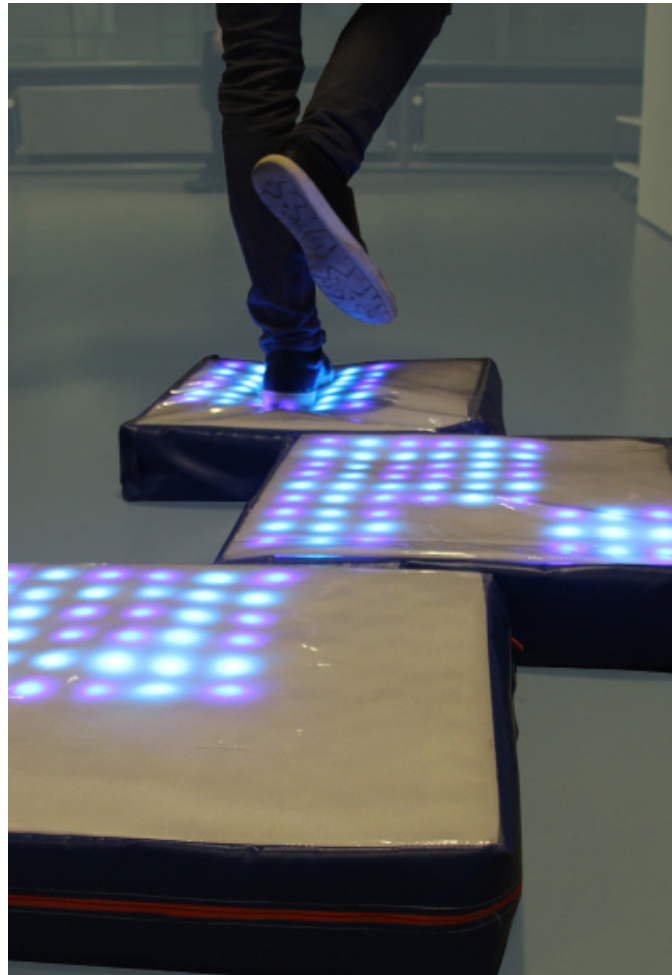# VersaTiles

Abstract

Nowadays it is hard to live without modern technologies. Everything is changing rapidly and new solutions are being invented on a daily basis. Unfortunately, there has not been much innovation in the educational systems; especially concerning Physical Education. The goal of this project is to design a fun and interactive product that allows for easy implementation in High School PE classes. VersaTiles are the result: small interactive mats that can communicate with other mats wirelessly. Together, they can form a regular mat, making possible bridge the gap between old and new teaching methods.

Authors Keywords

play, platform, physical education, interactive, high school, design.

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Video QR Code

Problem Statement

In today's society it is hard to live without modern technologies. Everything is changing rapidly and new solutions are being invented on a daily basis. Unfortunately, there has not been much innovation in the educational systems; especially Physical Education, henceforth called PE, did not change much over the past decades. This is a shame as the children of today will be the future of our society. Why not start teaching them all the 21st century skills that they need to obtain, in order to contribute to society, whilst they are still in schools [1]? One of the problems might be that schools have limited budgets, which makes it hard to adapt new technologies in a fast changing world. But these technologies can help to adapt the difficulty to the performance of students, which has been argued to be effective when it comes to learning in serious games [2]. Secondly, these technologies might level the playing field, giving less sporty students the chance to be included in the team and challenges during the lessons. They can help students to enjoy physical activity more, which influences their view on a healthy lifestyle. Technologies can help teachers to find more effective ways to teach and can help students to find more effective ways to learn [3]. Besides this, proper PE minimizes the skipping of classes and has a positive effect on study results [4] so innovation in physical education can help with other subjects as well. For these reasons, a decision was made to focus on the development of a product for the PE context that would solve most of the above stated problems and help the students and teachers of today.

Additional Research

A vital part of this project is the gym class curriculum and the core goals [5] that each school has to fulfill according to government regulation, which are:

- The student learns how to orient himself in different movement activities such as games, athletics, self-defense, gymnastics, movement on music and actual developments in the culture of moving. The student is to explore their own possibilities within these areas.
- The student learns how to broaden their movement repertoire by being confronted with challenging movement situations.
- The student learns the basics of applying movement activities at their own level.
- The student learns sportsmanlike behavior, learns to take the preference possibilities of others into account and learns to show respect and care for others.
- The student learns how to perform coordinating tasks that will allow individual and cooperative movement activities to be performed with others.
- The student learns about (and experiences) the value of health and wellbeing through practical movement activities.

To get a better understanding of what PE teachers do now, and how a class could be improved interviews were conducted [Appendix A] They answered that they did many games in class to support skills such as teamwork, and that they decided on the teams to make play fair, to not exclude less sporty students. One technology that is seen as valuable is video feedback with the use of an iPad. This feedback shows students the correct way to perform an exercise and helps the teacher to evaluate it. "We're connecting to the tools that students are already using in real life" – states Heather Gardner, Ophea's Curriculum Consultant. [3]

The reason that they did not use much technology yet (e.g. SmartGoals), mostly comes down to the price, in combination with the limited implementation possibilities provided. Versatility, easy placement and user friendliness is needed, but most certainly it must add to the PE class.

There are little specialized interactive tools for PE classes and the need for them is growing. Nevertheless, there is innovation around devices to help adults stay fit. For example, Tera, by Lunar Design [6], is a high-tech yoga mat for home fitness that detects movements and guides the user through different exer-

Sensigom has developed an interactive playground called Multigame that encourages physical exercise with fun multisensory games for all ages.[7]
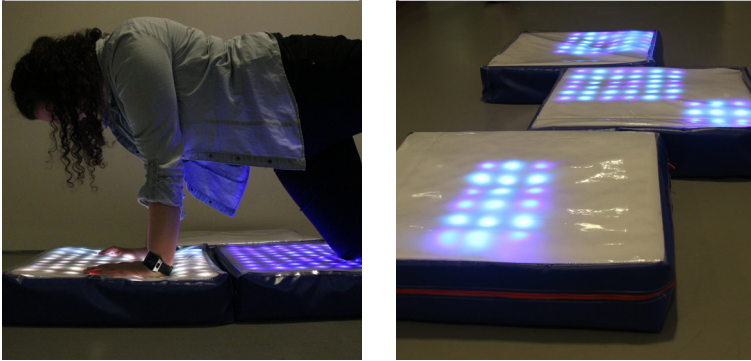Some of these products inspired the creation of VersaTiles.

Manifesto

We believe in promoting a positive image of physical exercise from a young age, which will teach teenagers their body affordances and contributes to healthy lifestyles during adulthood. Additionally, in our view, collaboration and coaching can be stimulated by sports helping students to develop their team building and social skills. Lastly our goal is to provide the current generation of PE teachers with an introduction to new technologies more suitable for this generation of students. We want to design fun, interactive products that allow for easy implementation in today's gym classes as well as provide adaptability to different exercises within the PE curriculum.

Design Guidelines

Our manifesto and the insights gained from the research led to the following list of design guidelines:
- Stimulate sportsman like behavior
- Bring variation in movement
- Be versatile
- Be fun
- Actively involve everyone
- Be challenging for each individual
- Afford students to learn about their own body affordances
- Afford playing high intensity sports
- Low effort in setting up and explaining

Mode one
Depending on how much area is pressed the color of the tile changes. This mode opens opportunities in open ended play.
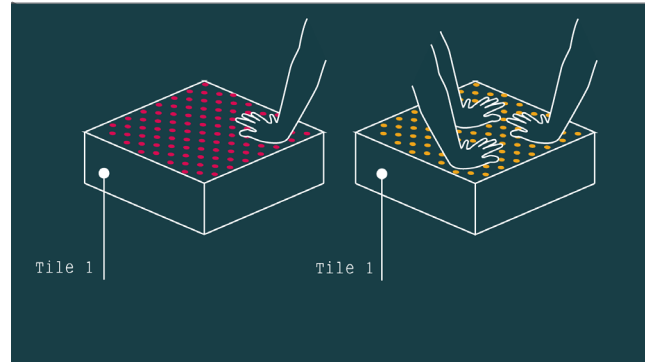

The Concept

VersaTiles are interactive mats created to be used during PE classes in High School, supporting learning that fits the students. The mats are 500mm by 500mm; six VersaTiles combined together can replace a regular mat in size and purpose. This makes it possible to use the product for teaching in a way that the teacher is used to as well as new ways of training that fit within the society of today. Each tile has nine pressure sensors, 81 LED lights, an Arduino (micro-controller) and a radio frequency transmitter, making it possible for a tile to be in different game modes and communicate wireless to another tile. A large battery is added to each tile to sustain usage throughout a full day of classes. With its LED lights and changeable modes VersaTiles brings innovation and variation into the class in a recognizable form. A form that is more fitting to the current generation of 'Homo Zappiens' [8]. The lights can also work as a persuasive element to draw students in.

Mode two
By adding pressure to a spot in one tile, another tile lights up in this spot.
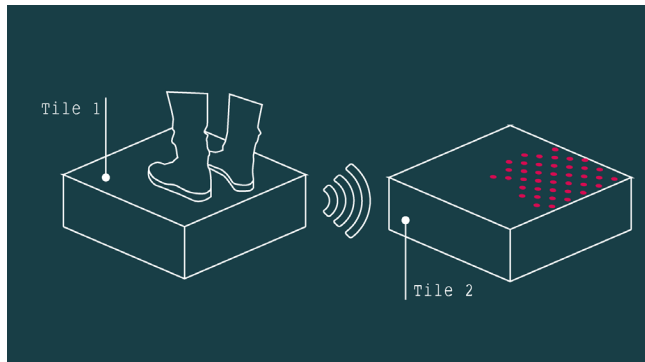

"The best thing about VersaTiles is the multifunctionality (...) this way you can keep the class interesting, because it is renewing for the children." "Yes, yes, and the lights."
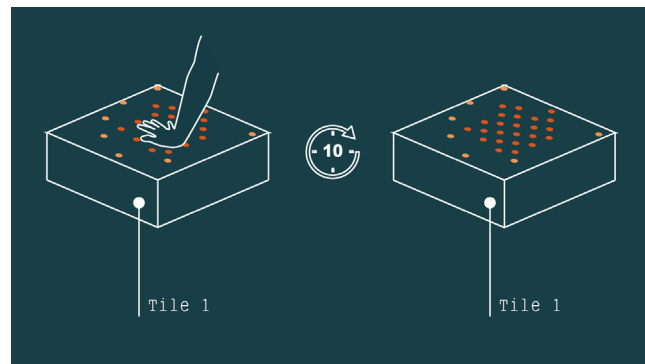- Fontys Sport Students

Mode three
Once a spot on the mat is pressed, the lights stay on for a few seconds creating a trace.

