intuitive. Additionally, we observed that the children were very eager to play with the tiles. We were forced to pause a few times to restart the Arduino. During these breaks, the children waited while holding one foot above the tile until they could play again.

Overall, our design seemed to afford a high play value as defined by Sallnäs Pysander, Back, Waern, & Paget (2020) as "a play environment that creates varied and evolving play that is sustained for longer periods, is recurring, socially dynamic and inclusive". We observed that while children would wander off occasionally, they repeatedly came back to play with our design. They played together or against each other, formed different teams, and switched seamlessly between different games and rules. Their play showed all the characteristics mentioned in the above definition, which was likely due to the open-ended design which affords many different potential opportunities and goals.

Figure 12: User testing with school children showed how well the open-ended approach worked.

We also observed a variety of play patterns, namely physical play, explorative play, social play and rule play. At first, the children were a little hesitant while figuring out how the interaction worked. After they discovered that the tiles lit up in different colours, they were very excited and stomped and jumped on the tiles. The children made up their own rules, for example trying to activate all tiles as fast as possible or dividing themselves into teams and trying to make all tiles light up in their team's colour (see **Figure 13**). Most of the time, between three and eight children were playing at the same time and interacting with each other.

The children showed great curiosity about future plans for the tiles. They asked questions about how the tiles were constructed, if we were planning to place them outside in the winter, and even gave suggestions for how to make them winter-proof. While they did not have any concrete wishes for improving the tiles, they expressed a wish to play games such as tic-tac-toe if there were a larger number of tiles, and asked us to incorporate music in the interaction.

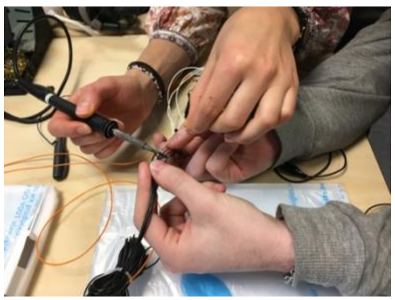

Figure 14: Soldering headers to wire endings for a modular easy-to-set-up design.

Figure 13: Children worked together and invented their own games.

We saw this user test as a validation of our concept design. Thus, we decided to keep the design for the final prototype, and to make eight more tiles to allow for a larger number of players. The results from the A/B-testing also led us to choose the second interaction mode, where the colours changed after each subsequent press. Our goal for the final prototype was to get the LEDs to work more reliably and to hopefully add a few animations to the lights.

Final Tile Design

The final design was inspired by a combination of the initial foam tile and the feedback received from various user testing sessions. The bottom layer consists of cardboard partially covered with aluminium tape which is connected to a ground wire; the middle layer is an approximately 1.5 cm thick foam piece with holes cut to accommodate the springs. The final layer comprises of a smooth 3 mm thick clear plexiglass. These three layers are secured together at the edges using duct tape (see **Figure 15** and **Figure 16**).

The underside of the plexiglass was covered with aluminium tape to embolden the effect of an LED light strip, who was fashioned with a 3D printed model to one side of each tile. The underside of the plexiglass also has five springs in an 'X' pattern connected to a 5V input. Springs in the corners are needed to ensure proper reading of inputs when stepping anywhere on the tile. This design causes a circuit to close when the tile is pressed.

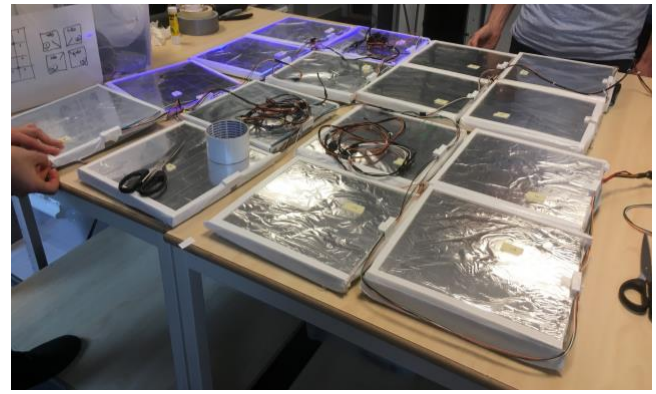

Figure 15: Final layout with sixteen tiles.