The modes are designed to be as adaptable as possible, offering a platform for teachers to come up with games themselves. Teachers have the habit of coming up with their own games for class and use different fora and channels to share their games. [9,10,11] Bringing out specific games with the tiles would limit their creative thinking about games and might restrict the versatility of the product. This is necessary to create improved employability for the tiles, making VersaTiles a good choice when spending money on renewing gym materials. [For the VersaTiles Code, see supplementary booklet]
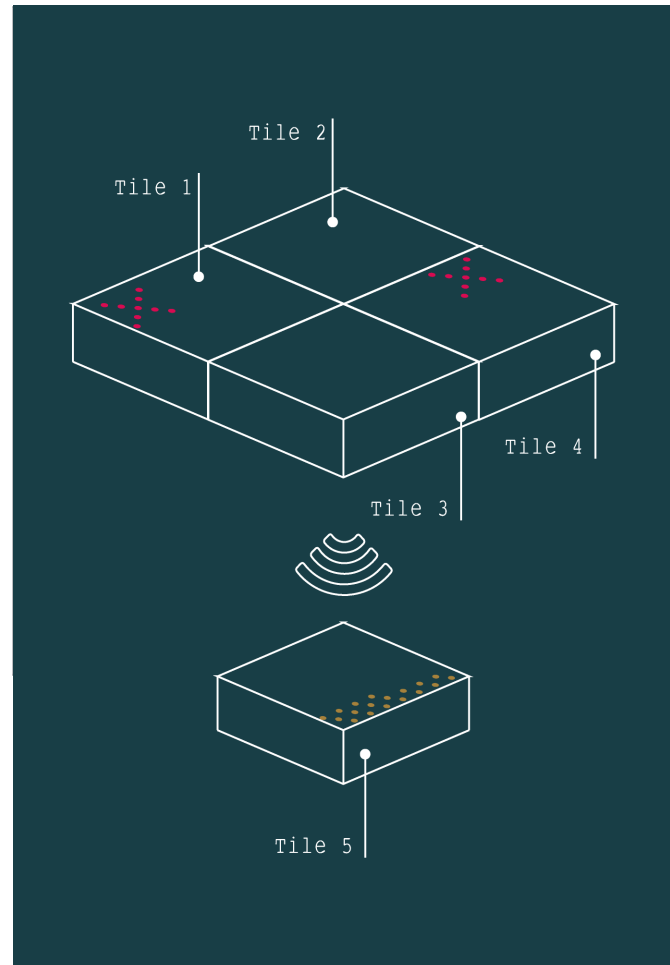

Mode four
VersaTiles randomly lights up small areas. By pressing them, point are scored and shown in another tile (in the illustration, that is Tile 5).
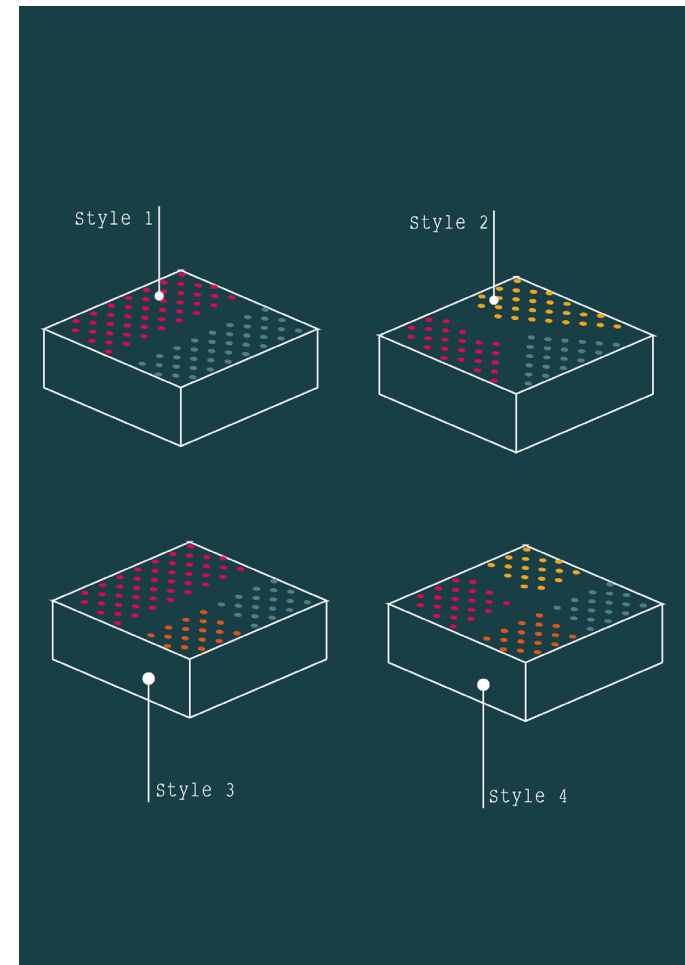
Mode five
Four styles of lighting up the mat are possible. Each one creates a different space division. At first, each tile randomly picks one style. After that, colors change every 5 minutes. The colors always change in the same order affording a teacher or students to divide the class in zones that for example change rules.
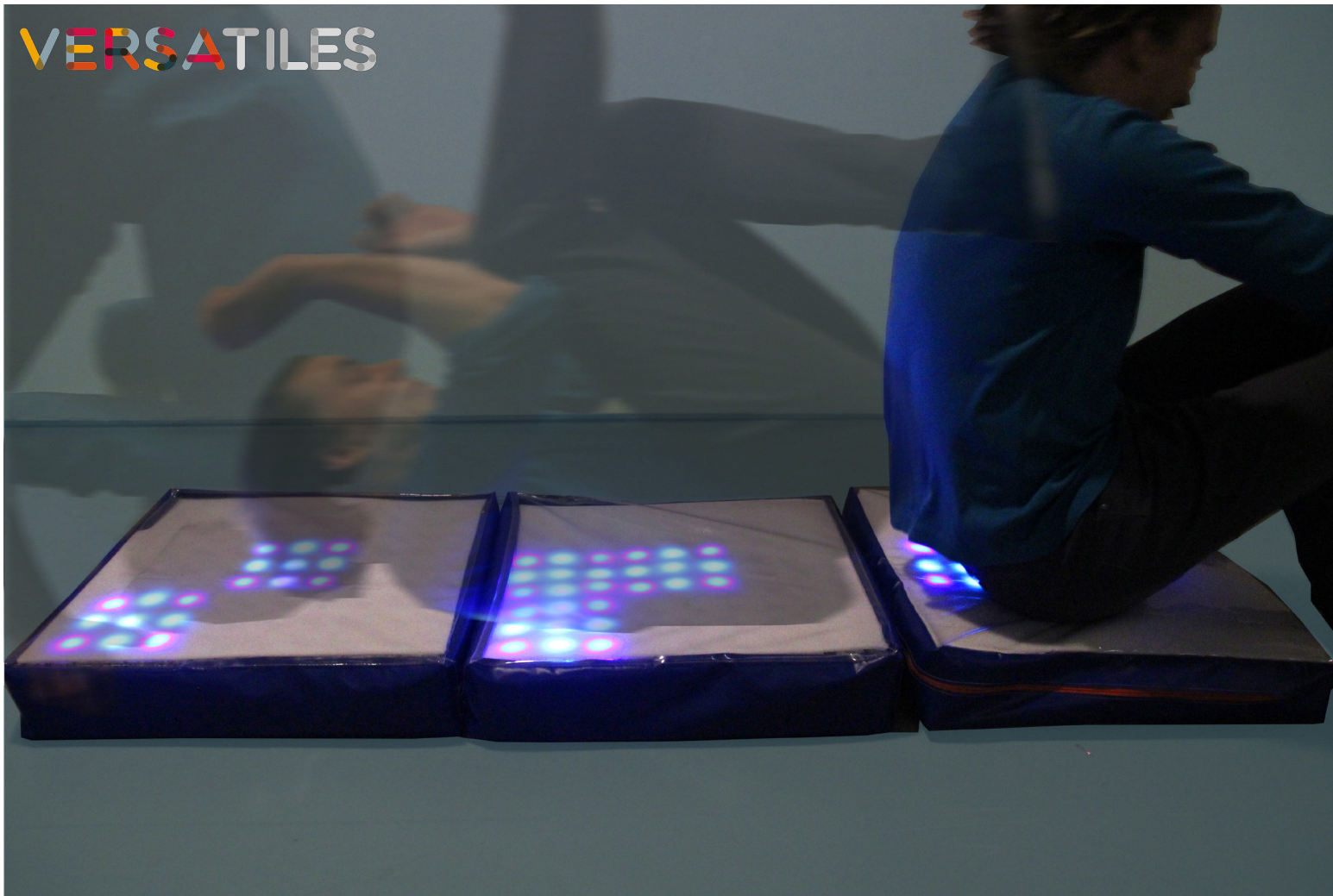
*"It is fantastic, and that is not something I say very quickly"*
- Willem Bouwman,
Managing director Janssen Fritsen Netherlands

The versatility in the modes brings the option for different kinds of play and games. This can be seen when looking at VersaTiles with the 'Lenses of Play' cards [12]. VersaTiles can be used for open ended play, where students can come up with their own rules stimulating skills such as collaboration and coaching. Although the form of play (physical play) is clear, it can still be combined with another form of play such as games with rules. The versatility can also be found in the playful experience opportunities (such as competition, challenge, exploration and expression) [13], which vary in each mode.

Although the mechanics of the tile are the same (pressure sensors, lights, communication) the dynamics vary in the modes, leading to different possible aesthetics depending on the game that a teacher decides to play. Challenge and sensation are aesthetics that can arise when using the mats in modes that fit training. Using them for open-ended play can also lead to expression and discovery and with help of a creative teacher the VersaTiles could even become part of a fantasy or narrative play. [14]
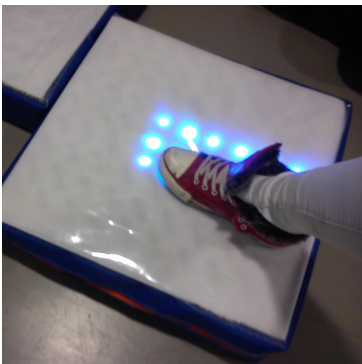
A mode can be unpredictable and challenging, training 21th century skills such as dividing attention and choosing the right focus falling under problem solving abilities, teamwork and communication[15]. Also, a mode can be used to show guidelines or feedback about the body positioning on the tile (e.g. where to push off the ground to gain momentum while using the rings during gymnastics). Lastly the mats can be used as traditional mats by not turning on the lights.