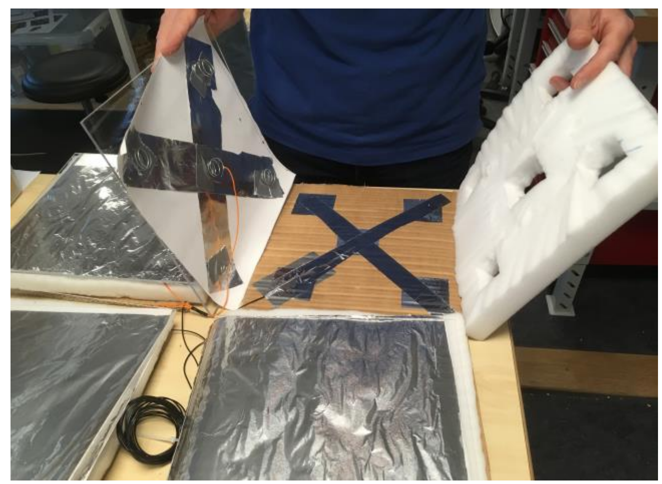

Figure 16: Tiles consisted of layers of cardboard, foam, conductive aluminium, and plexiglass.

The resulting tile feels soft and squishy under the feet but is sturdy enough to step and stomp on. Each tile is secured to the ground using duct tape to avoid slipping.

The tiles themselves are designed to be plug-and-play in batches of four tiles each (see **Figure 14**). This way the design can be scaled upwards indefinitely assuming enough power and a large enough microcontroller.

Final Programming Design
The final iterations of the tiles were designed to have simple and comprehensive interactions. While not in use, the tiles themselves would light up in a sequential pattern to create an idle animation. Upon receiving input, all other tiles would turn off leaving only the pressed tile alit. Holding down the tile for an extended period of time (3 seconds) would cause the colour to change between the three primary colours. Likewise, releasing and stepping on the same tile, or any other tile, would also elicit the same RGB colour change response. Immediately after input to a tile has ceased, the tile's respective brightness would decrement until the light had shut off. If no input from any tiles had been read for several seconds, the idle animation would begin once again.

Final Exhibition
Our final exhibition took place in Reaktorhallen, an old nuclear power plant turned design exhibition hall. We set up our tiles alongside projects from 8 other teams. Visitors of all different ages, including small children, came to test the projects, interacting with each project for as long as they wished.

Our project was very popular. People of all ages were consistently playing with it; children especially expressed aversion to leaving (see **Figure 17**). Some smaller children had trouble pressing down the tiles because they weighed too little and had to jump to activate the tiles or have their parent(s) press the tile for them. Despite this, those children came back repeatedly to play further. One unintentional aspect of our design was that the tiles were cushioned, and so if a child were to fall, that child would be unlikely to sustain any injury. This was a common positive feedback given to us by parents.

Figure 17: Children enjoying "Walk Over Me". Parents had difficulties getting their children off the floor to go check out other installations.

Compared to most other projects, our floor was quite high-fidelity. Several visitors, amongst them kindergarten teachers, saw "Walk Over Me" as the only project which could be immediately installed on a playground. While we had a small bug with one tile which made the entire floor flash white and then crash, we treated this glitch as a reward animation by restarting the floor with a short delay. Thus, it did not impact visitor's interactions and enjoyment negatively. Interestingly enough, discovering the 'secret' to make the floor turn white created an engaging challenge for older users.

Discussion and Reflections

At the beginning of this project, we aimed to create a playground installation which could make playing outside during cold winters more enjoyable while also encouraging social interaction between the players.