VersaTiles can challenge students or help them (e.g. mode two), this levels the playing field. It creates a magic circle where students are free to experiment without being judged by their peers[16]. Students can 'blame a mistake' on the mats (e.g. not hitting a moving cross of lights). This can increase team feeling of the whole class as they are competing with the mats rather than with each other. In this way there is challenge for students that perform very well in PE classes but there is also social play. This combination of social and challenging play makes physical exercise more enjoyable for everyone as the needs of more different player types are sustained. Also the exploring player type needs can be satisfied as different modes offer different dynamics and game possibilities, these possibilities can be explored.[17]

"I mostly liked the mode with the scoreboard (mode two). Because you can add a competitive element to games. And I think that for students that are different levels, it is as difficult. So there is more equality in games."
    - Daniëlle Dekkers, Fontys Sporthogeschool student

Depending on the chosen mode a teacher can use the set of six mats for the whole class or divide the class in smaller groups to practice with the mats. The division of the class in smaller groups all doing something different is an approach that is often chosen these days.[18]
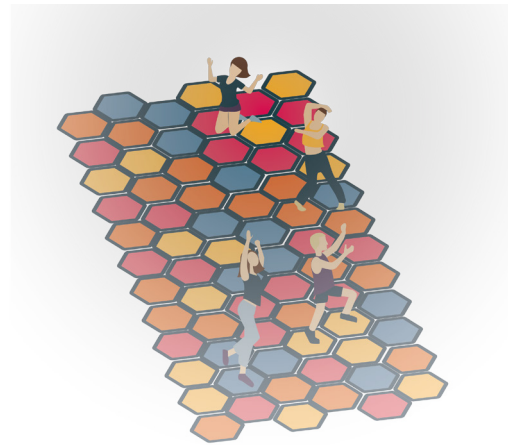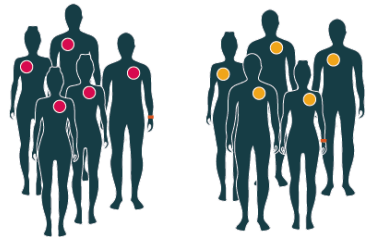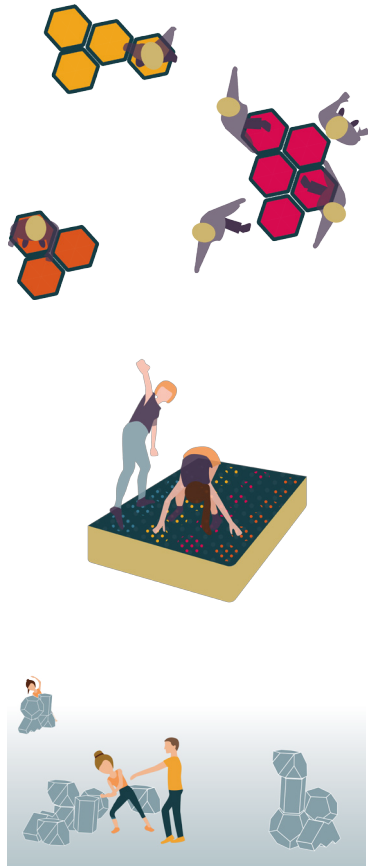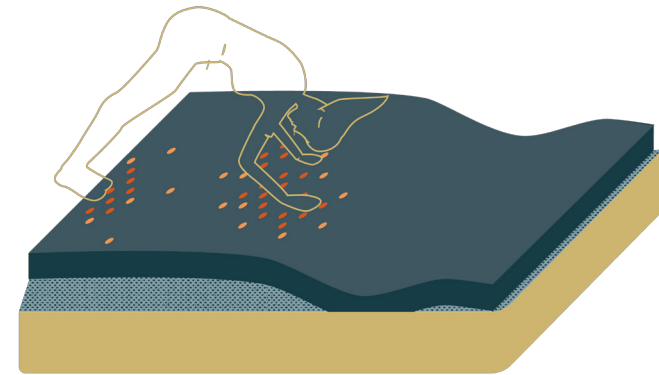
Development of the Concept

The design guidelines led to the development of multiple concepts for the midterm. This was done through an iterative brainstorm session where designs were validated based on the guidelines. Four concepts were chosen and further developed.

Versa(top left, top middle) consists of multiple hexagonally shaped tiles with a diameter of 600 mm containing LEDs and pressure sensors that can be placed on the floor during PE classes. Versa can be used during indoor sports to add an extra element of play into existing sports. The main focus of Versa is to be challenging for all players, be multifunctional and to allow for the inclusion of everyone by using different game modes and scenarios during PE classes.

Moving Matt(upper left, top right) is a large interactive gymnastics installation. Its main focus is to teach chil-

dren more about their own body affordances and offers variation in movement. Moving Matt is a large mat with a shape-changing surface, which includes pressure sensors and lights. The mat can help or challenge students depending on their level of skill, making sports equally challenging for all students.

You Block(lower left) is a series of interactive building blocks that stimulate teamwork and cooperation and afford various games. You block can be used by students to gain more insight in building, strategy and spatial vision.

Tagtical Play(bottom left) is a set of interactive wearable badges. Each badge contains a sensor and lights that will allow it to switch color once it is tagged. Tagtical Play eliminates the feeling of premade teams while keeping sports games dynamic and fun. By being able to swap color and thus teams, a new level of strategy can be added to the existing sports games practiced during PE.
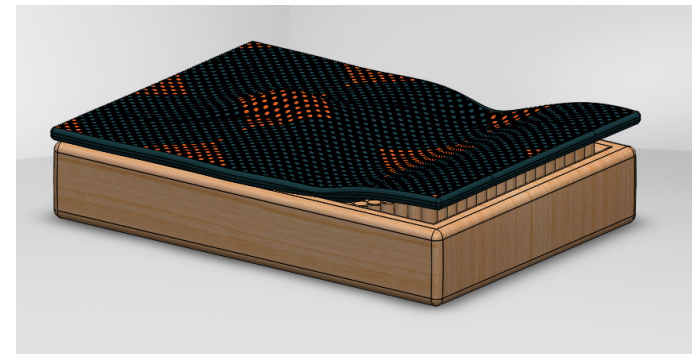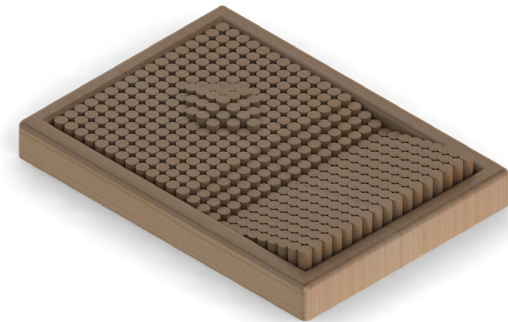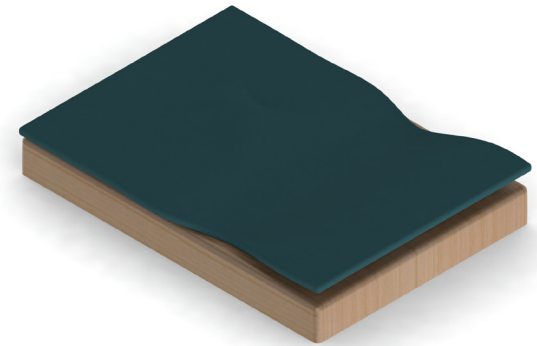
During the midterm these concepts were explained with 3D models and scenarios to experts within the department of Industrial Design and Janssen Fritsen. Janssen Fritsen is a company with experience in the fabrication of and development of PE equipment and is the main supplier of PE equipment in the Benelux. Both, the University and Janssen Fritsen experts cautioned the use of wearables and blocks and mentioned the importance of the PE learning goals and how they did not see a connection with these concepts.
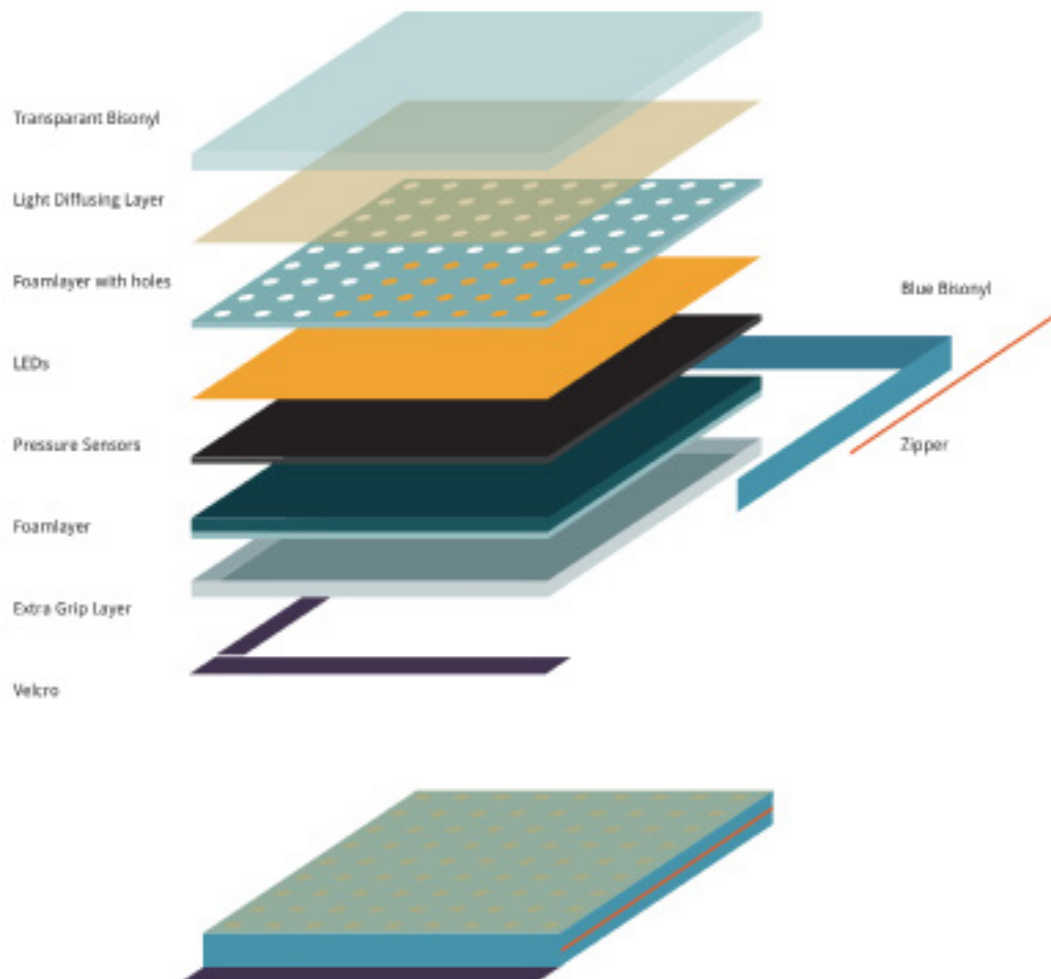
Regarding the Versa and Moving Matt concepts, it was mentioned that the technical feasibility might be a problem. Moving Matt was considered to be too big and the required materials would make it difficult for teachers and students to place the equipment. Versa on the other hand was considered to be too broad, it tried to achieve many things but none of them were specifically designed for a PE class scenario. It was advised to keep things simple, in terms of setup and interaction which is in line with
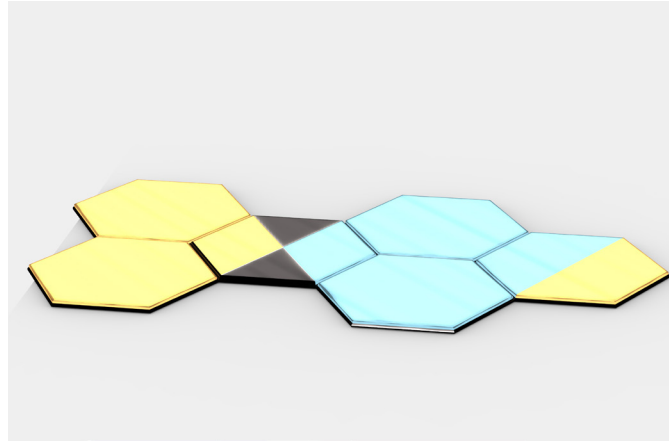
the design guideline. A good start would be to come up with scenarios that are helpful for teacher and students and to specify on how a product could help them with existing exercises.

In addition to this feedback the expert from Janssen Fritsen mentioned that pushing innovation on the market is difficult. When equipment breaks down, schools want to replace that equipment, but due to the limited budget they rather have a multifunctional mat than a product that only works for specific games. An interactive PE environment is being pushed on the market which includes things such as an interactive climbing wall, SmartGoals, a sound installation and more, but it misses an interactive mat. This is something that would be very successful according to Janssen Fritsen. A mat, after all, can be used for traditional exercises, but technology can be added to enrich the interaction and allow for different types of activities and exercises.

Transparant Bisonyl

Light Diffusing Layer

Foamlayer with holes

LEDs

Pressure Sensors

Foamlayer

Extra Grip Layer

Velkro

Blue Bisonyl

Zipper

The most well received aspects of the presented Versa and Moving Matt concepts were combined into a new concept. For this concept, inspiration was taken from the existing mat range of Janssen Fritsen. It was decided to design a mat that could be split into smaller tiles that could connect with each other via a wireless signal. The tiles were to have a LED grid and pressure sensors in order to control the LED's.

The main idea behind this direction was to provide schools that already have a limited budget with replacement equipment for existing mats. The new mat can add value to the current gym curriculum through light and play.

The concept was presented to students of Fontys Sporthogeschool in Eindhoven. The goal was to get feedback on the context and usefulness of the concept. The interactive mat was on the right track, but there was too much focus on specific game types. Teachers should be able to come up with this by using the product's core functionalities. This led to an improved concept. The product should be a platform rather than an accumulation of games and scenarios.

An earlier project from the department, A.I.M.., also made use of the Janssen Fritsen mats and incorporated LED's and pressure sensors to turn it into an interactive bench designed for inclusion. The report of this project was analyzed, to see how the design process of a mat with sensors and LED's could be streamlined and improved to better fit the VersaTiles concept. Insights gained include the use of a LED strip rather than separately soldering lights and the diffusion of lights by adding an extra layer between the LED's and the mat cover.
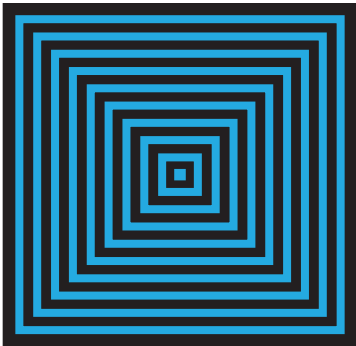
The making of; technical considerations

After developing the concept, VersaTiles needed to be experienced and tested. For this, one high fidelity prototype was made: it consists of three fully functional mats.

Lights (LEDs)
VersaTiles use light to give feedback and guide students through different exercises and games. The greater the number of LEDs, the clearer the communication with the mat. However, time, money and resources were also taken into account in order to choose the amount of LEDs that included in each tile. Three solutions were considered:

- Individual RGB LEDs, the most cost-effective solution but time-consuming: each LED has to be soldered by hand and each tile would contain 300 LED lights. An earlier project from the department, A.I.M., also made use of the Janssen Fritsen mats and incorporated LED's. The report of this project followed by a discussion with the developers showed that individual LED's were not advisable because of the high amount of work required to assemble them.

- RGB addressable LED strips, which are flat and include a chip that allows to control each led separately using an Arduino library: easy implementation but highly expensive. Some calculations were made to test if they were a possible solution by visualizing different arrangements of the lights. The density of lights was reduced to the minimum and prize was calculated. It was agreed by the designers that the maximum distance between led strips in order to give clear feedback to the user is 5 cm.
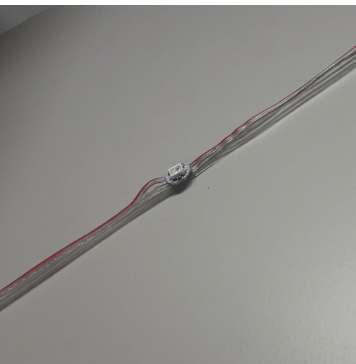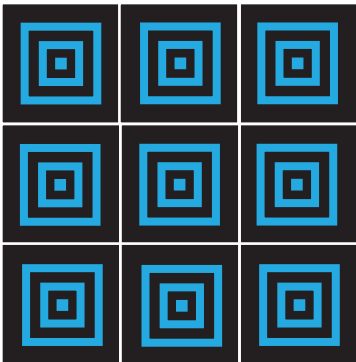
In the first visualization (top left), the cost of the LEDs is 90€ per tile. In the second visualization (lmiddle left) the
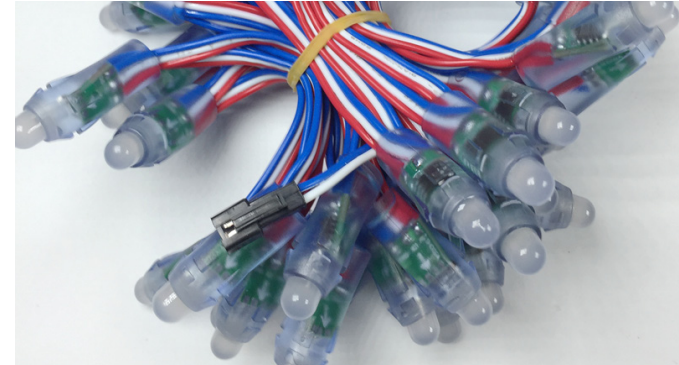
prize goes down to 55€ per tile but it means downgrading the quality of the product by making the nine pressure sensors inside the tiles more visible. Additionally, picking LED strips means not having a homogenous diffusion of light: each LED in the strip is few millimeters apart, while the separation between strips is 5 cm.

- RGB addressable LED strings, which have flexible cable in between each light. Thanks to this, the surface covered with one meter is bigger than the one that can be covered with one meter of LED strip, so the price is less than in the prior option (40€ per tile). Also, they provide a homogeneous diffusion of light because LEDs can be arranged in a matrix in which each light is separated 5 cm in every direction.

They are available in two types:
Type 1: they are bulky but at the same time shock and water resistant. They can handle up to 6V (top right).
Type 2: they are small and flat but fragile (bottom left). They can handle up to 5.3V, only leaving little margin for error as they need 5V to work.

Because of the advantages mentioned above, type 1 RGB addressable LED strings were the option chosen.

Top fabric
The top layer consists of a transparent fabric, called bisonyl. Bisonyl is a sturdy material that is used for a variety of applications ranging from storm covers to mat covers used by Janssen Fritsen themselves. There was chosen for a transparent material, as a colored layer would influence the visibility of the lights.
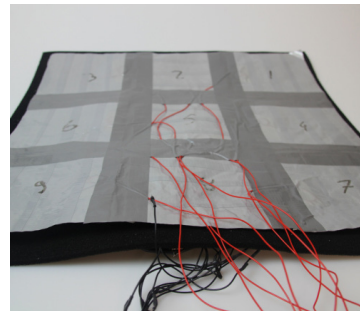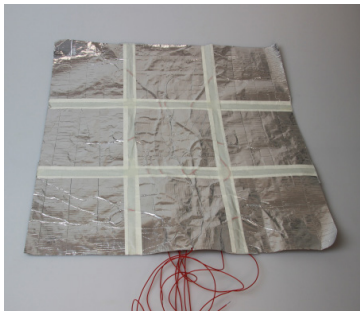
Pressure Sensors
Looking at the report of A.I.M., several pressure sensors were considered. Based on their argumentation, it was decided that the same pressure sensors are fitting VersaTiles. The sensors consist of two electrodes (left) and a resistive pressure sensitive material (Electro Static Discharge foam). They are cheap and can be made by hand. After performing a small test, it could be concluded that they could indeed be used for VersaTiles: they are not accurate but they can be used as digital input (LOW if it is not pressed, HIGH if it is pressed)[see Appendix B]

Diffuse material
The LED light bulbs are placed on top of the mat foam. There were different possible solutions to cover the cables visually and preserve a soft surface that were tested:

- Lower the opacity of the top transparent fabric with light diffusing films or frosted spray paint. As the LEDs are close to the fabric, these materials do not diffuse the light well enough.

- Felt with laser cut holes where the lights are, which is reinforced with tracing paper. The felt would cover the cables adding little volume to the prototype. The tracing paper would diffuse the light so the users do not directly see the light bulbs. This would eliminate the advantage of choosing a transparent top layer.

- Translucent packaging foam is thin and protects the electronics from impacts. As it is translucent, it does not need to be laser cut and it diffuses uniformly the light from all the LEDs in the tile.

The last option was selected as the best solution because of the benefits mentioned above as well as the selection of the LED strings: the big volume of the light bulbs could be camouflaged better with the softness of packaging foam than with felt. Moreover, the packaging foam did not need any holes.
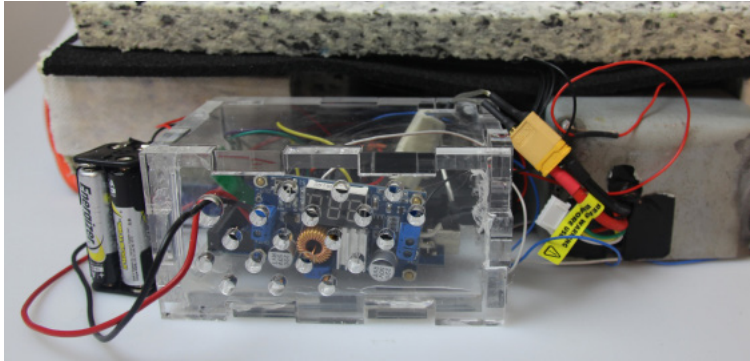
Battery

For powering 81 addressable RGB LED lights a low voltage is necessary, namely 5 V. However, for leaving on all LED's in white at full brightness almost 5 Ampère is needed. Such high Amperage released at once in a battery is rare, especially if they need to last longer than five minutes. Although not all lights are constantly on or white, the battery should survive a full day of classes in a school. Therefore a four cell Lipoly battery was chosen. 'ZIPPY Flightmax 3000mAH 4S1P 20C' This battery delivers 14.8V and therefore needs to be powered down by a voltage regulator that at the same time allows for 5A to be discharged at once 'XL4015 DC-DC Step-Down converter'. The battery needs to be charged with a special Li-Poly charger, as it is a battery that consists of several cells[See Appendix B]. Taking into account the wear, this battery can power white lights on full brightness for about one and a half hour.