So far, we have only tested "Walk Over Me" indoors at room temperature, both in daylight and in darkened rooms. Our observations of people playing with our design show that:

- "Walk Over Me" appeals to all ages. From toddlers to retired people, they play on the tiles for a sustained amount of time and come back repeatedly. Thus, it seems that our design succeeded in encouraging sustained play and maintaining players' interest and fun.
- "Walk Over Me" supports both individual play and interactions with others. Both children and adults invented different goals and games, playing with or against each other.
- By lighting up in different colours, the tiles gives immediate feedback if players have succeeded or not. In particular, perceived reward animations were seen as very exciting and enticed players to keep playing.

Challenging weather conditions make it difficult to realise our project in an outdoor setting. This is mostly a technical challenge, however, people would still come and play despite any cold and/or dark. While the tiles have an even greater effect in the dark, they would need to be made weather-proof. In particular, ice and rain could make them slippery and thus too dangerous to play on. Furthermore, the tiles themselves have sharp corners that may protrude dangerously if the tiles over time became uneven. If placed outdoors, the tiles should be covered by a roof to protect them from rain- and snowfall. Additionally, the cover could be made of a material that doesn't freeze easily, such as rubber.

Future Steps

Our final prototype had a size of 4x4 tiles, which allowed up to 4 adults or 8 children to comfortably play at the same time (see **Figure 18**). For future developments, we would like to make the floor even bigger, possibly covering the floor of an entire room. To accommodate such a large number of LEDs, we would need a stronger power source and cables to avoid power issues and interference.

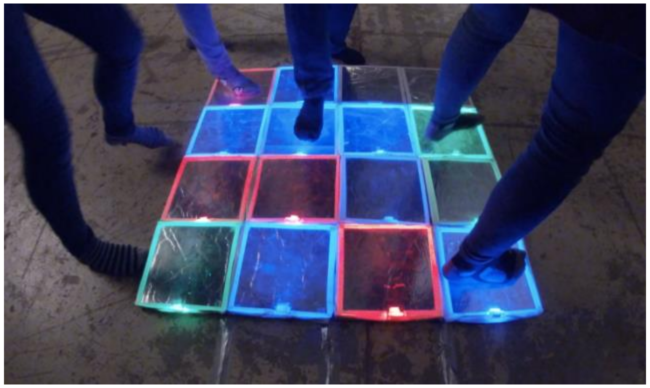

Figure 18: "Walk Over Me" is big enough for four adults to play on it simultaneously.

One possibility to enrich the interaction would be to allow users to switch between different modes, for example between open play and various rule-based games. There could be single-player games, such as whack-a-mole, tic-tac-toe, or any other game, such as two teams playing against each other to activate as many tiles as possible in their team's colour.

Another option would be to add music, by, for example, making each tile play a different melody as proposed by children in our last user test. This would incorporate yet another modality in our installation, allowing users to come up with audio-based games as well as visual games.

Conclusions

Through incorporating social interaction, simplicity, challenge, goals, and feedback as design principles into our product, we have created an environment that encourages multiple users to create their own play.

By iteratively testing the ideas, mock-ups, prototypes and final design, on different user groups, the design has evolved into an effective tool for promoting social play.

We conclude that the most powerful tool for creating play is to nurture the users' imagination. While originally, our product was designed to structure play by following specific rules or procedures, developers noticed that testers had a more enjoyable experience simply stomping on the tiles. Once we allowed for an easier method to swap colours, feedback from the testers became much more positive. For future projects, one should keep this lesson in mind; whatever function the product has, make that function simple to achieve.

Acknowledgements

We thank all the children, classmates and other testers who participated in one of our testing sessions and gave us helpful information and comments that we were able to use to improve our design. We also appreciate the indispensable guidance and support of our professor Ylva Fernaeus who provided us with knowledge and directions that helped guide our design process.

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