A powerful battery is also very dangerous when damaged or when there is a short circuit, therefore the battery is secured by a safety fuse. It is also protected against deformation through a steel casing. In the casing, fire resistant material (rockwool) is added for protection as well. The battery can be turned on with a switch.

The following experts were consulted during the process of selecting and fabricating a safe and working battery: Geert van denBomen, Roelof Lochmans
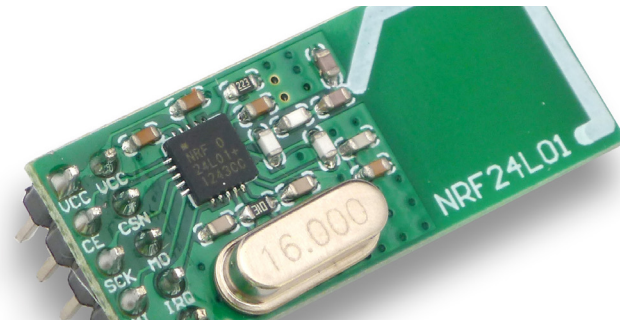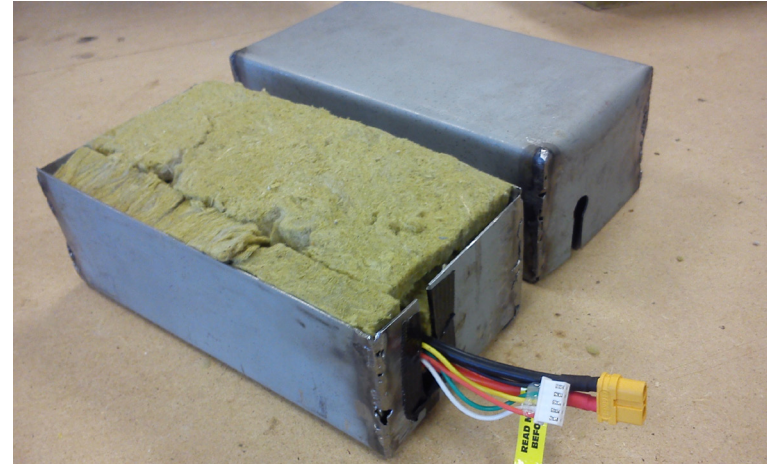
Connectivity

The final product makes use of a NRF24L01 radio frequency module to enable communication between different tiles. These modules can be used by microcontrollers to send and receive radio signal over a distance of 100 meters. The modules can communicate with multiple other nodes by making use of defined frequency channels. The modules are cheap, reasonably small and can be used for sensor networks and multi-receivers. Wi-Fi does not always have a steady connection which is fundamental for a good communication between the tiles. Nor was it necessary, considering that no information collected by the tiles needed to be saved online. [See Appendix B]

Modes

The modes of VersaTiles were designed by making drawings on a paper with the LED grid (top left) on it and with the aim to offer as many play possibilities as possible (see VersaTiles). The challenge was to not make them too specific, while at the same time being different from another mode. The modes that were thought of were discussed and there was decided on the feasibility of programming the mode. Modes that were not feasible to program were mostly to specific and therefore offered little playing possibilities as well. The eventually chosen and programmed modes were discussed before (see VersaTiles).
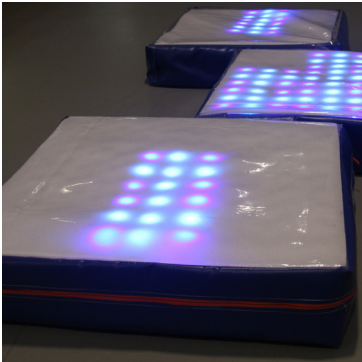
An example of a mode that was not picked because it was too specific, in combination with the trouble that comes when interacting with the VersaTiles with more students is: all LED's blink, until someone steps on the tile. Another tile starts blinking until the student leaves the tile and moves there. This mode could be used as unpredictable baseball honks or for 'chasing' the light, but when interacting with more students difficulty arises making this mode impossible to use. Modes that picked can be found in 'VersaTiles'.

Sewing

The cover of the mat mainly consists out of materials that were obtained through Janssen Fritsen. The top of the cover was the transparent material that has been discussed before. One of the mats has a zipper and the other two have Velcro strips to make sure that everything can be placed inside and changed if necessary (bottom right). Before everything was sewn, the experts at the Wearable Senses Lab were contacted. The available machines would normally not be suitable for these materials as they are too tough. However, after doing a

test piece (bottom left) on the industrial sewing machine, there was decided that it could be stitched in the TU/e lab, but only if a professional did it: accurate control was needed to not break the needle. In the end, Lonneke Baken would sew the covers with help and guidance of our team.
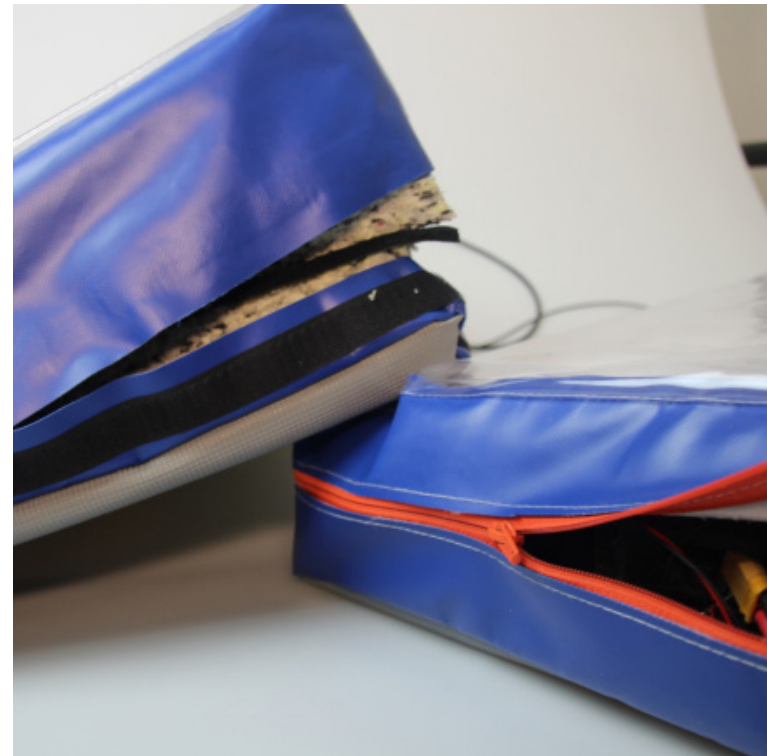
The final prototype consists out of three tiles (top left). One of the tiles represents the final design as it has a battery and a zipper, which should both be present in the end. The other two mats can be seen as less 'developed' as they need to be powered with an external power source (top middle) and have Velcro strips to open and close the cover. From top to bottom, the mats consist out of several layers (middle left). It starts with the diffuse layer, followed by a foam grid with LED's. This is followed by one side of the pressure sensors, the Electro Static Discharge foam and the second side of the pressure sensor. The bottom part consists of a final layer of foam, with place for electronics and the battery. The electronics were put into Perspex boxes for protection purposes (top right). All layers are kept together by the cover.
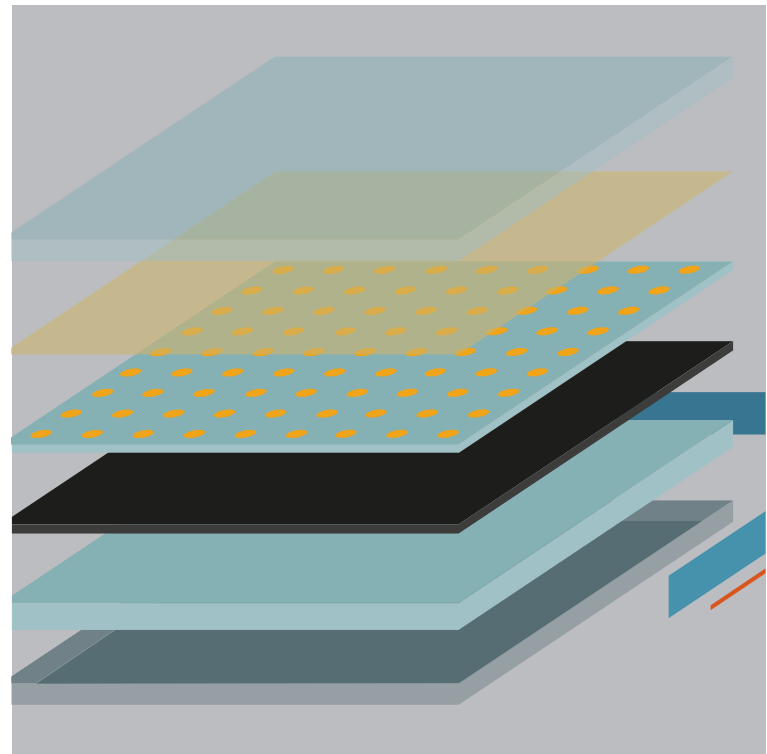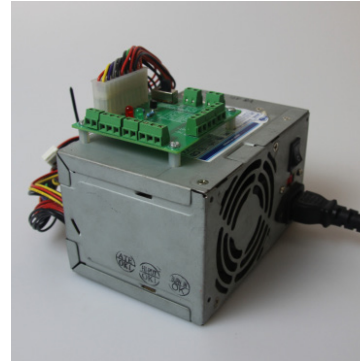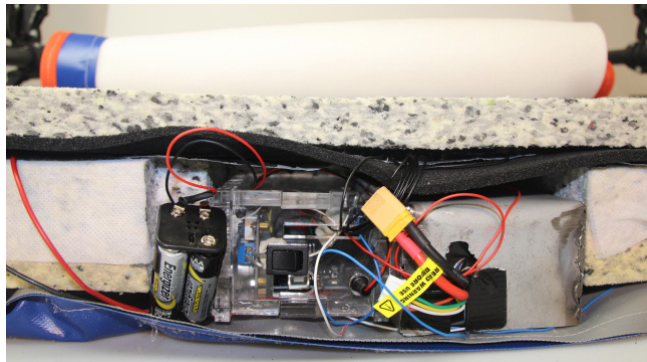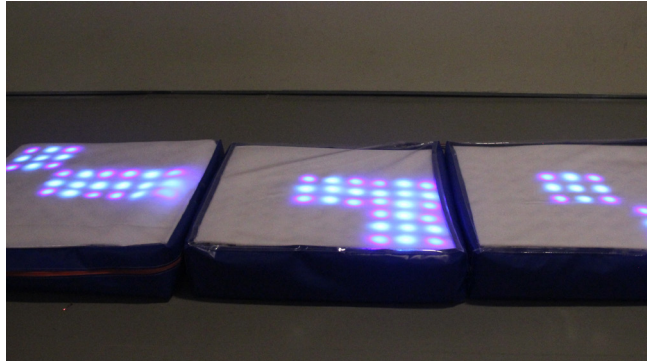
Expert evaluation and try-out session
When the prototype was finished, another meeting with the Fontys Sporthogeschool was held. In this meeting they were asked to try out VersaTiles and give feedback. The students were positive about the fact that the mats can be used for different games, traditional and new ones. Besides this, they mentioned that the novel experience could keep the lesson more interesting for the students. The modes that were most appreciated were the scoreboard, as it could create more equality in the playing field, and the mode where one person can set a 'trace' example, which is then displayed on another mat. When it comes to improvements, they advised to think more thoroughly about how long the lights should be on and how to place the mats on the wall as this is very important for ball games. Besides this, there should be made sure that modes can use the whole classroom to make them even more interesting.

"I would mostly use it to come up with creative new ways to play old games. To re-vitalize soccer, or baseball … to make those new and innovative. And to make them interesting for people that are good at sports, but also the people less good at sports"
– Fontys Sporthogeschool student

The pictures show the Fontys Sporthogeschool students interacting with the tiles.
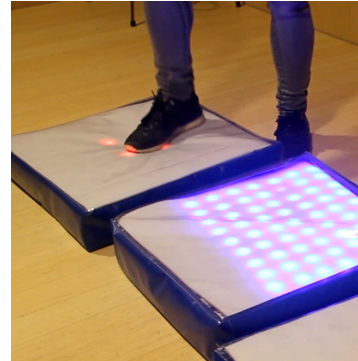
The change in mode two (lighting up part of the mat that are copied to other mats) is shown in the illustration. The lights stay on until a student 'turns them off'.
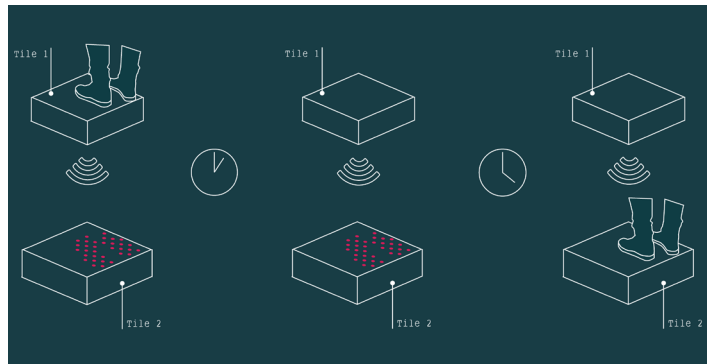
The illustration shows the changes in mode three, two traces: one that stays and is the example and one that fades again.
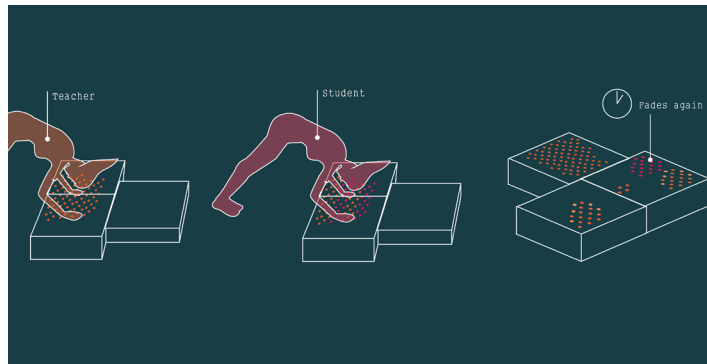
The illustration shows the change in mode four, that concerns the score counting tile.
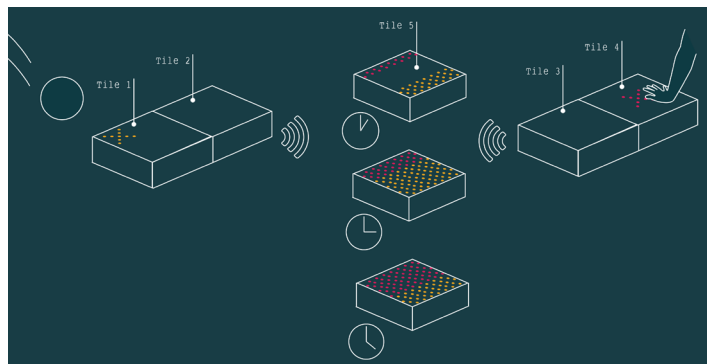
Discussion

In line with the changes that Fontys Sporthogeschool students suggested and the design vision and requirements a few changes in the modes are proposed.

Mode two (lighting up parts of the mat that are copied to other mats) can be improved by increasing the time the lights are on: the part that is lit up stays on until it is switched off by copying the movement. This way the feedback given by the mat is clearer because the spare of time with the lights on is bigger.

In mode three (tracing mode), the time the LEDs are on before fading should be adjustable. This can be combined with the possibility to set a teacher trace; here the teacher leaves the trace which does not fade until the teacher chooses to erase it. In another color the students leave their trace so they can see where the two overlap. The student's trace fades after a few seconds and the tile shows the teacher trace again.

In mode four, (in which crosses light up randomly) the score tile can be improved by looking at it with the 'Lenses of Play' cards and the player types in mind. To make the mode interesting for so the called 'killers' player type the mode should offer changing power balances[17]. The 'Lenses of Play' include a 'tipping point' card[12]: creating more 'tipping points' facilitates this changing power balance. A tipping point can be created by having the score of two teams each count from opposite sides. If both teams are at the middle they 'fight' to get the upper hand by taking a point from the other team by scoring twice after each other.

In mode five the time for the zones to change should also be possible to be set by the teacher.

Velcro
stripes

Velcro
stripes

These changes can be achieved with some small adjustments and the addition of an app to control the mats. The teacher only has to set a few (quick) values, making VersaTiles easy and fast to set up. The app to control VersaTiles is in line with the future plans. The future plans include the app, small mode changes, the addition of Velcro to combine the mats in one mat (plus, if necessary, a mat casing that keeps the small mats from tearing apart) and a mechanism to hang the mats on a wall. But the most important of all plans: user testing at a high school.

The pictures on the left illustrate from top to bottom: A teacher controlling VersaTiles with an app; VersaTiles attached to the wall with velcro; the VersaTiles combined as one mat.
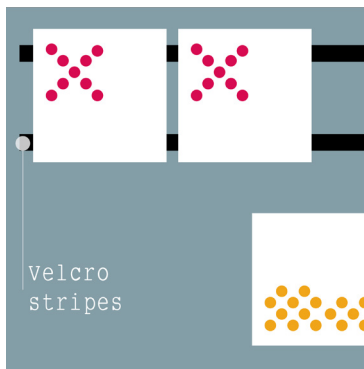
Besides making minor changes, some drastic changes to make VersaTiles work (better) are necessary. An Arduino Mega does not have enough working memory to process the code of all modes plus the code of communicating at once. A solution for this problem needs to be found to make the full prototype work with an application that controls it. The communication needs some work as well; now only pre-set communication works. This means that sending information to a random tile and changing to which tile to send every time cannot be done yet.

If the concept is taken further, stepping away from budgeting problems, it is interesting to add pressure sensors that actually measure pressure. In this way VersaTiles can be used for different sectors as well: training in top-level sports or revalidation. The revalidation sector already expressed interest in working with VersaTiles and offered user test possibilities. (J. P. M. Verberkt, policy officer at Libra) Not taking money into account at all, VersaTiles

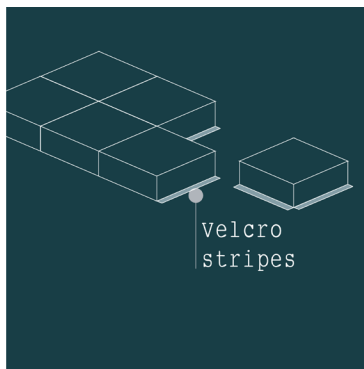could even be able to recognize who is interacting with it and change the difficulty levels accordingly, increasing the equality in challenges and creating a better flow.[19]

VersaTiles could be extended, not only by having the mats surface (LED lights) as a screen and feedback point, but by adding screens in the gym class that create a fully immersive experience when playing and learning as well. E.g. 'Apen kooien' can be done in the jungle.
Finally the technology of VersaTiles can be used in other gym-class equipment: creating a vault with pressure sensors and LED lights. Here there is no limit to the power supply size as it can be hidden in the box underneath.

Plans are made to use VersaTiles to compete in some design competitions as well. When university support is offered VersaTiles will be submitted to the Red Dot 'design concept' competition in the category education. Submitting the concept to the International Design Talent competition (Czech Republic) is also a consideration as the design fits well into the requirements and participation is free. Later, the Sportinnovator competition might be interesting as well.

Acknowledgements

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[Children with laptop] FotoSearch.es (Free Photo Stock)

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Top right image in Problem Statement.

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Top right image in Technical Considerations, Lights section.

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Bottom right image in Technical Considerations, Connectivity section.

**Appendix A
Teacher Interviews**

Interviews with three high school PE teachers were conducted orally and separate from each other, at Scholengemeenschap Were Di situated in Valkenswaard. The aim of the interviews was to get a better understanding about different ways of handling PE class and the opportunities in the PE class. Underneath the answers to the questions we asked can be found. Not every teacher uses all that is answered in his class but is gives an overview of what is currently done and what can be done.

What do you do to improve collaboration and inclusion?
- Games in teams.
- Choosing the teams myself.
- Collaboration games.
- Create challenges that fit the level of a student.
- Give children that perform very well extra challenges.
- Ask children what they want to do in class.
- Clean up together.

How do you handle problem and group behavior? (e.g. too many groups that exclude others etc.)
- Separating the problem children, putting them in separate teams from each other.
- Very situational dependent, talking to the problem children most of the times.
- Choosing the teams myself.
- Offer little possibilities to choose from.
- Reward children that collaborate well.

What should or could be improved in current classes? (Considering: content, planning, making it easier for the teacher)
- Increase the intensity of gym classes.
- Fusing PE classes with other classes creating collaborations with different courses.
- Spending less time getting ready (setting up gym equipment).
- More structure during the class and the semester.

What is your opinion about the usage of technology in class? (Smartgoals, iPad, interactive objects or games)
- It can work really well but movement and exercise is most important.
- As support for analyzing a movement and showing it in slow motion to the student it can work (named by all three teachers).
- Use it as feedback or to show an example.
- We know the technologies but most of them are expensive and can only do one thing. Maybe if Smart Goals also would be changeable in height and it can measure: So you can use it for gymnastic exercises such as jumps as well as the ball games and condition training it is used for now?
- We are now starting to work with iPads.

Why, do you think that some students don't like PE classes? And why do some students enjoy it very much (to your best guess)?
- Some students don't like moving and are lazy build while some students really enjoy taking action.
- I think most students like it because they can move (after a long day of sitting) and can collaborate with other students.
- Negative experiences, with for instance grades. Or a negative self-image can make someone dislike PE classes. It depends on the development of a student.

What should an interactive object or an interactive game definitely offer to ensure that you want to use it in class?
- Movement should come first (this is more important than the game or interactive element).
- Little explanation necessary (being able to start quickly).
- It should be multi-purpose (many functions).
- If it can make digital measurements that would be nice.

What do most children really have to learn in the PE classes; what causes the most trouble / where do students have issues with?
- Learn that movement and exercise is important.
- How to collaborate well.
- How to coach each other.
- How to teach someone else something you are good at.
- Controlling their motoric movements.
- Knowledge about their body affordances.

What do you do now to make the PE classes fun? Or what do you think makes it fun?
- Many different elements (such as swimming, gymnastics, soccer, running etc.). / A lot of variation.
- Little overlap. / A lot of variation.
- A lot of challenge(s).
- A different way of grading (largely based on motivation).
- Playing many games.
- Work with student individually.
- Tell a week beforehand what we are going to do the next week.

**Appendix B
Circuits**

Circuit of Pressure Sensors and LED's

LED-strip

Power Supply

Aluminium Foil
Electrostatic Discharge Foam
Aluminium Foil

47 KΩ
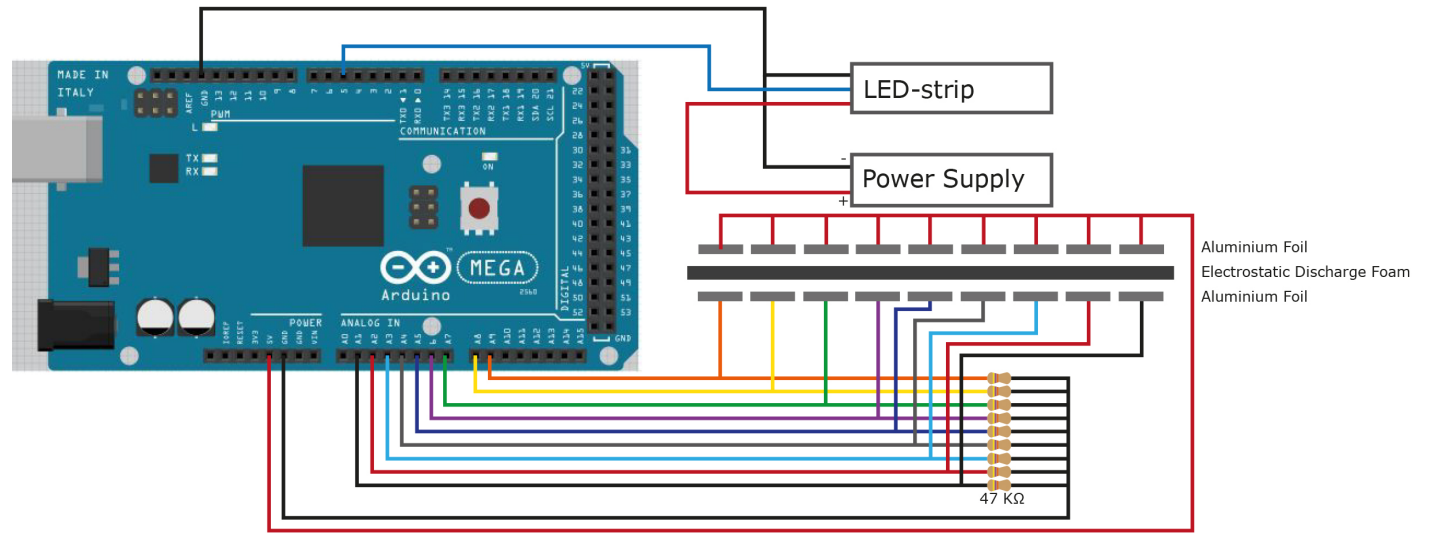
**Appendix C
Circuits**

Circuit of Battery and LED's

LED-strip

XL4015 DC-DC
step down converter

Battery

ZIPPY Flightmax
3000mAH 4S1P 20C

Power Switch

Fuse
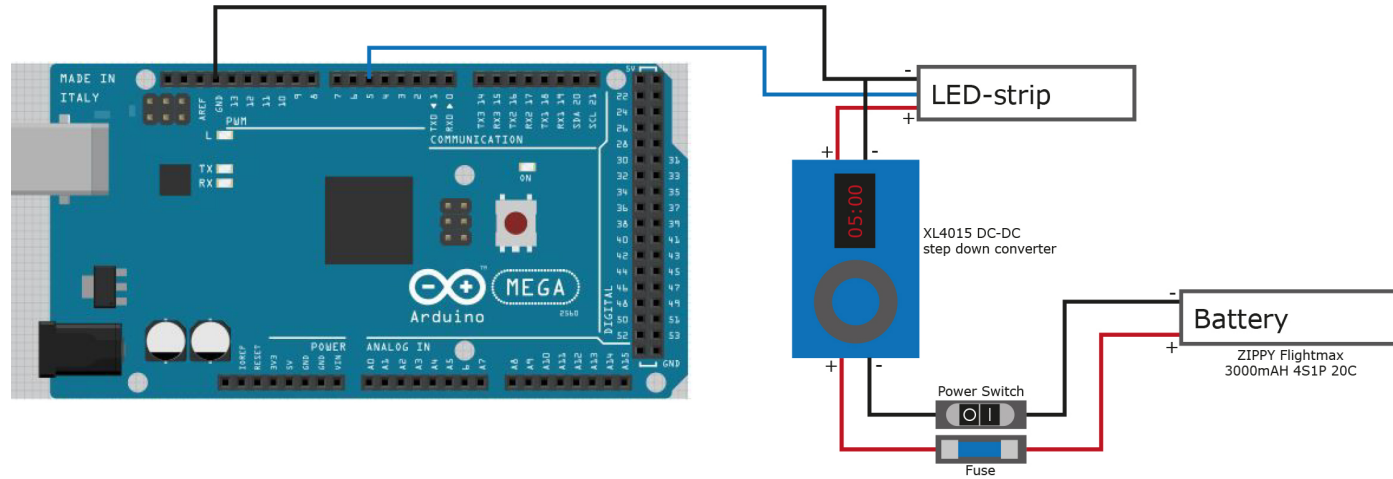
Circuit of NRF24L01 Module

VCC	VCC
CE	CSN
SCK	MO
MI	IRQ
GND	GND

NRF24L01
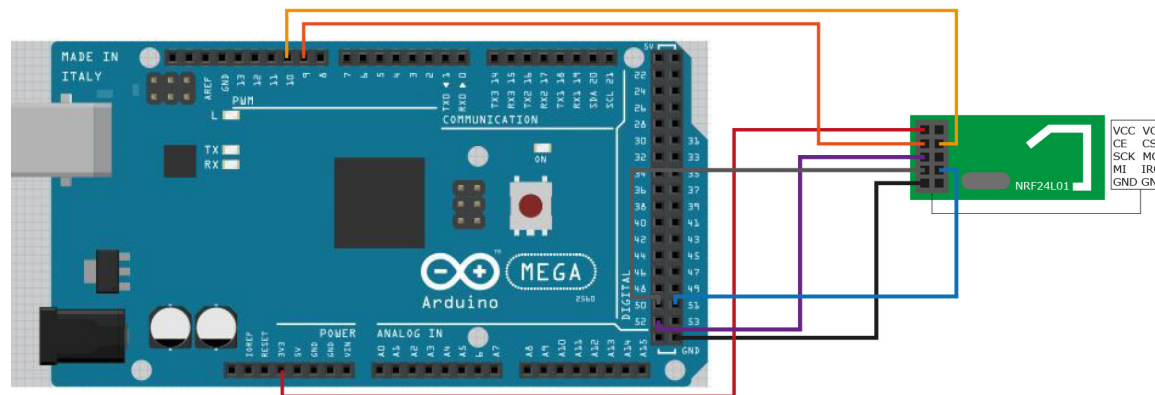
**Appendix D
Reflections**

Reflection Allitze Faro

I decided to join this squad because I learned that most of my favorite projects and electives had game elements in it. Before, I did not always focus on this consciously so this project gave me the opportunity do this, matching my vision.

Prototype
When looking at my previous project, my assessors told me that my technology and realization competence was not that visible and probably not developed enough. My prototypes were always low fidelity, and I never attempted to make a high fidelity prototype because I believe that others are better at making something look finished. Nevertheless, I wanted to improve my prototyping skills as this is also important for low fidelity prototypes. Besides this, having one finished prototype would be good to have during my education. In the end, I am really content with how our demonstrator turned out as it looks finished and gave me the opportunity to focus on this expertise area. I learned to make a working prototype wireless with a battery, about LEDs, to work with foam, sewing machines, and learned some basics when it comes to working with metal. All these skills will be helpful in my future projects as they can help me realize prototypes.

Planning
I am someone who really believes in working in teams as people can inspire each other and bring other expertise areas to a problem. Within our team, the work approaches were really different, which made it sometimes difficult to make fast progress when needed. A to do list and planning was missing, which made it hard for me to keep track of the progress and next steps. It made me feel a bit stuck. Therefore I decided to take the role of a time-keeper and schedule maker to make a better planning and to divide the work to make everything go more natural. I am really glad that I did this, because meetings became more effective and things went smoother in my experience. Looking back, I should have done this earlier as it might have saved us time, giving more time for user tests.

Communication
One of the things that I would like to improve in future projects is the communication between team members. Although the end result is really nice, it could have gone in other directions as well. At a certain point in the process, group members started to work at different places. This influenced the communication in a bad way as certain things were not communicated at all. This made it hard to keep track of each other's work, prioritize the same things, and similar things were sometimes done differently (leading to more work). This could be avoided by either working at the same place together or starting and ending the day together. In this way it is possible to update each other with the goals of the day and how they went.

Reflection Koen van Gaalen

Goals
I chose the Play and Learn squad this semester based on my designer identity and semester goals. For me it was important to work on different ways of implementing playfulness through interaction and technology this semester. Over the course of this project I have learned about new ways to realize my ideas through crafting and programming. I mainly worked on programming the connectivity between the VersaTiles, this gave me more insight in programming and the use of microcontrollers and technology in my prototypes. I am not well versed in programming, thus this was a challenge for which took me longer to overcome than I wanted. Nevertheless the results of my work could be combined with the work of my group members which lead to a working, professional looking final prototype.

Communication
An essential part of a group design project is communicating with your fellow students. Our final prototype shows how task division can lead to a coherent whole if you communicate correctly. Nevertheless we could have communicated better with each other during the final stages of the project as there were a few minor misunderstandings due to working in different places. These were all solved, but by communicating better with each other some setbacks could have been avoided. In the future it would be good to report on progress at the end of each project day in a meeting if I were to work in different places with a group again.

User Testing
Our final product was tested with Fontys Sporthogeschool students and we involved a lot of separate experts in the crafting and programming parts of our project to ensure we could realize a product that would be aesthetically pleasing and functional as well. I believe we missed an opportunity to test our final design in a PE class with students. This was mainly due to time constraint as crafting and programming took up most of our time, nevertheless an extensive user test would have provided us with more insights on improvements and application of our design in the right context. In addition, our final concept was chosen in a late stage of our design process and was ambitious and time-consuming resulting in the less time for testing.

Future Use
When designing for PE classes a lot of things have to be taken into consideration as can be read in our research. I am planning to continue designing for a comparable context and thus the theories, regulations and marketing aspects I learned during this semester are still suitable in my future at Industrial Design. I want to use next semester as an opportunity to test this design in context during my research semester.

Reflection Michelle van Lieshout

Collaboration
Our team complemented each other well in skills, knowledge and personality. In the team I was a motivator, always pushing for taking the concept further and doing more. Sometimes I went too far in this and my expectations (especially the expectations I set for myself) considering everything that needed to be done the time were unrealistic. For me this led to disappointment sometimes but for the other team members it delivered the push to exceed their expectations. This made me the caregiver of the team as well absorbing the stress, so the team performs better.

In the beginning the collaboration with the team went very well but after starting prototyping the communication hit some hurdles. E.g. How the LEDs are placed in the grid (important for the programming) and how the separate parts of the mat fit best on top of each other, gave problems. Because the LEDs had to be put in the grid all over again since how they were put in initially differed and this meant trouble for either the code or the fitting of the tile's top layer to the bottom layer. Putting the LEDs in the grid again had to be done while there was high time pressure, frustrating everyone. Another example is that the team did not know how the programming of the modes was going when it was going well (I communicated when something did not go as planned). Probably the small problems therefore were due to the enormous workload that made us tired and the prototyping at different locations which restrained us in communicating quickly and meeting up. Working at the same prototyping place and planning regular meet ups during the day where progress is discussed can work to solve this next time.

Attitude
'A platform- thinking attitude; users with different needs and goals but the same means'
During the process the guidelines changed with our gained knowledge and attitudes. We switched from making a product that offers an accumulation of games to a product that is a platform for teachers. Sometimes designers (and me) take it too far and they design the experience to the littlest detail, while designing to enable the users is the most important and they might not exactly do as planned. I learned to take into account that users are designers their selves and there are more affordances for your concept than you initially expected. Designing for a user group that has different expectations but the same means to achieve them (platform based thinking, taking a step back) is therefore always important in a design process. During the designing of the modes I tried to find the border between being too specific and being able to support certain forms of play and curricular exercises.

I somewhat succeeded as the modes were well received by the Fontys Sporthogeschool students although some modes need to afford a little more such as the tracing mode which should afford both: showing guidelines and feedback at the same time. To determine the extent of success of the mode design a user test with PE teachers and students should be conducted. The designing of platform modes in interactive PE equipment could also be a good research topic: This way a guideline can be designed that helps designing these modes and evaluate these modes. Because of my interest in research and because my next project will be in a squad that focusses on systems, this could possibly be an interesting subject for my research project. I will assess the possibility of this at the beginning of next semester.

I believe the 'platform perspective' should be taken each design project at least once to see the overall picture and find the opportunities that you are missing so you can make a deliberate decision regarding those opportunities. And from now on plan on doing this.

Knowledge and skills
I believe the process we went through, consisting of: quick topic research and user research, set guidelines, brainstorm ideas, work out concepts and iterate with many feedback sessions with stakeholders and user focus groups (sessions with the Fontys Sporthogeschool students) works very well and leads to quality, it ensures the design is theory build and fits the user group while leaving enough time to design and iterate on the design. Therefore I will try using this process more often.

During the making of the prototype I improved my programming skills and system thinking skills as I programmed the modes for VersaTiles. I needed for example to come up with a 'work-around' because certain library features did not allow me to send a pointer to an array with LEDs (which is an area above a pressure sensor) that needed to be switched off with a timer. For programming a lot of system and abstract thinking is necessary. I am now able to work with LED strips, self-made pressure sensors and communication modules and I increased the speed at which I program. This helps me make prototypes fast. Theory states that play is interactive and with my personal preference for (at least partially) tangible play and my vision focused on fun and play; programming and working with technology such as Arduino are very important. Therefore continuous practicing with these technologies helps me to communicate ideas fast through prototypes.

Making the product I learned about batteries, Voltages and current (something I somehow never understood well before bringing it into practice in VersaTiles) and how they are dangerous, can be put in series (which increases the voltage) and how to protect them well to create a safe product. I also learned how the Arduino interprets data (it compares signals) and that therefore the ground of your external power source should always be connected to the Arduino ground (otherwise it cannot compare the input signal with the 0-signal). Besides this I gained knowledge about materiality choices, (diffuse material, which LEDs to choose etc.) PE classes (curriculum, innovations, the marketing approach of Janssen-fritsen), fun and forms of play (lenses of play cards which work well to evaluate a game and design games, research into fun and play) and the use of scenarios (convenient to explain an idea but many different scenarios can be confusing when presenting).

I was able to use knowledge from my extra electives regarding fun and persuasive game design. Although the courses are more focused on digital game design the theories discussed in these courses helped design the modes and think of 'fun' scenarios with interactive products that fit in the curriculum of a PE class. I will continue to follow extra electives about fun, play and games as this interests me and helps me in my projects.

In the project we had to deal with multiple stakeholders: Janssen-fritsen, PE-teachers and students while we all have our own vision. To make this work we combined our personal visions in a group vision (e.g. we all wanted all children to be included in gym classes) that included research on the topic and user interviews. We incorporated feedback from our stakeholders and eventually succeed well in creating a prototype (concept) that adds value for all stakeholders including ourselves. "It is fantastic, and

that is not something I say very quickly" - Willem Bouwman, Managing director Janssen Fritsen Netherlands I am very proud at the end result and think that having small sessions with stakeholders throughout the process of designing works well for creating this value for all. Therefore I will change my approach to design projects by including many sessions with various stakeholders.

In short about PDP goals
"Make a high fidelity prototype that allows a user to experience the concept and is worthy of being send in to compete in well-known design competitions."
I believe I succeeded in this very well, the plan to send in the project for design competitions is already made and a possible client is very enthusiastic about the project as well. The process we took to design this concept (explained in the longer reflection), often communicating with stakeholders and the role in the team I took (motivator, pushing for more) are the reasons this worked out so well.

"Learn about fun and how a concept of a physical game can create the optimal setting for experiencing fun (because a designer can only design the elements that eventually should lead to fun). And see how this fun can be integrated in learning (the curriculum)."
During my courses I learned about fun, for this project learning about play was eventually more fitting because we switched to a 'platform product'. I learned more about how play and fun could be integrated in PE classes: offer a versatile product that can be used for games and exercises with engaging elements such as light.

"Lay a theoretical base for my vision in the area of play and learn."
I changed my vision according to the theory I found about

fun. I now see how fun is closely related to learning. (My vision can be found underneath)

"Work with a company as a stakeholder adding an extra restriction to the design concept possibilities (as it should also fit the company's direction). And make a product that has a higher chance of being developed (that is fit for the market and can be produced)."
At the demonstration day the director of Janssen-fritsen Netherlands stated that our product was a real product in the first stages of development. I believe this is due to the high-fidelity prototype where thought through decisions were made on how it could be developed and withstand rough usage. And the thought through concept that adds value for all stakeholders, which is supported with theory.

"Practice my presentation skills: be clear in what I tell, have a clear structure and stay calm."
During the midterm I practiced my presentation skills during the presentation for Janssen-fritsen. I managed to stay calm because I prepared very well but due to the many scenarios explained during the presentation there was little structure. The presentation slides, however, did help provide this structure. In short: slides can help provide structure, preparation helps to remain calm and too many different subject or scenarios decrease structure.

Vision
Current society asks us to constantly want something and be buried in work to achieve it. A question is simply answered with an 'I'm busy' and if you are not busy this is not necessarily socially accepted. When constantly working for something, we better love doing it.

What humans love doing is learning. Play is a way of learning that enables a user to step into a play zone that

involves no real world 'hard' consequence and therefore is considered more fun. Fun can be scientifically explained and a big part relates back to learning and finding and recognizing patterns.

Since I was a little kid I have been interested in story worlds and learning. These worlds range from narratives that are embodied in theme parks, (musical) plays that can be experienced in the theatre and the countless scenario's our brain thinkers up trying to anticipate situations that never happen. These worlds broadened my imagination and inspired me but most of all they taught me.

With my designs I aim for inspiration and learning. I incorporate fun through learning something in a non-threatening environment that is preferably loose from the 'real world' consequences. My designs enable experimenting which leads to new associations and ideas. I see myself designing for theatre, museum set ups, theme parks and schools.
some setbacks could have been avoided. In the future it would be good to report on progress at the end of each project day in a meeting if I were to work in different places with a group again.

Reflection Ana Torralba

When I chose to come to the TU/e I was looking for things such as merging technology with product design and developing my skills in prototyping in order to build a professional portfolio that reflects my interests and what I'm capable of doing. Working this semester here, has helped me realize about skills that I didn't know I had: making instead of studying forced me to step out my comfort zone. The biggest challenge for me was the development phase: in my previous education, design projects were completed when a concept was defined. However, after the Midterm presentation, my team and I decided to work together to develop our solution into a high-fidelity and functional prototype. It was the challenge I was looking for: a finished interactive product. One of my tasks was choosing some of the electronic components: LEDs and pressure sensors (making them and figuring out how they work by developing a testing code). I built the prototype which implied working with all kinds of materials and varied techniques: different foams, metal, fabric and electronics that were cut (with laser, dies and saws), sewn, and soldered. The finished product had the impact we wanted: in the Demo Day, visitors couldn't stand there listening to a long pitch because they wanted to try it! VersaTiles connected with users inspiring laughter and fun.

A huge reason of the success of the project is my team. We are all very different but, after an introductory phase, I learnt that we are complementary: while Michelle and I are the dreamers and passionate ones, Koen and Allitze are the objective and serene in the team. Both parts were needed in the project: while ones push the innovation and creativity, the others organize and take a step back to examine the situations. We all put a lot of effort and enthusiasm to make VersaTiles possible. During project meetings, I've noticed one of my flaws in relation to teamwork: I had ideas in mind and for me it was so easy to understand them that I didn't take enough time to explain myself. Therefore, some of the long discussions that frustrated me were caused by misconceptions. Now I explain my ideas thoroughly with examples, drawings or even with the help of the computer. Also, when I have one idea that I think is good, I prepare my arguments in order to convince the rest of the team instead of explaining it when it comes to my mind which sounded vague and confusing.

Moreover, the team helped me to understand better how TU/e works. They all studied their Bachelor's here. I observed that when someone sets a goal in their PDP, they fight for it even though circumstances are not the most favorable. For example, if one in the team knows a lot about LED technology but he set his goal in learning another thing, he won't offer himself to work with LEDs. At first for me, this was quite shocking. However now, I understand that this is the way to learn new things. I wanted to do more in this project about programming but I didn't because I thought others might do it better and quicker, and I prioritized the team interests. Next semester I want